THE

ARTILLERIST'S MANUAL,

AND

BRITISH SOLDIER'S COMPENDIUM.

By MAJOR F. A. GRIFFITHS,
R. F. P. ROYAL ARTILLERY.

SEVENTH EDITION.

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AND

BRITISH SOLDIER'S

COMPENDIUM.

By MAJOR F. A. GRIFFITHS,

R. F. P. ROYAL ARTILLERY.

Si quid novisti rectius istis,
Candidus imperti: si non, his utere mecum.

SEVENTH EDITION.

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PREFACE.

SEVENTH EDITION.

Similar to each of the preceding editions of "THE ARTILLERIST'S MANUAL, AND BRITISH SOLDIER'S COMPENDIUM," the present work contains much additional matter; and notice has been taken of the subjects in which improvements, or alterations have been adopted. To those Officers, and Non-commissioned Officers, who are in possession of the 6th edition of The Manual, it is advisable that I should specify the chief additions, &c., in the present edition, viz.:—

ALTERATIONS:

Percussion small arms.
Manufacture of cartridges.
Ball cartridge barrels, and boxes.
Carcasses.
Quick match.
Shells, weight, &c.
Ordnance, length, weight, &c.
Service, and management of heavy ordnance.
Wads for heavy ordnance.
Charges for the Royal Navy.

ADDITIONS:

Manual, and platoon exercise of Riflemen.
Instructions for aiming with the rifle musket.

Light infantry signals, and sounds.
Fusil exercise.
Instructions for pitching, and striking tents.
Lights, long. Lights, signal.
Parachute light ball.
Water fuze.
To extricate a shot when jammed in a gun.
To ascertain if a magazine is damp.
Detail for active service of 9-Pounder Troop of Royal Horse
Artillery.
Reserve of gun, and small arm ammunition.
Detail for active service—18-Pounder Field battery.
" " " 9-Pounder Ditto.
" " " 32-Pounder Howitzer Ditto.
Small arm ammunition reserve.
Exercise of rockets.
To estimate distances in the field.
To find the distance from an object, height known.
Instructions for the exercise, and service of great guns, and
shells, on board Her Majesty's ships.
Instructions for landing seamen, and marines, with Field pieces.
Charges for the Royal Navy, for boats.
Proportion of charges, for a 51-screw steam frigate.
Ditto Ditto 50-gun frigate.

Also—1 New Plate.
2 " woodcuts.
1 " diagram.

In the publication of each edition my object has been the same—to render *The Manual a Compendium* of all that can be required by Officers in the Field;

and if I may be allowed to judge by the gratifying manner in which the work has been received by the Officers of the United Services, my humble exertions have indeed been successful, ten thousand copies of The Manual, including the present edition, having been printed.

The extensive circulation of “The Artillerist’s Manual, and British Soldier’s Compendium,” is no doubt, however, chiefly to be attributed,—

1st. To the highly favourable notice of the Military Authorities, as evinced by the GENERAL ORDER of the Master-General of the Ordnance, dated 25th April 1840, and by the MEMORANDUM, dated Horse Guards, 10th December 1840.

2nd. To the considerate notice of The Lords Commissioners of the Admiralty, a copy of the work having been ordered to be included in the libraries of all Vessels of war.

3rd. To the liberal distribution, by the Honourable Court of Directors of the East India Company, of copies of each edition to the military authorities at the several Presidencies in India.

In conclusion, I have to express my grateful feelings to His Royal Highness the General Commanding in Chief, who has been graciously pleased to promulgate the MEMORANDUM, dated Horse Guards, 13th October 1856;[1] and my warm thanks are also due to the Officers of the various Departments at Head Quarters, for the kind manner in which they have invariably assisted me in the revision of the work, in order that each succeeding

edition may keep pace with the improvements, alterations, or requirements of the United Services.

F. A. GRIFFITHS.

Putney, October 13th, 1856.

(Copy.)

Horse Guards,

Memorandum.

13th October 1856.

His Royal Highness, the General Commanding in Chief, strongly recommends to the Officers, and Non-commissioned Officers of the Army, the Revised edition of a Work, entitled “The Artillerist’s Manual, and British Soldier’s Compendium,” a work replete with the most useful Military information, and of which Major Griffiths, R.F.P., Royal Artillery, is the author.

By command of
His Royal Highness,
The General Commanding in Chief,
(Signed) G. A. WETHERALL,
Adj.-General.

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PUBLICATIONS,

REFERRED TO, OR EXTRACTED FROM.

The Infantry Manual.	
Field Exercise, and Evolutions of the Army.	
Instruction of Musketry.	
Bombardier, and Pocket Gunner	{ Captain Adye.
	{ Major Elliott.
British Gunner	Captain Spearman.
Artillery	Mr. J. Landmann.
	{ Lieut.-General Sir H. Douglas, Bart.
Naval Gunnery	{ Captain Stephens.
	{ Lieut. Beauchant.
Instructions for the Exercise, and Service of Great guns, and Shells, on board Her Majesty's ships.	
Field battery Exercise, and Movements.	
The Horse, with a treatise on draught.	
Directions for the guidance of the Farriers of the Royal Artillery	} Mr. C. Percivall.
Instructions, and Regulations for the Service, and Management of Heavy Ordnance, &c.	
Fortification	{ Lieut.-General Pasley.
	{ Mr. J. Landmann.

	{ Mr. Lochée.
Field fortification	{ Captain Malorti.
	{ Captain Macaulay.
Military Surveying	Lt.-Col. Basil Jackson.
Treatises on Attack, and Defence	Lt.-Colonel Jebb.
Artificial fireworks	Mr. G. Mortimer.
	{ Dr. Hutton.
Mathematics	{ Dr. O. Gregory.
	{ Mr. Trotter.
Practical Geometry	Mr. J. Landmann.
Natural Philosophy	Dr. Fergusson.

The practical Mechanic’s guide.

The practical Engineer’s guide.

The Engineer’s, and Contractor’s pocket-book

Tables	Mr. Beardmore.

&c. &c. &c.

THE

ARTILLERIST'S MANUAL,

AND

BRITISH SOLDIER'S COMPENDIUM.

PART I.

INFANTRY EXERCISE, MOVEMENTS, &c.

MUSKET—FLINT LOCK.

	lb.	lb.
Weight of Musket	10 }	11
Do. of Bayonet	1 }	
Charge, Ball cartridge 6 drams.		
Blank cartridge 5 drams.		

PERCUSSION SMALL ARMS.

1. Percussion Musket, Smooth-bore: 1842

Pattern.

Barrel	{Length	3 ft. 3 in.

	{Diameter of bore	·753 inch.
Musket	{Length	4 ft. 7 in.
	{Weight	10 lb. 2 oz.
Bayonet	{Length beyond muzzle	1 ft. 5½ in.
	{Weight	1 lb. 1 oz.
Arm complete	{Length	6 ft. ½ in.
with bayonet	{Weight	11 lb. 3 oz.

Bullet (Spherical) ·689 inch diameter, weight 490 grains.

Charge, 4½ drams F. G.

Sixty rounds with 75 Caps = 6 lb. 10 oz.

2. Artillery Carbine: 1853 Pattern.

Barrel	{Length	2 feet.
	{Diameter of bore	·577 in.
Carbine	{Length	3 ft. 4½ in.
	{Weight	6 lb. 7½ oz.
Sword Bayonet	{Length	1 ft. 10¾ in.
beyond muzzle	{Weight	1 lb. 12 oz.
Arm Complete	{Length	5 ft. 3 in.
with bayonet	{Weight	8 lb. 3½ oz.

The Rifling is 3 grooves and one turn, 6 ft. 6 in. [2]

Bullet	{Weight	530 gr.
	{Diameter	·568 in.

Charge of Powder, 2 drams F. G.

Weight of 20 Rounds, with 25 Caps = 1 lb. 11 oz. 2 drams.

3. Regulation Rifle—Musket: 1851 Pattern.

Barrel	{Length	3 ft. 3 in.
	{Bore	·702 in.
Rifling, 4 Grooves, one turn in 6 ft. 6 in.		
Musket	{Length	4 ft. 7 in.
	{Weight	9 lb. 9¼ oz.
Bayonet	{Length beyond muzzle	1 ft. 5½ in.
	{Weight	15½ oz.
Arm complete with bayonet	{Length	6 ft. 0½ in.
	{Weight	10 lb. 8¾ oz.
Bullet (Minie)	{Weight	696 gr.
	{Diameter	·691 in.

Sixty rounds and 75 Caps = 7 lb. 0 oz. 8 drs.

Charge, 2½ drs. F. G.

4. Enfield Rifle—Musket: 1853 Pattern.

Barrel	{Length	3 ft. 3 in.
	{Bore	·577 in.
Three grooves, one turn in 6 ft. 6 in.		
Musket	{Length	4 ft. 7 in.
	{Weight	8 lb. 8 oz.
Bayonet	{Length beyond muzzle	1 ft. 5½ in.
	{Weight	11 oz.
Complete with Bayonet	{Length	6 ft. 0½ in.
	{Weight	9 lb. 3 oz.
Bullet	{Weight	530 gr.

	{Diameter	·567 in.

Charge, 2½ drams F. G.

Sixty rounds and 75 Caps = 5 lb. 8 oz. 4 drams.

5. Victoria Carbine: (For Cavalry.)

Barrel	{Length	2 ft. 2 in.
	{Bore	·733 in.
Bullet (Spherical)	{Weight	490 gr.
	{Diameter	·689 in.

Charge, 2½ drams F. G.

Arm complete	{Length	3 ft. 6 in.
	{Weight	7 lb. 9 oz.

6. Naval Rifle.

1842 Pattern. Percussion musket, Rifled with 3 or 4 grooves.

Bullet (Minie),	{Weight	848 gr.
with iron cup	{Diameter	·746 in.

Charge, 3 drams F. G.

7. Pistol: Army pattern.

Barrel	{Length	9 inches
	{Weight	1 lb. 6 oz.
	{Diameter of bore	·733 in.
Arm complete	{Weight	3 lb. 4 oz.
	{Length	1 ft. 3½ in.

Charge of Powder for Ball cartridges, 2½ drams.

Ball, Lead, the same as for the Line-pattern Musket.

BLANK CARTRIDGES.

The charge of powder for Blank cartridges, for all the above-mentioned Small arms, is the same; viz., 3½ drams.

The cartridges are made with *blue* paper.

MANUFACTURE OF CARTRIDGES.

The following articles are required for the manufacture of Cartridges:

Five tin measures, containing two and a half drams.

Five tin funnels. A large knife.

An iron straight edge for cutting the paper.

Five cylindrical mandrels of hard wood, to roll the cartridge.

A former, to make the hollow in the inner case, to receive the point of the bullet.

A set of tin patterns for shaping the paper.

Cartridge paper and fine white paper.

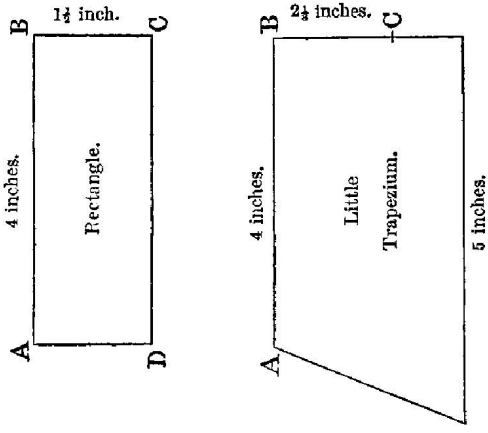
Bullets and *gunpowder*.

To construct the Cartridge.—Cut the paper according to the patterns, place the rectangle (fig. 9) on the little trapezium (fig. 10), the sides A B C of the rectangle coinciding with the sides A B C of the trapezium, lay the mandrel on the rectangle, parallel to the side B C, the base of the mandrel even with the side C D of the rectangle; roll the whole tightly on the mandrel; place it vertically, and fold the

remainder of the trapezium paper into the hollow in the base of the mandrel; commencing with the acute angle of the trapezium, make use of the point of the former to close the folds; examine the bottom of the inner case thus formed, to see that there remains no hole for the escape of the powder when charged; introduce the point of the bullet into the aperture at the base of the mandrel; take the trapezium envelope (fig. 11), place the mandrel and bullet parallel to the side F G, the base of the bullet at half an inch from the base F H, of the envelope; press up the point of the bullet into the cavity; roll the envelope tightly on the bullet and on the mandrel; fold the remainder of the envelope on the base of the bullet, commencing with the acute angle; place the base of the cartridge on the table; withdraw the mandrel, squeezing the case of the cartridge with the left hand, and raising up the mandrel with the right hand.

To charge the cartridge, introduce the point of the copper funnel into the bottom of the case of the cartridge; pour in 2½ drams of fine grain powder from the powder-flask; withdraw the funnel, taking care that none of the powder escapes between the case and the envelope; squeeze the top of the cartridge, and twist it round.

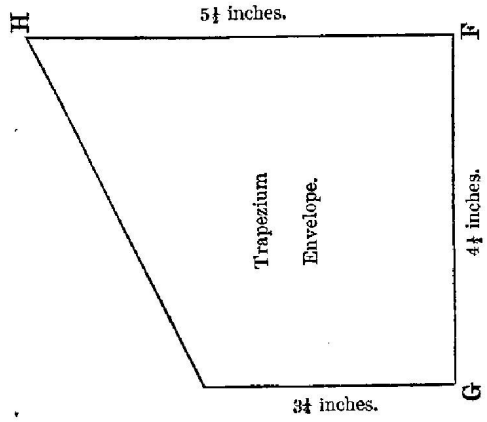
Fig. 9. Fig. 10.



1½ inch. 4 inches. Rectangle.

2⅛ inches. 4 inches. 5 inches.
Little Trapezium.

Fig. 11.



5½ inches. 4½ inches. 3¼ inches.
Trapezium Envelope.

When completed, the base of the cartridge must be dipped up to the shoulder of the bullet in a pot of grease, consisting of six parts tallow to one of bees-wax.

SMALL ARM AMMUNITION.

Dimensions of Boxes.

Length, 1 ft. 4 in. Depth, 8⅝ in. Breadth, 7¼ in. including the cleat.

Weight of Boxes.

Empty, 7 lb. 6 oz.

Contents and Weight of Barrels and Boxes.

	Barrel.			*Box.*		
	No. of Cart-ridges.	No. of Caps.	Weight filled.	No. of Cart-ridges.	No. of Caps.	Weight filled.
			lb. oz.			lb. oz.
Rifle Musket, Pattern 1842	500	625	79 0	..	..	..
Rifle Musket, ” 1851	700	875	66 4	500	625	65 4
Rifle Musket, ” 1853	700	875	73 8	560	700	60 6
Artillery Carbine	800	1000	81 8	660	825	63 0

Victoria Carbine	700	875	69	0	600	750	60 8

INSTRUCTIONS FOR BROWNING GUN BARRELS.

The following ingredients, viz.:—

1½ oz. of Spirits of wine,
1½ oz. Tincture of steel,
½ oz. of Corrosive sublimate,
1½ oz. of Sweet spirit of Nitre,
1 oz. of Blue vitriol,
¾ oz. of Nitric acid.

are to be mixed and dissolved in one quart of soft water.

Previous to commencing the operation of browning, it is necessary that the barrel 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 best for this purpose: a plug of wood is then to be put into the nose of the barrel, 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 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 the barrel will be made of a very dark-brown colour.

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 common oil. It is particularly directed that the use of the hard hair-brush be discontinued in browning, and the steel scratch-card or scratch-brush used in place of it, otherwise the browning will not be durable, nor have a good appearance. The browning mixture must be kept in glass bottles, as it will soon lose its virtue if kept in earthenware.

The locks are on no account to be made of the hardening colour, as the repetition of the operation of hardening has a very injurious tendency.

PERCUSSION FIRELOCKS.

Muskets with Percussion locks require to be carefully handled, to prevent the cocks being made loose, by which their direct fall on the nipples would be rendered uncertain.

They will, at all times, when unloaded, be used with the cocks down upon the nipples; but, when they are loaded, the caps, or primers, will be put on, and the muskets carried *at half-cock* for safety, there being then less risk of accidental explosion than with the cocks resting on the caps.

When marching with the cap on, the cock will be brought up under the arm-pit, the sling resting on the arm; but at other times the firelock may be carried with the barrel downwards, the right hand grasping the piece between the loop and swell; and

the left the right arm just below the elbow.

INFANTRY EXERCISE, AND MOVEMENTS,

Extracted from

"FIELD EXERCISES AND EVOLUTIONS OF THE ARMY,"

the Parts and Sections being numbered according thereto.[3]

PACES.

Slow time, each step, 30 inches, and 75 paces in a minute.

Quick time, each step, 30 inches, and 108 paces in a minute.

Double time, each step, 36 inches, and 150 paces in a minute.

Back step, each 30 inches. *Side* or *Closing step*, 10 inches.

To calculate the number of Paces (each 30 inches) required for a given number of Files.

As a soldier occupies 21 inches, take two-thirds of the number of Files in the division, and add an inch for each File.

Table of the number of Paces corresponding to a given number of Files.

Number of Files in a Division, each occupying 21 inches.	5	15	16	18	20	30	40	50
Front of Divisions in Paces of 30 inches.	P. I.	P. I.	P. I.	P. I.	P.	P.	P.	P.
	3 15	10 15	11 6	12 18	14	21	28	35

FLINT FIRELOCKS.

MANUAL EXERCISE.

1. Secure arms.
2. Shoulder arms.
3. Order arms.
4. Fix bayonets.
5. Shoulder arms.
6. Present arms.
7. Shoulder arms.
8. Port arms.
9. Charge bayonets.
10. Shoulder arms.
11. Advance arms.
12. Order arms.
13. Advance arms.
14. Shoulder arms.
15. Support arms.
16. Stand at ease.
17. Attention.
18. Carry arms.
19. Slope arms.
20. Stand at ease.

21. Attention.
22. Carry arms.
23. Order arms.
24. Unfix bayonets.
25. Stand at ease.

PLATOON EXERCISE.

As front rank standing.
or, *As rear rank standing.*
— *As front rank kneeling.*
— *As rear rank kneeling.*
1. Prime, and Load.
2. Handle cartridge.
3. Prime.
4. 'Bout.
5. Draw ramrods.
6. Ram down cartridge.
7. Return ramrods.
8. *As front rank*, Ready.
9. Present.
10. Load.
11. Shoulder arms.

As rear rank, Ready, &c.

AS A COMPANY.

Prime and Load.
Company Ready.
Present.
At the word "Cease firing,"
the Company, if made ready, receives the words,
Half-cock arms.
Shoulder arms.
Or the word will be given to
"Fire a volley; and half-cock,"

(*at priming position*,)
Shoulder arms.
Shut pans.

INSPECTION OF A COMPANY.

1. Attention.
2. Fix bayonets.
3. Shoulder arms.
4. Rear rank take open order—March.
5. Open pans.
6. Slope arms.
7. Carry arms.
8. Shut pans.
9. Order arms.
10. Examine arms.
11. Return ramrods.
12. Unfix bayonets.
13. Rear rank take close order—March.
14. Stand at ease.

DISMISSAL OF A COMPANY.

Attention.
Shoulder arms.
Recover arms.
Ease springs.
Right face.
Lodge arms.

PERCUSSION FIRELOCKS.

MANUAL EXERCISE.

Words of Command similar to those for Muskets with Flint locks.

THE PLATOON EXERCISE, AND DIFFERENT FIRINGS FOR THE ORDINARY OR RIFLE MUSKET.

To load from the shoulder, standing	Prepare to load.
” *from the Advance, standing*	Prepare to load.
” *from the Order, standing*	Prepare to load.
	Load.
	Rod.
	Home.
	Return.
	Cap.
As Front, or Rear rank	—Yards, Ready,
	Present.
	Load, *&c., as above*.
To shoulder, when at the Capping position	Shoulder arms.
To advance arms, from the Capping position	Advance arms.
To make ready from the shoulder	—Yards—Ready.
” *from the Advance*	—Yards—Ready.
To fire kneeling	As front rank kneeling.
	—Yards—Ready.
	Present.
	Load, *&c., as above*.
	Cap.
	Shoulder arms.
	Advance arms.
To load from the shoulder,	As front rank, kneeling.
as Front Rank, kneeling	Prepare to load.
To load from the Advance,	As front rank, kneeling.
as Front Rank, kneeling	Prepare to load.

	Shoulder, *or* } *as before*
	Advance arms, } *directed.*
	As rear rank, kneeling, Yards—Ready.
	Present.
	Load, *&c., as above.*
	Cap.
	Shoulder, *or* } *as before*
	Advance arms, } *directed.*
To load from the shoulder, as Rear Rank, kneeling	As rear rank, kneeling, Prepare to load.
To load from the Advance. as Rear Rank, kneeling	As rear rank, kneeling, Prepare to load.
As a Company, Load	Company, at yards, Ready.
	Present.
	Half-cock arms.
	Shoulder arms.

Firing as a wing, or as a Battalion, is performed precisely as laid down for a Company.

A Company, Wing, or a Battalion can load, or make ready from the Order with the same ease, as from the shoulder.

Trailing arms	Trail arms.
	Change arms.
To resist Cavalry	Prepare to resist Cavalry.

Ready, &c.

FUSIL EXERCISE.

1. Secure arms.
2. Shoulder arms.
3. Order arms.
4. Fix bayonets.
5. Shoulder arms.
6. Port arms.
7. Charge bayonets.
8. Shoulder arms.
9. Support arms.
10. Stand at ease.
11. Attention.
12. Carry arms.
13. Slope arms.
14. Stand at ease.
15. Attention.
16. Carry arms.
17. Trail arms.
18. Shoulder arms.
19. Order arms.
20. Unfix bayonets.
21. Stand at ease.
22. Attention.

THE MANUAL AND PLATOON EXERCISES OF RIFLEMEN.

THE MANUAL EXERCISE.

Present arms.
Shoulder arms.
Order arms.
Shoulder arms.
Support arms.
Carry arms.

Trail arms.
Shoulder arms.
From the Order, to Trail arms.
Trail arms.
From the Trail, to Order arms.
Order arms.
Fix swords.
Shoulder arms.
Charge bayonets.
Shoulder arms.
Order arms.
Unfix swords.
Stand at ease.

THE PLATOON EXERCISE.

Prepare to load.
Load.
Rod.
Home.
Return.
Cap.
Shoulder.
Make ready.
Present.
After firing, the rifle to be brought immediately to the position of—
Prepare to load.

INSTRUCTIONS FOR AIMING WITH THE RIFLE MUSKET.

Firing at a Human figure.	*Firing at the Target.*
At 100 yards.—Aim at the waist.	Aim with the sight down, straight at the bull's-eye.

At 150 yards.—Raise the sliding-bar, raise the sight, and aim with the 200 yards' point at the thigh.	Raise the sliding-bar, raise the sight, aim with the 200 yards' point at the bottom of the black ring.
At 200 yards.—Aim at the waist with the 200 yards' point.	Aim at the bull's-eye with the 200 yards' point.
At 250 yards.—Press down the sliding-bar, aim with the 300 yards' point at the knees.	Press down the sliding-bar, aim with the 300 yards' point six inches below the black ring.
At 300 yards.—Aim with the 300 yards' point at the waist.	Aim with the 300 yards' point at the bull's-eye.
At 350 yards.—Raise the sliding-bar at half distance between the 300 and 400 yards' point, and aim at the waist.	Raise the sliding-bar to half distance between the 300 and 400 yards' point, and aim at the bull's-eye.

From 400 yards to 800 yards.—Make use of the sliding-bar, by raising it to the respective distances, as marked on the back sight.

WORDS OF COMMAND FOR FUNERAL PARTIES.

Ranks open—Arms shouldered—Bayonets unfixed, facing the quarters of the Deceased.

When the Corpse is brought out:

| Present arms—Reverse arms—Rear rank take close
| order—March.

Divisions, Sub-divisions, or Sections are wheeled forwards (or backwards) to form Column left in front.

| Rear rank take open order—March.

When arrived at the Burial-ground:

| Halt—Ranks, left and right wheel—Quick
| march—Halt—Inwards face—Rest upon your
| arms reversed—Stand at ease.

When the Corpse has passed through:

| Attention—Reverse arms—Re-form Column—Ranks,
| right and left wheel—Quick march—Halt,
| front—March.

When facing the grave:

| Rest upon your arms reversed—Stand
| at ease.

After funeral service:

| Attention—Present arms—Shoulder arms—Load
| with blank cartridge—Fire three volleys
| in the air—Order arms—Fix bayonets—Shoulder
| arms—Rear rank take close order—March.

March back to barracks, right in front.

COMPANY DRILL.

Part 2.—Section 1.—Formation of the Company.

The Company is ordered to "FALL IN" at close order; is then sized from flanks to centre; and told off in Sub-divisions, and four sections. In Column of Sections, the Senior officer takes the Leading, the second senior the Third, the third Senior the Fourth, and the junior the Second section. The Company is also told off by "Threes from the right," numbered 1, 2, 3. Should there be a blank file in telling off the company in line, it will invariably be the fourth file from the left. The Company is also told off from the right by alternate files, right, and left.

In Close order the Rear rank is one pace, in Open order two paces, and for inspection three paces, from the front rank.

S. 2. Marching to the Front.

BY THE RIGHT (LEFT, OR CENTRE) — MARCH.

The Company will occasionally be ordered, to Step out—Mark time—Step short—Open, and close ranks—Oblique—Diagonal march.

S. 3. The Side, or Closing step.

TO
THE
RIGHT
(OR
LEFT)
CLOSE
—
QUICK
MARCH
—
HALT.

S. 4. The Back step.

STEP
BACK
—
MARCH.

*S. 5. To form four deep.**

FORM
FOUR
DEEP
—
MARCH.

REAR
FORM
FOUR
DEEP
—
MARCH.

RIGHT
FORM
FOUR
DEEP
—
MARCH.

** In telling off the files, should the last file be a right file, the left file on its right will double in the rear of it, completing it to four deep, and leaving the other Section only two deep*

LEFT
FORM
FOUR
DEEP
—
MARCH.

To re-form two deep, from each of these formations.

FRONT.
(OR
HALT
—
FRONT.†)

† *If the Company is in movement.*

S. 6. File marching.

TO THE LEFT FACE —QUICK MARCH.	Halt, Front.

From the Halt.

ADVANCE IN DOUBLE fiLES FROM THE CENTRE—SUB-DIVISIONS INWARDS FACE —QUICK MARCH.	*After facing, the leading files disengage.*

FRONT FORM COMPANY—(OR, TO THE RIGHT FORM COMPANY.)	Forward. *Right Sub-division*—Halt, Front, Dress. *The remainder of the Company march on in file, and form in succession on left of halted Sub-division.*

On the March.

ADVANCE IN DOUBLE FILES FROM THE CENTRE.	Sub-divisions, inwards turn —Right and left wheel.

S. 7. Wheeling from a Halt.

RIGHT (OR LEFT) WHEEL—QUICK MARCH.	Halt, Dress.

S. 8. Wheeling forward by Sub-divisions, from Line.

BY SUB-DIVISIONS RIGHT WHEEL—QUICK MARCH.	Halt, Dress.

S. 9. Wheeling backward by Sub-divisions, from Line.

BY SUB-DIVISIONS ON THE LEFT BACKWARD WHEEL—QUICK MARCH.	Halt, Dress.

S. 10. Marching on an Alignement, in Open column of Sub-divisions.

MARCH—(OR, QUICK MARCH).	

S. 11. Wheeling into Line, from Open column of Sub-divisions.

1. HALT—LEFT WHEEL INTO LINE—QUICK MARCH.	Halt, Dress, Eyes front.

2. On the Moveable pivot.

SHOULDERS FORWARD—FORWARD (OR, HALT, DRESS.)	

S. 12. In Open column of Sub-divisions entering into a new direction on a moveable pivot.

	Right (or left) shoulders forward—Forward.

S. 13. Counter-marching.

Counter-march by files.

RIGHT (OR LEFT) FACE—QUICK MARCH.	Halt, Front, Dress.

Counter-march by ranks.

RIGHT AND LEFT FACE—RIGHT COUNTERMARCH—QUICK MARCH.	Halt, Front, Dress.

S. 14. Wheeling on the centre of the Company.

COMPANY ON THE CENTRE—MARCH.	Halt, Dress.

COMPANY { RIGHT / LEFT / RIGHT ABOUT } WHEEL

{ LEFT }
ABOUT

S. 15. Diagonal march.

The pivots, or outward Files, march in the direct line to which they have faced, the others conforming to them.

S. 16. Increasing the Front of an Open column halted Right in front.

FORM COMPANY.	Left Sub-division, Left half face—Quick march—Halt, Front, Dress up.

Diminishing the front of an Open column, halted.

FORM SUB-DIVISIONS.	Left Sub-division—Right about three-quarters face—Quick march. *2nd Senior.* Halt, Front, Dress.

S. 17. Increasing the front of an Open column, on the march.

FORM COMPANY.	Left Sub-division, Left half turn, Double—Front turn, Quick.

Diminishing the front of an Open column, on the march.

FORM SUB-DIVISIONS.	Left Sub-division, Mark time—Right half turn—*2nd Senior*, Front turn.

When the above movements, 16 and 17, are performed Left in front, the Words RIGHT will be altered to LEFT, and LEFT to RIGHT. The same directions apply to sections.

S. 18. In Open column of Sub-divisions to pass a short defile, by breaking off files.

BREAK OFF —— FILES.	—— Files on the left, Right turn —Left wheel.

After passing the defile.—Files to the front.

S. 19. The Company in line halted, or on the march, moves to a flank in Column of sections, or Sections of threes.

SECTIONS (OR THREES) RIGHT (OR LEFT) SHOULDERS FORWARD (*if halted,* QUICK MARCH—FORWARD.)	

When Pivots are required to be accurately dressed, or when the alignement of the Company is to be preserved.

SECTIONS (OR THREES) ON THE RIGHT (OR LEFT) BACKWARDS WHEEL—QUICK MARCH.	Halt, Dress.

To re-form Company on the march.

SECTIONS (OR THREES) RIGHT (OR LEFT) SHOULDERS FORWARD— * FORWARD —(OR HALT, DRESS.)	* If the march is to be continued.

For accurate dressing, or when the alignement is to be preserved.

RIGHT (OR LEFT) WHEEL INTO LINE— QUICK MARCH.	Halt, Dress.

S. 20. Forming Company, Sub-divisions, Sections, or Sections of threes, from file marching.

FRONT FORM COMPANY (SUB-DIVISIONS, OR SECTIONS) — *FORWARD.	* If the march is to be continued.

Marching in file from the right, to form the Company to the Left flank.

HALT— FRONT.	

Marching in file from the right, to form the Company to the Right flank.

ON THE LEADING fiLE TO THE RIGHT FORM COMPANY.	

To form to the Right about.

ON THE LEADING fiLE TO THE RIGHT ABOUT FORM COMPANY.	

S. 21. To form to either flank, from Open column of Sub-divisions.

To the Left flank.

HALT—LEFT WHEEL INTO LINE —QUICK MARCH.	Halt, Dress, Eyes front.

To form the Company to its Right flank.

TO THE RIGHT FORWARD FORM COMPANY.	*Leading sub-division* Left shoulders forward—Forward, Halt, Dress. *2nd Sub-division (Left oblique till clear of the right Sub-division)*—Left shoulders forward—Forward, Halt, Dress up.

S. 22. Company moving to the front, to gain ground to a flank, by march in echellon, by sections.

SECTIONS
RIGHT—
FORWARD.

To form Company—

FORM
COMPANY
—
FORWARD.

S. 23. To form the Rallying square.

FORM THE RALLYING SQUARE. *When the Square is to march*— THE SQUARE WILL MOVE TO THE FRONT, (REAR, RIGHT, OR LEFT,) INWARDS FACE— QUICK MARCH— HALT— PREPARE TO RESIST CAVALRY —READY.* REDUCE THE SQUARE— QUICK MARCH.

** If ordered to fire, the Standing ranks only will commence an independent fire.*

MODE TO BE OBSERVED IN DISMISSING A COMPANY OFF PARADE.

Recover arms.
Right face.
Lodge arms.

In turning in a Guard, or Piquet, the same mode is to be observed.

MANNER OF INSPECTING A COMPANY ON PARADE.

Attention.
Fix bayonets.
Shoulder arms.
Rear rank take open order—March.
Slope arms.

The inspection of Arms will now take place

Carry arms.
Order arms.
Examine arms.
Return ramrods.

An inspection of the Appointments, Clothing, &c., is now to be made.

Unfix bayonets.
Rear rank take close order—March.
Stand at ease.

MOVEMENTS OF A BATTALION.

Part 3.—Section 1. Commands.

All words of command must be given short, quick, and loud.

S. 2. Degrees of march.

The Slow step is particularly applicable to purposes of parade, and occasionally to the march of extended lines.

The Quick march is the usual pace to be applied to all general movements of Battalions, or greater bodies, in Column, or Line.

The Double march is only to be applied to the movements of the Divisions of a battalion, except upon peculiar occasions for short distances.

S. 3. Marching in line.

The March in line is generally adopted where the country is open.

S. 4. Wheeling.

Wheels are made on a *Halted pivot* from Line into Column, and from Column into Line. The principle of the *Moveable pivot* must always be applied to the wheel of divisions marching in column. Wheels of divisions may be either made forward, or backward. In progressive movements they are to be made *Forward*, but particular occasions require that they should be made *Backward* on the pivot flank. *The Backwards* wheel need not, however, be practised where the ground is uneven, and the Divisions stronger than 15 or 16 files: where

this is the case, the Command will be

FORM Halt,
OPEN Front.
COLUMN,
RIGHT
(OR
LEFT)
IN
FRONT
—
RIGHT
ABOUT
FACE
—
RIGHT
(OR
LEFT)
WHEEL
—
QUICK
MARCH.

S. 5. Movements.

Every movement must be divided into its distinct parts, and each part executed by its cautionary and executive words of command. All field movements and firings are to be performed with fixed bayonets, except when troops are acting as Light infantry.

S. 6. The Alignement.

To march in an Alignement is to make troops march in any straight line, which joins two given points—or to form upon any such given line. When troops are to form in a straight line, two necessary

points in it must always be previously ascertained. One, the point of *Appui* at which one flank of the Body is to be placed, and the other the distant point of formation or dressing, on which the front of the body is directed.

S. 7. Points of formation.

The line on which troops move, or are successively to form, may be taken up to any extent by the prolongation of an original short base, given in the direction which the Commander of a line will point out.

S. 8. Dressing.

The Officer in dressing is placed on that flank of his division to which the men's eyes are turned on the word "DRESS," and from the second file from the flank of the Company towards which his wheeling flank moves from column, or his inward flank from echellon: he makes his corrections on his intermediate point. In all wheelings into line the word "EYES FRONT" will be given as soon as the dressing is completed. When Officers change from one flank to the other in order to close, they will pass by the front, and repass by the rear of their Companies. On all other occasions, when it is necessary to change their flanks in line, they will pass and repass by the rear.

S. 9. Open column.

All changes of position, by means of the Open column, will be effected by the formation of a column, right or left, in front, on the named division. If on a flank division, the caution will specify whether the other flank is to be thrown back, or forward: if on a central division, the caution will in

like manner specify which wing is to be thrown forward. An open column may effect a change of position upon its front, rear, or any central division by the named division wheeling up according to the front to which it is intended to change; and the other divisions facing, and filing into the new alignement.

S. 10. Column at Quarter distance, and Close column.

When Close columns are formed, the Companies or Divisions must be at one pace distance. In the wheel of a Column at quarter or close distance, the leading division acts as a moving base for the rear Companies to follow; its length of step is regulated according to the depth of the column, and when at quarter distance must be very short to enable the rear to circle simultaneously round at the usual pace. Upon the wheel being ordered, all the rear divisions make a half face to the wheeling flank; but at a quarter distance, the leading division will advance six paces on the word "QUICK (OR DOUBLE) MARCH," and will wheel round the pivot file at a shortened pace, while each succeeding division will advance, in circling round, to quarter distance, which will leave room for the rear divisions to circle into their relative positions at that distance. In wheeling on the Moveable pivot, the rear divisions make a half turn towards the shoulder brought forward, and the front division wheels and advances at a shortened pace in the new direction, the rear divisions circling round. In Close column, the supernumeraries will form on the reverse flanks of companies; and when the column marches to a flank, they will move with their companies; when the Close column is to countermarch they will remain on the reverse flank, and countermarch on their own ground. When a Column deploys on a rear division,

the named division when uncovered will move up to the front (which its covering Serjeant will mark); the points, therefore, necessary for the formation of the Battalion will be taken in prolongation of these points, and the Divisions which successively move up must *Halt*, *Front*, until their front is clear.

S. 11. Echellon.

The Echellon position and movements are applicable to the oblique or direct changes of situation, which a Battalion may be obliged to make to the front or rear, or on a particular fixed division of the line. The oblique changes are produced by the wheel (less than the quarter circle) of divisions, which places them in the echellon situation. The direct changes are produced by the perpendicular and successive march of divisions from line to front or rear. In Echellon, the inner flank, (or that which first joins its preceding division when the line is to be formed forward,) is the directing one; and in Oblique echellon the wheels are made on it, into echellon—forward, and into line—backward.

Practical rule for the Battalion and Line on all occasions of Wheeling by Companies into echellon.

> "Each covering Serjeant having previously placed himself before or behind a given file (the 8th) from the standing flank, will take the named number of paces from the centre of that file on the arc of the circle, and thereby become a direction for the Company to wheel up to, and halt."

As eight paces from the eighth file complete the Quarter circle, so four paces give the One-eighth, and two paces the One-sixteenth of the circle. All changes of front by the Echellon march are performed by the forming divisions wheeling half the angle wheeled by

the division to be formed upon. In all changes of position by echellon, whether direct or oblique, the leaders of companies will invariably be on that flank towards which the change of position is to be made. But in taking ground to a flank on the march, in echellon of Sub-divisions or Sections, Companies' leaders remain in their places as when in line.

S. 12. Squares.

Squares are formed either from Line, or from Column at full, half, or quarter distance. *The Hollow square*, four deep, is sufficiently solid to oppose an attack of Cavalry: it possesses, at the same time the advantage of rendering the fire of all the men available to the resistance of the enemy. *The Solid square* should seldom be adopted, because a proportion of the men cannot give their fire. Close columns should in all cases when practicable, open therefore to quarter distance, and form Square (as in Sec. 21, No. 1, Part III.). But as every position in which a Battalion may be placed should be susceptible of ready resistance against Cavalry, the Close column can always assume an efficient posture of defence, by the six centre Companies wheeling outwards by Threes, and closing to the front, and the two rear Companies facing to the right about: the Officers and Serjeants taking post in the centre. The wing of a battalion can in like manner form the solid square from a Close column of Sub-divisions. When Cavalry is not to be resisted, it will be sufficient to form the Square two deep to the rear. The formation of Battalion squares, either from Line or Column, is to be completed as expeditiously as possible; and the Squares may afterwards be placed in direct echellon for mutual defence.

S. 13. Firings.

In all movements, Firing should commence after a formation. In firing by Companies, the Leaders will give the Word "*Ready*" when the previous division fires, preserving the pause of slow time between this and "*Present*," the men firing when they have covered their objects. In firing by wings, one wing will receive the word "*Ready*," the instant the other has completed its loading. Great care must be taken in file firing that it is not hurried, and that the men "*Present*" deliberately. The value of a soldier's ammunition, and a jealousy of its expenditure without effect, must be carefully inculcated; for in proportion as a cool and well-directed fire serves to distract and throw an enemy into disorder, so is a wild, confused, and hurried fire (which is always without effect) calculated to give him confidence, and a contempt for his opponent. Soldiers should, therefore, bear in mind that nothing makes so strong an impression on an enemy, as the thinning of his ranks by a well-directed fire; and that nothing tends more to animate and encourage troops than the diminished fire from ranks so thinned; affording also the most favourable opportunity for a successful charge. In firing in square, the two front ranks are to come to the kneeling position without cocking, on preparing to receive cavalry. The standing ranks in square will fire independently from the right of faces.

Street firing.

A Column at open, half, or quarter distance, formed in a street or narrow ground where deployment is impracticable, may be required to fire previous to charging forward, or by successive divisions in retiring. It will be performed in the following manner:—

If advancing, the two front Companies only will fire in succession; the leading Company firing and loading kneeling, the second Company closing to the front, and firing standing. When the enemy's fire has been overcome, or at any favourable moment that may present itself, the column will charge briskly forward, and make good the ground it is contending for.

In retiring, the leading division will give its fire; Slope arms; Face outwards by sub-divisions; File to the rear; Re-form Company; Load; and remain halted, until its front is again clear, or the whole column is put in motion. The moment the front of the second company is clear, it will give its fire; Face outwards by sub-divisions; and file to the rear as above directed: and so on by companies in succession: the companies thus follow each other, and when the front of the column occupies the whole breadth of the street, the outward files of companies will double in the rear, to give the companies which have fired room to pass. It must never be forgotten, in entering towns or villages occupied by the enemy, that the first thing to be done, on gaining a footing in the place, is to clear the houses on both flanks, and the column should on no account proceed through the streets without previously occupying the houses on either side; the troops employed for that purpose breaking through partition walls, or pushing on from house to house, so as to accompany the march of the main body, and protect its flanks.

FORMATION OF THE BATTALION.

When the Battalion is formed, there is to be no interval between any of the Companies, and every part of the front of the Battalion should be equally

strong. The Grenadiers will be on the right, Light company on the left, the other companies from right to left. The Battalion will be told off into Right, and Left wings.

FORMATION OF THE BATTALION, AT CLOSE ORDER.

The Commanding officer is advanced in front for the general purpose of exercise when the Battalion is single; but in the March in line, and in the firings, he is in the rear of the Colours. The Lieutenant-colonel is behind the colours, twelve paces from the supernumerary rank. The 1st Major is six paces in the rear of the second Battalion company from the right flank; 2nd Major at the same distance in the rear of the second Battalion company from the left; the Adjutant at the same distance in rear of the colours. One Officer is on the right of the front rank of each company, and One on the left of the Battalion; all these are covered in the rear rank by their respective Serjeants; and the remaining Officers and Serjeants are in a third rank behind their companies. The colours are placed (both in the front rank) between the two Centre companies. The supernumerary rank is at three paces distance when in Line; and when in Column, it is at the distance of one pace.

When the Battalion takes Open order.

REAR RANK TAKE OPEN ORDER — MARCH.

Officers of Companies and those with the Colours dress three paces in front of the Line. The 1st Major is on the right of the Officers, the 2nd Major on the left. The Adjutant on the left of the front rank. The Colonel ten paces, and the Lieutenant-colonel six paces, in front of the Colours.

When the Battalion resumes Close order.

REAR
RANK
TAKE
CLOSE
ORDER
—
MARCH.

EVOLUTIONS OF THE BATTALION.

MOVEMENTS OF THE BATTALION FROM LINE.

S. 14. 1. The Battalion halted, and correctly dressed, is to advance in Line.

Commander's Words of command.	*Executive Words of command, Directions, &c.*
THE BATTALION WILL ADVANCE —MARCH (OR QUICK MARCH)— HALT.	

2. When the Battalion is to retire.

THE
BATTALION
WILL
RETIRE
—
RIGHT
ABOUT
FACE
—
QUICK
MARCH.

3. While advancing in Line, the Battalion may form to either flank by the Divisions wheeling to the Bight (or Left) on the Moveable pivot, and forming on the flank Company (which will be halted in the direction of the new front) by the Echellon march of divisions.

S. 15. When a Battalion advancing in Line is to charge.

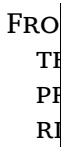
PREPARE
TO
CHARGE
—
CHARGE
—
HALT.

S. 16. When a Battalion moving in Line passes a wood, &c., to Front or Rear, by the flank march of Companies in file.

1. *If to pass to the Front.*



2. *If to pass to the Rear.**



FROM THE PROPER RIGHT (OR LEFT) OF COMPANIES PASS BY fiLES TO THE REAR — LEFT (OR RIGHT) TURN — RIGHT (OR LEFT) WHEEL — HALT — FRONT.

* *The Battalion in Line having arrived at the point where it must break. Companies may also pass to the front or rear by Sections of Threes.*

3. *If a Battalion in first Line passes through a second, which advances and relieves it.*

PASS BY fiLES TO THE REAR — RIGHT FACE — RIGHT WHEEL — QUICK MARCH — HALT — FRONT.

The relieving Battalion marches up within twelve Paces of the front Line, the Companies of which proceed to the rear through the second Line.

4. *When the second Line does not advance to relieve the first.*

PASS BY fiLES TO THE REAR — LEFT TURN — RIGHT WHEEL.

The first Line retires, and when within twelve paces passes through the second.

S. 17. *When the Battalion advances, or retires, by half*

Battalion, and fires.

1. *If the Battalion is in march, and advancing.*

THE BATTALION WILL ADVANCE BY WINGS. (*2nd Major*) LEFT WING, HALT — MARCH (OR QUICK MARCH). (*Senior Major*)* RIGHT WING, HALT — READY — PRESENT — LOAD — MARCH (OR QUICK MARCH). (*2nd Major*) LEFT WING,

* *After having advanced 15 paces.*

HALT
—
READY,
&C.

2. *If the Battalion is in march, and retiring.*

THE BATTALION WILL RETIRE BY WINGS. (*Senior Major*) RIGHT WING, HALT — FRONT. (*2nd Major*)* LEFT WING, HALT — FRONT. (*Senior Major*) RIGHT WING, READY — PRESENT — LOAD — RIGHT ABOUT FACE — MARCH (OR

* *After retiring 15 paces.*

† *When Right wing has retired 15 paces.*

QUICK
MARCH).
(2nd
Major)
LEFT
WING,
HALT
—
FRONT.
†LEFT
WING,
READY
—
PRESENT
—
LOAD,
&C.

S. 18. A Battalion in Line to move to attack, or pass a bridge, &c., to the front, from either flank, or from the centre.

1. *If from a Flank, by Companies, or Sub-divisions.*

RIGHT (OR LEFT) DIVISION TO THE FRONT. — REMAINING DIVISIONS, RIGHT (OR LEFT) SHOULDERS FORWARD — QUICK MARCH — FORWARD.

Rear Divisions successively—Right (or left) shoulders forward—Forward.

2. *When the Column arrives near the point where the Line is to re-form.*

FORM *Leading Division*, Halt, Dress up.
LINE—*Remaining Divisions successively*—Right (or left)
ON shoulders forward—Forward.—Halt—Dress up
THE —Eyes front.
FIRST
DIVISION
—
REMAINING
DIVISIONS,
RIGHT
(OR
LEFT)
SHOULDERS
FORWARD
—
FORWARD.

3. *If the advance is from the Centre.*

TWO CENTRE SUB-DIVISIONS TO THE FRONT.

Right wing Sub-divisions first throw Right shoulders, and afterwards Left shoulders forward.

Left wing Sub-divisions first throw Left shoulders, and afterwards Right shoulders *forward, Sub-divisions successively*—Forward.

REMAINING SUB-DIVISIONS, RIGHT AND LEFT SHOULDERS FORWARD

—

QUICK MARCH

—

FORWARD.

4. *When the Double column arrives near the point where the Line is to be formed.*

FORM LINE ON TWO CENTRE SUB-DIVISIONS. — REMAINING SUB-DIVISIONS, RIGHT AND LEFT SHOULDERS FORWARD — FORWARD.

Remaining Sub-divisions successively—Right (or left) shoulders forward—Forward—Halt—Dress up—Eyes front.

5. *To form Line to the right, from the Double column.*

FORM LINE TO THE RIGHT — RIGHT WING LEFT SHOULDERS FORWARD.

Right wing Sub-divisions—Halt, Dress. *Left wing Sub-divisions successively*—Left shoulders forward—Forward—Halt, Dress up—Eyes front.

S. 19. A Battalion in Line to retire over a bridge, or defile, or retreat from a Flank or Flanks, in rear of the Centre.

1. *If from a flank.*

RETIRE BY COMPANIES (OR SUB-DIVISIONS) FROM THE LEFT (OR RIGHT) IN REAR OF THE RIGHT (OR LEFT).

Left (or Right) Company—Company (or Sub-division)—Right about face—Quick march—Right (or Left) shoulders forward—Forward. *When at inward flank of right (or left) Division*—Right (or left) shoulders forward—Forward. *The other Divisions follow in succession.*

2. *If the Retreat is from both flanks.*

RETIRE FROM BOTH FLANKS BY SUB-DIVISIONS IN REAR OF THE CENTRE.

Right (or left) Sub-division—Right about face—Quick march—Right (or left) shoulders forward—Forward. *When arrived at the proper points*—Right (or left) shoulders forward—Forward.

Remaining right, and left Sub-divisions follow in succession. Two centre Sub-divisions, when the Divisions next to them have commenced their second wheel—Right about face—Quick march.

S. 20. A Battalion in Line to march off in Column of divisions, successively to a flank.

1. *If the Movement is along the rear, and from the right flank.*

THE BATTALION WILL MOVE IN COLUMN OF DIVISIONS (OR SECTIONS) FROM THE RIGHT ALONG THE REAR.

Right Division (or Section)—Left face—Left wheel—Quick march—Front turn.

2. *When the Movement is from the left flank.*

Left Division (or Section)—Right face—Right wheel—Quick march—Front turn.

In both movements the Divisions follow in succession the leading division.

S. 21. When the Battalion, halted in Line, is to form Square on a named Company, or on two centre Sub-divisions.

1. If on a Central company.

COLUMN AT QUARTER DISTANCE ON THE RIGHT (OR LEFT) CENTRE COMPANY —THREES, RIGHT AND LEFT SHOULDERS FORWARD —DOUBLE MARCH,	*When the Companies reach their places in Column, they receive successively* Threes right (or left) shoulders forward—Halt, Dress.
FORM SQUARE— QUICK MARCH. *When the Second Company has closed upon the front Company, which stands fast* — SECTIONS OUTWARDS.	*The two rear Companies close up, and form the rear face of the Square, receiving* Halt—Right about face. *The remaining Companies wheel outwards by Sections, the rear Sections closing to the front, after the wheel.*

2. If on a Flank Company, and to a flank.

SQUARE ON THE RIGHT (OR LEFT)
COMPANY
—
COMPANIES RIGHT (OR LEFT) SHOULDERS FORWARD
—
DOUBLE MARCH
—
FORWARD.

Leading Company—Halt.
Second Company closes on it—Halt.
Remainder (except the two last Companies), as they successively arrive at Quarter distance—Sections outwards. *Two last Companies when closed up*—Halt—Right about face.

3. When the Square is to resist Cavalry.

PREPARE FOR CAVALRY — READY. — *KNEELING RANKS — READY — PRESENT — LOAD. PREPARE FOR CAVALRY (OR SHOULDER ARMS).

The Kneeling ranks do not cock until required to fire.

The Standing ranks fire by Files.

** The Kneeling ranks, when required to fire a volley.*

4. To reduce the Square.

RE-FORM COLUMN — QUICK MARCH.

Rear sections of side Faces step back to wheeling distance, pivot men facing to their proper front, and at QUICK MARCH *wheel backwards*—Halt, Dress. *Front Company advances to quarter distance*—Halt, Dress. *Two rear Companies retire*—Halt, Front, Dress.

5. If the Square is to be formed on the two centre Sub-divisions.

ON THE TWO CENTRE SUB-DIVISIONS FORM SQUARE.	*The outer Sub-divisions of the two centre Companies face inwards, and leading files disengage; the two flank Companies face inwards, and the remaining Companies of the Battalion face to the right about.*
RIGHT AND LEFT SHOULDERS FORWARD.	*No. 1, 2, 3, 6, 7, 8 Companies, Sections successively*, Halt, Front. *The two centre Sub-divisions close by the side step, upon the interval left by the Colours. The Sub-divisions of the two flank Companies are conducted to form the rear Face, the right Sub-division of the Grenadiers covering its left Sub-division, and the left Sub-division of the Light Company covering its right Sub-division, each receiving* Halt, Right (or Left) face.
QUICK MARCH.	

6. To reduce the Square and form Line.

RE-FORM LINE—QUICK (OR DOUBLE) MARCH.	*The flank Companies face outwards; and the rear Sub-divisions of the centre face outwards, and file into line at* QUICK (OR DOUBLE) MARCH—Halt, Front, Dress. *The two centre Sub-divisions open by the side step to right, and left. The flank Companies move in file to their respective places. The other Companies deploy by Sections and (when at their places) receive* Right (or left) shoulders forward—Forward—Halt, Dress up.

7. But should it have been previously necessary to move the Square.

FORM DOUBLE COLUMN OF SUB-DIVISIONS — QUICK MARCH.

The rear Sub-divisions of the side faces fall back to Section distance, and the Pivot men face to their proper front, and at QUICK MARCH, *the Sections which formed the side faces wheel backwards; and the two Sub-divisions of the front face, and four Sub-divisions of the rear face, advance to quarter distance. The Sub-divisions of front face receive*—Halt. *Sub-divisions of the rear face receive*—Halt—Front.

8. When the Line is retiring, the Square may be formed at once without halting.

ON TWO CENTRE SUB-DIVISIONS FORM SQUARE.

The two centre Sub-divisions Halt—Front. *The outer Sub-divisions of centre Companies* Inwards turn," *and the formation will proceed (as directed in No. 5, Section 21) at the Double March.*

S. 22. When the Battalion forms a Square, or Oblong two deep, to protect baggage, &c., against Infantry.

1. FORM SQUARE, TWO DEEP, ON THE TWO CENTRE COMPANIES.

The two centre Companies stand fast, remaining Companies face to the rightabout, and at QUICK MARCH *the two centre Companies (4 and 5) close inwards: the remainder right, and left shoulders forward, and move into Square. Nos. 1, 2, and 3, form the right face, 6, 7, and 8 the left face, the Grenadier, and Light Infantry the rear face of the Square, respectively receiving* Halt, Front, Dress.

REMAINING COMPANIES, RIGHT AND LEFT SHOULDERS FORWARD — QUICK MARCH.

2. When the Square or Oblong is to march by any one face.

THE SQUARE WILL MARCH TO THE FRONT (REAR, RIGHT, OR LEFT) FACE.

Flank Faces—BY SUB-DIVISIONS ON THE RIGHT AND LEFT BACKWARDS WHEEL—QUICK MARCH.	*The rear face advances two paces and faces about*—Halt, Dress.
QUICK MARCH.	*The Square marches two faces in Line, (by their centre,) and two faces in Open column of Sub-divisions.*
HALT—REFORM SQUARE—QUICK MARCH.	*The Sub-divisions in column wheel up and form their faces, and the rear face will close up and then face about.*

3. To reduce the Square.

FORM LINE—RIGHT AND LEFT SHOULDERS FORWARD—QUICK MARCH.	*The two centre Companies open out by the side step, to leave room for the Colours. Remaining Companies*, Right (or left) shoulders forward—Forward—Halt, Dress up.

S. 23. A Battalion halted in Line, to change front to the rear upon the centre.

CHANGE FRONT TO THE REAR UPON THE CENTRE.	*Centre Companies*—Right (or left) face—Right Counter-march—Quick march—Halt, Front, Dress up—Eyes front.
Remaining Companies, THREES RIGHT, AND LEFT SHOULDERS FORWARD —RIGHT AND LEFT COUNTER-MARCH— QUICK MARCH.	*The Companies pass each other by the left, those of the Right wing describing a circle to allow room for the others to pass, and when in their proper position*—Right (or left) shoulders forward—Forward—Halt, Dress up—Eyes front.

CHANGES OF POSITION OF THE BATTALION FROM LINE BY MOVEMENTS OF THE OPEN COLUMN ON A FIXED POINT.

S. 24. The Battalion to change position to the front on the right halted Company, by throwing forward the whole Left, and by the flank march of Companies.

1. FORM OPEN COLUMN IN FRONT OF THE RIGHT COMPANY — REMAINING COMPANIES — RIGHT FACE — QUICK MARCH.	*If the change of front is to be at right angles with the old line, the right Company stands fast; if oblique to it, that Company will wheel back on the right flank as many paces as will make it perpendicular to the new direction. Remaining Companies face to the right, and disengage to the left*— Halt, Front, Dress.
RIGHT WHEEL INTO LINE.	Halt, Dress—Eyes front.

2. The Battalion may change its position to the Left, Right thrown forward, by the formation of the Open column in front of the left halted Company.

3. If the Change of position is effected by the formation of the Open column on a central Company, the caution will specify which flank is to be thrown forward. *The Companies face inwards, and disengage.*

4. When a Battalion is to change position on a flank halted Company, by throwing back the other flank.

FORM OPEN COLUMN IN REAR OF THE RIGHT (OR LEFT) COMPANY — REMAINING COMPANIES — RIGHT (OR LEFT) FACE— QUICK MARCH.	*Remaining Companies*—Halt, Front, Dress.
RIGHT (OR LEFT) WHEEL INTO LINE— QUICK MARCH.	Halt, Dress—Eyes front.

ON A DISTANT POINT.

S. 25. The Battalion in line changes position by breaking into Open column, marching up in column to the point where its head is to remain, and entering the line by the flank march of Companies.

RIGHT (OR LEFT) FACE. *The Battalion in Open column to form at a point where its leading flank is to be placed, receives*—Halt— *when its leading division is at wheeling distance short of that point.*

—

QUICK MARCH.
HALT.

S. 26. The Battalion formed in line, changes position by breaking into Open column, marching to a point where its head is to rest, and to which its rear divisions form, by successively passing each other, and wheeling up.

FORM LINE TO THE REVERSE flANK. *Leading division*—Right (or left) shoulders forward—Forward—Halt, Dress. *Remaining divisions successively*—Right (or left) shoulders forward—Forward—Halt, Dress up.

OPEN COLUMN MOVEMENTS.

S. 27. When the leading flank of the Column is changed by the successive march of Divisions from the rear to the front.

HALT
—
BY
SUCCESSIVE
DIVISIONS
—
REAR
WING
TO
THE
FRONT.

If Right in front; Rear Company—Right face—Quick march—Front turn. *Remaining Divisions in succession, when their rear Division passes them*—Right face—Quick march—Front turn. *If left in front, the rear Divisions are faced to the left.*

S. 28. To change the Wings of a column formed upon a road, where the space does not admit of the Flank movement.

BY
DOUBLE
FILES
FROM
THE
CENTRE,
REAR
WING
TO
THE
FRONT.
TWO
CENTRE
SECTIONS
OUTWARDS
WHEEL
—
QUICK
MARCH.*

Rear Company—Inwards face, by Files from the Centre. *Remaining Companies**—Halt, Dress. *Rear Division when clear of the column*—Form Company—Forward. *Remaining Divisions in succession when clear*—Inwards face—Quick march—Form Company—Forward.

S. 29. When the Column, at open, or half distance, is

required to form a Square.

1. *If the Square is to be formed on the front Company.*

FORM SQUARE UPON THE FRONT COMPANY — QUICK MARCH. (*Vide S. 21, No. 2.*)



2. *If upon a central Company.*

FORM SQUARE ON THE RIGHT (OR LEFT) CENTRE COMPANY.
—
RIGHT (OR LEFT) WING
—
RIGHT ABOUT FACE
—
QUICK (OR DOUBLE) MARCH.

The Officer commanding the named Division, gives—Sections outwards; *the rear Sections closing on the front Sections. The Left wing will close to Section distance, and the Companies receive, in succession*—Sections outwards; *the Right Wing will move to the Centre, rear Rank in front, and when each Company shall close up to the one preceding it, Companies 3, 4, 5, 6,* Front turn, Sections outwards, *and the rear Sections close to the front. Nos. 1 and 2*—Halt, Front,—*Nos. 7 and 8*—Halt, Right about face.

3. If an Open column, moving to front, or rear in File, or Sections of Threes, be attacked by Cavalry.

If in File.

FORM SQUARE ON THE CENTRE — WINGS INWARD TURN — DOUBLE MARCH. *The Divisions turn to the right, and left; and if the Column be right in front, when the left centre Company has turned it receives*—Sections outwards; *the Wings close on the centre, at the double march, and each Company wheels outwards into Square; as in No. 2.*

If the Column is moving in Sections of Threes.

RIGHT (OR LEFT) SHOULDERS FORWARD. FORWARD — SQUARE ON THE CENTRE — RIGHT WING, RIGHT ABOUT TURN — DOUBLE. *The Formation proceeds as before. The Column is re-formed as directed in S. 21, No. 4.*

QUARTER DISTANCE, AND CLOSE COLUMN.

S. 30. When a Battalion forms a close, or quarter distance Column, from Line.

1. If a Close Column before, or behind, either of the flank Companies.

FORM CLOSE (OR QUARTER DISTANCE) COLUMN ON ——— COMPANY, RIGHT (OR LEFT) IN FRONT — RIGHT (OR LEFT) FACE — QUICK MARCH. *All except the named Company*—Halt, Front, Dress.

2. On a central Company.

INWARDS FACE — QUICK MARCH. *All except the named Company*—Halt, Front, Dress.

In the same manner, Column may be formed from Line upon any Company facing to the rear; that

Company countermarching by files, and the Wings facing outwards, and countermarching to the right, or left; and forming as before.

In all Counter-marches from Line, the Company of formation will be faced by the command of its own Officer.

3. If a Quarter distance Column upon any named Company.

FORM COLUMN AT QUARTER DISTANCE, RIGHT (OR LEFT) IN FRONT,
——
ON COMPANY
—
REMAINING COMPANIES, THREES
—
SHOULDERS FORWARD
—
QUICK (OR DOUBLE) MARCH
—
FORWARD.

Shoulders forward—Halt, Dress, *as in Nos. 1 and 2.*

The leading threes of the Company next the one of formation must wheel upon its centre file in disengaging to the rear.

4. The Close column may be formed from Open column.

CLOSE TO THE FRONT — QUICK (OR DOUBLE) MARCH. *Or without halting* — CLOSE TO THE FRONT — DOUBLE. *If on the March, Leading division*—Halt. *Remaining divisions successively*—Halt: *When on the Double march*—Quick.

S. 31. When the Column, at close, or quarter distance, marches to a flank.

COLUMN
WILL
MARCH
TO
THE
RIGHT
(OR
LEFT)
flANK
—
RIGHT
(OR
LEFT)
FACE
—
QUICK
MARCH
—
HALT,
FRONT.

If the Column is at quarter distance, it may be marched to a flank in Sections of threes.

THREES
RIGHT
(OR
LEFT)
SHOULDERS
FORWARD
—
QUICK
MARCH
—
FORWARD.

S. 32. When the Column at quarter distance, moving

to front, or rear, takes ground to the Right, or Left, by the Echellon march of Sections.

1. SECTIONS RIGHT (OR LEFT) — FORWARD.
2. RE-FORM COLUMN — FORWARD.

Officers remain on their proper pivot flank.

Ground may be taken to a flank by the diagonal march.

RIGHT (OR LEFT) HALF TURN.

S. 33. When a Column halted, at Close, or Quarter distance, is to wheel on a fixed, or moveable pivot.

1. At close distance on a fixed pivot.

COLUMN TO THE RIGHT (OR LEFT) WHEEL — QUICK (OR DOUBLE) MARCH — HALT.

The flank file of front Company will face.
Remaining Companies make a half face.
Vide S. 10. No. 6.

2. At close distance on a moveable pivot.

RIGHT (OR LEFT) SHOULDERS FORWARD — HALT (OR FORWARD).

Rear Divisions will make a half turn to the outward flank, and circle round.

If the Column is to wheel in double time.

DOUBLE—FORWARD— QUICK.

3. At Quarter distance on a fixed pivot.

RIGHT (OR LEFT) WHEEL.

Rear Divisions half face to the wheeling flank. The front Division will advance six paces, and wheel at shortened pace round the Pivot, the rear Divisions circling round.

—

QUICK (OR DOUBLE) MARCH

—

HALT.

4. At Quarter distance on a moveable pivot.

RIGHT (OR LEFT) SHOULDERS FORWARD

The Front division moves round at a short pace, the pivot-man gradually advancing in the new direction.

—

DOUBLE

—

FORWARD

—

QUICK.

S. 34. When a Close, or Quarter distance Column is to change its front by the wheel and countermarch of Sub-divisions round the centre.

1. If at the halt.

COUNTER MARCH BY SUB-DIVISIONS ROUND THE CENTRE — RIGHT (OR LEFT) SUB-DIVISIONS — RIGHT ABOUT FACE — QUICK (OR DOUBLE) MARCH — *HALT, FRONT, DRESS.

The Reverse sub-divisions face about. The whole wheel round in succession.

* *When the leading Sub-division is in a line upon the new front of the Column.* Front *applies to the Reverse sub-divisions only.*

2. If the Column at Quarter distance is on the march.

RIGHT
(OR
LEFT)
SUB-
DIVISIONS
—
RIGHT
ABOUT
TURN
—
FRONT
TURN
—
FORWARD.

S. 35. When a Column at close, or quarter distance, is to open out to full, or half distance, from front, or rear.

1. If from the front.

COLUMN, WITH OPEN FROM THE FRONT — *The requisite number of paces are counted by the leaders of each Division.* Halt, Front.
—
RIGHT
ABOUT
FACE
—
QUICK
MARCH.

2. If from the rear.

COLUMN WILL OPEN FROM THE REAR — QUICK MARCH. *Each Division leader gives* Halt *to the Company in his front, when at the ordered distance.*

DEPLOYMENTS.

Deployments are made from Column invariably on the base of the front Company; Close columns deploy in File.

S. 36. When the Battalion in column of Companies, at Close, or Quarter distance (right in front), deploys into Line.

FROM CLOSE COLUMN.

1. On the Front Company.

DEPLOY ON THE FRONT COMPANY — REMAINING COMPANIES, LEFT FACE — QUICK MARCH. *Each Company, in succession*—Front turn—Halt, Dress up—Eyes front.

2. On the Rear Company.

DEPLOY ON THE REAR COMPANY — REMAINING COMPANIES, RIGHT FACE — QUICK MARCH.

When the front of the named Company is clear, the Officer commanding it gives— Double march—Halt, Dress up—Eyes front—*Remaining Companies successively* —Halt, Front. *When uncovered*, Quick march, *and when in the alignement*, Halt, Dress up—Eyes front.

Deployments on a central Company are performed in a similar manner. In deploying on a rear, or central Company, the Company of formation will be moved up in Double time.

FROM QUARTER DISTANCE COLUMN.

3. When a Battalion in Column of Companies at quarter distance, right in front, deploys upon its Front division.

DEPLOY ON THE FRONT COMPANY — REMAINING COMPANIES, THREES — RIGHT SHOULDERS FORWARD — QUICK (OR DOUBLE) MARCH — FORWARD.

Left shoulders forward—Forward— Halt, Dress up—Eyes front.

4. On a Rear Company.

DEPLOY ON THE REAR COMPANY — *When the Front is clear, Rear Company* —Double march—Halt, Dress up—Eyes front. *The other Companies successively* —shoulders forward—Halt. *When uncovered* —Quick MARCH—Halt, Dress up—Eyes front.

—

REMAINING COMPANIES, THREES

—

LEFT SHOULDERS FORWARD

—

QUICK MARCH

—

FORWARD.

The Base points are three paces in advance of the Front Company of the Column.

ECHELLON FORMATIONS AND MOVEMENTS.

S. 37. When a Battalion from Line wheels forward by Companies, to either flank, into Echellon.

1. Halt,
COMPANIES Dress.
———
PACES
TO
THE
———
WHEEL
—
QUICK
MARCH.

2. When the Echellon thus formed marches forward, and halts.

QUICK MARCH—HALT.

S. 38. When the Battalion having wheeled from Line into Echellon, has marched, and halted, and is to form back parallel to the Line it quitted.

WHEEL Halt, Dress—Eyes front.
BACK
INTO
LINE
—
QUICK
MARCH.

S. 39. When the Battalion having wheeled from Line into Echellon, has marched and halted, and is to form up oblique to the Line it quitted.

1. If the Formation is made forward.

LEADING DIVISION.

Leading Division—Halt, Dress—Eyes front.

Remaining Divisions—shoulders forward—Halt, Dress up—Eyes front.

PACES
RIGHT
(OR
LEFT)
WHEEL
—
QUICK
MARCH.
FORM
LINE
—
QUICK
MARCH.

2. If the wheel of the leading Division exceed the number of paces which it before wheeled from Line into Echellon, the others wheel up one-half of that excess, move on, and successively dress up with it.

3. If the formation is to be on the prolongation of the front Division as it stands, the others wheel back one-half of what they originally wheeled forward, then move on, and dress up with it.

S. 40. When the Battalion formed in Line changes front on a fixed flank Company, by throwing forward the rest of the Battalion.

CHANGE FRONT ON ——— COMPANY, RIGHT (OR LEFT) THROWN FORWARD, ——— COMPANY ——— PACES RIGHT (OR LEFT) WHEEL. *Company of formation*—Halt, Dress.

REMAINING COMPANIES, PACES TO THE ——— WHEEL — QUICK MARCH.* QUICK MARCH.† *Remaining Companies*—Halt, Dress.

——— † ——— shoulders forward—Halt, Dress up—Eyes front.

S. 41. When the Battalion changes front on a fixed flank Company, by throwing back the rest of the Battalion.

CHANGE FRONT ON —— COMPANY, RIGHT (OR LEFT) THROWN BACK.	—— Company on the —— backwards wheel—Quick march—Halt, Dress.
REMAINING COMPANIES, RIGHT ABOUT FACE, —— PACES TO THE —— WHEEL—QUICK MARCH.	Halt, Dress.
QUICK MARCH (OR MARCH).	—— shoulders forward—Halt, Front, Dress up—Eyes front.

S. 42. When the Battalion changes front on a central Company, by advancing one Wing, and retiring the other.

The Company of the Wing to be thrown back is wheeled backward, and the Company of the wing to be brought forward is wheeled forward; or a Central Company is wheeled upon its centre into the new direction.

—— WING, RIGHT ABOUT FACE— COMPANIES —— PACES INWARDS WHEEL — QUICK MARCH.	Halt, Dress.
QUICK MARCH.	*Companies successively*—shoulders forward— *and when in Line, those of the advancing Wing receive*—Halt, Dress up: *the retiring Wing*—Halt, Front, Dress up.

S. 43. When, from Open column, the Companies wheel backward into Echellon, in order to form in Line on the front Company.

1. FORM LINE ON THE LEADING DIVISION REMAINING DIVISIONS ——— BACKWARD WHEEL — QUICK MARCH. ——— QUICK MARCH.

The front Company remains square to the Column, or is wheeled backward into the intended direction of the Line by its Officer.

If the front Company remains square, the remaining Companies wheel back four paces, or the eighth of a circle; but if the direction be Oblique, then the remaining Companies wheel one-half the number wheeled by the front Company, in addition to the eighth of a circle—

——Halt, Dress. —— shoulders forward—Halt, Dress up—Eyes front.

2. If the Line be formed on the rear Company of the Column, that Company will stand fast, the others will receive.

RIGHT ABOUT FACE — Halt, Dress.
— shoulders forward—Halt, Front, Dress up
— Eyes front.

PACES ON THE BACKWARDS WHEEL — QUICK MARCH. QUICK MARCH.

3. If the Line is to be formed on a rear Company, but facing to the Rear.

FORM LINE ON REAR COMPANY, FACING TO THE REAR. THE COLUMN WILL COUNTER-MARCH. — Halt, Front, Dress—Eyes front.

—Face— Quick march. Form line on the leading Division. Remaining Divisions, four paces on the —— backward wheel— Quick march.* Quick march.†	* Halt, Dress. † —— shoulders forward—Halt, Dress up—Eyes front.

4. If the Line be formed on a Central Company of the Column.

FORM LINE ON THE RIGHT (OR LEFT) CENTRE COMPANY, —— WING RIGHT ABOUT FACE— FOUR PACES ON THE RIGHT (OR LEFT) BACKWARDS WHEEL — QUICK MARCH.	*All except the central Company* Halt, Dress.
QUICK MARCH.	*Companies of Wings (except Company formed on)*—— shoulders forward—Halt, Dress up—Eyes front. *Or* —— shoulders forward—Halt, Front, Dress up—Eyes front.

S. 44. When from Line the Companies of a Battalion march off in Echellon, successively and directly to the front; and again form Line to the front, or flank.

1. When the intention is to form Line to the front.

ADVANCE IN DIRECT ECHELLON OF COMPANIES FROM THE RIGHT (OR LEFT).	*When the leading Division receives*—Halt, *the others move on, and* Halt, Dress up, *in line with it.*

2. When the intention is to form Line to the flank.

FORM LINE TO THE RIGHT (OR LEFT) flANK.	*Leading Division*—Halt, Dress—Eyes front.
BY DIVISIONS, SHOULDERS FORWARD—FORWARD.	*Remaining divisions*—Halt, Dress up— Eyes front.

3. If a Column is to be formed to the flank, from a direct Echellon.

FORM —— shoulders forward—Halt, Dress.
COLUMN
IN
REAR
OF
THE
LEADING
DIVISION
—
THREES
—
SHOULDERS
FORWARD
—
FORWARD.

S. 45. When a Battalion, in Echellon of Companies, halted, or in motion, is required to form square.

COMPANIES, RIGHT (OR LEFT) SHOULDERS FORWARD — FORWARD — FORM SQUARE.

The formation will proceed as directed in Section 29.

S. 46. When a Battalion marching in Line is to take ground to a flank by the Echellon movement of Sub-divisions, or Sections.

1. SUB-DIVISIONS (OR SECTIONS) RIGHT (OR LEFT)—FORWARD.

2. When sufficient ground has been taken to the flank.

RE-FORM LINE—FORWARD — HALT.

3. When sufficient ground has been taken in Echellon to a flank, and a forward formation of the Line is to be made.

FORM LINE ON THE LEADING DIVISION. *The head Division is wheeled up two paces more and halted. Divisions successively* —— shoulders forward. Halt, Dress up—Eyes front.

In taking ground to a flank, if a small degree of obliquity from the former position is to be taken, the Line may wheel forward by Companies; if a greater, by Sub-divisions; and if a greater still, by Sections.

LIGHT INFANTRY.

SIGNALS AND SOUNDS FOR REGULATING MOVEMENTS.

The Officers' call—*as established, and therefore not numbered.*

1. To extend.
2. To close.
3. To advance.
4. To halt.
5. To fire.
6. Cease firing.
7. To retreat.
8. Assembly.
9. Incline to the right.

10. Incline to the left.
11. The alarm.

INFANTRY SWORD EXERCISE.

Words of command throughout

THE PROGRESSIVE INSTRUCTIONS OF THE DRILL.

The words in Italics are to serve as a caution only.

SECTION I.

EXTENSION MOTIONS, AND POSITIONS.

Attention.
First extension motions.—One—Two—Three—Four—Five.
First position in three motions.—One—Two—Three.
Second position in two motions.—One—Two.
Balance motions.—One—Two—Three—Four.
First position.
Third position in two motions.—One—Two.
Second extension motions.—One—Two—Three.
First position.
Front.
Stand at ease.
Attention.
Positions.
First—Second—First—Third.
First—Second—Third—Second.
Single attack—Double attack.
Advance—Single attack—Retire—Double attack.
Front—Stand at ease.

Section II.

PREPARATORY INSTRUCTION WITH THE SWORD.

Attention.
Draw swords—Return swords—Draw swords—Slope swords.
Stand at ease.

Attention.
Prepare for Sword exercise.
Right prove distance—Slope swords.
Front prove distance—Slope swords.
Assault.
One—Two—Three—Four—Five—Six—Seven.
First Point—Two—Second Point—Two—Third Point—Two.
Defend.
Second—Third—Fourth—Fifth—Sixth—Seventh.
Parry—Two. Slope swords. Stand at ease.
Attention.
Guard—Inside guard—Outside guard.

Cut one.	First guard.
Cut two.	Second guard.
Cut three.	Third guard.
Cut four.	Fourth guard.
Cut five.	Fifth guard.
Cut six.	Sixth guard.
Cut seven.	Seventh guard.
First point.	Two.
Second point.	Two.
Third point.	Two.

Parry. Two.
Guard. Slope swords.
Stand at ease.

Section III.

REVIEW, OR INSPECTION EXERCISE.

Attention.
Prepare for Sword exercise.
Right prove distance—Slope swords.
Front prove distance—Slope swords.
Guard—Inside Guard—Outside guard.
One—Two—Three—Four—Five—Six—Seven.
Points—First—Second—Third—Parry.
Guard—Slope swords.

SWORD PRACTICE.

Guard.
Inside, and outside Cuts.—One—Two—Three—Four—Five—Six.
Inside guard.
Outside Cuts.—Two—Four—Six.
Outside guard.
Inside Cuts.—One—Three—Five.
Guard—Slope swords—Stand at ease.

Section IV.

ATTACK AND DEFENCE.

Attention.
Front rank, Right about face—Prepare for Attack, and Defence.

Prove distance—Slope swords.
Guard—Inside guard—Outside guard.
Left cheek—Right cheek—Wrist—Leg.
Left side—Right side—Head.
First point—Two—Third point—Two.
Guard—Slope swords.

Point, and Parry.—Guard—Third point—Point.
Point (continuing as long as requisite).
Guard—Slope swords—Stand at ease.

SECTION V.

STICK DRILL.

First Practice.

Guard—Continuing the same words of command and movements as in the "Attack and Defence" in Section 4th, omitting the word "Two" in the delivery of each point.

Second Practice.

Guard—Continuing, &c., as the "Point and Parry," but not exceeding Six points.

Third Practice.

Guard—Leg—Inside guard—Leg.
Outside guard—Leg—Guard—Slope swords.

Fourth Practice.

Guard—Head—Head—Leg—Leg—Head—Head—
Guard.
Slope swords.

Fifth Practice.

Head—Head—Arm—Head—Head—Arm.
Head—Head—Right side—Head—Head—Right side.
Slope swords.

When perfect, by Word of command, the whole of this Section is to be performed in Quick time, by the drill officer naming only the practice required, but first giving the caution—*Stick drill by practice divisions.*

INSTRUCTIONS FOR PITCHING, AND STRIKING TENTS.

1. Whenever possible, the quartermaster, or an officer acting for him, with a non-commissioned officer and a camp colourman per company, will precede the corps to be encamped.

2. This officer will take up ground for the companies' and the officers' and other tents, &c., according to the directions he may have received, to conform to one or other of the methods laid down in the "Regulations for Encampments," marking by a picket the spot to be occupied by each tent-pole, and taking care that the lines of tents are perpendicular and correctly covered.

3. Before arriving in camp the men will be told off for their several functions as pole-men, peg-men, and unpackers of tents, two men being allotted for each of these duties, and six in all for every tent. More than this number only impede each other.

Each tent requires, therefore, one section of threes to pitch, or strike it.

4. From the remainder of the company the parties

will be told off for provisions, wood, water, fire, guards and pickets, and for the pitching of the officers' orderly-room, store-room, guard-tents, &c.

To each tent, as far as possible, a non-commissioned officer will be told off.

5. It is known that the soldiers' tent, with its cords, occupies a space of nearly 6 yards—that is, between 7 and 8 paces from pole to pole.

6. The pole-men, being stationed at the spots indicated by the pickets, the pole is lowered, and the cap of the tent fixed on, and all things prepared for the raising of the tent. On the signal, or word of command, the whole of the poles are raised together, the skirt of the tent being lifted over the poleman's head.

7. It will be remembered, that, to insure stability, four of the cords which divide the circumference accurately into quarters, must be first made fast before any of the others.

8. Each cord must be stretched on the true prolongation of the tent seam.

9. The slides must be made fast at an equal distance from the tent and the ground peg, so as to permit shifting, as expansion or contraction of the cord ensues on atmospheric changes.

10. The non-commissioned officer sees that the door is properly placed, and attends especially to the fastenings of the first four pegs, with a view to the general uprightness of the pole and security of the tent, under the general superintendence of the company's officers; one being stationed at the flank, the more easily to detect and correct errors.

11. In order to strike the tents, all the pegs are

drawn except the four first driven, and four men place themselves at these in readiness for the signal; they draw these pegs, and hold down the tent till the signal be given.

12. On the signal, the pole-men lower the poles to the rear, and come out by the door, bringing the poles with them.

13. In rolling up the tent, the cap is turned on one side, in such a manner as shall make it visible at one end when the tent is rolled. This prevents the cap from cutting the tent.

PART II.

ROYAL ARTILLERY.

CARBINE EXERCISE.

MANUAL EXERCISE.

Present arms.
Shoulder arms.
Order arms.
Shoulder arms.
Slope arms.
Stand at ease.
Attention.
Carry arms.
Trail arms.
Shoulder arms.
Order arms.
Trail arms.
Order arms.
Fix bayonets.
Shoulder arms.
Charge bayonets.
Shoulder arms.
Order arms.
Unfix bayonets.
Stand at ease.

PLATOON EXERCISE.

1. As a front rank standing.
2. As a rear rank standing.
3. As a front rank kneeling.

4. As a rear rank kneeling.
As front rank standing, Load.
Handle cartridge.
Draw ramrods.
Ram down cartridge.
Return ramrods.
'Bout.
Prime.
As front rank—Ready.
Present.
Load, *as before directed.*
'Bout.
Prime.
Shoulder arms.
As rear rank standing—Ready.
Present.
Load.
&c., &c.

TO FIRE KNEELING.

As front rank kneeling—Ready.
Present.
Load, *as before directed.*
'Bout.
Prime.
Order, or Shoulder arms.
As rear rank kneeling—Ready.
Present.
Load, *as before directed.*
'Bout.
Prime.
Order, or Shoulder arms.
Wing or Battalion: Company, prepare to load. Load.
Company, Wing, or Battalion. } Ready. } Present.
Half-cock arms.

Shoulder arms.

To fire a volley, and half-cock.
Ready.
Present.
Shoulder arms.

INSPECTION OF A COMPANY.

Double distance—Rear rank take open order —March.
Port arms.
Half-cock arms.
Ease springs.
Shoulder arms.
Order arms.
Examine arms.
Return ramrods.
Fix bayonets.

DISMISSAL OF A COMPANY.

Recover arms.
Right face.
Lodge arms.

TO FIRE A FEU-DE-JOIE.

With blank cartridge—Load.
Ready.
Present.

Commence firing from the right, and then reload.

After the third fire.

Shoulder arms.
Present arms.
Shoulder arms.
Order arms.

Three cheers.

FUNERAL EXERCISE.

Present arms.
Reverse arms.
Rest upon your arms reversed.
Stand at ease.
Attention.
Reverse arms.
Rest upon your arms reversed.
Present arms.
Shoulder arms.
With blank cartridge—Load.
Ready.
Present.

After the third round.

Shoulder arms.
Rear rank take close order—March.

On all occasions the percussion Carbine, when capped, or having the snap-cap on, is to be kept at the half-cock, either when the soldier is on duty, or at drill, or when the carbine is lodged in the arm-rack of the guard-room or barrack-room; and on no account whatever is the cock to be allowed to remain down upon the cap at any time, except during the interval between the words of command, “Fire,” and “Load,” in the Platoon exercise.

SWORD, ROYAL ARTILLERY.

		lb.	oz.	
Weight	{ Sword	2	7½	4 lb. }

	{ Scabbard, steel	1 8½ }	
		inches.	
Length	{ Blade	28¾ }	33¾ inches.
	{ Handle	5 }	

Light Cavalry pattern of 1822, for Royal Horse Artillery.

		lb. oz.	
Weight	{ Sword	2 5 }	4 lb. 6 oz.
	{ Scabbard, steel	2 1 }	
		inches.	
Length	{ Blade	35 }	40¾ inches.
	{ Handle	5¾ }	

CAVALRY, SWORD EXERCISE.

Review, or Inspection exercise.

Right prove distance—Slope swords.
Front prove distance—Slope swords.
Perform Sword exercise—First division—Second division.

The time to be taken from the Flugleman as follows:

—

Words of Command.	*Flugleman.*
Right prove distance	Right.
Slope swords	Right.
Front prove distance	Right.
Slope swords	Right.
Perform sword exercise.	
Engage	Right.
Right guard	Right.
Left guard	Right.
Assault 1, 2, 3, 4, 5, 6, 7, 1st, 2nd, 3rd, Left and Right.	
Right defend, 2nd, 3rd, 4th, 5th, 6th, 7th, Parry Right.	
Left defend, 2nd, 3rd, 4th, 5th, 6th, 7th.	
Parry	Right and Left.
Slope swords	Left.

FIRST DIVISION.		SECOND DIVISION.	
Assault	Left.	Assault	Left.
One	Left.	One	Left.
Point	Left.	Point	Right.
Two	Right.	Two	Right.
Point	Right.	Point	Left.
Three	Right.	Three	Right.
Point	Right.	Point	Left.

Four	Left.	Four	Left.
Point	Left.	Point	Right.
Five	Left.	Five	Left.
Point	Left.	Point	Right.
Six	Right.	Six	Right.
Point	Right.	Point	Left.
Seven	Right.	Seven	Right.
Point	Right.	Point	Right rear.
Slope swords	Right.	Slope swords	Right rear.

FORMATION FOR SWORD EXERCISE ON FOOT.

Officers take post in front.	Right prove distance.
Quick march.	Slope swords.
From the inward flanks of wings	Front prove distance.
tell off by Threes.	Slope swords.
From the right of the left wing	Sword exercise.
open your files.	First division.

Quick march.	Second division.
From the right of threes to the front, File.	Eyes right.
	Return swords.
Quick march.	Front form line.
Halt.	Quick march.
Prepare for sword exercise.	Close to the right of the left wing.
Eyes right.	
Draw swords.	Inwards face.
Slope swords.	Quick march.

FORMATION FOR SWORD EXERCISE MOUNTED.

From the right of threes to the front, File.	Slope swords.
	Sword exercise.
March.	First division.
Halt.	Second division.
Right prove distance.	Front form ranks.

Slope swords.	March.
Front prove distance.	

OFFICERS' SALUTE.

The Officers to be formed in line at four paces distant from each other, "Standing at ease" with the point of the sword lowered between the feet, the edge to the right, and left hand covering the right.

ATTENTION—Carry swords.

REAR RANK TAKE OPEN ORDER—"Recover swords" and move forward an oblique pace to the left, so as to be placed in front, and just clear of the second File.

MARCH—Advance three paces to the front, and bring the sword to the "Port," the blade being diagonally across the body, the edge upwards, and arms nearly extended; the left elbow bent with the hand as high, and in front of the shoulder; holding the blade between the forefinger and thumb, the knuckles to the front, and elbows close to the side.

PRESENT ARMS—"Recover swords" at the second motion of the carbine; and at the third motion lower the sword (to the full extent of the arm) to the right, with the edge to the left, and point in the direction of the right foot, the elbow close to the side, at the same time raising the left arm as high as the shoulder, and bringing the hand round by a circular motion over the peak of the cap, the knuckles uppermost, and fingers extended.

SHOULDER ARMS—"Recover swords" at the first motion of the carbine; and at the second motion "Port swords."

REAR RANK TAKE CLOSE ORDER—"Right face;" and as the right foot is drawn to the rear, "Recover swords."

MARCH—Move back into the front Rank. "Front" and "Carry swords."

The Salute on the march is to commence when at ten paces from the Reviewing officer, the Officer on the right giving the signal to prepare the other Officers by raising the fingers of the left hand two paces, previous to saluting; the sword is then raised by extending the arm to the right, and by a circular motion brought to the "Recover;" and continuing the motion to the right shoulder, from whence the sword is lowered, and the left hand is then gradually raised over the peak of the cap in the manner before directed. The time for completing the salute is six paces, commencing with the left foot, and may be divided (for Drill practice) as follows:—First pace, the sword raised to the right; Second pace, to the "Recover;" Third pace, to the right shoulder; Fourth pace, the sword lowered to the right; Fifth pace, the left arm raised; Sixth pace, hand brought to the peak of the cap.

The head should be slightly turned towards the Reviewing Officer, whilst passing him, and having done so six paces, and given the signal (as before) "Recover swords" at one pace, and in "Port" the following pace.

The same time is given for the Salute when mounted (which is to be completed in four motions), but the sword should then be kept in a line with the

knee.

On the march, or when manœuvring, the sword may be carried to the full extent of the arm, the guard of the hilt resting upon the inside of the fingers, the back of the blade being against the hollow of the shoulder.

PART III.

ORDNANCE, CARRIAGES, ETC.

ORDNANCE.

GUNS.

Guns are distinguished from each other by their metal, and weight of their shot.

A Gun is divided into five parts, which are named *Cascable*, *First reinforce*, *Second reinforce*, *Chase*, *Muzzle*.

The metal is made thicker towards the breech than at the muzzle, to strengthen the piece, for the elastic force of the Gunpowder is there greatest, and diminishes in power as the space it occupies is extended. The metal is made thinner towards the muzzle to make the gun lighter.

The Dispart is half the difference between the diameter of the Gun at the base ring and at the swell of the muzzle. By affixing on the muzzle a piece of metal equal to the height of the dispart, the line of sight will be made parallel to the axis of the bore, and therefore an object within point blank range can be seen. Howitzers, and some guns which have a patch or projection on the upper part of the muzzle, have no dispart, the semi-diameter of the muzzle with the patch added to it being equal to the semi-diameter of the base ring. Iron ordnance (Bloomfield's) are intended to have a degree and a

half dispart, but the founder is allowed two-tenths of an inch variation in casting Iron ordnance, for any difference which there may be between the intended and actual diameter of the base ring and muzzle.

Light Brass Field Guns 12, 6, and 3-pounders have a dispart of one degree, and Medium 12-pounders and 9-pounders have one degree and a quarter.

The Angle of dispart is the number of degrees the axis of the bore would point above the object aimed at, when laid by the surface of the gun.

Point blank range is when the piece is laid at the object without any elevation; the plane and the axis of the bore being parallel to each other. *Its distance is measured* from the muzzle of the piece (fired with the service charge of powder) to the first graze of the shot, or point at which it first touches the ground.

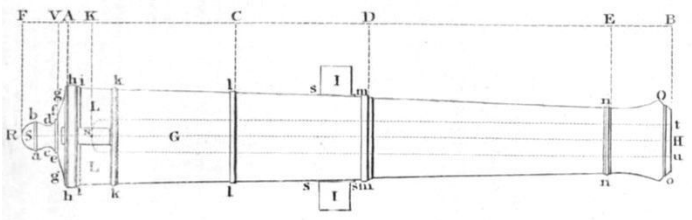
When a Shot is fired from a gun, it is acted upon by three forces:—

1st. The explosion of the Powder, which urges it forward.

2nd. The resistance of the Air, which tends to stop it.

3rd. The force of gravity, which causes it to descend.

A BRASS GUN.



NAMES OF THE SEVERAL PARTS OF A GUN.

AB *Length of the Gun*
AC *First Reinforce*
CD *Second Reinforce*
DE *Chase*
EB *Muzzle*
FA *Cascable*
GH *Bore*
RH *Axis of the Piece*
I *Trunnions*
L *Vent Field*
N *Vent*
O *Swell of the Muzzle*
VAK *Breech*
S *Button*

ab *Button Astragal*
cd *Neck*
ef *Neck Fillet*
g *Breech Ogee*
h *Base Ring*
i *Base Ring Ogee*
k *Vent Field Astragal & Fillets*
l *First Reinforce Ring*
m *Second Reinforce Ring & Ogee*
n *Muzzle Astragal & Fillets*
o *Muzzle Mouldings*
s *Shoulder of the Trunnion*
tu *Diameter of the Bore or Calibre*

When a Shot has been fired from a gun one second of time, it has fallen 16-1/12 feet; in two seconds, 64⅓ feet; in three seconds, 144¾ feet; and

proportionally for every additional second.[4] For this reason, it is necessary to give a certain degree of elevation to a gun: as, for instance, should *the time of flight* of a shot be two seconds, the gun must be pointed 64⅓ feet above the object intended to be struck, because in that time it will have fallen through that space; therefore, the more distant the object is, the greater must be the elevation given to enable the shot to reach it.

There are three modes of extending the range of a Shot without increasing the charge of powder, viz.:—

1st. By raising the piece to a higher level.

2nd. By giving its axis greater elevation.

3rd. By excentric projectiles; recent experiments having shown that if the centre of gravity is placed directly above the centre of figure the range is greatly increased.[5]

A Tangent scale is affixed to the breech of Guns and Howitzers, by means of which the requisite elevation may be given, and the object seen at the same time. This scale has divisions, called degrees, marked on it, and it is placed in a groove at the breech, from which it can be raised (being fastened by a screw) to give the necessary elevation.

The divisions on the Tangent scale are found by multiplying the length of the piece in inches, from the base ring to the swell of the muzzle, by ·017455, and the product will give the length nearly of each degree or division on the tangent scale. By subtracting the dispart from this product, the length of the tangent scale above the base ring for one degree of elevation will be obtained.

The Sights of a gun are two small notches marked

on the upper part of the base ring (or on the top of the tangent scale) and swell of the muzzle. Their situation is ascertained by means of a spirit level.

The line of metal is an imaginary line drawn along the surface of the metal between the two sights.

The line of metal Elevation is obtained by laying a Gun at an object by means of the sights, without giving any elevation; from the thickness of metal at the breech, the line of metal elevation varies from one to two degrees.

The Centre of metal is indicated by a line drawn through the uppermost point of the base ring and swell of the muzzle; and is ascertained by means of a spirit level.

Windage is the difference between the diameter of the bore, and that of the shot. The windage formerly allowed was one-twentieth the diameter of the shot, but it is now reduced considerably: (Field Guns having only one-tenth of an inch) and this diminution of windage is very beneficial, longer ranges being obtained with the same charges of powder, and also greater precision of fire.

The Vent, for every nature of Ordnance, is two-ninths of an inch in diameter.

Bouching a gun is fixing a pure copper vent into it; which is done by drilling a hole in the piece, where the vent is usually placed, about one inch in diameter, and screwing therein a piece of wrought copper with a vent of two-ninths of an inch through the centre of it.

Tertiating a gun is examining the thickness of metal, whether the bore is perfectly straight, the trunnions properly placed, &c. It is performed by

means of calliper compasses, and other instruments.

Quadrating a gun is ascertaining if it is properly placed on its carriage, and if the wheels are of an equal height.

A Gun is honeycombed when the surface of the bore has cavities, or holes in it.

The Length of a gun is ascertained by measuring it from the rear of the base ring to the face of the muzzle.

The Calibre of a gun is the diameter of the bore.

To find the length of a gun, in feet and inches, its length in Calibres being known—

Divide the product of the number of Calibres and the diameter of the bore, in inches, by 12, and the quotient will be the length in feet and inches.

To find the Number of calibres in the Length of a gun.

Divide the length of the gun in inches by the number of inches in the calibre.

Gun metal is a compound of 8 lb. or 10 lb. of tin, to 100 lb. of copper. The property of tin being to harden, the largest proportion (10 lb.) is used for mortars, they requiring a greater degree of hardness than guns.

Ordnance cast of gun metal are generally designated *Brass Ordnance*.

Brass guns are used for field batteries, they having been considered preferable to iron for the service, being lighter than iron guns could be cast of the same calibre, without risking their bursting.

Brass guns are, however, soon rendered unserviceable by repeated and quick firing.

Iron guns are better adapted for batteries in the attack or defence of towns or fortresses, and also for service on board ship; being less expensive than brass, and better able to sustain long-continued and rapid firing. At the siege of Badajoz the firing continued for 104 hours, and the number of rounds fired from each 24-pounder averaged 1249; at the siege of St. Sebastian, each piece fired about 350 rounds in 15½ hours. None of these guns were rendered unserviceable; but three times the number of brass guns would have been required to produce the same effect, or maintain such long and rapid firing.

Service Charges of powder.

For heavy guns	⅓ the weight of the shot.
For light do.	¼ do. do.

The Point blank range of Iron 32, 24, 18, and 12-pounders with solid shot varies from 380 to 260 yards; from which to 1200 yards, every ¼ degree increases the range about 100 yards; and from 1200 to 1500 yards, every ¼ degree increases the range about 50 yards.

The Point blank range of Brass, Medium 12, 9, and Heavy 6-pounders, with solid shot, is 300 yards, and from which to 700 yards, every ¼ degree elevation increases the range 100 yards; from 700 to 1000, every ¼ degree increases it 75 yards, and from 1000 to 1200, every ¼ degree increases it 50 yards.

The Point blank range of Brass, Light 12, 6, and 3-pounders is 200 yards, from which to 600 yards,

each ¼ degree increases the range 100 yards, and from 600 to 1000, each ¼ degree increases it 50 yards.

Note.—For Weights, Dimensions, Ranges, Charges, &c., vide Tables.

HOWITZERS.

Howitzers are a short description of Ordnance, either Brass or Iron, and are used for projecting Shells. Their principal advantages are that they can be more easily loaded, and are considerably lighter, in proportion to their calibre, than Guns; and they also may be used as Mortars. They have no dispart, the diameter of the base ring and swell of the muzzle being equal, except in the 24 and 12-pounders; which, however, are provided with a patch to make up the difference.

Millar's howitzers differ from the old pattern in the increased length, being from six to ten calibres; and in the conical form given to their Chambers (called *Gomer*) which are the frustrum of a cone, terminating in an hemisphere.

Note.—Vide Tables for Weights, Dimensions, Ranges, Charges, &c.

CARRONADES.

A Carronade is a short piece of Iron Ordnance, with a loop under the reinforce instead of trunnions. Its construction is materially different to that of guns; having a chamber; a part scooped out inside the muzzle forming a cup; also a patch on the reinforce. They take their name from the Carron Foundry (where they were first cast for the Navy in 1779), are

considerably lighter than Guns of similar calibres, and are fired with charges of about one-twelfth the weight of the shot.

Carronades are chiefly used on board ship, but occasionally in casemates, and retired flanks of fortresses.

The highest charge is	one-eighth the weight of the shot.
The lowest charge	one-sixteenth do. do.

Note.—For Weights, Dimensions, Ranges, &c., vide Tables.

MORTARS.

Mortars differ from Guns in the construction of their bore, and also in their form, which is considerably shorter, the metal being much thicker, and the trunnions being at the extremity of the breech.

They are used for throwing Shells into a town, or battery, setting fire to and overthrowing works, blowing up magazines, and breaking through the roofs of barracks, casemates, magazines, &c. They are distinguished from each other by the diameter of their bore. Their chambers are in the form of a frustrum of a cone, in which the powder is more concentrated; the Shell fits close to the sides of the piece, and thereby receives the whole force of the expansion of the powder. The greatest charges their chambers will contain, and the corresponding Ranges, are as follows:—

	13-inch.	10-inch.	18-inch.

	Land Service.	Land Service.	Land Service.
Greatest charge	9 pounds.	4 pounds.	2 pounds.
Greatest range	2706 yards.	2536 yards.	1726 yards.

When Mortars are used in firing on Inclined planes, up or down hill, should the inclination be considerable, take half the angle it makes with the horizon, and add it to, or subtract it from 45 degrees (which is for a medium plane), and it will give *the greatest range upon the required plane*.

Note.—Vide Tables of Dimensions, Weight, Charges, Ranges, &c.

VALUE OF ORDNANCE.

BRASS ORDNANCE.

Dependent on the market price of metals; at £100 per ton, after their combination, the value of gun metal is from 4 pence to 4½ pence per lb.

IRON ORDNANCE.

The value is variable according to the market price. Average from £14 to £16 per ton, according to the nature of the ordnance, the higher price being the value of the smaller pieces.

PROOF OF ORDNANCE.

All natures of Ordnance undergo several kinds of proof before they are received into the service:—

1st. They are gauged as to their several

dimensions, internal and external; as to the justness and position of the bore, the chamber, vent, and trunnions, &c.

2nd. They are fired with a regulated charge of powder and shot, being afterwards searched to discover irregularities, or holes produced by the firing.

3rd. By means of engines, an endeavour is made to force water through them.

4th. They are examined internally by means of light, reflected from a mirror.

IRON GUNS.

The guns are first examined as to their proper dimensions, in which no more than ·3 of an inch variation is allowed; and in the diameters of the bore only ·033 from 42 to 18 pounders, and ·025 from 12 to 6 pounders; but in the position of the bore ·5 of an inch out of the axis of a piece from a 42 to an 18 pounder, and ·334 of an inch from a 12 to a 6 pounder is allowed.

They are then fired twice with the charge in the following table, with one shot and two high junk wads, and examined with a searcher after each round.

In this examination they must not have any hole or cavity in the bore of two-tenths of an inch in depth behind the first reinforce ring, or one-fourth of an inch in depth before this ring.

PROOF CHARGES.

Nature	42 Pr.	32 Pr.	24 Pr.	18 Pr.	12 Pr.	9 Pr.	6 Pr.	3 Pr.

Charge, in pounds	25	21½	18	15	12	9	6	3

BRASS GUNS.

From 3 to 12 pounders the diameter of the bore must not vary more than ·025 of an inch, nor in any dimensions more than ·2.

PROOF CHARGES.

Nature	12 Pr. medium.	12 Pr. light.	9 Pr.	6 Pr.	3 Pr.
Charge	4 lb.	4 lb.	3 lb.	2 lb.	1 lb.

The 12 pounders are fired twice, the remainder three times. Any hole ·15 of an inch upwards, or sideways in the bore, or ·1 in the bottom, between the breech and first reinforce; or ·2 of an inch upwards, or sideways, or ·15 in the bottom of the bore before the first reinforce ring, will be sufficient to condemn them.

MORTARS, AND HOWITZERS.

The exterior dimensions are in no respect to deviate more than ·1 of an inch in the 10, and 8 inch Howitzers, and ·05 of an inch in the 24, and 12 pounder Howitzers, and Royal and Coehorn Mortars, and Howitzers. Their bores and chambers must not deviate from their true diameters, or positions more than ·025 of an inch.

PROOF CHARGES.

The Brass Mortars, and Howitzers are fired twice with their chambers full of powder, and an iron

shell. The Mortars on their own beds at an elevation of about 75 degrees, and the Howitzers on their carriages at an elevation of about 12 degrees. The Iron Mortars are proved with a charge equal to the full chamber, and a solid shot equal in diameter to the shell. Royal or Coehorn Mortars, and also 24, and 12 pounders, or Royal Howitzers, having a hole of ·1 of an inch in depth in the chamber, or ·15 of an inch in the chase are rejected. A hole ·15 of an inch in depth in the chamber, or ·2 of an inch in the chase is sufficient to condemn the 10 and 8 inch Howitzers.

CARRONADES.

The bores, and chambers of Carronades must not deviate more than ·05 of an inch from their true dimensions, and positions.

PROOF CHARGES.

They are proved with two rounds, with their chambers full of powder, and one shot and wad. A hole of ·2 of an inch in depth in the bore, or ·1 in the chamber condemns the piece.

WATER PROOF.

All Ordnance, after having undergone the before-mentioned proofs, and the subsequent searchings, are subject to the *Water proof*. This is done by means of a forcing pump, having a pipe or hose fitted and secured to the mouth of the piece, and a plug to stop up the vent.

After two or three efforts to force the water through any honeycombs or flaws, which there may be in the bore, they are left to dry, and generally the next day examined by light reflected from a mirror. If the bore should contain any small holes or flaws, which have not been discovered by the former

proofs, they are very readily found by this, as the water will continue to weep or run from the holes, after the solid parts of the bore are perfectly dry.

When a gun bursts in proving, the remainder in proof at the same time are subjected to another proof round.

Ordnance condemned, for any of the foregoing reasons as unserviceable, is marked as follows:—

D × for faulty in dimensions.

S × by Searcher. W × by Water proof.

Condemned Shells are thus marked:—

F — for Fuze hole faulty.

N × for Non-concentric. W × for Water proof.

INSTRUCTIONS FOR THE CARE AND PRESERVATION OF IRON ORDNANCE.

Great attention should be paid to the care and preservation of iron Ordnance when in Depôt or on Service, to prevent the irreparable injury Guns sustain from rust and corrosion.

With this view the first step to be taken is to clear their bores and exterior surfaces from all rust and dirt, which is done on the inside with circular Spring Scrapers, fixed on the end of a long shaft or handle, these scrapers are made to press strongly on the sides of the cylinder, and by being drawn backwards and

forwards by two or three efficient labourers, will remove the rust, and if not in a very bad state, will restore a regular smooth surface; the bottom or end of the bore is also scraped with a tool for that purpose, and the vent is opened by passing a square steel rimer of its diameter through it, gently turning the tool round until the vent is clear; after which the bore must be well brushed out, first with a hard round brush, and then with a Turk's-head brush, so that not the least dirt remains in it. This being performed, the first coat of lacquer may be laid on, to which when dry, a second is to be added. This is done with a common painter's brush, fixed vertically on the end of a staff sufficiently long to reach down the cylinder; and the bottom of the bore is lacquered by another brush fixed horizontally at the end of the staff; the outside or exterior parts of the pieces are also to be well scraped with an old sea-service sword, or steel tool of that nature, tolerably sharp, especially about the mouldings, where former coatings and dirt have accumulated, and when the rust will not give way, it should be slightly hammered, so as to loosen it. These operations must be continued until the whole coat of old paint, rust, or dirt, is completely removed, after which the dust must be well brushed or rubbed off, and the piece will then be fit to receive its first coat of anticorrosion, to which, when dry, a second is to be added.

Before the work is commenced the pieces should be arranged as nearly as possible in the places where they are to remain, as too much rolling is apt to disturb the coating of paint, especially before it has gained sufficient hardness to be durable.

The following objects also require to be

particularly attended to—viz.:

In skidding Guns, &c., care must be taken that they are laid under metal, so that their muzzles may be sufficiently inclined downwards to prevent rain or any moisture lodging, and the bores from time to time should be swept out, as dust or sand blowing into them and being suffered to remain, would be very destructive; nor should the Guns be ever stacked one over the other, if the space where they are kept is sufficiently large to admit of their being laid in single tiers.

After the Ordnance is once got into a complete state of preservation, by following these instructions, very little trouble or expense will attend their being kept so, for a slight coat of anticorrosion on the exterior, and a thin coat of lacquer in the cylinder every three or four years, is all they will require, provided they are every now and then brushed out as before stated.

On coating the Guns, it may be found useful to let the painter mark on them the date, which will show how long it lasts, as this may differ at different stations, especially such as are exposed to much damp air, and it will afford the means of calculating the necessary demands of articles for this purpose at stated periods.

The same rules are to be observed in the preservation of all iron Ordnance mounted on works, with regard to the application of lacquer and anticorrosion, and the precautions of keeping the pieces laid under metal, and frequently brushing out their bores, &c., as recommended in the foregoing instructions.

MIXTURE OF INGREDIENTS FOR COATING AND

LACQUERING IRON ORDNANCE.

	lb.		
Anticorrosion	40	Linseed oil, gallons	4
Black (Grant's) ground in oil	4	Turpentine (spirits of) pint	1
Red lead, as a drier	3		

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 is required for present use.

BLACK LEAD LACQUER, FOR THE BORE OR CYLINDER.

	lb.		lb.	oz.
Black lead (Cumberland)	9	Red lead	2	8
Linseed oil, gallons	4	Lamp black, or wad	0	4

The oil to be boiled, and the paint to be well ground. This will keep. Great care should be taken in boiling the oil, as any damp falling in would cause an explosion.

INSTRUCTIONS FOR LACQUERING SHOT, AND SHELLS.

All Shot and Shells (including Shrapnell) are first to be cleaned exteriorly by the machine or otherwise, and then such as are found sufficiently correct and up to their proper gauge are to be twice lacquered with the following composition, leaving sufficient time between for the coats to become perfectly dry and hard. The warmest weather is the proper time for this operation. Ten labourers can examine, clean, and lacquer with two coats one thousand shot in a

day, provided the weather be favourable.

COMPOSITION.

Grant's black 40 lb. Red lead 5 lb. Raw linseed oil 5 gallons.

The red lead is to be ground into a part of the oil, in order that the whole of the ingredients may be thoroughly incorporated.

TO RENDER ORDNANCE UNSERVICEABLE BY SPIKING, ETC.

The most effectual method of rendering Guns unserviceable, or of no further use, is by removing one or both of the trunnions, which may be done by striking it near its end with a sledge hammer; or by firing a shot against it from a carronade, or howitzer, the muzzle of the piece being placed near the trunnion.

Brass Ordnance may also be rendered unserviceable by firing whole or broken shot into the bore from another piece; or by filing a shot against the chase, which generally bulges the metal within the bore.[6]

For spiking Ordnance, two kinds of spikes are used: —

1st. *The Common spike*, which is 4 inches long, ·27 inches in diameter at the head, and about ·1 at the point. It is driven as far as it will go into the vent, and afterwards broken off close to the gun.

2nd. *The Spring or temporary spike*, which is ·17 in diameter, and varies in length from 3·25 to 5·25 inches. It has a flat head to prevent its falling through the vent into the bore, and also a spring about two inches in length, which extends from the point towards the head. In passing through the vent,

this is compressed, but as soon as it is clear of the metal, it expands and cannot be withdrawn, unless it is again compressed sufficiently to allow its being again drawn into the vent, which may be done by pressing a rammer head against it, provided the spring is towards the muzzle, which may be known by a small notch cut in the head of the spike to point out its direction.

A long spike with a soft point may be driven into the vent, and the end projecting into the bore clenched; which, as well as either a common nail or even a wooden peg would answer as a temporary expedient if a proper spike were not at hand. Should a momentary abandonment of the guns become unavoidable, by taking away the cap-squares, elevating screws, quoins, linch-pins, or side-arms, the Enemy will be prevented using them for some time.

An artilleryman should, however, *never forget* that the *guns are his Standard*, which it should be his pride and glory to defend to *the last moment*, never deserting them without positive orders to do so, or until the last glimmering hope of saving them is destroyed. But should the necessity of abandoning the guns appear imperative, then let the Artillerist remember that a *parting shot* (especially canister) at the advancing columns of the enemy, may insure not only his own safety, but also that of a large portion of the army.

UNSPIKING ORDNANCE.

If a gun has been spiked with a Common steel spike, load with a charge of powder equal to half the shot's weight: lay a leader of quick match along the bore, and double shot the gun, introducing the shot, however, very carefully.

By affixing a piece of slow match to the end of the quick match which reaches to the muzzle, the gun may be easily and safely fired. Should the spike not be removed, the operation may be repeated.

When Brass guns have been spiked, it would be advisable, a day or two before making the above experiment, to scratch round the spike with a graver, and pour a few drops of Sulphuric, or Nitric acid into the circle, which, being repeated, will find its way down between the spike and the metal, particularly if the former is not perfectly round. When the gun cannot be unspiked by the above-mentioned operations, make a large fire round the breech to soften the spike, and after the gun has been gradually cooled, the spike may generally be removed by using the drill.

When a gun cannot be unspiked, the only means of rendering it serviceable is to drill another vent, about half an inch from the original one.

To drill a new Vent will require about an hour per inch. Care must be taken that a very small drill is first used, and afterwards one rather less than the diameter of the vent, otherwise the vent will run the risk of being too much enlarged.

Length, Weight, Calibre, Charge, &c., of Ordnance

Nature of piece.	Length. In feet and inches.	Length. In Calibres.	Weight.	Calibre.	Charges, Land Service. Service.	Charges, Land Service. Proof.
	ft. in.		cwt.	inches.	lb. oz.	lb. oz.
10-Inch	9 4	11·	85	10·	12 †	20
8	9	13·3	65	8·05	10 †	20
	8 10	13·05	60	8·05	10 †	20
	8	11·82	52	8·05	8 †	16
	6 8	9·93	50	8·05	8 †	14
68 Pr.	10 10	16·15	112	8·12	18	30
	10	14·78	95	8·12	14	28
	9 6	14·	87	8·12	14	25
56 Pr.	11	17·6	98	7·65	14	28
	10	16·	87	7·65	14	25
42 Pr.	10	17·21	84	6·97	14	25
	10	17·21	75	6·97	14	25
	9 6	16·43	67	6·93	10	23
32 Pr.	9 7	17·95	64	6·41	10	21 5
	9 6	17·78	56	6·41	10	21 5
	9	16·35	46	6·35	6	12
	8 6	16·	45	6·35	7	16
	8	14·9	48	6·41	8	21 8
	8	15·1	42	6·35	6	14
*	7 6	14·1	40	6·35	6	12
*	6 6	12·38	32	6·3	5	10
*	6	11·4	25	6·3	4	9

	24 Pr.	9	6	19·57	50	5·82	8	18
		9		18·54	48	5·82	8	18
		6	6	13·39	33	5·82	6	12
	18 Pr.	9		18·52	42	5·29	6	15
		8		18·14	38	5·29	6	15
	*	7		16·24	22	5·17	3	7
	*	6		13·92	20	5·17	3	7
	*	5	6	12·76	15	5·17	2	5
	12 Pr.	9		23·14	34	4·62	4	12
		8	6	22·	33	4·62	4	12
		7	6	19·46	29	4·62	4	12
		6		15·57	21	4·62	4	10
	9 Pr.	8	6	24·28	28	4·2	3	9
		7	6	21·4	26	4·2	3	9
		7		20·	25	4·2	3	9
		5	6	15·71	17	4·2	2	8
	6 Pr.	7	6	24·53	21	3·66	2	6
		6		19·6	17	3·66	2	6

* Bored-up guns. † Hollow shot.

Length, Weight, Calibre, Charge, &c., of Ordnanc

Nature of piece.	Length. In feet and inches.		Length. In Calibres.	Weight.	Calibre.	Charges. Service.		Charges. Proof.	
	ft.	in.		cwt.	inches.	lb.	oz.	lb.	oz.
CARRONADES.									
68 Pr.	5	4	7·9	36	8·05	5		13	
42	4	6	7·8	22	6·84	3	8	9	
32	4		7·6	17	6·25	2	10	8	
24	3	9	7·9	13	5·68	2		6	
18	3	4	7·7	10	5·16	1	8	4	
12	2	8	7·	6	4·52	1		3	
IRON HOWITZERS.									
10-inch	5		6·	40	10·	7		7	
8	4		6·	20	8·	4		4	
IRON MORTARS.									
13-inch	4	5	4·	100	13·			20	11
13	3	5	2·8	36	13·			9	
10	3	9	4·5	52	10·			9	8
10	3	9	4·5	41	10·			9	8
10	2	4	2·8	16	10·			4	
8	1	10	2·7	8	8·			2	
BRASS GUNS.									
12 Pr.†	6	6	17·	18	4·62	4		5	
9 Pr.	6		17·	13½	4·2	2	8	3	8
6 ‡	5		16·3	6	3·66	1	8	2	
3 †	4		16·4	3	2·91		12	1	

3 †	3		12·3	2¼	2·91		10	1	
1	5		29·8	2½	2·01		6		12
BRASS HOWITZERS.									
32 Pr.	5	3	10·5	18	6·3	3	0	3	0
24	4	8·6	9·8	13	5·72	2	8	2	8
12¼	3	9·2	9·8	6½	4·58	1	4	1	4
4⅘	1	10	4·8	2½	4·52		8		8
BRASS MORTARS.									
10-inch	2	3	2·7	12¼	10·			4	
8	1	9	2·6	6½	8·			2	
5½	1	3	2·6	1¼	5·62				7
4⅘	1	0	2·6	¾	4·52				5

* Shot for guns: Shells for howitzers and mortars. † Medium. ‡

CARRIAGES.

Garrison carriages are made of oak and other hard wood. *Trucks* iron; but in those situations which are not exposed to enfilade, the carriages are cast iron.

Ship carriages.—The Brackets and Transoms are elm, *Axletrees* oak, *Trucks* elm.

Field gun carriages.—All Travelling carriages are now made entirely of oak. *The Carriages*, for the heavy iron 12 and 9-pounders with bracket-trail, and also for all heavy battering ordnance, are made of oak. *Limbers* have the axletree beds of oak; *Futchells*, *Splinter*, or *Sweeping-bar*, of ash; *Foot-boards*, fir or elm. *Limber boxes* have the sides elm, and the rest fir. *Ring-tires* are used for light 3-pounders and hand-cart wheels. *Shafts* are always made of ash. *Wheels* have the *Nave* of elm, *Spokes* (12) of oak, *Felloes* (6) of ash.

Sleighs are used for the conveyance of artillery, during the winter, in Canada.[7] The sleigh consists of a platform six feet ten inches long, and three feet ten inches wide, placed on runners sixteen inches high; upon this rest two strong transoms, to which the brackets supporting the gun are secured. A box, distinct from the ammunition boxes, is placed on each side of the gun, together capable of containing about thirty rounds of ammunition, and which serve as seats for Nos. 1 and 6. These boxes usually contain the shot, and small stores carried in the axletree boxes, as well as long reins for driving, when in single draught. The extreme breadth of the runners is three feet.

Packing the Intrenching tools, &c.

Marching order.—In marching order, the following stores and intrenching tools are *on the gun sleighs*; two fitting ropes, one spare swingletree; swords of Nos. 1 and 6 on front platform under breast of gun, claw hammer, wrench, and pincers; in sockets, two portfire sticks on right rear of platform.

On No. 1 ammunition sleigh; two fitting ropes, prolonge, two spare swingletrees, and sword of No. 3, on front part of platform; carbines of No. 1 and 6, on front box; spare sponge, and worm on platform right of boxes; spare handspike on left side; 4 spare traces between front and rear boxes; swords of Nos. 4 and 5 on platform in rear of boxes, covered by knapsacks of Nos. 1, 6, 5, and 4. The knapsacks are strapped from off-handle of off-box to rear handle of rear box.

On No. 2 sleigh; felling axe, and two camp kettles, on front of platform; sword of No. 2 on front box; pickaxe in rear of front box; four spades strapped to front of rear boxes; four water buckets strapped to guard irons of front box, two at each side; swords of Nos. 7 and 8 in rear of boxes, covered by knapsacks of Nos. 2, 3, 7, and 8.

DEPRESSION CARRIAGES.

Of these there are two descriptions—

1st. Those in the batteries at Gibraltar.
2nd. Those constructed for general service.

These latter carriages are similar to common standing carriages, excepting that they are about a foot longer, and the front transom is hollowed so as to allow of a greater depression, and has a bolt behind it for the end of the stool bed. There is also a skid, or transom, placed across the last step of the

carriage, which has a thread in it for the elevating screw that supports one end of the stool bed. These carriages admit of a depression of 30°, but after every round the piece must be brought horizontal to load, which is done by taking out altogether the rear transom. *Depression Carronade carriages* differ from the common carriages in having their trucks in rear instead of in front. They are depressed by an iron segment of a circle, which is moveable in a slit in the trail, and which has holes in it about an inch apart, through which a bolt is to be placed to support it at any height, the intermediate depression being given by a screw.

Weight of Field Carriages, Limbers, &c.

Spare wheels are not included in the following Table of weights.

Nature of Carriage.		No. of Rounds.	Weight. cwt. qrs. lb.	Total. cwt. qrs. lb.
18 Pr. Iron	Gun		38 2	66 2 18
	Carriage		18 1 26	
	Limber		7 1 10	
	Side-arms		24	
	Stores		2 14	
18 Pr. Waggon	Limber		8 2 10	37 2
	Ammunition	24	5 6	
	Stores		1 12	
	Body		10 3 24	
	Ammunition	36	7 2 17	
	Stores		3 2 17	
Brass 12 Pr. Medium	Gun		18	44 17
	Carriage		12 2 8	
	Limber	24	8 3 6	
	Ammunition		3 2 22	
	Side-arms		1 14	
	Stores		2 23	
12 Pr. Medium Ammunition Waggon	Limber		9 2 2	36 1 9
	Ammunition	32	4 3 2	
	Stores		2 27	
	Body		10 3 24	
	Ammunition	48	6 3 24	
	Stores, Tent, &c.		3 2 8	

12 Pr. Medium	{ Carriage		13	1	21	}			
Spare wheel	{ Limber		8	2	11	}	30	1	15
Carriage	{ Stores		8	1	11	}			
9 Pounder	{ Gun		13	2		}			
	{ Carriage		12	1	8	}			
	{ Limber		8		17	}	38	2	9
	{ Ammunition	32	3	2	25	}			
	{ Side-arms			1	10	}			
	{ Stores			2	23	}			
	{ Limber		8	1	24	}			
9 Pounder	{ Ammunition	32	3	2	25	}			
Ammunition	{ Stores			2	27	}	34	1	17
Waggon	{ Body		10	3	24	}			
	{ Ammunition	64	6	3	22	}			
	{ Stores, &c.		3	2	5	}			
9 Pounder	{ Carriage		12	2		}			
Spare wheel	{ Limber		7	3	11	}	29	2	15
Carriage	{ Stores		9	1	4	}			

Nature of Carriage.		No. of Rounds.	Weight. cwt. qrs. lb.	Total. cwt. qrs. lb.
6 Pr. Heavy	{ Gun		12 1	}
	{ Carriage		11 26	}
	{ Limber		8 24	} 36 2 11
	{ Ammunition	50	3 3 18	}
	{ Side-arms		1 4	}
	{ Stores		2 23	}
6 Pr. Heavy Ammunition Waggon	{ Limber		8 24	}
	{ Ammunition	50	3 3 18	}
	{ Stores		2 27	} 33 19
	{ Body		8 3 21	}
	{ Ammunition	100	7 3 8	}
	{ Stores		3 2 5	}
6 Pr. Heavy Spare wheel Carriage	{ Carriage		11 2 14	}
	{ Limber		7 3 11	} 28 2 20
	{ Stores		9 23	}
6 Pr. Light	{ Gun		6	}
	{ Carriage		9 1 15	}
	{ Shot, Axletree	6	1 27	}
	{ Side-arms		1 2	} 28 23
	{ Limber		8 1 18	}
	{ Ammunition	40	2 3 22	}
	{ Stores		2 23	}
6 Pr. Light	{ Limber		8 1 18	}
	{ Ammunition	48	3 2	}

Ammunition	{ Stores			2	27	}	33	3	8
Waggon	{ Body		10	3	3	}			
	{ Ammunition	100	6	3	11	}			
	{ Stores		3	2	5	}			
6 Pr. Light	{ Carriage		9	2	11	}			
Spare wheel	{ Limber		7	3	11	}	26	2	26
Carriage	{ Spare Stores		9	1	4	}			
	{ Gun		6			}			
	{ Carriage		8	1	24	}			
	{ Shot, Axletree	8		1	10	}			
3 Pr. Heavy	{ Side-arms				24	}	26	2	15
	{ Limber		8		6	}			
	{ Ammunition	70	2	3	14	}			
	{ Stores			2	21	}			
	{ Limber		8		6	}			
3 Pr. Heavy	{ Ammunition	70	2	3	14	}			
Ammunition	{ Stores			2	27	}	30	1	25
Waggon	{ Body		8	3	18	}			
	{ Ammunition	168	6	1	14	}			
	{ Stores		3	2	2	}			

Nature of Carriage.		No. of Rounds.	Weight. cwt. qrs. lb.			Total. cwt. qrs. lb.		
3 Pr. Heavy Spare wheel Carriage	{ Carriage { Limber { Stores		9 7 7	3 3	15 11 3	24	3	1
3 Pounder Light	{ Gun { Carriage { Shot, Axletree { Limber { Ammunition { Side-arms & Stores	34	3 4 3 1 	1 3 2	 8 16 4 8 3	12	3	11
3 Pounder Light	{ Car Stores, &c.	60	6	1	24	6	1	24
5½ in. Howitzer Heavy	{ Howitzer { Carriage { Limber { Side-arms & Stores	24	10 13 8 5	 3 1 1	 15 3 11	37	2	1
5½ in. Howitzer Heavy, Ammunition Waggon	{ Limber { Body, &c. } { Ammunition }	60	8 24 yy	1 1 yy	3 18 yy	32	2	21
5½ in. Howitzer Light	{ Howitzer { Carriage { Limber		4 10 8	3 1 1	 23 16	26	3	21

	{ Ammunition	22	3	1	10	}		
5½ in. Howitzer	{ Limber		8		16	}		
Light, Ammunition	{ Body, &c.		10	3	3	}	28 1	9
Waggon	{ Ammunition	62	9	1	18	}		
	{ Howitzer		2	2		}		
4⅖ in. Howitzer	{ Carriage		5	1	2	}	13	11
	{ Limber		3	1	16	}		
	{ Ammunition, &c.	16	1	3	21	}		
Limber 4⅖ in.	{ Carriage		3	3	20	}	7	26
Howitzer	{ Ammunition, &c.	32	3	1	6			
32 Pounder Brass	{ Carriage		13	3	2	}	23 3	13
	{ Limber		10		11			
	{Howitzer		12	2		}		
24 Pounder Brass	{Carriage		12	2	13	}		
Howitzer	{Side-arms				25	}	39 1	11
Gen. Millar's	{Limber		8	2	4	}		
	{Ammunition	24	4	3	2	}		
	{Stores			2	23	}		
	{Limber		8	2	4	}		
24 Pounder Brass	{Ammunition	24	4	3	2	}		
Howitzer	{Stores			2	27	}	35 1	20
Ammunition	{Body		10	3	4	}		

Waggon	{Ammunition	36	6	3	24	}
	{Stores		3	2	15	}

Nature of Carriage.		No. of Rounds.	Weight. cwt. qrs. lb.	Total. cwt. qrs. lb.
12 Pr. Brass Howitzer Gen. Millar's	{ Howitzer		6 2	}
	{ Carriage		9 3 14	}
	{ Side-arms		23	} 29 17
	{ Limber		8 21	}
	{ Ammunition	36	3 2 20	}
	{ Stores		2 23	}
12 Pr. Brass Howitzer Ammunition Waggon.	{ Limber		8 1 3	}
	{ Ammunition	36	3 2 20	}
	{ Stores		2 27	} 31 2 13
	{ Body		8 3 22	}
	{ Ammunition	64	6 1 12	}
	{ Stores		3 2 13	}
3 Pr. Colonial service Gun 4 feet	{ Gun		3	}
	{ Carriage		4 3	} 12 15
	{ Limber, Stores, &c.	34	5 12	}
	{{ Car		3 3 14	}} 6 1 24
	{{ Stores, &c.	60	2 2 10	
1 Pr. Mountain service Gun drawn by two mules	{ Gun		2 2	}
	{ Carriage		2 3 2	} 8 1 22
	{ Four small boxes		2 20	}
	{ Stores, &c.	72	2 2	}

Carried on the backs of 2 mules	{ Two large boxes	112	2	4	} 2	2	1		
	{ Ammunition, &c.		1	3 25					
Forge Waggon with lockers, &c.	{ Limber		8	9	} 24			11	
	{ Body		9	2 25	}				
	{ Bellows			2 15	}				
	{ Anvil		1	2 18	}				
	{ Smith's tools, &c.		4		}				
Forge cart, Cavalry, complete; including frame, &c.zz			11	2 16	} 11	2	16		
Flanders waggon Ammunition			15	2	} 15	2			
Store Limber	{ Limber		8	9	} 18	3	16		
Carriage	{ Body, &c.		10	3 7					
Ball cartridge	{ Limber		7	2 4	}				
	{ Body lb.oz.		7	26	}				
Waggon	{ 20 Boxes at 12 4		2	21	} 34	2	7		
Gen. Millar's	{ 20,000 Rounds		16	2 27	}				
	{ 2,000 Flints & Boxes			3 13	}				
Sling Cart			16	1 17	} 16	1	17		
Large Gyn	{ Gyn		9	2 22	} 12	2	19		
	{ Blocks and Tackles		2	3 25					
Common Gyn	{ Gyn		7	3 3	} 10	2	4		

{ Blocks and Tackles		2	3	1	
Traversing Platform (Iron)		51		} 72	2
Platform Carriage (24 Pounder) Iron		21	2	18	18

Nature of Carriage.	No. of Rounds.	Weight. cwt. qrs. lb.	Total. cwt. qrs. lb.
Devil Carriage { Large carriage		28 2 7	} 36 15
{ Small Ditto complete		7 2 8	
Sling Waggon { Carriage		18 0 26	} 27 1 27
{ Limber		9 1 1	
Large Pontoon { Carriage		13 3 20	}
{ Two pontoons Carriage		9 1 9	} 45 20
{ Appurtenances Blanshard's		21 3 19	}
Small Pontoon { Carriage		9	}
{ Five pontoons Carriage		5	} 21 1 23
{ Appurtenances Blanshard's		7 1 23	}
Small boat for { Carriage		7 5	} 10 2
{ Wooden boat Pontoon bridge		3 2	5
Baggage cart		9 0 7	
Hand cart		4 3 4	
French cart		5 2 13	
Ball Cartridge cart		7 3 4	

Class.	WHEELS. Guns, Howitzers, &c.	Diameter.	Weight.

		feet.	inches.	cwt.	qrs.	lb.
				per pair.		
1	*or Heavy* 6-Pounder *Wheel*, used by 12-Pr. Gun and Limber, by 9-Pr. and heavy 6-Pr. Gun carriage, and by heavy 5½ inch, and 24-Pr. Howitzer Carriage	5		4	2	4
2	*or Light* 6-Pr. *Wheel*, used by Limbers of the above, and by light 6-Pr. heavy 3-Pr., light 5½ inch and 12-Pr. Howitzer carriage and Limber, and by Body and Limber of ammunition Waggon	5		3	3	18
3	used by Light 3-Pr.	4	4	2	1	
4	used by mountain Guns, &c.	3			3	22
24 Pr.	Gun and 10-inch Howitzer	5		8	1	12
18	Ditto 8-inch ditto	5		7		
Limber to the above		3	10	3	2	10
Platform Waggon, hind		5		5	1	26
Ditto ditto fore		4		4	2	
Devil Carriage, hind		7		12	1	18
Ditto ditto fore		5		5	1	26
Sling cart, Gun or Mortar		5	6	8	3	10
Flanders Waggon, hind		5		3	3	18

Ditto ditto	fore	4	2	2	3	20
Hand cart		4	4	2		1

Weight of Carriages for Iron guns, Heavy howitzers, &c., also Weight of Traversing platforms.

Nature of Ordnance.	Travelling.		Garrison, with trucks, &c., complete.		Traversing Platforms.	
	Gun Carriage.	Limber.	Wood.	Iron.	Wood.	Iron.
Guns.	cwt. qrs. lb.	cwt. qrs. lb.	cwt. qrs. lb.	cwt. qrs. lb.	cwt.	cwt.
42 Pr.			16 3 13	26 1	23	51
32			15 1 2	23 2	23	
24	23 3 25	7 1 27	13 2 23	21 2	19	
18	18 1 26	7 1 27	12 3 1	18 3 19	19	
12	12 22	6 11	11 2 7	17 16	19	
9	11 2 6	6 11	10 1 13	15 1 7		
6			9 20	14 19		
3			6 1 24			

Millar's Howitzers.						
10 in.	31 2 9	7 1 27	16	25 1 5		
8	24 1 13	7 1 27	14	18 1 18		
5½	11 2 23	6 10		15 1 24		
Carronades.			Block Trail.			
68 Pr.			17 2 25			
42			10 1 21			
32			8 3 24	11 3		
24			7 3 21	10 3 20		
18			6 3 20	9 2 10		
12			6 1	8 1 12		

Nature of Ordnance.	Weight	Carriages, Garrison, Wood, Sliding.	Dwarf traversing Platforms.		Carriages, Garrison, Common Wood.	Traversing Platforms, common.
			Wood.	Iron.		

Guns.	cwt.	cwt. qrs. lb.	cwt. qrs. lb.	cwt. qrs. lb.	cwt. qrs. lb.	cwt. qrs. lb.
68 Pr.	112	16 0 26				
56 Pr.	98	18 2 22	31 1 26			
8 in.	65	13 1 0	26 0 21	52 0 5	13 3 11	25 1 2
32 Pr.	56	12 1 23	26 0 21	52 0 5	13 3 0	25 1 2

Weight and Dimensions of Trucks, for Land Service.

Nature of Trucks.	Fore.				Hind.			
	Diameter.		Width of sole.	Weight of a pair.	Diameter.		Width of sole.	
	Truck.	Hole.			Truck.	Hole.		
	ft. in.	in.	in.	cwt. qrs. lb.	ft. in.	in.	in.	ll
42 Pr.	17	7·5	6·62	3 0 20	14	7·5	5·	
32	17	7·5	6·62	3 0 20	14	7·5	5·5	
24	17	6·5	5·	2 1 26	14	6·5	4·5	
18	17	6·5	5·	2 1 26	14	6·5	4·5	
12	17	6·5	5·	2 1 26	14	6·5	4·5	
9	17	6·5	5·	2 1 26	14	6·5	4·5	
6	16	5·5	4·25	1 3 4	14	6·5	3·5	
3	16	5·5	4·25	1 3 4	14	6·5	3·	

Weight and Dimensions of Mortar beds.

OLD PATTERN.

Nature of Bed	Weight.			Dimensions.		
Land service.				Length.	Breadth.	Height.
	cwt.	qrs.	lb.	ft.in.	ft.in.	ft.in.
13 Inch Iron	35	2	22	5 5½	3 1	2 1
10 Inch Iron	16	1	16	4 4	3 1	1 7

8 Inch Iron	7	2	27	3 3	3 1	1 3
5½ Inch Wood	1		10	2 7	1 3	9
4⅖ Inch Wood		3	5	2 5	1 3	

NEW PATTERN.

Nature of Bed	Weight.			Dimensions.		
Land service.				Length.	Breadth.	Height.
	cwt.	qrs.	lb.	ft.in.	ft.in.	ft.in.
13 Inch Iron	35	2	20	6 1	3 2¾	2 ½
10 Inch Iron	17	3	16	4 4	3 1	1 7
8 Inch Iron	8	3	3	3 3	3 1	1 3

The Breadth and Length of each Bed are measured from the extremities of the traversing bolts.

PART IV.

RANGE, ELEVATION, ETC., OF BRASS ORDNANCE.

SOLID SHOT.			COMMON CASE SHOT.		
Elevation.	Med. 12 Pr. 9 Pr. Long 6 Pr.	Light 12 Pr. Ditto 6 Pr. Heavy 3 Pr.	Elevation.	Med. 12 Pr. 9 Pr. Long 6 Pr.	Light 12 Pr. Ditto 6 Pr. Heavy 3 Pr.
degrees.	yards.	yards.	degrees.	yards.	yards.
P. B.	300	200	P. B.	150	100
¼	400	300	¼	175	125
½	500	400	½	200	150
¾	600	500	¾	225	175
1	700	600	1	250	200
1¼	775	650	1¼	275	225
1½	850	700	1½	300	250
1¾	925	750	1¾	325	275
2	1000	800	2	350	300
2¼	1050	850			
2½	1100	900			
2¾	1150	950			
3	1200	1000			
3¼	1250	1050			
3½	1300	1100			
3¾	1350	1150			
4	1400	1200			

24 Pr. Howitzer. Charge 2½ lb.					12 Pr. Howitzer. Charge 1½ lb.			
Com. Shells.			C. Case.		Com. Shells.			C
Elev-ation.	Fuze.*	Range.	Elev-ation.	Range.	Elev-ation.	Fuze.*	Range.	Elev ation
deg.	10ths	yds.	deg.	yds.	deg.	10ths	yds.	deg.
P. B.		250	P. B.	150	1	1	400	P. B
¼		300	¼	175	1¼	1½	450	¼
½		350	½	200	1½	2	500	½
¾		400	¾	225	1¾	2½	550	¾
1	1	450	1	250	2	3	600	1
1¼	1½	500	1¼	275	2¼	3½	650	1¼
1½	2	550	1½	300	2½	4	700	1½
1¾	2½	600	1¾	325	2¾	4½	750	1¾
2	3	650	2	350	3	5	800	2
2¼	3½	700	2¼	375	3¼	5½	850	
2½	4	750	2½	400	3½	6	900	
2¾	4½	800			3¾	6¼	950	
3	5	850			4	7	1000	
3¼	5½	900			4¼	7½	1025	
3½	6	950			4½	7¾	1050	
3¾	6½	1000			4¾	8	1075	
4	7	1025			5	8¼	1100	
					5¼	8½	1125	
					5½	8¾	1150	

* Fuze—Old pattern.

Ranges, Elevation, &c., of 8-inch Howitzer.

Common Shells.				Shrapnell Shells.		Ric	
Charge.	Fuze.	Elevation.	Range.	Fuze.	Elevation.	Charge.	Elev
lb.	inches	deg.	yards.	inches	deg.	lb.	d
4	·3	2	450	..	..	..	
	·4	2½	600	·3	2⅝	1	
	·52	3	750	·5	3½	1·5	
	·65	3¾	900	·7	4½	1·5	
	·8	4½	1050	·9	5⅝	2	
	·95	5⅜	1200	1·1	6⅞	2·5	
	1·1	6¼	1350	1·35	8¼	2	
	1·3	7¼	1500	1·6	9¾	2·5	
	1·5	8¼	1650				
	1·75	9⅜	1800			1	
	2·	10½	1950			2	
	2·3	11¾	2100				
	2·6	13	2250			3	
	3·	14⅜	2400			3	
	3·4	15¾	2550			3	
	3·9	17¼	2700				

32 Pr. Brass Howitzer.

Range.	Common Case.	Common Shell.		Shrapnell Shell.		Range.	Common Case.
Yards.	Elev-ation.	Elev-ation.	Fuze.	Elev-ation.	Fuze.	Yards.	Elev-ation.
200	P B					1150	
300	1°					1200	
400	2°	¾	·2	P B		1250	
450		⅞	·2	¼	·2	1300	..

500		1°	·2	½		1350	..
550		1¼	·3	1°		1400	..
600		1⅜	·3	1¼		1450	..
650		1½	·3	1⅝	·3	1500	—
700		1¾	·4	2°		1550	
750		2°	·4	2¼		1600	
800		2¼	·5	2½	·4	1650	
850		2½	·5	2¾		1700	
900		2¾	·6	3°	·5	1750	
950		3°	·6	3¼		1800	—
1000		3¼	·7	3½	·6	1850	
1050		3⅝	·7	3¾		1900	
1100		4°	·8	4°	·7	2000	

Range, Elevation, &c., of Brass Ordnanc

SHRAPNELL SHELLS.

12 Pr. Medium.				9 Pr.				
Shell filled 10 lb. 13¼ oz. Shell empty 5 lb. 10 oz. Number of Balls 63				Shell filled 8 lb. 1¼ oz. Shell empty 4 lb. 9½ oz. Number of Balls 41				Sh Sh Nu
Letter & Length of Fuze.	Elevation.	Range.		Letter & Length of Fuze.	Elevation.	Range.		Lett Len of F
		from	to			from	to	
in.10ths.	deg.	yds.	yds.	in.10ths.	deg.	yds.	yds.	in.1
B ·2	1⅜	660	960	B ·2	1⅜	640	920	
C ·3	1⅞	820	1110	C ·3	1⅞	800	1060	B
D ·4	2¼	960	1230	D ·4	2¼	930	1180	C
E ·5	2¾	1080	1340	E ·5	2¾	1050	1290	D
·6	3¼	1195	1445	·6	3¼	1160	1390	E
·7	3¾	1301	1545	·7	3¾	1260	1480	
·8	4⅜	1415	1645	·8	4⅜	1360	1570	
·9	5⅛	1520	1740	·9	5⅛	1455	1655	
1 ·	5¾	1620	1830	1 ·	5¾	1550	1740	
1 ·1	6⅜	1720	1920	1 ·1	6⅜	1640	1820	1
1 ·2	7	1815	2005	1 ·2	7	1725	1895	1
1 ·3	7⅝	1905	2085	1 ·3	7⅝	1805	1965	1
1 ·4	8¼	1990	2160	1 ·4	8¼	1885	2035	1
1 ·5	8⅞	2070	2230	1 ·5	8¾	1960	2100	1
1 ·6	9⅜	2140	2290	1 ·6	9⅜	2030	2160	1
1 ·7	10	2200	2340	1 ·7	10	2095	2215	1
				1 ·8	10¾	2165	2275	1
								1

SHRAPNELL SHELLS.

Part 2 of 2

24 Pr. Howitzer.			12 Pr. Howitzer.		
S. filled 21 lb. 4 oz.			S. filled 10 lb. 13¼ oz.		
S. empty 11 lb. 1 oz.			S. empty 5 lb. 10 oz.		
No. of Balls 129			No. of Balls 63		
Letter & Length of Fuze.	Elevation.	Range.	Letter & Length of Fuze.	Elevation.	Range.
in.10ths.	deg.	yds.	in.10ths.	deg.	yds.
·1	1	450	·1	1¼	450
·1½	1¼	500	·1½	1½	500
B ·2	1½	550	B ·2	1¾	550
·2½	1¾	600	·2½	2	600
C ·3	2	650	C ·3	2¼	650
·3½	2¼	700	·3½	2½	700
D ·4	2½	750	D ·4	2¾	750
·4½	2¾	800	·4½	3	800
E ·5	3	850	E ·5	3¼	850
·5½	3¼	900	·5½	3½	900
·6	3½	950	·6	3¾	950
·6½	3¾	1000	·6½	4	1000
·7	4	1050	·7	4¼	1025
·7½	4¼	1100	·7½	4½	1050
·8	4½	1125	·7¾	4¾	1075
·8½	4¾	1150	·8	5	1100
·9	5	1175	·8¼	5¼	1125
·9½	5¼	1200	·8½	5½	1150
			·8¾	5¾	1175
			·9	6	1200

Ricochet Practice with Brass Ordnance.

Chg. = Charge.
Ele. = Elevation.

Range in yards.	Solid Shot.				Common Shells.						
	12 Pr. Medium Gun.		9 Pr. Gun.		24 Pr. Howitzer Shell, 16 lb.		12 Pr. Howitzer Shell, 8 lb.		5½ in. Howitzer heavy Shell, 16 lb.		S
	Chg.	Ele.	Chg.	Ele.	Chg.	Ele.	Chg.	Ele.	Chg.	Ele.	Ch
	oz.	deg.	oz.	deg.	lb. oz.	deg.	oz.	deg.	lb. oz.	deg.	oz
					6	7½					
400					9	4¾			12	5	
			8	4					8	8	
	6	6½	7	5	8	9			12	7	
	5	7	6	6¼	10	7½					
			5	6¾	11	6			10	9	
500					12	5¼			8	11	
					14	5					
			7	6½	9	7¾	6	7			
600			6	7½	12	6½	8	6	1	6¾	
			5	9½	1	4¾	10	5	12	9	

Note.—When Shot are fired from the 24 Pounder and 12 Pou
Elevation must be about half a degree more than when Shells are used

CHARGES FOR THE ROYAL NAVY.

For Boats.

				lb.	oz.
	{ Howitzer	{ 24 Pounder		2	8
Cartridges		{ 12 Pounder	{ Heavy	2	0
filled with	{		{ Light	1	4
Powder	{ Gun	6 Pr. Light	{	1	8
	{		{	0	4
	{ Carronade	12 Pounder		1	0

CHARGES FOR THE ROYAL NAVY.

High; Medium; Low: equivalent to
Distant; Full; Reduced.

	Gun.	High	Medium	Low.	Proof.
	cwt.	lb.	lb.	lb.	lb.
18-Pounder.	42	6	4½	3	15
” ”	38	6	4½	3	15
” ”	22		3	2	7
” ”	20		3	2	7
” ”	15		2	—	5
24-Pounder.	50	8	6	4	18
” ”	48	8	6	4	18
” ”	33		6	4	12
” ”	20		2½	—	6
32-Pounder*.	64	10	8	6	21½
” ”	58	10	8	6	21½
” ”	56	10	8	6	21½
” ”	46	8	6	—	21½
” ”	48 }	8	6	5	21½
” ”	50 }				
” ”	50 A	8	6	4	18
” ”	45 B	8	7	5	16
” ”	42 C	6	4	2½	14
” ”	41	6	4	2½	12
” ”	40	6	4	2½	12
” ”	32	5	3 and 4	2½	10
” ”	25		4	2½	9
” ”	25		4	2½	9

42-Pounder.	84	14	10	5	25
” ”	75	14	10	5	25
” ”	67	—	10	6	23
56-Pounder.	98	16	10	5	28
” ”	87	14	10	5	25
68-Pounder.	112	20	10	5	30
” ”	95	16	12	8	28
” ”	87	14	10	6	25
8-Inch Gun.	65	10	8	5	20
” ”	60	10	8	5	20
” ”	52	8	—	5	16
” ”	50	—	8	5	14
10-Inch Gun.	112	16	—	—	25
” ”	86	12	—	6	20

* Charge of powder, for firing 32-pounder shells, 8 lb.

In changing the charge from Distant to Full, add ¼ degree elevation as far as 1000 yards, and half a degree beyond that range.

Double Shotting.—Double shotting may be employed with 32-pounder guns of

56 cwt.	charge 6 lb.	up to	400 yards.
42 ”	” 4 lb.	”	300 ”
25 ”	” 2½ lb.	”	200 ”

With double shot and reduced charge, give double the elevation, and half a degree additional, for the reduced charge.

Range, Charge, Elevation, &c., of Iron Ordnance.

P.B. = Point Blank
Diam. = Diameter

Nature.	Weight.	Length.		Diam. of the bore.	Charge of powder.		Range in ya				
							P.B.	1°	2°	3°	
GUNS.	cwt.	ft.	in.	in.	lb.	oz.					
42 Pr.	85	10		9·60	14		400	940	1340	1620	1
32 Pr.	63	9	7	6·41	10	10½	380	760	1130	1455	1
	56	9	6	6·41	10	10½	380	760	1130	1455	1
	48	8		6·41	8		330	680	1015	1300	1
	40	7	6	6·35	6		340	675	985	1260	1
*	32	6	6	6· 3	5		330	670	945	1210	1
*	25	6		6· 3	4		225	485	735	995	1
	25	5	4	6· 3	4		225	485	735	995	1
24 Pr.	50	9	6	5·82	8		360	755	1125	1417	1
	48	9		5·82	8		360	755	1125	1417	1
	40	7	6	5·82	8		340	730	1080	1377	1
	33	6	6	5·82	6		260	530	805	1082	1
18 Pr.	42	9		5·29	6		360	730	1080	1377	1
	38	8		5·29	6		340	710	1075	1347	1
12 Pr.	34	9		4·62	4		360	720	1075	1337	1
	29	7	6	4·62	4		340	710	1040	1307	1
9 Pr.	26	7	6	4· 2	3		330	685	1015	1278	1
6 Pr.	17	6		3·66	2		320	655	985	1238	1
CARRONADES.											
68 Pr.	36	6	4	8·05	5	10½	270	540	812	1042	1
42	22	4	6	6·84	3	8	240	515	810	983	1
32	17	4		6·25	2	10	235	485	705	905	1
24	13	3	9	5·68	2		225	435	650	826	1
18	10	3	4	6·16	1	8	220	430	620	787	

12	6	2	8	4·62	1	205	375	580	738

* Bored-up guns.

Carronades.

Nature	68 Pr.	42	32	24	18	12
Charge	lb. oz.	lb. oz.	lb. oz.	lb.	lb. oz.	lb.
	5 8	3 8	2 10	2	1 8	1
	yards.					
P. B.	450	400	330	300	270	230
1 Degree	650	600	560	500	470	400
2 ” ”	890	860	830	780	730	580
3 ” ”	1000	980	900	870	800	740
4 ” ”	1100	1020	970	920	870	810
5 ” ”	1280	1170	1080	1050	1000	870

Range, &c., of Iron Ordnance.

SHRAPNELL SHELLS.

68 Pr.Carronade.		8 in. Howitzer.		24 Pr. Gun.		18 Pr.
	lb. oz.		lb. oz.		lb. oz.	
Charge	4 0	Charge	4 0	Charge	5 0	Charge
S. filled	61 4	S. filled	61 13	S. filled	21 5	S. filled
S. empty	32 2	S. empty	32 2	S. empty	11 0	S. empty
No. of Balls 337		No. of Balls 337		No. of Balls 128		No. of Ba 90
Elevation.	Fuze.	Elevation.	Fuze.	Elevation.	Fuze.	Elevation.
deg.	tenths.	deg.	tenths.	deg.	tenths.	deg.
2½	4	2¾	3½	1¼	2	1¼
3½	6	3	6	1¾	3½	2
5	8½	6	10	2½	5	3

Range, Elevation, &c., of 12, 10, and 8 inch Guns, 32 Pr. Carronade and 8 inch Iron Howitzers.

P. B. = Point Blank.

Nature of Ordnance.	Length.		Weight.		Charge.		Elevation in degrees; Range in yards and seconds.					
							P.B.	1°	2°	3°	4°	5°
	feet.	in.	cwt.	qrs.	lb.	oz.						
12 in. Gun (Hollow shot)	8	4	90	3	12		240	540	790	1020	1250	140
{	7	6	57	3	7		210	460	720	935	1160	135
10 Do. (H. S.) {	8	4	62	1	8		250	570	810	1030	1230	140
{	9	4	84		12		325	630	930	1200	1460	170
8 Do. (H. S.)	6	8½	50		7		210	320	570	830	1130	130
8 Do. (Solid shot)	8	6	60		9	7	340	640	960	1190	1300	150
8 Do. }	9		65		10		300	580	940	1220	1480	170
Time of Flight }							¾”	2”	3”	4¼”	5½”	7”
Ditto. { (Hollow shot)	9		65		12		370	700	1050	1230	1540	170
Time of { Flight							1”	2¼”	3”	4¼”	6”	6½
32 Pounder Carronade Gun	5		25		4		200	470	730	960		
10 inch iron Howitzer	5		40		7				600			120
8 inch Ditto.	4		21		4				450	730		

Range, Elevation, &c., of 12, 10, and 8 inch Guns, 32 Pr. Carronad and 8 inch Iron Howitzers.

(Part 2 of 2)

Nature of Ordnance.	Length.	Weight.	Charge.	Elevation in degrees; Range in yard				
				8°	9°	10°	11°	12°
	feet. in.	cwt. qrs.	lb. oz.					
12 in. Gun (Hollow shot)	8 4	90 3	12					
{	7 6	57 3	7					
10 Do. (H. S.) {	8 4	62 1	8					
{	9 4	84	12					
8 Do. (H. S.)	6 8½	50	7					
8 Do. (Solid shot)	8 6	60	9 7					
8 Do. }	9	65	10	2290	2430	2510	2710	2930
Time of } Flight				9¾”	10½”	11½”	12¼”	12½”
Dittoo. { (Hollow shot)	9	65	12	2090	2310	2400	2510	2720
Time of { Flight				8¾”	10”	10½”	11½”	12½”
32 Pounder Carronade Gun	5	25	4					
10 inch iron Howitzer	5	40	7	1500		1926		2078
8 inch Ditto.	4	21	4	1227		1506		1725

The above Ranges for the 12 and 10 inch Guns are with hollow shot, weighing and 84 lb.

The 8 inch Gun carries either hollow shot, plugged, 48 lb.; or shell

Vide also NAVAL GUNNERY. Table of Tangent Practice, 8 inch G

56 Pounder Gun, and 68 Pounder Gu

Weight, Ranges, &c.

	Gun.	Shot.	Charge.	P B	1°	2°	3°	4°	5°	6°
	cwt.	lb.	lb.	yds.	yds.	yds.	yds.	yds.	yds.	yds.
56 Pr.	98	S S	16	490	930	1340	1720	2000	2200	2400
	87	S S	14	380	900	1310	1660	1940	2100	2310
68 Pr.	112	S S	20	400	980	1400	1760	1980	2240	2480
	95	S S	15	310	700	1070	1430	1710	1930	2130
	95	Shell	16	350	850	1250	1560	1840	2100	2350
	87	S S	14	300	680	1050	1360	1650	1900	2140
	87	Shell	14	310	710	1080	1350	1610	1850	2080

8 Inch Gun.

Length, 9 feet; Weight, 65 cwt.; Height of gun above the plane, 5 feet 7 inches.

Nature of shot.	Charge.	Elevation.	First graze.	Flight.	Second graze.	Extreme range.	Time of flight.	I
	lb.	Degrees.	Yards.	Sec.	Yards.	Yards.	Sec.	
Solid	10	P. B.	315	1”	901	3207	20”	
	10	1°	660	2”	1006	2803	19”	
	10	1½°	818	3”	1240	2433	16”	
	9	P. B.	343	1”	776	2683	17”	
	9	1°	615	2”	970	2483	15”	

RICOCHET FIRING.

1. When adopted in the field, the guns should seldom be elevated above 3 degrees, as the objects fired at are generally cavalry and infantry, and the lower the angle the longer will the shot preserve its force, and have effect.

2. In the ricochet of a fortification of any kind, the elevation should seldom exceed 10 degrees to throw the shot over the parapet a little higher than the level of the battery; and, on the whole, the best elevation to enfilade a work is from 6 to 9 degrees, measured above the crest of the parapet with corresponding charges.

3. The charge, and elevation being known for any range, when the gun and parapet are on the same level, the same charge, and elevation may be used so long as the difference of level does not exceed one-

twentieth of the horizontal distance between them, the elevation being given by the tangent scale, and the gun laid at the parapet, whether above or below its own level.

Ricochet Practice with Iron Ordnance.

Range in yards.	Round Shot.							
	68 Pr. Carronade.*		24 Pr. Gun, 9 Feet.		18 Pr. Gun, 8 Feet.		12 Pr. Gu 8½ Feet	
	Charge.	Elevation.	Charge.	Elevation.	Charge.	Elevation.	Charge.	El ti
	lb. oz.	deg.	lb. oz.	deg.	lb. oz.	deg.	lb. oz.	d
400			12	6¼	9	6½	8	
			10	7¾			6	
			8	11				
600	1 12	7	6	6	1	5¼	12	
	1 8	8¾	1 8	4	12	7	10	
			1	6½			8	
800			2	3¾	1 8	4¼	1	
			1 8	5½	1	7	12	

* Note.—When Shells are fired from the 68 Pounder Carronade, the Elevation must be decreased about half a degree.

Part 2 of 2

Range in yards.	Common Shell.					
	10-inch Howitzer Shell, 92 lb.		8-inch Howitzer Shell, 46 lb.		24 Pr. Howitzer Shell, 16 lb.	
	Charge.	Elevation.	Charge.	Elevation.	Charge.	Elevation.
	lb. oz.	deg.	lb. oz.	deg.	lb. oz.	deg.
400	2 8	6¼	1 8	6	9	4¾
	2	8½	1	9½	6	7½
600	3	6½	1 8	8¼	1	4¾

	2	8	8¼	1	4	10	12	5¼
							9	7½
800	4		6¼	2	8	6¼		
	3	8	7½	2		6½		

MORTARS.

Practical rules.

To find the Charge for a given Range at 45° elevation.

13 inch Mortar.—To the range, in yards, add half the range, multiply the sum by ·03 for the charge, in ounces.

10 inch Mortar.—When the range is under 1350 yards, add to the range 160, and multiply by ·02; and if the range is over 1350 yards, add one-fifth of the range, and multiply by ·02 for the charge, in ounces.

8 inch Mortar.—To the range, in yards, add 20, and the sum multiplied by ·015 will give the charge, in ounces.

5½ inch Mortar.—To the range in yards, add 150, and multiply by ·08, for the charge, in ounces.

4⅘ inch Mortar.—To the range in yards add 300, and multiply by ·06, for the charge, in drams.

To find the Time of flight, the range being given. Divide the square root of the range, in feet, by 4·5 for the time of flight, in seconds.

To find the Range, the Time of flight being given. Multiply the time of flight, in seconds, by 4·5, and square the product for the range, in feet.

To find the length of Fuze,[8] for a given range. Multiply the time of flight, in seconds, by ·22, for the 13, and 10 inch mortars, and by ·24 for 8, 5½, and 4⅘ inch mortars, for the length of fuze, in tenths.

Mortar Practice at 15°, 25°, and 45° Eleva

13 INCH IRON.				10 INCH IRON.			
Weight			36 cwt.	Weight			16 cwt. 2 qrs.
*Shell filled			200 lb.	Shell filled			92 lb.
Burst. powder			6 lb. 12 oz.	Burst. powder			2 lb. 10 oz.
Blowing powder			2 oz.	Blowing powder			1½ oz.
Elevation.	Charge.	Fuze.	Range.	Elevation.	Charge.	Fuze.	Range.
degs.	lb. oz.	in.	yds.	degs.	lb. oz.	in.	yds.
45	2 1½	1·9	450	45	1 ½	1·9	450
	2 3	2·	500		1 2	2·	500
	2 4¾	2·1	550		1 3¼	2·1	550
	2 6	2·2	600		1 4¾	2·2	600
	2 7¾	2·3	650		1 6	2·3	650
	2 9½	2·4	700		1 7½	2·4	700
	2 11¾	2·45	750		1 9	2·45	750
	2 14	2·5	800		1 10	2·5	800
	3 ½	2·55	850		1 11	2·55	850
	3 3	2·6	900		1 12	2·6	900
	3 5½	2·65	950		1 13	2·65	950
	3 8	2·7	1000		1 14	2·7	1000
	3 10	2·75	1050		1 15¼	2·75	1050
	3 12	2·8	1100		2 ½	2·8	1100
	3 14	2·85	1150		2 1¾	2·85	1150
	4	2·9	1200		2 3	2·9	1200
	4 5	3·	1300				
	4 15	3·2	1500				
	5 10	3·4	1700				

* The Shells were filled with sand.

Part 2 of 2

5½ INCH BRASS.				4⅘ INCH BRASS.			
Weight 1 cwt. 1 qr. 10 lb.				Weight 3 qrs. 19 lb.			
Shell filled 16 lb.				Shell filled 8 lb.			
Burst. powder 10 oz.				Burst. powder 5 oz.			
Blowing powder ½ oz.				Blowing powder ½ oz.			
Elevation.	Charge.	Fuze.	Range.	Elevation.	Charge.	Fuze.	Range.
degs.	lb. oz.	in.	yds.	degs.	lb. oz.	in.	yds.
15	6	·7	350	15	4 8	·8	450
	7	·75	400		4 12	·85	500
	7 8	·8	450	25	4	1·1	540
	8	·85	500				
25	5 8	1·1	480				
45	4 8		300	45	2 6	1·65	300
	4 12		350		2 9	1·7	350
	5	1·75	400		2 12	1·75	400
	5 4	1·8	450		3	1·8	450
	5 8	1·85	500		3 4	1·85	500
	5 12	1·9	550		3 8	1·9	550
	6	1·95	600		3 12	1·95	600

Greatest Charges, and Ranges.

	lb.	oz.	yds.
13 Inch, Sea	20	0	4200
10 ”	10	8	4000
13 Inch, Land	9	0	2900
10 ”	4	0	2400
8 ”	2	0	2000
5½ ”		9	1200
4⅖ ”		4·5	1000

Distance from the parapet of a battery, the parapet being 8 feet high, for Mortars at the following elevations:—

Elevation	45	30	20	15	10 degrees.
Distance	12	13	21	30	40 feet.

PART V.

STORES, IMPLEMENTS, COMBUSTIBLES, ETC., REQUIRED IN BATTERIES.[9]

BALLS, LIGHT.

Light Balls are thrown from mortars at night, to discover the operations of the enemy's working parties, &c.

Light balls burn from 10 to 20 minutes.

Composition.

	lb.	oz.		lb.	oz.
Saltpetre, pulverized	6	4	Rosin, pounded	1	14
Sulphur, ground	2	8	Linseed oil, boiled	0	7½

BALLS, SMOKE.

Smoke balls are fired from mortars to suffocate the men in mines, &c., or to prevent them continuing their work. They are also used to conceal manœuvres, &c., from an enemy.

Smoke balls burn from 25 to 30 minutes.

Composition.

	lb.	oz.		lb.	oz.
Corned mealed powder	5	0	Swedish pitch	2	0
Saltpetre, pulverized	1	0	Tallow	0	8
Sea coal	1	8			

To construct hollow Globes, or Cases for Light Balls, &c.

The canvas, or paper, may be formed in the following manner, viz.:—With radius of half the intended calibre, describe the circle A B C D (*vide Figure 20, Practical Geometry*), and divide the same into four equal parts. From B with radius A B describe arc A E, from A with radius A B describe arc B E, and from E with radius E A describe arc A B. Eight pieces, as E A B, will form a ball nearly, the edges being brought close together.

CARCASSES.

Carcasses, a species of shell, are filled with composition, the flame from which is extremely powerful, and nearly unextinguishable. They are much used in bombardments of towns, setting fire to shipping, &c., and are discharged from guns, mortars, and howitzers, similarly to common shells; from which, however, they differ, in being made thicker, to enable them to withstand the intensity of fire; and in having three fuze holes instead of one.

Carcasses burn from 8 to 10 minutes.

Common shells may be made to produce effects similar to carcasses, by filling them with a proportion of Valenciennes composition, and bursting powder.

All carcasses have three holes; and, from guns and howitzers, are fired with sabots.

Carcass Composition.

	lb.	oz.
Saltpetre, pulverized	6	4
Sulphur, sublimated	2	8
Rosin, pounded	1	14
Antimony, pounded	0	10
Tallow	0	10
Turpentine	0	10

Valenciennes Composition.

	lb.	oz.
Saltpetre, pulverized	6	4
Sulphur, sublimated	2	8
Rosin, pounded	1	4
Antimony, pounded	0	10
Linseed oil, 6 oz. 14 drams.		

Weight, and Dimensions of

Carcasses.

Nature of Carcass. Land Service.	Exterior Diameter.	Weight, empty.		Weight, filled.	
	inches.	lb.	oz.	lb.	oz.
13 Inch	12·84	220	0	234	8
10 Inch	9·84	97	0	104	0
8 Inch	7·86	52	4	57	0

5½ Inch	5·59	15	8	17	1
4⅘ Inch	4·45	8	4	9	1
42 Pr.	6·85	28	14	30	10
32 Pr.	6·1	23	3½	24	8
24 Pr.	5·54	15	6	16	9½
18 Pr.	5·04	13	12	14	7½
12 Pr.	4·4	8	6	8	13

CARTRIDGES FOR GUNS, HOWITZERS, ETC.

Nature of Ordnance.	Charge of powder.	Dimensions.		
		Length.	Circumference.	
			Superior.	Inferior.
GUNS, IRON.	lb. oz.	ft. in.	ft. in.	ft. in.
68 Pounder	18	1 8·6	1	1
56	20	1 10·	1 3·	1 3·
”	16	1 10·	1	1
”	14	1 10·	11·3	11·3
”	10	1 10·	9·	9·
”	6	1 10·	7·2	7·2
42	14	1 11·1	1 9·4	1 9·4
32	10	1 9·8	1 7·9	1 7·9
24	8	1 6·3	1 5·6	1 5·6
18	6	1 7·	1 4·5	1 4·5
12	4	1 4·5	1 2·5	1 2·5
9	3	1 2·2	1 1·	1 1·
6	2	1 1·1	1 1·5	1 1·5
12 Inch	12	1 6·5	1 6·5	1 2·
10	12	1 5·5	1 3·	1
8	10	1 7·	1 1·5	10·
GUNS, BRASS.				
12 Pr. {Medium	4	1 4·5	1 2·5	1 2·5
{Light	3	1 1·5	1 2·5	1 2·5
9	2 8	1 1·1	1 1·	1 1·
6 {Heavy	2	1 2·2	11·5	11·5
{Light	1 8	11·2	11·5	11·5
3 {Heavy	1	9·7	9·	9·
{Light	12	9·	9·	9·
HOWITZERS.				

Iron.	{10 Inch	7		1	1·8	1	3·8		9·7
	{ 8	4		1	1·7	1	1·2		7·
Brass.	{24 Pr.	2	8	1	0·2		10·		6·3
	{12	1	4		10·8		8·5		5·8
	{ 5½ inch	2			10·3		5·9		3·8
	{ 4⅖		8		7·6		5·		3·
CARRONADES.									
68 Pr.		5	10	1	8·3	1	9·	1	9·
42		3	8	1	5·	1	7·1	1	7·1
32		2	10	1	6·	1	5·5	1	5·5
24		2			11·	1	3·9	1	3·9
18		1	8		10·	1	1·8	1	1·8
12		1			8·8	1	1·2	1	1·2
6			12		7·5		10·1		10·1

When the circumference of the Cartridge is not uniform, each Cartridge is made of two pieces, and the dimensions given are for one piece only.

FUZES, OLD PATTERN.

The wooden cases for holding the Fuze composition are made of well-seasoned beech. The interior diameter of the cup is equal to three times that of the bore, and its depth is equal to 1½ of the said diameter. The thickness of wood at the bottom of the bore is equal to two diameters.

Fuze composition.	lb.	oz.	*Blind fire for Night.*	lb.
Saltpetre, pulverized	3	4	Meal powder	11½
Sulphur, sublimated	1	0	Wood ashes	9½

Pit-mealed powder	2	12

Fuzes, being bored for Field guns, or cut to the length required for the range of Garrison guns, are made to fit the Shell correctly by means of a rasp and cutter; after which they are carefully driven into the Shell with a mallet and setter, leaving only the cup of the Fuze out of it. The Fuze is uncapped when placed in the piece.

13 inch Fuze burns 40 Seconds.	5½ inch Fuze burns 20 Seconds.
10 do. do. 35 do.	do. do. 15 do. 4
8 do. do. 30 do.	

All natures of Fuzes, when driven with the above composition, burn one inch in five seconds; but when driven with mealed powder, they burn two inches in the same time.

BOXER'S FUZE.

The composition bore is made excentric with regard to the exterior, and two powder channels are bored upon that side in which there is the greatest thickness of wood. A hole is bored through the mealed powder at the top, and into the fuze composition, to insure the ignition of the fuze composition from the priming. Two rows of holes, two inches apart, are made into the powder channels, and the bottom hole in each row is continued to the axis of the composition bore. The small side holes, with the exception of the bottom ones, are filled with pressed powder, and a small portion of clay. The powder channels contain rifle powder, and the bottom side holes have a piece of

quick match placed in them. Beyond this quick match, the powder channels in the fuze for common shells are filled with putty; but in the Shrapnell fuze the corresponding portion contains quick match, which is continued from one channel to the other through a groove made in the bottom. A piece of quick match is tied into the cup, and it is recommended that this quick match is laid over the side before the shell is set home. The bursting powder is contained in a tin cylinder,[10] and is admitted through a hole at the bottom of the socket. There is a small hole in the side of the shell, through which the balls, and composition, which is run between them, are admitted. It is recommended that the bursting powder be placed in the tin cylinder before going into action, and the plug covered with serge, inserted in the fuze hole. The bursting powder can be speedily removed from the shell, if necessary; and, from its being separated from the balls, it will not be liable to injury, even when subjected to the action of travelling.

A simple boring-bit is supplied to each gun, in case the borer, specially made for the fuze, is lost, or damaged.

Captain Boxer's 5½ inch fuzes are to be adopted for all natures of guns and howitzers, one inch in length for Shrapnell shells, and two inches in length for common shells.

FUZES, METAL.

Fuzes, for the Naval service specially, are formed of gun metal, and are screwed into a gun metal bouched screw hole in the shell.

Metal fuzes are of three natures, viz., 3-inch, 4-inch, and short-range Fuzes. The first is driven with

mealed powder, and will burn seven seconds; the second is driven with fuze composition, and will burn twenty seconds; and the short-range fuze is also driven with the composition, and will burn two seconds. These fuzes are driven and primed precisely the same as wooden fuzes; but instead of being capped with canvas, have a screw metal cap.

The fuzes are screwed into the shells, the holes of which are bouched with metal to receive them; they are screwed into the left hand, so that unscrewing the cap in the same direction prevents the possibility of the fuze being loosened by that operation.

The diameter of the fuze holes for all natures of shells, fitted to receive metal fuzes, is exactly the same.

A 3-inch metal fuze will burn seven seconds, and is calculated for ranges not exceeding 1,900 yards. A 4-inch metal fuze will burn ten seconds, and is not to be used at a greater distance than 2,400 yards.

Bickford's Water Fuze, which burns about two or three feet in a minute, may be advantageously used for exploding gunpowder under water, for the destruction of booms, vessels, &c.

GREASE.

The composition used for greasing wheels is composed of equal parts of tallow and coarse sweet oil melted together, and it is made up in kegs of 28 lb. each. In warm weather the proportion of tallow must be increased.

GRENADES, HAND.

A Land service Hand grenade weighs 1 lb. 13 oz., and may be thrown from 40 to 60 feet. The diameter

of the Fuze composition is ·2 of an inch, length 2·25 inches, and weight 3 drams.

Fuze Composition.

Saltpetre, 3 lb. 4 oz.; Sulphur, 1 lb.; Mealed powder, 2 lb. 12 oz.

On service the Grenades are charged with 1½ oz. of powder.

GUN COTTON.

Although there appears no prospect of Gun cotton being used in the British service as a substitute for gunpowder, it is advisable that every Artillerist should be cognizant of its merits and demerits; for circumstances may arise when this new impulsive power may be advantageously employed. The exploding cotton is thus prepared:—Common well-cleaned cotton is dipped for about half a minute in highly-concentrated nitric acid (made by the distillation of ten parts of dried saltpetre, and six of oil of vitriol), and then instantly placed in water, which must be often renewed, in order to free the cotton from the acid with which it is impregnated. Care must then be taken that all the knotty particles of the cotton are properly disentangled, and that it is thoroughly dried. After the explosive preparation is ready for use, the smallest portion explodes when struck on an anvil with a hammer, like fulminating-powder; when kindled with a glowing body, it takes fire just like gunpowder; and, when used in a gun, its operation, though in a far greater proportion to its weight, is similar to that of gunpowder. Gun cotton is employed in the same manner as gunpowder: a piece of it is rammed down the barrel, then a bit of wadding, and after that a ball; a copper cap ignites

and explodes the cotton.

To Dr. Otto, professor of chemistry in Brunswick, we are indebted for the foregoing description of the preparation of the explosive cotton; and the intrinsic value of this impulsive agent has been ascertained by Colonel Mordecai, at Washington, in 1845, 1847, 1848. The following are the results of this scientific officer's experiments for the purpose of determining the fitness of Gun cotton, as a substitute for gunpowder in the military service:—

1. Explosive cotton burns at 380° Fahrenheit, therefore it will not set fire to gunpowder when burnt in a loose state over it.

2. The projectile force of explosive cotton, with moderate charges, in a musket or cannon, is equal to that of about twice its weight of the best gunpowder.

3. When compressed by hard ramming, as in filling a fuze, it burns slowly.

4. By the absorption of moisture, its force is rapidly diminished, but the force is restored by drying.

5. Its bursting effect is much greater than that of gunpowder, on which account it is well adapted for mining operations.

6. The principal residua of its combustion are water and nitrous acid; therefore the barrel of a gun would be soon corroded, if not cleaned after firing.

7. In consequence of the quickness and intensity of its action, when ignited, it cannot be used with safety in the present fire-arms.

8. An accident on service, such as the insertion of two charges before firing, would cause the bursting

of the barrel; and it is probable that the like effect would take place with the regular service charges, if several times repeated.

GUNPOWDER.

The component parts of Powder are 75 parts of nitre, 10 of sulphur, and 15 of charcoal.

Cylinder powder is made from charcoal that has been burnt in iron cylinders; and *Pit powder* from charcoal burnt in common pits.

Gunpowder, when ignited, expands with a velocity of about 5,000 feet per second; and the pressure of the fluid is about 2,000 times that of common air.

One pound of Powder measures 32 solid inches.

A cubic foot of Government powder weighs about 58 pounds.

Gunpowder is manufactured by reducing the nitre, sulphur, and charcoal to powder; they are then mixed, moistened with water, and again mixed in a mill for five or six hours, or until the mixture is as intimate as possible, for upon this the strength of the powder chiefly depends.

When taken from the mill, the composition is put in a press, and formed into hard cakes about a quarter of an inch thick; these, when dry, or nearly so, are broken by wooden mallets into small pieces, and reduced into grains by being put into sieves, and forced by means of a wooden roller through circular holes of the proper diameter.

Good powder should be devoid of smell, and of uniform colour, approaching to that of a slate. The particles should be perfectly granulated, and free from cohesion. It should admit of being readily

poured from one vessel to another.

In powder that has become damp, large lumps are formed: should the damage, however, not be very considerable, these concretions may be reduced by drying the powder in a hot-air stove, rubbing and loosening the grains; but powder thus affected never thoroughly regains its lost strength.

To test the purity of powder.—Lay a dram of it on a piece of clean writing-paper, and fire the heap by means of a red-hot iron wire: if the flame ascend quickly with a good report, leaving the paper free from white specks, and without burning holes in it, the goodness of the ingredients and proper manufacture of the powder may be safely inferred.

Good powder blasted upon a clean plate of copper should leave no track or mark of foulness.

Powder exposed for 17 or 18 days to the influence of the atmosphere ought not to increase materially in weight. One hundred pounds of powder should not absorb more than twelve ounces: if it increase in weight more than one per cent., the powder should be condemned.

Proof of Gunpowder.

To prove the strength of *large grain or common powder*, 2 ounces are fired from 8-inch Gomer mortars (at an angle of 45˚), placed on stone beds, and so fixed as not to recoil. These mortars are loaded with shot weighing 68 pounds, and the average of the ranges, with Government powder of Waltham Abbey, is 250 feet. Powder made of common pit charcoal will only project such a ball, under the same circumstances, about 220 feet; and powder that has been re-stoved will only produce a

range of from 107 to 117 feet.

A musket, charged with two drams of *fine grained or musket powder*, should drive a steel bullet through 15 or 16 half-inch elm boards, placed three quarters of an inch from each other, the first board being set at 40 inches from the muzzle of the musket: with re-stoved powder, the bullet will only perforate from 9 to 12 of the boards.

The quality of large grain powder is ascertained by its general appearance, its firmness, glazing, uniformity of grain, and density.

POWDER MARKS.

The various sorts of Powder are distinguished by the following marks on the heads of the barrels:—

L G	Large grain.
F G	Fine grain.
R A	For rifle arms.
L G	Large grain.
F G	Fine grain.
R S	Re-stoved.

Red L G, or F G, denotes powder of the best quality. *White* L G, or F G, is an inferior Powder for salutes, &c.

POWDER MAGAZINES.

To ascertain if a Magazine is damp.—Soak a piece of sponge in a solution of salt of tartar, or common salt and water: let it be well dried and weighed, and then be placed in the magazine, which, if damp, will cause the sponge to become heavier.

A small weight, suspended by a piece of catgut, or hair, will also discover moisture, causing the former to contract and the latter to lengthen.

POWDER BARRELS.

Whole Barrels contain 100 lb., and Half Barrels 50 lb., of powder, whether fine or coarse.

Dimensions of Powder barrels.

	Whole barrels. inches.	Half barrels. inches.	Quarter barrels. inches.
Depth	20½	16¾	14
Diameter at top	15½	12¼	9½
Do. at bulge	16¾	13¼	10¼
Do. at bottom	15½	12¼	9½

BUDGE BARRELS.

Weight of Barrel, copper-hooped, 10 lb., hazel-hooped, 6 lb.

Length of barrel 10½ inches } each barrel will contain 38 lb.
Diameter ” 13 ” }

BOXES TO CONTAIN POWDER, CORRESPONDING TO THE BARRELS.

External dimensions.	Whole boxes. inches.	Half boxes. inches.	Quarter boxes. inches.
Length	16¾	13¼	10¼
Breadth	16¾	13¼	10¼

Depth	20½	16¾	14

These boxes are lined with copper, tinned.

HANDBARROWS.

Length, 5 ft. 3 in. Breadth, 2 ft. Weight, 19 lb.

HANDSPIKES.

Length, 5 ft. Diameter at top, 1·25; Diameter at bottom, 2·75 inches. Length of square, 1 foot 9 inches. Weight of ten, 64 lb.

There is a larger kind, 6 feet in length; weight of ten, 100 lb.

LEVERS.

	ft. in.		lb.
Iron shod, length	4 0	Weight of 5	36
Common	6 6	Do.	54

LIGHTS, BLUE.

Blue lights are used for signals, &c., and will burn half a minute.

Composition.

	lb.	oz.
Saltpetre, ground	1	12
Sulphur, sublimated	0	7
Red orpiment	0	2

LIGHTS, LONG (BOXER'S).

The paper case is 10 inches long, 6 inches of which are filled with composition; one end is left open to fix on a wooden holder; the other end is fitted with a nipple, on which a percussion cap is to be placed. By giving the cap a smart blow on some hard substance, it ignites the composition, which will burn for six minutes.

Composition.

	lb.	oz.
Saltpetre, ground	7	0
Sulphur, sublimated	1	12
Red orpiment	0	8

LIGHTS, LONG (OR STEVENS').

The composition is similar to that for blue lights. The cases are made of brown paper, and are of the same diameter as the one-pound signal rocket. The case is cut to the length of 9·75 inches, one end being perforated at an inch from the bottom to allow a wooden pin to pass through it, for the purpose of attaching the handle to the case.

Two coats of paint are given to the cases.

A long light will burn five minutes.

LIGHTS, SIGNAL (BOXER'S)

This is similar to the LIGHT, LONG, but has only one inch of composition.

MATCH, QUICK.

Composition.

	lb.	oz.		
Cotton wick	2	2	Gunpowder	12 lb.
Gum arabic	0	8	Water	4 quarts.

Four pounds of the gunpowder are mixed into a thin paste with a portion of the gum-water *boiling*, in this the cotton is then immersed. Six pounds of gunpowder made into a stiff paste, with the remainder of the gum-water, is spread on the top of the match, which is afterwards reeled off, the remaining two pounds of powder being sifted on the match while on the reel, and some of the stiff paste being held in the hand through which the match passes.

MATCH, SLOW.

Slow match is prepared from slightly-twisted hemp rope, which is dipped in a solution of lime water and saltpetre.

One yard burns about three hours. One skein, 35 yards, weighs seven pounds.

During the Siege of Gibraltar, Slow match was thus made:—Eight ounces of saltpetre were put in a gallon of water, and just made to boil over a slow fire, strong blue paper was then wetted with the liquor, and hung to dry. When dry, each sheet was divided into two parts, which were rolled up tight, and the outward edges pasted down. Each half sheet would burn three hours.

French slow match is made by soaking light twisted white rope in a solution of one pint of rain water, and three quarters of an ounce of sugar of lead.

PARACHUTE, LIGHT BALL (BOXER'S).

This light ball consists of a paper shell, enclosing two tin hemispheres, one containing the composition, the other the parachute. The shell is fired from a mortar, having a fuze, fixed in the usual manner, which communicates with the bursting powder, opens the shell, and lights the composition in the hemisphere attached to the parachute, which, suspended in the air, renders conspicuous the objects required to be illuminated.

Composition.

	lbs.	oz.
Saltpetre, ground	7	0
Sulphur, sublimated	1	12
Red orpiment	0	8

PENDULUMS.

A Pendulum is readily made with a musket ball, and a piece of silk. The length of a Pendulum is measured from the centre of the ball to the end of the loop on which it swings.

Length of Pendulums to vibrate	{ 1 Seconds	39·14	inches
	{ ½ Seconds	9·8	”
	{ ¼ Seconds	2·45	”

To find the length of a pendulum to make a given number of vibrations.

Rule.—As the square of the given number of vibrations is to the square of 60, so is the length of the standard (39·14 length for one second) to the

length sought.

Or, multiply 39·14 by the square of the time required for the Pendulum to vibrate—viz., by the square of ½ = ¼, for ½ second; and by the square of 2 = 4 for two seconds.

To find the number of vibrations, the length of pendulum being given.

Rule.—Multiply 60 seconds by the square root of 39·14, divided by the length of the given pendulum.

Or say, As the given length is to the standard length, so is the square of 60 (its vibrations per minute) to the square of the number required.

PORTFIRES.

Portfires are of four different natures—viz., Common portfires, Percussion portfires, Miners' portfires, and Slow portfires.

A common portfire is 16 inches long, and will burn 15 minutes.

Composition.

	lb.
Brimstone, sublimed	2
Powder, cylinder mealed	1
Saltpetre, pulverized	6

PORTFIRES, PERCUSSION.

Composition.

Brimstone, sublimed	4
Powder, cylinder mealed	1
Saltpetre, pulverized	8

The percussion priming is added to these portfires at the stations where they are used (principally for the Coast Guard), and is simply a small glass globule, containing sulphuric acid. This is embedded in loose composition, which ignites on the globule being broken. A percussion portfire will burn 5 minutes.

PORTFIRES, MINERS.

Composition.

	lb.	oz.
Saltpetre, pulverized	0	8
Sulphur, sublimed	0	8
Powder, cylinder mealed	1	0

PORTFIRES, SLOW.

The paper, which is called blue sugar-loaf paper, is wetted by dissolving 12 ounces of saltpetre in one gallon of water, wetting each sheet separately on both sides with a brush, one side being dried before the other is made wet.

Slow portfires burn from three to four hours.

Portfires were made during the Siege of Gibraltar in the following manner: Two ounces of nitre were dissolved in a gallon of water, and sheets of soft brown paper dipped in the solution; these, when dry, were rolled up to about the size of common portfires.

Portfires may be made by boiling square rods of lime, birch, or poplar, in a solution of nitrate of lead for six hours (a quart of water to every pound of the nitrate); the matches are then dried, and afterwards boiled in spirits of turpentine; they are then wiped and dried. A yard of this match will burn three hours.

COAST GUARD PORTFIRES.

Composition.

Saltpetre 8 lb. Sulphur 4 lb. Cylinder mealed powder 1 lb.

QUOINS.

Nature.	Length.		Width.	Thickness.
	ft.	in.	inches.	inches.
42 Pr.	2	3	10·75	6·75
32 ”	2	3	10·75	6·75
24 ”	2	9	9·5	6·75
18 ”	2	9	9·5	6·75
12 ”	1	11	9·25	6·25
9 ”	1	11	9·15	6·

ROCKETS.

There are two descriptions of Rockets:—

1st.—*Signal Rockets.* 2nd.—*Congreve Rockets.* (*Vide* PART VI.)

SIGNAL ROCKETS.

Signal rockets are of two natures—viz., 1 lb. and ½ lb. Rockets. They are fired from a tube, the ignition being effected by means of a percussion tube.

Composition.

	lb.
Saltpetre, pulverized	4
Sulphur, sublimed	1
Dog-wood charcoal	1½

Composition for Stars of Rockets.

	lb.		
Saltpetre, pulverized	8	Isinglass	3 oz. 8 drs.
Antimony, pounded	2	Vinegar	1 quart.
Cylinder mealed powder	1	Spirits of Wine	1 pint.
Sulphur, sublimed	2		

The head of a 1 lb. rocket contains 36 stars, and that of the ½ lb. rocket 24 stars.

SHELLS.

Shells are hollow iron Shot, and are of various descriptions, viz.:—

1st.—The *Common shell*, with one fuze hole, used in the attack and defence of fortresses, &c., against shipping, and troops.

2nd.—The *Carcass*, which has three fuze holes, is filled with burning composition, and is used to set fire to towns, &c.

3rd.—The *Compound-shot*, which is filled with lead to increase the impetus of the shot, and the extent of the range.

4th.—The *Shrapnell shell*, which is very destructive when used against bodies of Cavalry or Infantry, as it produces the same effect as common Case or Canister shot from guns or howitzers, but at a much greater range.[11]

Diameter and thickness of each Shell now in the Service.

Nature of Shell.		Mean Diameter.	Thickness.	Bursting Powder.	
		inches.	inches.	lb.oz.	dr.
	{ 13 Inch	12·84	2·146	6 8	
	{ 10 ”	9·84	1·646	5 8	
COMMON	{ 8 ”	7·86	1·39	2 4	
	{ 5½ ”	5·595	0·936	0 10	
	{ 4⅖ ”	4·454	0·746	0 5	
	{ 32 Pr.	6·177	1·034	1 0	
	{ 10 Inch	9·85	1·35	5 8	
NAVAL	{ 8 ”	7·925	1·35	2 4	
	{ 32 Pr.	6·177	1·034	1 0	
	{ 8 Inch	7·86	0·82	10	
	{ 32 Pr.	6·177	0·64	6	
	{ 24 ”	5·595	0·58	3	
SHRAPNELL	{ 18 ”	5·099	0·53		
DIAPHRAGM	{ 12 ”	4·454	0·477	1	12
	{ 9 ”	4·08	0·41	1	8
	{ 6 ”	3·55	0·356	0 0	12

All shells are now issued in the Field Service, *loaded*, and secured with a metal plug.

SHOT, CASE OR CANISTER.

The common Case or Canister shot consists of a number of balls packed in tin canisters of a cylindrical form: the balls being of different weights according to the size of the gun. For field service the

balls are counted into the case, and laid in tiers, but for other purposes they are loosely thrown in till the case is filled. The top being soldered on, the bottom of the tin case is nailed on to the wooden bottom, and the heads of the nails are soldered. These shot should seldom be used at a greater distance than 300 yards, and even at that range they scatter so much as to be nearly unserviceable; but at from 100 to 200 yards they are very destructive.

SHOT, COMMON CASE, OR CANISTER.						
Nature of Ordnance.		Weight of ball.	Number in each case.	Weight of case filled.		
		lb. oz.		lb.	oz.	dr.
IRON GUNS.	10 Inch* {	1	34	} 82	7	
		13⅛	50			
	8 Inch*	8	90	48	12	
	8 Inch*	8	90	48	12	
	68 Pr.*	8	90	50	4	
	56 Pr.*	1	50	52	11	
	42 Pr.†	8	85	45	15	
	32 Pr.†	8	66	34	13	
	24 Pr.†	8	46	10	7	
	18 Pr.†	6	46	10	7	
	12 Pr.†	4	46	12	2	
	9 Pr.†	3	44	9	11	
	6 Pr.†	2	40	5	10	
	3 Pr.†	1½	34	3	9	8
BRASS GUNS.	12 Pr.‡	2	126	17	4	
	‡	6½	41	16	14	
	9 Pr.‡	1½	126	12	15	
	‡	5	41	13	2	8
	6 Pr.‡	1½	85	8	13	
	‡	3¼	41	8	15	8
	3 Pr.‡	1½	41	4	3	8
HOWITZERS.	10 Inch*	8	170	85	6	
	8 Inch*	2	258	35	15	8

5½ Inch†	2	100	14	11	8
4⅘ Inch†	2	55	7	14	8
24 Pr.*	2	140	19	0	8
12 Pr.*	2	84	11	9	
CARRONADES.68 Pr.†	8	90	47	5	8
42 Pr.†	8	66	33	11	
32 Pr.†	8	40	20	13	
24 Pr.†	8	32	16	12	8
18 Pr.†	6	31	12	14	
12 Pr.†	4	32	8	3	8
9 Pr.†	3	30	6	7	8
6 Pr.†	2	30	4	9	

* Iron Tampeon. † Wood Tampeon. ‡ Tier Shot.

SHOT, GRAPE.							
Nature of Ordnance.		Weight of ball.		Number in each case.	Weight of Grapeshot.		
		lb.	oz.		lb.	oz.	dr.
GUNS.	10 Inch		3	24	81		
Shot Quilted.	68 Pr.	}	3	15	50	7	
	8 Inch						
	56 Pr.		4	12	56	14	
	42 Pr.		4	9	41	6	
	32 Pr.		3	9	29	11	
	24 Pr.		2	9	20	10	
	18 Pr.	1	8	9	16	12	
	12 Pr.		1	9	11	2	
	9 Pr.		13⅛	9	8	12	
	6 Pr.		8	9	8	7	
	3 Pr.		8	9	2	9	
CARRONADES.	68 Pr.		3	15	52	8	
Tin Case Shot.†	42 Pr.		4	9	37	15	
	32 Pr.		3	9	30	6	
	24 Pr.		2	9	20	9	
	18 Pr.	1	8	9	15	10	
	12 Pr.		1	9	11	0	8
	9 Pr.		13⅛	9	9	1	
	6 Pr.		8	9	5	2	

† Wood Tampeon.

STOOL BEDS.

NATURE.	BEDS.					BLOCKS.	
	Length.	Breadth.	Thickness.	Length.		Breadth.	Dept
	ft.	in.	in.	ft.	in.	in.	in.
42 Pr.	2·91	11	4·5	1	5	4·75	9
32 ”	2·91	10	4·25	1	5	4·75	9
24 ”	2·83	10	4·25	1	4	4·5	8
18 ”	2·85	9·5	4·25	1	3	4·5	8
12 ”	2·85	9·5	4	1	3	4·5	8
9 ”	2·85	9·5	4	1	1	4·5	8

TUBES.

Tubes are of five different natures—viz., Common quill, and Dutch or Paper tubes for exercise, and Detonating quill, and Brass tubes; and Friction tubes for service.

All tubes are gauged to two-tenths of an inch diameter.

The pipes for the *Quill tubes* are 2½ inches long; and the barrels of *Dutch tubes* are 1¾ inch in length. [12]

Composition for Common tubes.

Mealed powder, mixed with spirits of wine into a stiff paste.

DETONATING TUBES.

The quills of these tubes are cut to 2¾ inches in length. Small, or pigeon quills, are also prepared for the arms to receive the detonating composition; these are cut to ¾ of an inch in length; and a small hole is bored in the centre to communicate the composition to the body of the tube. The body of the tube is filled precisely in the same way as common

tubes.

Composition for the Crosses, or Arms, of Detonating tubes.

	grains.
Chlorate of potassa	230
Antimony	230
Glass, finely pounded	73

Brass tubes, *common*, are 3 inches long, and the cups, previous to being stamped, are one inch in diameter.

They are filled similarly to common quill tubes.

FRICTION TUBES.

These tubes are of copper, and are three inches in length. The detonating composition is inserted in a tin arm, into which is introduced and pressed down tight, by the sides of the aim, a piece of copper, grooved; with a small ring to receive the cord for firing the tube, and gun.

WADMILTILT.

Length, 14 ft. 6 in. Breadth, 11 ft. 6 in. Weight, 50 lb.

WOODEN BOTTOMS.

They are riveted to shot for brass guns to prevent the bore being indented in front of the seat of the shot by the first impulse of the powder: and to Shells, to keep the fuze in the centre of the bore.

PART VI.

FIELD BATTERY EXERCISE.[13]

STANDING DRILL.

Section. 1. Telling off the Detachments.[14]

Section 2. Posts of the Detachment.

Art. 1.—In Action.

No. 1. At the handspike.

Nos. 2, 3. Outside the wheels: with Howitzers rather in rear of the muzzle; with Guns in line with the front of the wheels.

Nos. 4, 5. In line with the breech.

No. 6. Five yards in rear of the left wheel.

No. 7. In rear of the Limber.

No. 8. Ten yards in rear of No. 6.

No. 9. Four yards in rear of the Limber.

Art. 2.—In Order of March.

No. 1. On the off-side at the wheel horses' heads.

Nos. 2, 3. In line with the muzzle.

Nos. 4, 5. In line with the breech.

Nos. 6, 7. In line with the axletree of the Limber.

Nos. 8, 9. In line with the splinter bar.

Art. 3.—In Front.

In line, ten yards in front of the leading horses.

Art. 4.—In Rear.

In line, two yards in rear of the muzzle of the Gun.

Art. 5.—In line with the gun axletree, one yard to the right or left of the wheel.

Art. 6.—Mounted.

No. 1. On the right.	} On the Gun limber.
No. 6. On the left.	
No. 3. On the right.	} On the Waggon limber.
No. 2. On the left.	
No. 3. On the right.	} On the front of the Waggon body.
No. 2. On the left.	
No. 7. On the right.	} On the rear of the Waggon body.
No. 8. On the left.	

When there are 9 men, No. 9 between Nos. 5 and 4.

Section 3. Change of Position of Detachments.

1. FORM THE ORDER OF MARCH.	*Nos. 1.* Right face. Double march.
2. FORM THE ORDER OF MARCH.	*Nos. 1.* Left face. Double march.
3. DETACHMENTS REAR.	*Nos. 1.* Right about face. Double march. Halt. Front.
4. DETACHMENTS FRONT.	*Nos. 1.* Double march. Halt.
5. DETACHMENTS RIGHT.	*Nos. 1.* Right (or left) face. Double march, front turn. Halt.
6. DETACHMENTS REAR.	*Nos. 1.* Right about face. Double march. Halt, front.

7. DETACHMENTS FRONT.	*Nos. 1.* Double march. Halt. Front.

Section 4. Detail of Duties in the service of Ordnance.

No. 1 Commands, and lays the Gun.

No. 2 Sponges.

No. 3 Loads, and serves ammunition.

No. 4 Serves the vent, and primes. After the discharge he clears the vent with the drift, previous to reloading.

No. 5 Fires.[15]

No. 6 Serves ammunition.

No. 7 Attends the Limber, and serves ammunition to No. 8.

No. 8 Assists No. 7.

No. 9 Attends the ammunition Waggon.

CHANGING ROUND.

No. 2	becomes	No. 4.	No. 8	becomes	No. 6.
No. 4	”	No. 9.	No. 6	”	No. 1.
			No. 1	”	No. 5.
No. 9	”	No. 7.	No. 5	”	No. 3.
No. 7	”	No. 8.	No. 3	”	No. 2.

Exercise, with Reduced Numbers.

Nos. Retained.	Distribution of duties.

	1	2	3	4	5	6	7	8
1, 2	1, 4, 5	2, 3, 6						
1, 2, 3	4, 5	2	3, 6					
1, 2, 3, 4	1	2	3, 6	4, 5				
1, 2, 3, 4, 5	1	2	3, 6	4	5			
1, 2, 3, 4, 5, 6	1	2	3	4	5	6		
1, 2, 3, 4, 5, 6, 7	1	2	3	4	5	6	7	
1, 2, 3, 4, 5, 6, 7, 8	1	2	3	4	5	6	7	8

DISTANCES REQUIRED

for a Battery of 6 Guns (4 horses to each Carriage).

In Line, from muzzle to muzzle	15	yards.
In Column of Route	177	”
” Sub-divisions	87	”
” Divisions	87	”
” Half battery	72	”

A Gun, or Waggon, with 4 Horses covers 11 yards of ground, from front to rear.

For every additional pair of Horses 4 yards should be added.

A Battery of 6 Guns, when limbered up at full intervals, occupies from

Right to left 78 yards.
Front to rear 26 yards.

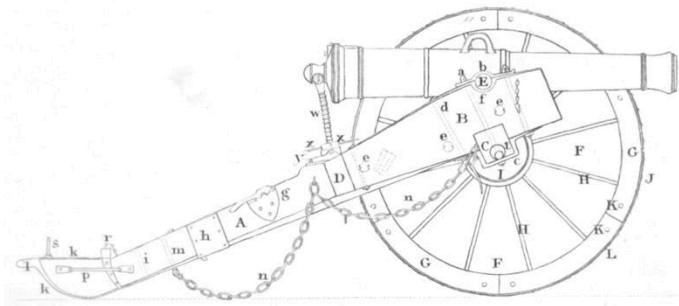
On each flank, 22 additional yards should be allowed.

A battery of 6 Guns, when unlimbered for Action, at full intervals, occupies from

Right to left 78 yards.
Front to rear 37 yards.

The space required for reversing a Gun with 4 Horses is 9 yards, and for a Waggon about 8 yards.

ELEVATION OF A 9 P^{R} BRASS FIELD CARRIAGE.

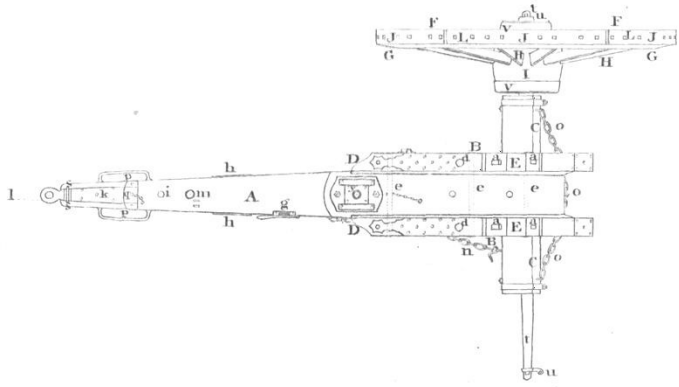


NAMES OF THE PRINCIPAL PARTS OF A FIELD GUN CARRIAGE.

A Block, or Trail.	J Tire, or Streak.	g Portfire clipper.	q Handspike shoe.
B Cheeks, or Brackets.	K Rivets.	h Locking plate.	r Handspike pin.
C Axletree.	L Tire, or Streak bolts.	i Trail plate bolt.	s Handspike ring.
D Ogee.	a Eye, or Capsquare bolts.	k Trail plate.	t Axletree arms.
E Trunnion holes.	b Capsquares.	l Trail plate eye.	u Dragwashers.
F Wheel.	c Axletree bands.	m Chain eye bolt.	v Nave hoops.
G Felly.	d Bracket bolts.	n Locking chain.	w Elevating screw.

H Spokes.	e Transom bolts.	o Breast, or advancing chain.	x Handles of elevating screw.
I Nave.	f Trunnion plates.	p Trail handles.	y Elevating screw box.

PLAN OF A 9 PR BRASS FIELD CARRIAGE.



Section 5. Method of performing the duties of serving ordnance.

Section 6. Ranges.

Section 7. Method of laying a piece of ordnance.

Section 8. Limbering up.

FRONT (REAR, RIGHT, OR LEFT) LIMBER UP. | Halt: Limber up.

Section 9. Unlimbering, or coming into action.

To the front, rear, right or left. The reverse of limbering up.

Section 10. Moving with the Prolonge.

PREPARE TO RETREAT WITH THE PROLONGE.	*Nos.* 1

THE BATTERY WILL RETIRE.	Right about face.
HALT.	Front.
UNHOOK PROLONGE.	
PREPARE TO ADVANCE WITH THE PROLONGE.	*Nos.* 3
ACTION.	Drive on.

Section 11. Mounting field ordnance, with the materials belonging to the battery.

Section 12. Dismounting field ordnance, with the materials belonging to the battery.

Section 13. Shifting shafts.

Section 14. Disengaging a shaft horse, when he falls, or is disabled in action.

Section 15. Changing wheels, when the lifting jack is not at hand.

Section 16. Shifting the medium 12 pounder.

Section 17. To remove disabled field artillery.

Section 18. Exercise with Drag-ropes.

1. A light 6 pounder with its limber requires 15 men, six of whom are told off entirely for the drag-ropes, the other men at the gun also assisting in manning them: No. 9 is always in the shafts, and No. 8 at the point of the shaft, near side. A 9 pounder requires additional men, and a double set of drag-ropes.

2. The drag-rope men are numbered off from 10 upward. Nos. 10, 12, 14, are with the left drag-rope; 11, 13, 15, with the right; 10, 11, carry the drag-ropes.

3. The gun being limbered up, and the detachment and drag-rope men in the order of march, at the word "HOOK ON," Nos. 8 and 9 get into their places; 10 and 11 move outside the gun detachments to the rear, and hook on to the gun drag-washers, passing the end of the drag-ropes at once to the front.

The Nos. then man the drag-ropes as follows:—Nos. 10 and 11 outside, close to the drag-washer; 2, 12, 3, and 13 the centre of the drag-rope; 4, 14, 5, and 15 the front; 6 and 7 the ends. The gun detachments inside, and the drag-rope men outside. No. 1 at the point of the shafts, off-side. At the word "UNHOOK," Nos. 10 and 11 unhook, coil up the drag-ropes; and the whole then form the order of march.

4. At the word "ACTION," whether to the "FRONT," "REAR," "RIGHT," or "LEFT," the drag-ropes are at once quitted; Nos. 10 and 11 unhook, and coil them up; and the whole of the drag-rope men retire with the limber, forming in front of it two deep, as they were numbered off. In limbering up, the drag-rope men form the order of march, and wait for the word to hook on.

FORMATION OF A BATTERY.

A battery of Artillery is generally composed of six pieces of ordnance, to which a Company of Artillery is attached. The number of ammunition, forge, and store waggons varies according to the nature of the ordnance.

Section 19. Fitting of saddles, bridles, harness, &c.

Section 20. Harnessing.

Section 21. Carrying forage.

Section 22. Instruction for Drivers.

Section 23. Parade, and inspection.

The Battery, limbered up, is told off by sub-divisions, divisions, and half batteries.

One gun and its waggon	constitute	a sub-division.
Two sub-divisions	”	a division.
Three sub-divisions	”	a half battery.

The battery is numbered from right to left by sub-divisions. It is then told off into three divisions. No. 1 the right; No. 2 the centre; No. 3 the left. Sub-divisions Nos. 1, 3, and 5 are also distinguished as right sub-divisions of divisions; and Nos. 2, 4, and 6 the left; the two centre sub-divisions are also to be named. It is also told off into half batteries, and these are distinguished by right, centre, and left sub-divisions of half batteries. The gun of direction should always be named. A flank gun is generally named with a battery of four guns, and the right centre gun with a battery of six guns.

Spare carriages, with the battery, form a third, and, if necessary, a fourth line, in rear. The forge and store-waggon always in the centre, and the ammunition waggons on the flanks, covering those in the front line.

Section 24. Posts, and duties of Officers, and mounted Non-commissioned officers, &c., at exercise.

Second Captain.

In line, limbered up.—One horse’s length in rear of the centre.

In column.—Two horses’ length from the centre on

the reverse flank.

In action.—He assists the Captain in general superintendence.

He dresses all points of formation, gives the word "*Steady*," when they have been correctly taken up, and the formation completed. When required he commands a division.

Subalterns.

In line, limbered up.—The senior on the right of the right division; the second on the left of the left division; the junior on the right of the centre division.

In column of route.—On the pivot flanks of their leading sub-divisions.

In column of divisions.—On the pivot flanks of their respective divisions.

In column of half-batteries.—The subaltern of the centre division, on the pivot flank of the leading half battery. The others continue on the same flank of their sub-divisions as when in line.

In action.—Between the guns of their divisions, a little in rear.

They command the divisions to which they are attached, dressing in line with, and close to the leaders, and always with the guns.

In shifting from one flank to the other.—It is always along the front, and at a canter; and in joining the new sub-division, the officer always turns his horse's head inwards.

Staff Serjeants.

In line, limbered up.—The senior on the right of the marker of the right division. The junior on the left of the marker of the left division.

In column of route.—One on the reverse flank of the leading gun; the other on the pivot flank of the rear carriage.

In column of divisions.—One between the guns of the leading, the other between the guns of the rear division.

In column of half-batteries.—On the reverse flank of the waggons of each half battery.

They take up points in changes of position. In line formations, 10 yards from the flank sub-divisions; in column formations, 10 yards in front and rear. They dress the markers when there is no staff officer; and the limbers and waggons in action.

Markers.

In line, limbered up.—In line with the leaders of the waggons, and covering their officers.

In column of route.—With their leading waggons covering their officers. (Without waggons, covering their officers, and in line with the centre horses of the gun.)

In column of divisions, and half-batteries.—They cover their officers. (Without waggons, on the reverse flank of their divisions.)

In action.—Those of the right, and centre divisions on the right of the leaders of the limbers of their right sub-divisions. The marker of the left division, on the left of the leaders of the limber of the left sub-division.

They take up points in changes of position; in line formations, for the sub-division nearest the one of formation; in column formations, for the pivot sub-division.

Farriers, and Artificers.

The farrier is generally attached to the forge; but when the battery is limbered up he is in the centre, in rear of the second captain. The other artificers are told off in the gun detachments when not mounted.

Trumpeters.

In line, limbered up.—On the right of the battery, in line with it, one horse's length distant.

In column.—One horse's length in front.

During manœuvres.—One with the commander; the other in rear of the battery.

MANŒUVRES OF A BATTERY OF SIX PIECES.

Section 25. BATTERY IN LINE.

1. To advance. Commanding officer's word of command repeated by officers.

[16]THE BATTERY WILL ADVANCE —MARCH.	*The officer, and marker of the sub-division of direction take up points.*

2. To retire.

RIGHT (OR LEFT) REVERSE —MARCH.	

3. To come into action.

ACTION FRONT.	*Senior staff-serjeants.*—Left reverse.

4. To diminish (or increase) intervals on the march.

To diminish.

HALF, OR QUARTER, INTERVALS ON—SUB-DIVISION.	*Nos.* 1. Right (or left) half turn—Trot—Front turn—Trot—(except No. 1 of the named sub-division).

To increase.

FULL INTERVALS ON—SUB-DIVISION.	

5. To take ground to a flank.

RIGHT (OR LEFT) TAKE GROUND — MARCH.	*The officers shift to the pivot flank of what will become their leading sub-divisions.*

6. To make a half turn on the march.

RIGHT (OR LEFT) HALF TURN—MARCH.	

7. To form Column of divisions in rear of a flank.

FORM COLUMN OF DIVISIONS IN REAR OF THE RIGHT.	*Centre division*—Right reverse—March—By the left—Left take ground—Halt—Dress.
MARCH.	*Left division*—Right reverse—March—By the left—Left half turn—Left take ground—Halt—Dress.
FORM COLUMN OF DIVISIONS IN REAR OF THE LEFT.	*Centre division*—Left reverse—March—By the right—Right take ground—Right take ground—Halt—Dress.
MARCH.	*Right division*—Left reverse—March—By the right—Right half turn—Right take ground—Halt—Dress.

8. To form Column of divisions in front of a flank.

FORM COLUMN OF DIVISIONS IN FRONT OF THE LEFT—	*Centre division*—Forward—March—Left take ground—Waggons close intervals—Right take ground—Halt—Dress.
MARCH.	*Right division*—Forward—March—Left half turn—Left half turn—Waggons close intervals—Right take ground—Halt—Dress.
FORM COLUMN OF DIVISIONS IN FRONT OF THE RIGHT—	*Centre division*—Forward—March—Right take ground—Waggons close intervals—Left take ground—Halt—Dress.
MARCH.	*Left division*—Forward—March—Right half turn—Right half turn—Waggons close intervals—Left take ground—Halt—Dress.

9. To form Column of divisions on the centre division.

This manœuvre is a combination of Nos. 7 and 8.

10. To change front to the rear.

First method. By a countermarch.

THE BATTERY WILL CHANGE FRONT TO THE REAR—GUNS RIGHT, WAGGONS LEFT TAKE GROUND—MARCH—	*The officers shift to the pivot flank of their leading guns—viz., to the left of 1, 3, and 5 guns.*
RIGHT COUNTERMARCH—FRONT TURN—HALT—DRESS.	

Second method. On the centre.

CHANGE FRONT TO THE REAR ON THE CENTRE—MARCH.	*Centre division*—Sub-divisions inwards about wheel—March—Halt—Dress. *Right division*—March—Left wheel—Left wheel—Halt—Dress. *Left division*—March—Right wheel—Right wheel—Halt—Dress.

Third method. When at diminished intervals; on the march.

THE BATTERY WILL CHANGE FRONT TO THE REAR; ON THE CENTRE. LEFT HALF BATTERY—HALT—HALF BATTERIES INWARDS ABOUT WHEEL—FORWARD.

11. To change front to a flank.

First method. Right (or left) back, on a flank subdivision.

Nos. 1.

CHANGE FRONT TO THE RIGHT ON NO. 6. MARCH.

6. Left wheel—Left about wheel—Halt—Dress.

5. } Right reverse.
4. } Left shoulders.
3. } Right reverse.
2. } Halt—Dress.
1. }

Nos. 1.

CHANGE FRONT TO THE LEFT ON NO. 1. MARCH.

1. Right wheel—Right about wheel—Halt—Dress.

2. } Left reverse.
3. } Right shoulders.
4. } Left reverse.
5. } Halt.
6. } Dress.

For Action.

CHANGE FRONT TO THE RIGHT, ON NO. 6, FOR ACTION. MARCH (OR CHANGE FRONT TO THE LEFT ON NO. 1, FOR ACTION. MARCH).

The named sub-division comes into action in the new direction; the others proceed as before, and come into action to the rear.

Second method. Right (or left) forward, on a flank sub-division.

Nos. 1.

CHANGE FRONT TO THE LEFT ON NO. 6. MARCH.

6. Right wheel—Right about wheel —Halt—Dress.

5. }
4. }
3. } Right shoulders.
2. } Halt—Dress.
1. }

Nos. 1.

CHANGE FRONT TO THE RIGHT ON NO. 1—MARCH.	1. Left wheel—Left about wheel—Halt—Dress.
	2. } 3. } Left shoulders. 4. } Halt. 5. } Dress. 6. }

For Action.

CHANGE FRONT TO THE RIGHT ON NO. 1 FOR ACTION—MARCH—(OR CHANGE FRONT TO THE LEFT ON NO. 6, FOR ACTION—MARCH).	*The named sub-division comes into action in the new direction; the others proceed as before, and come into action to the front.*

Third method. To the right (or left) *on a central sub-division*, one flank thrown forward, the other back.

This is a combination of the First and Second methods.

Note.—A battery may change its front, Half right, or Half left, on the same principle as already detailed. The commanding officer's word would be "CHANGE FRONT, HALF RIGHT (OR HALF LEFT) ON—SUB-DIVISION."

These manœuvres can be executed on the same principle, by divisions, or half batteries.

A Battery can also change front on a moveable pivot by a simple wheel.

12. To advance from a flank, in column.

ADVANCE FROM THE RIGHT, IN COLUMN OF DIVISIONS — MARCH.		Forward by the left. March.
	Right division.	
	Centre, and left divisions	Right take ground. March—Left take ground.
	Nos. 1.	
	2. } Waggon right.	Waggon rear.
	4. }	

ADVANCE FROM THE LEFT, IN COLUMN OF DIVISIONS —MARCH.	*Left division*	Forward by the right—March.
	Centre, and right divisions	Left take ground—March. Right take ground.
	Nos. 1.	
	5.} Waggon left.	Waggon rear.
	3.}	

13. To advance from the centre, in double column of sub-divisions.

ADVANCE FROM THE CENTRE, IN A DOUBLE COLUMN OF SUB-DIVISIONS —MARCH.	*Centre division*—Forward.—Trot—March. *Right division*—Left take ground—March. *Left division*—Right take ground—March.
	Nos. 1. 2. } Right take ground—Trot. 1. } Right take ground.

5. } Left take ground—Trot.
6. } Left take ground.

14. To move from a flank along the front in a column of divisions.

MOVE FROM THE RIGHT, ALONG THE FRONT, IN COLUMN OF DIVISIONS. MARCH.	Forward—March. Left wheel.

Note.—To advance from the left, along the front, is done in the same manner.

15. To advance from a flank, in echellon of sub-divisions.

ADVANCE FROM THE RIGHT, IN ECHELLON OF SUB-DIVISIONS —MARCH.	

Advancing from the Left is done on the same principle.

Note.—A Battery in echellon of Sub-divisions, if required to change its front when in action, can do so at the word "ACTION LEFT" (OR RIGHT), by merely throwing the trails round, and bringing the guns into the new direction, the limbers and waggons forming in rear of their guns.

16. To advance from a flank in echellon of divisions.

ADVANCE FROM THE RIGHT, IN ECHELLON OF DIVISIONS —MARCH.	*The right division advances, the centre moves off in succession, when at its wheeling distance, in rear of the leading one.* *The left division follows in the same manner.*

Advancing from the Left is done on the same principle.

Note.—A Battery in echellon of Divisions, if required to change its front when in action, does so as follows:—

CHANGE FRONT TO THE LEFT, ON THE LEFT GUNS OF DIVISIONS —MARCH.	*Nos.* 1. 2. } 4. } Action left. 6. } 1. } Front limber up. 3. } Left wheel—Halt. 5. } Action front.

An echellon of Half batteries is formed in the same manner as that of divisions; the rear half battery must, however, keep its wheeling distance from the leading one. When in action, if the front is to be changed, it is better to do it on a centre gun.

Retirements in echellon, are done on the same principle as the advance.

17. To retire from a flank in column.

First Method.

RIGHT DIVISION TO THE REAR—MARCH.	*Right division*—Sub-divisions inwards about wheel—March.
	Centre and left divisions—Forward—Right wheel—March—Right wheel.

To retire with the Left division is done on the same principle.

Second method.

RETIRE FROM THE RIGHT, IN COLUMN OF DIVISIONS—MARCH.	*Right division*—Right reverse—March.
	Centre, and left divisions—Right take ground—March—Right take ground.
	Nos. 1.
	2. } Gun left.
	4. } Gun rear.

18. To retire from the centre in a double column of sub-divisions.

In order to perform this manœuvre, the battery should be reversed, and then (with waggons leading) it is performed in the same manner as the advance from the centre, in a double column.

19. To retire from a flank by alternate Half batteries, in action.

When a battery in line, in action, is ordered to retire from a flank by alternate Half batteries, the named half battery at once limbers up to the rear, retires to its distance in echellon, and comes into action. As soon as this half battery is in action, the other limbers up to the rear, retires, passes the half battery in action, and so on. The senior officer of each half battery gives the word of command.

Note.—This manœuvre would generally be practised with the prolonge.

20. To break into column to a flank.

BREAK INTO COLUMN OF DIVISIONS TO THE RIGHT, MARCH.

Nos. 1. } Right take ground.
3. } Guns front.
5. }
2. }
4. } Right wheel.
6. }

Breaking into Column to the Left can be done on the same principle.

A Column of Half batteries can be formed in the same manner; the pivot sub-divisions wheeling as before, but the others after taking ground, must

incline away to gain their required intervals.

Note.—This movement would generally be employed in breaking into column from line, to march past with other troops; and with half batteries it would be done at reduced intervals.

21. To increase, and diminish the front.

First method.

From Column of route, to form Column of divisions, on the march.

Column, right in front.

FORM COLUMN OF DIVISIONS.	*Right division*—Forward by the left.
	Centre and left divisions.—Forward by the left. Trot—Walk.
	Nos. 1.
	2. }
	4. } Left half turn—Trot—Front turn.
	6. }

Column, left in front.

FORM COLUMN OF DIVISIONS.	*Left division*—Forward by the right.
	Centre and right divisions.—Forward by the right—Trot—Walk.
	Nos. 1.
	5. }
	3. } Right half turn—Trot.
	1. } Front turn.

Second method.

From Column of route, to form Column of divisions, in succession.

Column, right in front.

IN SUCCESSION FORM COLUMN OF DIVISIONS.	*Nos.* 1.
	1. }
	3. } Halt.
	5. }
	2. } Left half turn.
	4. } Front turn.
	6. } Halt—Dress.

Column, left in front.

IN SUCCESSION FORM COLUMN OF DIVISIONS.	*Nos.* 1.
	6. }
	4. } Halt.
	2. }
	5. } Right half turn.
	3. } Front turn.
	1. } Halt—Dress.

Third method.

From Column of divisions, to form Column of route, on the march.

Column right in front.

FORM COLUMN OF ROUTE. | *Centre and left divisions*—Halt.

Nos. 1.
1. Forward.
3. } Forward—March.
5. }
2. } Halt—Right half turn—March.
4. } Front turn.
6. }

Column left in front.

FORM COLUMN OF ROUTE. | *Centre and right divisions*—Halt.

Nos. 1.
6. Forward.
4. } Forward—March.
2. }
5. } Halt—Left half turn.
3. } March—Front turn.
1. }

22. To bring the Rear to the front, in succession, on the march.

First method. In Column of route.

REAR SUB-DIVISION TO THE FRONT. | *Nos.* 1.

6. }
5. }
4. } In succession { Right half turn.
3. } { Front turn.
2. }

Second method. In Column of divisions.

REAR DIVISION TO THE FRONT THROUGH THE INTERVALS.

Centre and rear divisions in succession.
Inwards close—Forward—Full intervals.

23. To form Line on the leading division.

Divisions right in front.

LEFT OF THE FRONT FORM LINE—MARCH.

Centre division—Left take ground—March—Right take ground—Halt—Dress.

Left division—Left take ground—March—Right half turn—Right half turn—Halt—Dress.

Divisions left in front.

RIGHT OF THE FRONT FORM LINE—MARCH.

Centre division—Right take ground—March—Left take ground—Halt—Dress.

Right division—Right take ground—March—Left half turn—Left half turn—Halt—Dress.

On the March.

The centre and rear divisions make a half turn towards the intended line, and come up at an increased pace.

For Action.

RIGHT (OR LEFT) OF THE FRONT FORM LINE FOR ACTION—MARCH.	Halt—Action front.

24. To form Line on the rear division.

Divisions right in front.

RIGHT OF THE REAR FORM LINE—MARCH.	*Centre division*—Right take ground—March—Right take ground—Right reverse—Halt—Dress.
	Right division—Right take ground—March—Right half turn—Right half turn—Right reverse—Halt—Dress.

Divisions left in front.

LEFT OF THE REAR FORM LINE—MARCH.	*Centre division*—Left take ground—March—Left take ground—Left reverse—Halt—Dress.
	Left division—Left take ground—March—Left half turn—Left half turn—Left reverse—Halt—Dress.

For Action.

RIGHT (OR LEFT) OF THE REAR, FORM LINE FOR ACTION, FRONT—MARCH.	*The standing division comes into action to the front: the others, as they arrive in line, come into action to the rear.*

25. To form Line on the centre division.

This manœuvre is a combination of Nos. 23 and 24.

26. To form Line to the rear on the leading division.

Divisions right in front.

FORM LINE TO THE REAR, ON THE LEADING DIVISION — MARCH.

Right division—Sub-divisions inwards about wheel—March—Halt—Dress.

Centre division—Right take ground—March—Left take ground—Sub-divisions inwards about wheel—Halt—Dress.

Left division—Right take ground—March—Left half turn—Left half turn—Sub-divisions inwards about wheel—Halt—Dress.

Divisions left in front.

FORM LINE TO THE REAR, ON THE LEADING DIVISION — MARCH.

Left division—Sub-divisions inwards about wheel—March—Halt—Dress.

Centre division—Left take ground—March—Right take ground—Sub-divisions inwards about wheel—Halt—Dress.

Right division—Left take ground—March—Right half turn—Right half turn—Sub-divisions inwards about wheel—Halt—Dress.

27. To form Line to the rear of the rear division.

Divisions right in front.

FORM LINE TO THE REAR, ON THE REAR DIVISION — MARCH.

Right division—Left wheel—March—Right shoulders—Right shoulders—Halt—Dress.

Centre division—Left wheel—March—Left wheel—Halt—Dress.

Left division—Sub-divisions inwards about wheel—March—Halt—Dress.

Divisions left in front.

FORM LINE TO THE REAR, ON THE REAR DIVISION — MARCH.

Left division—Right wheel—March—Left shoulders—Left shoulders—Halt—Dress.

Centre division—Right wheel—March—Right wheel—Halt—Dress.

Right division—Sub-divisions inwards about wheel—March—Halt—Dress.

28. To form Line to the rear on the centre division.

This is a combination of Nos. 26 and 27.

29. To form Line to the reverse flank on the leading division.

Divisions right in front.

FORM LINE TO THE RIGHT flANK ON THE LEADING DIVISION — MARCH.	*Right division*—Right wheel—March —Halt—Dress. *Centre, and left divisions*—Left half turn—March—Front turn—Right wheel—Halt—Dress.

Divisions left in front.

FORM LINE TO THE LEFT flANK ON THE LEADING DIVISION — MARCH.	*Left division*—Left wheel—March—Halt—Dress. *Centre, and right divisions*—Right half turn—March—Front turn—Left wheel —Halt—Dress.

30. To wheel into Line.

Divisions right in front.

LEFT WHEEL INTO LINE— MARCH.	*Nos.* 1. 1. } Sub-divisions, left 3. } wheel—Halt—Dress. 5. }

2. } Sub-divisions, right wheel—Right
4. } about wheel—Halt—Dress.
6. }

Divisions left in front.

RIGHT WHEEL INTO LINE—MARCH.

Nos. 1.

2. } Right wheel.
4. } Halt—Dress.
6. }
1. } Left wheel—Left about wheel.
3. } Halt—Dress.
5. }

31. To deploy on the rear division.

Note.—All deployments are on the front base.

Divisions right in front.

DEPLOY ON THE REAR DIVISION—MARCH.

Right division—Right take ground—March—Right take ground—Right reverse—Halt—Dress.

Centre division—Right take ground—March—Left take ground—Halt—March—Halt—Dress.

Left Division—Forward—March—Trot—Halt—Dress.

Divisions left in front.

DEPLOY ON THE REAR DIVISION — MARCH.	*Left division*—Left take ground—March—Left take ground—Left reverse—Halt—Dress.
	Centre division—Left take ground—March—Right take ground—Halt—March—Halt—Dress. *Right division*—Forward—Trot—March—Halt—Dress.

For Action.

DEPLOY ON THE REAR DIVISION, FOR ACTION FRONT—MARCH.	The Divisions all proceed as before, except that the leading division, instead of going to the rear and reversing, comes into action to the right, or left, when in its place; the other divisions come into action to the front.

32. To deploy on the Centre division.

DEPLOY ON THE CENTRE DIVISION — MARCH.	*Right division*—Right take ground—March—Right take ground—Right reverse—Halt—Dress.
	Centre division—Forward—Trot—March—Halt—Dress. *Left division*—Left take ground—March—Right take ground—Halt—Dress.

33. To countermarch.

THE COLUMN WILL COUNTERMARCH — DIVISIONS BY SUB-DIVISIONS INWARDS ABOUT WHEEL — MARCH —HALT — DRESS.	*The Sub-divisions wheel about* inwards, and halt on their markers. The officers moving up with their sub-divisions.

On the March.—The markers fall in rear of their officers.

34. From Double column of sub-divisions to form Line to the front.

RIGHT AND LEFT OF THE FRONT, FORM LINE— MARCH.	*Nos.* 1. 2. { Right half turn—Front turn. 1. { Halt—Dress. 5. { Left half turn—Front turn.

6. { Halt—Dress.

On the March.—The rear sub-divisions move up at an increased pace.

For Action.—At the word "MARCH," the two leading sub-divisions come into action to the front: the other sub-divisions come into action in succession as they arrive in line.

35. From Double column of sub-divisions, to form line to a flank.

FORM LINE TO THE RIGHT, ON THE RIGHT HALF BATTERY — MARCH.

Nos. 1.
3. } Right wheel—Halt—Dress.
2. } Forward—Right wheel.
1. } Halt—Dress.
4. } Forward—Right wheel.
5. } Halt—Dress.
6. }

To form Line to the left is done on the same principle.

INSPECTION, AND REVIEW.

A single Battery.

The Battery is formed in line limbered up; the detachments in the order of march.

The waggons at order—viz., ten yards in rear of their guns.

The Officers at order—viz., the Subalterns one horse's length in front of, and in the centre of their divisions.

The second Captain on the right of the battery, in line with the Subalterns.

The Staff serjeants on the outer flanks of the waggons.

The Markers move up into the places of their officers.

The Commanding officer in the centre of the battery, one horse's length in front of the Subalterns.

As the Inspecting Officer arrives, the Officers draw swords and salute; taking the time from the Commanding officer, whose word of command is "GENERAL SALUTE, DRAW SWORDS." The officers then recover their swords in like manner. As soon as the inspection has been made, the Commanding officer gives the word, "TAKE CLOSE ORDER—MARCH," when the officers and markers return to their places in line, the officers sloping their swords; and the waggons move up.

Marching past.

This may be done either by Divisions, or by Half batteries; in the latter case usually at half intervals.

THE
BATTERY
WILL
MARCH
PAST.

BREAK
INTO
COLUMN
OF
DIVISIONS
(OR
HALF
BATTERIES
AT
HALF
INTERVALS)
TO
THE
RIGHT
—
MARCH.

At thirty yards from the Inspecting officer, the Subaltern officers in command of divisions, or half batteries, give the word, "TAKE ORDER—EYES RIGHT," and move out one horse's length in the front of, and in the centre of their divisions. In Half batteries, the two officers of the leading half battery between the guns of it; the officer of the rear half battery in front of his centre gun. The Commanding Officer two horses' length in front of the battery, and the Second Captain in rear of the battery. The officers salute at six yards distance from the Inspecting officer, and recover their swords at ten yards past him. At twenty yards past, the Subaltern officers in command of divisions (or half batteries) give the word, "TAKE CLOSE ORDER."

In trotting past the detachments are mounted; the officers remain on the flanks, and carry swords as they pass the Inspecting officer, giving the word, "EYES RIGHT."

Should a battery be required to *rank past*, it wheels as before, until it arrives on the line of the Inspecting officer, when it halts.

THE BATTERY WILL RANK PAST—MARCH.

The battery advances in a column of route, the officers in front of the guns, the markers, staff-serjeants, and farrier in front of the waggons. The officers and drivers salute, as before. The spare carriages in rear of the divisions to which they belong: the second Captain in rear of the whole.

EQUIPMENT OF A BATTERY.

Sec. 32. Packing the Intrenching tools, Camp equipage, &c., &c.

1.—In equipping a battery for the march, the stores, intrenching tools, camp equipage, &c., are packed as follows:—

On gun limber.

Two carbines on the front of the boxes, barrels up.
Two fitting ropes on the foot board.
One swingletree between the foot board and the splinter bar.
One felling axe on the splinter bar, edge inwards.
One bill-hook under the foot board.
Two spades on the sides of the boxes, and fastened to the splinter bar.
One grease tin on the front of the axletree.
One pickaxe under the axletree.
One prolonge between the boxes, above the washer box.
Two water buckets on the back of the axletree.
Two corn sacks; two blankets folded (21 inches by 16), on the box
lids, the blankets uppermost.

On gun carriage.

One claw hammer } On each cheek.
One wrench hammer }
One pair of pinchers on the cheek.
One spare sponge, wadhook, and handspike, under the trail.
Two camp kettles in rear of axletree.

The whole of these stores, &c., are buckled on by Nos. 1, and 6.

On waggon limber.

One picket line on the foot board.
One lifting jack on the foot board.
One grease tin on the front of the axletree.
Two corn sacks, two blankets folded, on the box lids.

These stores are buckled on by Nos. 4, and 5.

On waggon body.

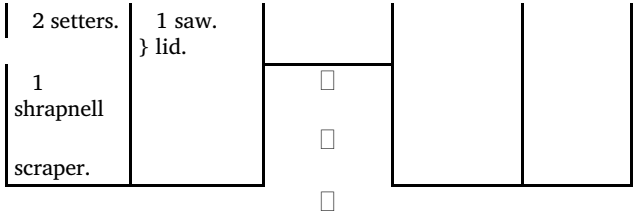
Four picket posts, two on each side of the boxes.
One maul under off end of rear foot board.
Spare horse-shoe box, under the front foot board.
Grease magazine under near end of rear foot board.
Four blankets on the box lids.
One camp kettle on the rear of the axletree.

These stores are buckled on by Nos. 2, 3, 7, and 8.

18 Pounder Gun.

LIMBER.

NEAR BOX.		MIDDLE BOX.	OFF BOX.	
3 solid shot, under.			6 solid shot.	3 solid shot, under.
3 common case, over.	6 shrapnell.		12 6 lb. cartridges	3 common case, over.
1 auger.	6 6 lb.} cartridges.			1 hammer.
1 corkscrew.	6 4½ }		6 portfires } on	1 set irons
1 clipper	6 5 oz. bursters.		slow match } lid.	priming.
portfire.	2 fuze boxes.			1 lock.
2 files.	2 fuze bags.			1 powder
1 funnel.	24 fuzes in four	4 couples.		horn.
1 knife.	bundles.			1 punch.
1 mallet.	1 powder horn.	2 linchpins		2 common
1 pincers.	quick match.			spikes.
1 rasp.	needles.	2 washers.		1 spike-
1 saw.	worsted.			spring.
1 scissors.	6 portfires } on			



FORE BOX.

10 sets of horse-shoes.	10 sets of horse-shoes.
6 shrapnell in two tiers. 24 fuzes in four bundles. 100 tubes. 1 spunge. 1 rammer head.	12 solid shot. 12 6 lb. } cartridges. 5 4½ lb. } 6 5 oz. bursters. 1 skein slow match.

HIND BOX.

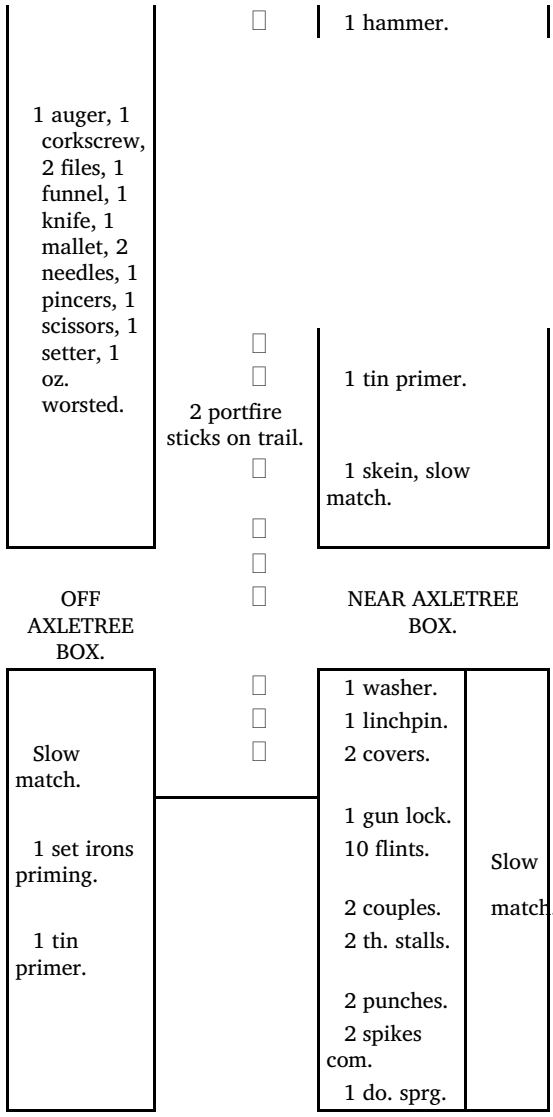
12 solid shot. 18 6 lb. cartridges. 2 tube boxes. 2 thumb-stalls. 2 portfire sticks. 1 skein slow match. 1 ditto Hambro' line. 1 ditto marline. 50 cartridges flannel, empty.	6 solid shot in two tiers.

Grease magazine. 10 sets of horse-shoes.

12 Pounder Medium Gun.

LIMBER.

NEAR BOX.	MIDDLE BOX.	OFF BOX.
9 4 lb. cartridges. 2 fuze bags, 6 in each. Quick match. 5 portfires } 1 saw } On lid.	6 shrapnell shells. 6 4 lb. cartridges. 6 4½ oz. bursters. Quick match.	9 4 lb. cartridges. 7 portfires on lid.
3 common case. 2 fuze boxes, 6 in each.		3 common case. 1 set irons priming. 1 punch. 100 tubes; 1 tube pocket.
6 solid shot, in 2 tiers.		6 solid shot, in two tiers.


1 hammer.
1 auger, 1 corkscrew, 2 files, 1 funnel, 1 knife, 1 mallet, 2 needles, 1 pincers, 1 scissors, 1 setter, 1 oz. worsted.
1 tin primer.
2 portfire sticks on trail.
1 skein, slow match.
OFF AXLETREE BOX.
NEAR AXLETREE BOX.
Slow match.
1 set irons priming.
1 tin primer.
1 washer.
1 linchpin.
2 covers.
1 gun lock.
10 flints.
2 couples.
2 th. stalls.
2 punches.
2 spikes com.
1 do. sprg.
Slow match.

Medium 12 Pounder Ammunition Waggon.

LIMBER.

NEAR BOX.

4 shrapnell. 40 fuzes, in 4 bundles.	6 solid shot. 8 4 lb. cartridges. 6 portfires, on lid.	MIDDLE BOX.	6 solid shot. 8 4 lb. cartridges. 6 portfires, on lid. 1 tube pocket. 100 tubes.	4 common case.
1 sk. Hambro' line.	6 shrapnell. 8 4 lb. cartridges. 10 4½oz. bursters.	2 washers. 2 linchpins.	6 solid shot.	1 skein of slow match.
1 sk. marline.	quick match.	2 couples.	8 4 lb. cartridges.	

OFF BOX.

FORE BOX.

15 sets of horse-shoes. 15 sets of horse-shoes.

4 solid shot, under. 4 shrapnell, over. 48 fuzes, in 4 bundles.	8 shrapnell. 12 4 lb. cartridges. 12 4½oz. bursters. Quick match (24 lengths).	8 solid shot. 12 4 lb. cartridges. 1 skein slow match.

HIND BOX.

8 solid shot.	8 solid shot.	8 solid shot, in 2 tiers.
12 4 lb. cartridges.	12 4 lb. cartridges.	1 spunge head. 1 rammer head.
50 empty flannel cartridges.		

9 Pounder Gun.

LIMBER.

NEAR BOX.

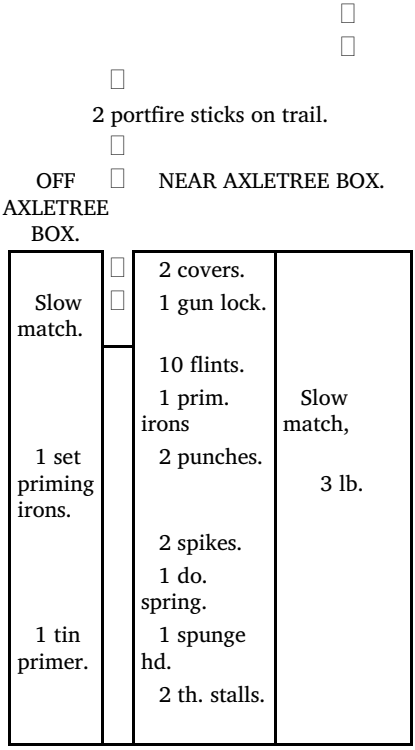
4 com. case.	6 solid shot.
1 auger.	
1 corkscrew.	8 2½lb.
2 files.	cartridges.
1 funnel.	
2 fuze boxes	6 portfires } On
6 in each.	1 saw } lid.
1 knife.	
1 mallet.	6 shrapnell.
2 needles.	
1 pincers.	8 2½lb.
1 saw set.	cartridges.
1 scissors.	6 3½oz.
1 setter.	bursters.
1 oz.worsted.	Quick match.
	2 fuze bags,
	6 in each.

MIDDLE BOX.

1 heavy washer.
1 light washer.
1 heavy linchpin.
1 light linchpin.
2 couples.
1 rammer head.

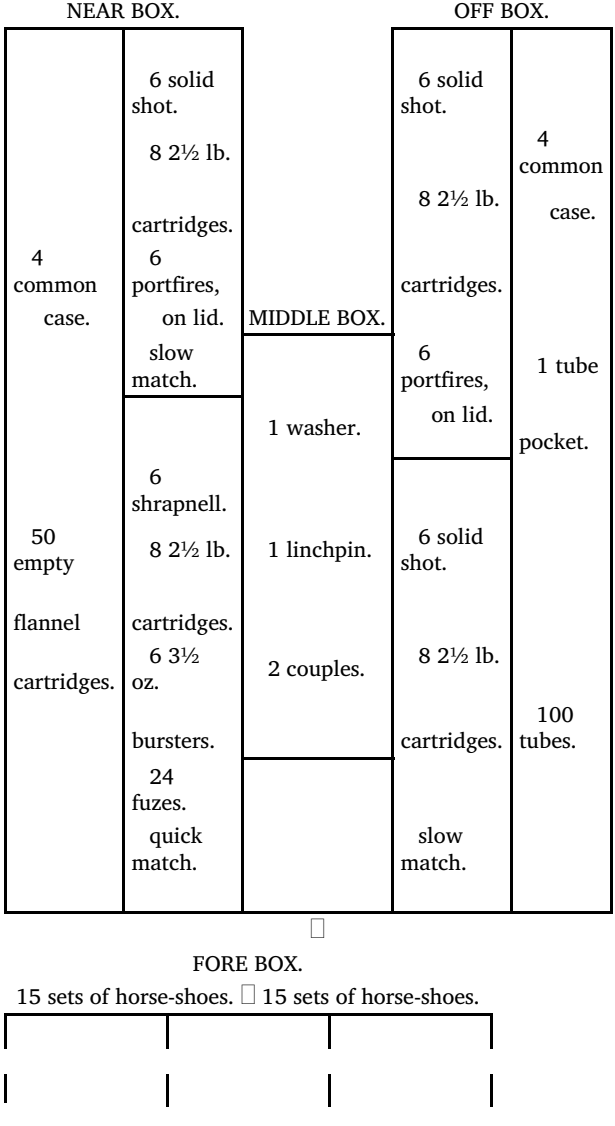
OFF BOX.

6 solid shot.	4 com. case.
8 2½lb.	1 tube
cartridges.	pocket.
6 portfires,	
on lid.	
Slow match.	100 tubes.
	1 tin primer.
6 solid shot.	
8 2½lb.	1 hammer.
cartridges.	


2 portfire sticks on trail.
OFF AXLETREE BOX.
NEAR AXLETREE BOX.
Slow match.
1 set priming irons.
1 tin primer.
2 covers.
1 gun lock.
10 flints.
1 prim. irons
2 punches.
2 spikes.
1 do. spring.
1 spunge hd.
2 th. stalls.
Slow match,
3 lb.

9 Pounder Ammunition Waggon.

LIMBER.



	8 shrapnell.	8 solid shot.
16 solid shot.	13 2½ lb. cartridges.	14 2½ lb. cartridges.
9 3 lb. cartridges.	8 3½ oz. bursters.	32 fuzes, in 4 bundles.
	quick match.	

HIND BOX.

8 solid shot.	8 solid shot.	
14 2½ lb. cartridges.	14 2½ lb. cartridges.	16 solid shot, in 2 tiers.
50 empty flannel cartridges. 1 skein marline. 1 ditto Hambro' line. slow match.		

Light 6 Pounder Gun.

NEAR BOX.

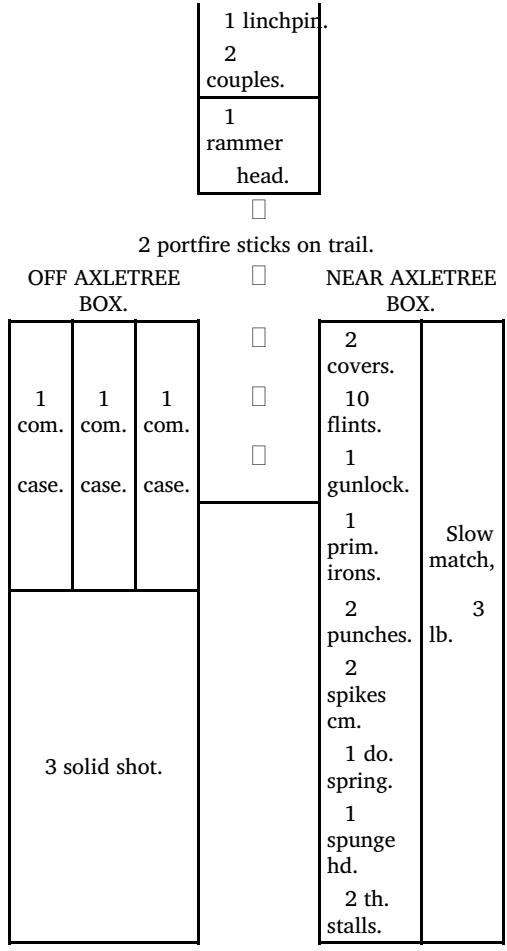
4 com. case.		
1 auger.	8 solid shot.	8 shrapnell.
1 corkscrew.		
2 files.		9 1½ lb.
1 funnel.	13 1½ lb.	cartridges.
2 fuze boxes,	cartridges.	
8 in each,		8 2½ oz.
C. and D.		bursters.
1 knife.		
1 mallet.		2 fuze bags,
2 needles.		8 in each,
1 pincers.		E. and 1 inch.
1 saw set.		
1 scissors.	6 portfires} on	Quick match.
1 setter.	1 saw } lid.	
1 oz. worsted.		

OFF BOX.

		4 common
8 solid shot.	8 solid shot.	case.
11 1½ lb.	13 1½ lb.	1 tin
cartridges.	cartridges.	primer.
100 tubes.	6 portfires on lid.	1 tube
Slow match.		pocket.
		1 hammer.

MIDDLE BOX.

1 washer.


1 linchpin.
2 couples.
1 rammer head.
2 portfire sticks on trail.
OFF AXLETREE BOX.
NEAR AXLETREE BOX.
1 com. case.
1 com. case.
1 com. case.
3 solid shot.
2 covers.
10 flints.
1 gunlock.
1 prim. irons.
2 punches.
2 spikes cm.
1 do. spring.
1 spunge hd.
2 th. stalls.
Slow match, 3 lb.

Light 6 Pounder Ammunition Waggon.

LIMBER.

NEAR BOX.

	8 solid shot.	8 shrapnell.
4 common case, under.	12 1½ lb. cartridges.	11 1½ lb. cartridges.
4 solid shot, over.	slow match.	8 2½ oz. bursters.
	6 portfires, on lid.	32 fuzes, in 4 bundles.
		quick match.

OFF BOX.

8 solid shot.	8 solid shot.	
12 1½ lb. cartridges.	13 1½ lb. cartridges.	4 common case, under.
100 tubes.		4 solid shot, over.
slow match.	6 portfires, on lid.	

MIDDLE BOX.

1 washer.
1 linchpin.
2 couples.

FORE BOX:

15 sets of horse-shoes.□ 5 sets of horse-shoes.

	10 shrapnell.	
	16 1½ lb. cartridges.	15 solid shot.
20 solid shot, in	10 2½ oz. bursters.	
2 tiers.	40 fuzes,	27 1½ lb. cartridges.
	in 4 bundles.	
	100 tubes.	1 tube pocket.
12 1½ lb. cartridges.	quick match.	
	6 portfires.	1 skein marline.
	slow match.	

HIND BOX.

15 solid shot.	10 solid shot.	30 solid shot,
		in 3 tiers.
27 1½ lb. cartridges.	18 1½ lb. cartridges.	
		5½ lb. slow
100 empty flannel	1 skein Hambro' line.	match.
cartridges.		

8 Inch Howitzer.

LIMBER.

NEAR BOX.

2 shrapnell.
6 4 lb. cartridges.
6 15 oz. bursters.
64 shrapnell fuzes, in 4 bundles.
2 fuze bags.
6 fuze boxes.
6 portfires, on lid.

2 shrapnell, in 2 tiers.

2 shrapnell, in 2 tiers.

MIDDLE BOX.

2 couples.

1 linchpin.

1 washer.

OFF BOX.

2 common shells, in 1 tier.
6 4 lb. cartridges.
6 1 lb. 14 oz. bursters.
2 tube pockets.
2 thumb-stalls.
100 tubes.
6 portfires, on lid.

2 common shells, in 2 tiers.

2 common shells, in 2 tiers.

1 skein slow match.

15 common fuzes.

WAGGON BODY.

FORE BOX.

10 sets of horse-shoes. 10 sets of horse-shoes.

2 shrapnell, in 2 tiers.

8 4 lb. cartridges.

7 15 oz. bursters.

1 shrapnell, under.

1 common case, over.

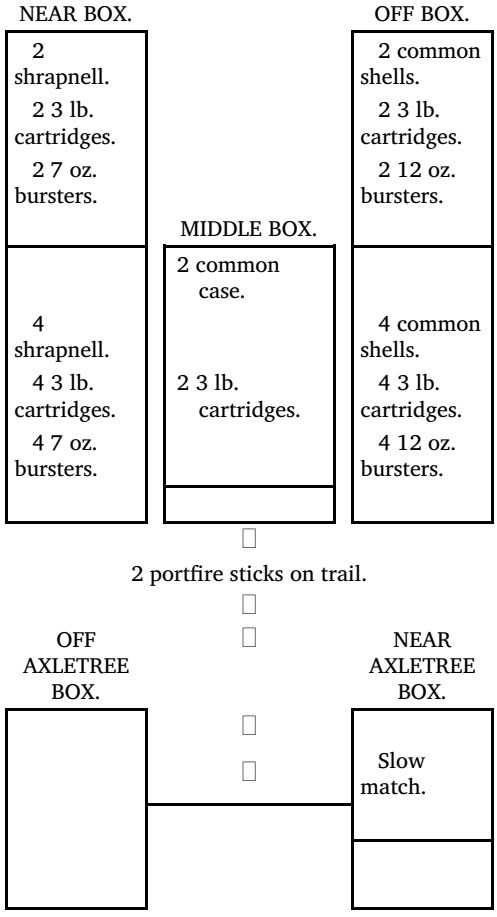
2 shrapnell, in 2 tiers.	28 shrapnell fuzes, in 4 bundles.	2 shrapnell, in 2 tiers. 1 skein—match.

HIND BOX.

1 common shell, under. 1 common case, over.	8 4 lb. cartridges.	2 common shells, in 2 tiers.
1 common shell, under. 1 common case, over. 1 skein Hambro' line.	6 1 lb. 14 oz. bursters. 50 empty flannel cartridges.	2 common shells, in 2 tiers. 1 skein marline.

32 Pounder Howitzer.

LIMBER.



32-Pounder Howitzer Ammunition Waggon.

NEAR BOX.

				OFF BOX.		
2 shrapnell, in 2 tiers.	12 3 lb. cartridges. 10 7 oz. bursters.	4 shrapnell. 2 common case.	MIDDLE BOX.	6 common shells, in 2 tiers.	12 3 lb. cartridges. 12 12 oz. bursters.	6 common shells, in 2 tiers.

FORE BOX.

10 sets of horse-shoes. 10 sets of horse-shoes.

6 shrapnell, in 2 tiers.	6 shrapnell. 9 3 lb. cartridges. 12 7 oz. bursters.	3 common shells. 6 3 lb. cartridges. 3 12 oz. bursters.

HIND BOX.

3 common shells. 6 3 lb. cartridges.	6 common shells. 9 3 lb. cartridges.	6 common shells, in 2 tiers.

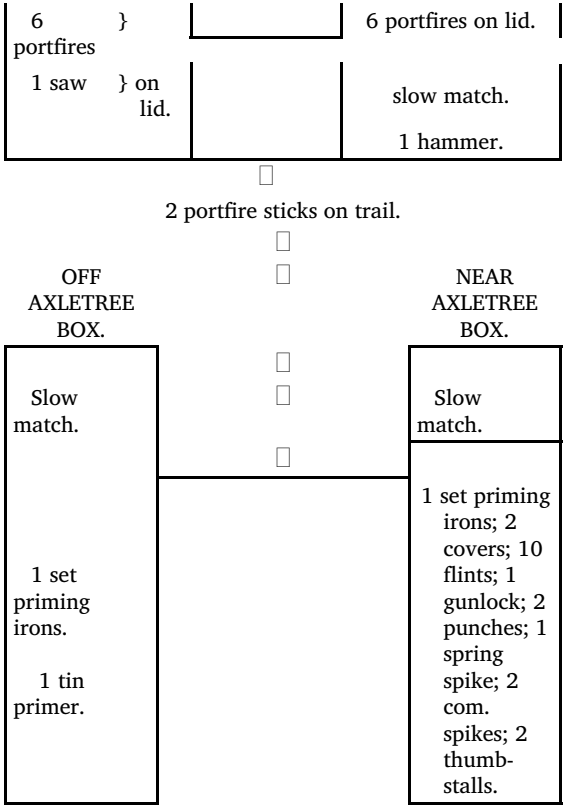
6 12 oz. bursters.	9 12 oz. bursters.	

grease magazine. 10 sets of horse-shoes.

24-Pounder Howitzer.

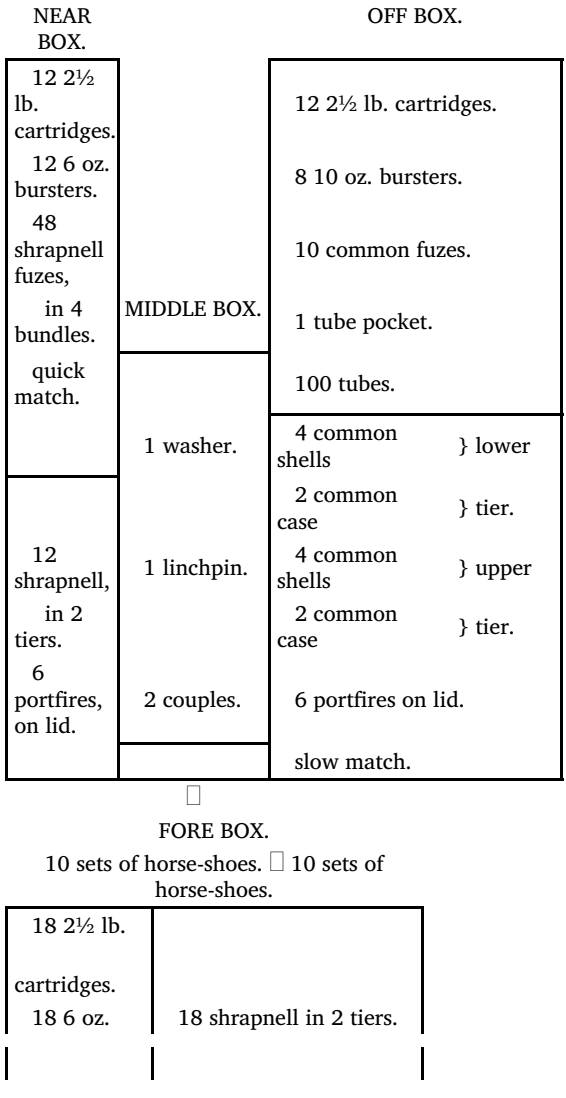
LIMBER.

NEAR BOX.		OFF BOX.
12 2½ lb. cartridges; 12 6 oz. bursters; 1 auger; 1 corkscrew; 1 funnel; 2 fuze boxes; 2 fuze bags, 12 fuzes in each; 50 empty flannel cartridges; 1 knife; 1 mallet; 2 needles; 1 pr. pincers; 1 saw set; 1 pr. scissors; 2 setters; 1 oz. worsted; quick match.		12 2½ lb. cartridges; 8 10 oz. bursters; 10 common fuzes; 1 pr. compasses; 2 files; 1 rasp; 1 rule; 1 scraper; 1 tube pocket; 100 tubes; 1 tin primer.
	MIDDLE BOX.	
12 shrapnell, in 2 tiers.	2 washers. 2 linchpins. 2 couples.	4 common shells } lower 2 common case } tier. 4 common shells } upper 2 common case } tier.


6 portfires } on lid.
1 saw
6 portfires on lid.
slow match.
1 hammer.
2 portfire sticks on trail.
OFF AXLETREE BOX.
NEAR AXLETREE BOX.
Slow match.
1 set priming irons.
1 tin primer.
Slow match.
1 set priming irons; 2 covers; 10 flints; 1 gunlock; 2 punches; 1 spring spike; 2 com. spikes; 2 thumb-stalls.

24-Pounder Howitzer Ammunition Waggon.

LIMBER.



bursters. 72 shrapnell fuzes, in 4 bundles. Quick match.	1 skein of slow match.

HIND BOX.

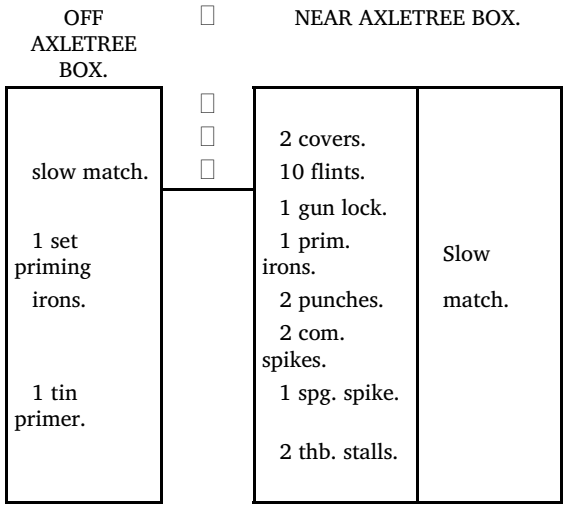
7 common shells }	
2 carcasses } lower tier.	
9 common shells, upper tier.	18 2½ lb.
1 skein marline.	cartridges.
1 skein Hambro' line.	
1 spunge head.	16 10 oz.
1 rammer head.	bursters.
50 empty flannel cartridges.	
20 common fuzes.	

12-Pounder Howitzer.

LIMBER.

NEAR BOX.		MIDDLE BOX.	OFF BOX.	
12 shrapnell, in 2 tiers.	6 shrapnell.		2 common shells	12 common shells, in 2
1 auger.	18 1¼ lb. cartridges.		4 common case.	tiers.
1 corkscrew.	18 4½ oz. bursters.		18 1¼ lb. cartridges.	1 compasses.
1 funnel.	2 fuze boxes.		14 5 oz. bursters.	17 common fuzes.
1 knife.	(C and D),			2 files.
1 mallet.	16 in each.			1 hammer.
2 needles.	2 fuze bags,	1 washer.		1 rasp.
1 pr. pincers.	(E and 1 inch,)	1 linchpin.		1 rule.
1 saw set.	18 in each.	2 couples.	6 portfires,	1 shell scraper.
1 pr. scissors.	quick match.		on lid.	slow match.
2 setters.	6 portfires,		1 saw, on lid.	1 tin primer.
1 oz. worsted.	on lid.			100 tubes.
72 fuzes.				1 tube pocket.

2 portfire sticks on trail.


OFF AXLETREE BOX.
NEAR AXLETREE BOX.
slow match.
1 set priming irons.
1 tin primer.
2 covers.
10 flints.
1 gun lock.
1 prim. irons.
2 punches.
2 com. spikes.
1 spg. spike.
2 thb. stalls.
Slow match.

12-Pounder Howitzer Ammunition Waggon.

LIMBER.

NEAR BOX.

12 shrapnell, in 2 tiers.	6 shrapnell.
	18 1¼ lb.
72 fuzes, in 4 bundles.	cartridges.
	18 4½ oz.
Slow match.	bursters.
6 portfires, on lid.	quick match.

MIDDLE BOX.

1 washer.

1 linchpin.

2 couples.

OFF BOX.

2 common shells.	12 common shells, in
4 common case.	2 tiers.
18 1¼ lb.	17 common fuzes.
cartridges.	slow match.
14 4½ oz.	1 shell
bursters.	scraper.
6 portfires.	100 tubes.
	1 tube pocket.

FORE BOX.

15 sets of horse-shoes. 15 sets of horse-shoes.

16 shrapnell, in 2 tiers.	28 1¼ cartridges.	16 shrapnell, in 2 tiers.
8 1¼ lb. cartridges,	32 4½ oz.	64 fuzes in 2

over.	bursters.	bundles.
64 fuzes in 2 bundles.	quick match.	slow match.

HIND BOX.

16 common shells, in 2 tiers.	28 1¼ lb. cartridges.	4 com. shells } 4 carcasses } under. 8 common shells, above.
34 common fuzes.		1 skein Hambro' line.
100 flannel cartridges, empty.	28 5 oz. bursters.	1 skein marline. 1 rammer head. 1 spunge head.

Sec. 34. Weight of Riders, Harness, Ordnance, Carriages, &c., of a Field battery equipped.

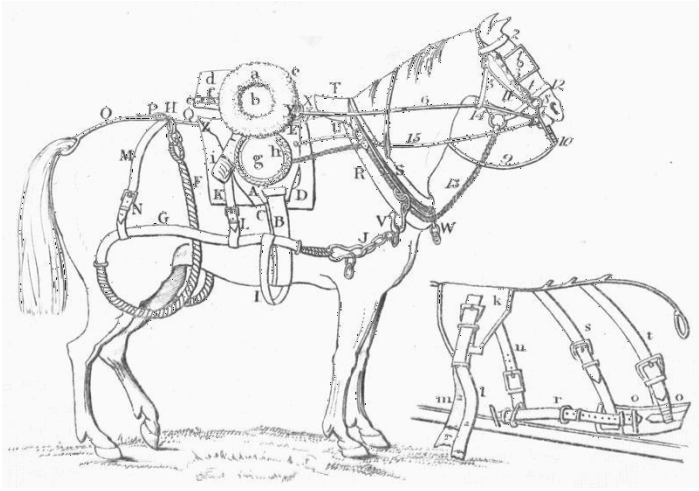
		st.	lb.
Lead	Riding set of harness, with head-collar and chain	4	8
	Driver, in marching order (including greatcoat and apron)	12	3
	Total weight carried by riding horse	16	11
	Off set, with head-collar, chain, &c., and man's kitt	5	4
Wheel	Riding set of harness, with head-collar and chain	5	0
	Driver, in marching order (including greatcoat and apron)	12	3
	Total weight carried by riding horse	17	3
	Off set of harness, with head-collar, chain, &c., and man's kitt	6	2
	Mounted N. C. officer's appointments, including greatcoat, apron, and kitt	5	2
	Non-commissioned officer	12	10

Total weight carried by horse	17 12

The average weight of an Artillery horse is 10 cwt. 2 qrs.

Ordnance, Carriages, and Stores.

	12-pounder.	9-pounder.	24-pounder howitzer.	12-pounder howitzer.	Light 6-pounder.
	cwt. qrs. lb.	cwt. qrs. lb.	cwt. qrs. lb.	cwt. qrs. lb.	cwt. qrs. lb.
Gun, carriage, and limber	39 2 15	33 1 23	32 3 3	24 2 7	23 3 11
Side arms, intrenching tools, &c.	3 14	3 10	2 25	2 23	3 2
Ammunition, &c.	3 3 17	3 3 20	4 3 25	3 3 15	3 2 16
Total	44 1 18	38 0 25	38 1 25	29 0 17	27 1 1
Waggon limber & body, including spare wheel	19 1 14	19 0 26	17 0 25	17 0 25	18 2 26
Stores, intrenching tools, spare horse-shoes, &c.	4 0 7	4 0 7	4 0 7	4 0 7	4 0 7
Ammunition	11 3 26	10 3 16	12 0 5	10 1 9	10 2 8
Total	35 1 19	34 0 21	33 1 9	31 2 13	33 1 13



Off Leader.

Shaft Harness.

OFF LEADER

A *Pad or Off Saddle*
B *Surcingle*
C *Girth of the Pad*
D *Pannel of Dº*
E *Pad Staples*
F *Trace*
G *Pipe of Dº*
H *Hook of Dº*
I *Belly Band of Dº*
J *Trace Lines*
K *Bearing Strap*
L *Buckling Piece of Dº*
M *Hip Strap*
N *Buckling Piece of Dº*
O *Crupper*
P *Crupper Ring*
Q *Buckling Piece of Crupper*

R *Collar*
S *The Hames*
T *The Housing*
U *The Housing Strap*
V *Shoulder Link & Hook*
W *Breast Chains or Links*
X *Wither Strap*
Y *Bearing Hook*
Z *Cantle of Pad*
a *Sheepskin*
b *Valise*
c *Baggage Strap*
d *Mess Tin*
e *Dº. Strap*
f *Buckle of Dº*
g *Wooden Canteen*
h *Forage Cord*
i *Nose Bag*

THE BRIDLE.

1 *Winker*
2 *Front or Brow Band*
3 *Cheek*
4 *Cheek Billets*
5 *Throat Lash*
6 *Bearing Rein*
7 *Bit*
8 *Cheek of Dº*
9 *Leading Rein*
10 *Bar of the Bit*
11 *Head-Collar*
12 *Nose Band*
13 *Collar Chain*
14 *Jowl Strap*
15 *Side Rein*

SHAFT HARNESS.

k *Pad or off Saddle*
l *Back Band*

m *Shaft Tugs*
n *Bearing Strap*
o *Breeching*
r *Strap of Breeching*
s *Loin Strap*
t *Hip Strap*

Detail of a 9-Pounder Troop of Royal Horse Artillery for Active Service, with the Army in the East.

Key:
A = Number of Carriages.
C = Gunners.
D = Drivers.
E = Riding.
F = Draught.
G = Total.

K = Sets of Appointments N. C. Officers and Men.
L = Harness Sets Double.
M = Lead.
N = Wheel.

A	Equipment.	Men.			Horses.				L			
		C	D	G	E	F	G	K	M	N		
4	9-Pounder Guns	40	16	56	40	32	72	40	12	4		
2	24-Pounder Howitzers	20	8	28	20	16	36	20	6	2		{ (
6	Gun Ammunition Waggons	12	18	30	4	36	40	4	12	6	Officers.	{ S
5	Howitzer Ammunition Waggons	10	15	25	2	30	32	2	10	5		{ I

1	Store Limber Waggon	.	3	3	.	6	6	.	2	1	
1	Spare Gun Carriage	.	3	3	.	6	6	.	2	1	
1	Forge	.	3	3	.	6	6	.	2	1	
1	Rocket Carriage	.	4	4	.	8	8	.	3	1	Non-Comm-
1	Store Cart	.	1	1	.	2	2	.	.	1	issioned
1	Medicine Cart	.	1	1	.	2	2	.	.	1	Officers
2	Light Forage Waggons	.	4	4	.	8	8	.	2	2	and Men.
3	Water Carts	.	3	3	.	6	6	.	.	3	
.	{For 2 Staff Serjeants, { 2 Trumpeters, { 1 Farrier, { 3 Shoeing-Smiths	.	.	.	8	.	8	8	.	.	Artificers.
.	{Spare Men, Officers' { Servants and Bâtmen, { &c., and Spare	15	44	59	6	16	22	.	4	4	
.	{ Horses Officers' Horses	.	.	.	12	.	12	.	.	.	
.	Bât Horses	.	.	.	.	6	6	.	.	.	
28	Total Carriages. Total	97	123	220	92	180	272	74	55	32	

Detail of the Reserve of Gun and Small Arm Ammunition, Royal Horse Artillery, for Active Service with the Cavalry of the Army in the East.

Key:
A = Number of Carriages.
C = Gunners.
D = Drivers.
E = Riding.
F = Draught.
G = Total.

K = Sets of Appointments N. C. Officers and Men.
L = Harness Sets Double.
M = Lead.
N = Wheel.

A	Distribution.	Men.			Horses.				L			
		C	D	G	E	F	G	K	M	N		
12	Gun Ammunition Waggons	.	36	36	.	72	72	.	24	12		
6	Howitzer Ammunition Waggons	.	18	18	.	36	36	.	12	6		{
6	Carbine Ammunition Waggons	.	18	18	.	36	36	.	12	6	Officers.	{

1	Store Limber Waggon	.	3	3	.	6	6	.	2	1		{
1	Forge	.	3	3	.	6	6	.	2	1		{
.	2 Portable Forges	2	.	2	2	.	2	.	.	.		
3	Light Forage Waggons	.	6	6	.	12	12	.	3	3		{
3	Water Carts	.	3	3	.	6	6	.	.	3	Non-Comm-	{
1	Store Cart	.	1	1	.	2	2	.	.	1	issioned	{
1	Medicine Cart	.	1	1	.	2	2	.	.	1	Officers	{
	{ 2 Staff Serjeants,										and	{
	{ 9 Serjeants,										Men.	{
	{ 6 Corporals,											{
.	{ 6 Bombardiers,	.	.	.	30	.	30	30	.	.		
	{ 3 Trumpeters,											{
	{ 1 Farrier,										Artificers.	{
	{ 3 Shoeing-Smiths											{
.	Servants and Bâtmen	7	7	14	.	.	.	.	.	.		{
.	Mounted Gunners	48	.	48	48	.	48	48	.	.		
.	Spare Men	49	50	99	.	.	.	.	.	.		
.	Spare Horses	.	.	.	12	42	54	8	10	10		
34	Total Carriages. Total	106	146	252	92	220	312	86	65	44		

Detail of a 9-Pounder Field Battery, Royal Artillery, for Active Service with the Army in the East.

Key:
A = Number of Carriages.
C = Gunners.
D = Drivers.
E = Riding.
F = Draught.
G = Total.

H = Sets of Appointments.
I = Officers.
J = N. C. Officers.
L = Harness Sets Double.
M = Lead.
N = Wheel.

A	Equipment.	Men.			Horses.			H		L		
		C and D		G	E	F	G	I	J	M	N	
4	9-Pounder Guns	40	16	56	.	32	32	.	.	12	4	
2	24-Pounder Howitzers	20	8	28	.	16	16	.	.	6	2	
6	Gun Ammunition Waggons	12	18	30	.	36	36	.	.	12	6	
5	Howitzer Ammunition	10	15	25	.	30	30	.	.	10	5	Officers.

	Waggons											
1	Store Limber Waggon	.	3	3	.	6	6	.	.	2	1	
1	Spare Gun Carriage	.	3	3	.	6	6	.	.	2	1	
1	Forge	.	3	3	.	6	6	.	.	2	1	
1	Rocket Carriage	.	4	4	.	8	8	.	.	3	1	Non-Comm-
1	Store Cart	.	1	1	.	2	2	.	.	.	1	issioned
1	Medicine Cart	.	1	1	.	2	2	.	.	.	1	Officers
2	Light Forage Waggons	.	4	4	.	8	8	.	.	2	2	and Men.
3	Water Carts	.	3	3	.	6	6	.	.	.	3	
.	For Staff-Serjeants and mounted Non-Com. Officers	.	.	.	14	.	14	.	14	.	.	
	For Trumpeters	.	.	.	2	.	2	.	2	.	.	
	For Farrier	.	.	.	1	.	1	.	1	.	.	Artificers.
	For Shoeing-smiths	.	.	.	1	.	1	.	1	.	.	
.	Spare Men, Officers' Servants and Bâtmen, &c., and Spare Horses	15	24	39	2	20	22	.	1	3	3	
.	Officers' Horses	.	.	.	6	.	6	6	.	.	.	
.	Bât Horses	.	.	.	.	6	6	.	.	.	.	
28	Total Carriages. Total	97	103	200	26	184	210	6	19	54	31	

9-Pounder Field Battery, Royal Artillery.—Detail of the RIGHT Division.

Key:
A = Number of Carriages.
B = N. C. Officers and Artificers.
C = Gunners.
D = Drivers.
E = Riding.
F = Draught.

H = Sets of Appointments.
I = Officers.
J = N. C. Officers.
L = Harness Sets Double.
M = Lead.
N = Wheel.

	Equipment.	No. 1 Sub-division.								
			Men.		Horses.		H		L	
A		B	C	D	E	F	I	J	N	M
2	9-Pounder Gun	.	10	4	.	8	.	.	1	3
3	Gun Amm. Wag.	.	2	3	.	6	.	.	1	2
1	Forge	.	.	3	.	6	.	.	1	2
1	Forage Waggon	.	.	2	.	4	.	.	1	1
1	Store Cart	.	.	.	.	.	.	.	.	.
1	Water Cart	.	.	.	.	.	.	.	.	.

.	Staff Serjeants	.	.	.	.	.	.	.	.	.
.	Serjeants	1	.	.	1	.	.	1	.	.
.	Corporals	.	.	.	.	.	.	.	.	.
.	Bombardiers	2	.	.	1	.	.	1	.	.
.	Trumpeters	1	.	.	1	.	.	1	.	.
.	Farriers	1	.	.	1	.	.	1	.	.
.	Shoeing-smiths	1	.	.	.	.	.	.	.	.
.	Collar-maker	.	.	.	.	.	.	.	.	.
.	For Officers	.	.	.	1	1	1	.	.	.
.	Spare	.	4	4	.	4	.	.	1	.
9	Total.	6	16	16	5	29	1	4	5	8

A	Equipment.	No. 2 Sub-division.									
		B	Men.		Horses.		H		L		
			C	D	E	F	I	J	N	M	
2	9-Pounder Gun	.	10	4	.	8	.	.	1	3	
3	Gun Amm. Wag.	.	4	6	.	12	.	.	2	4	
1	Forge	.	.	.	.	.	.	.	.	.	
1	Forage Waggon	.	.	.	.	.	.	.	.	.	
1	Store Cart	.	.	1	.	2	.	.	1	.	
1	Water Cart	.	.	1	.	2	.	.	1	.	
.	Staff Serjeants	1	.	.	1	.	.	1	.	.	
.	Serjeants	1	.	.	1	.	.	1	.	.	
.	Corporals	1	.	.	1	.	.	1	.	.	
.	Bombardiers	1	.	.	.	.	.	.	.	.	
.	Trumpeters	.	.	.	.	.	.	.	.	.	
.	Farriers	.	.	.	.	.	.	.	.	.	
.	Shoeing-smiths	1	.	.	.	.	.	.	.	.	
.	Collar-maker	1	.	.	.	.	.	.	.	.	
.	For Officers	.	.	.	1	1	1	.	.	.	
.	Spare	.	2	4	.	4	.	.	.	1	

Officers	{ 1st Captain (No. 2)
	{ Senior Lieut (No. 1)
	{ Staff Serjeant
	{ Serjeants
Non-Comm-	{ Corporal
issioned	{ Bombardier
Officers	{ Gunners
and Men.	{ Drivers
	{ Trumpeter
	{ Farrier
Artificers.	{ Shoeing-smiths
	{ Collar-make
Horses.	{ Riding
	{ Draught
Appointments.	{ Officers
	{ N. C. Officers
Harness.	{ Wheel
	{ Lead

9	Total.	6	16	16	4	29	1	3	5	8

N. B.—The Gunners attached to first line of waggons are the Officers' Servant Bâtmen, viz.—2 to each sub-division. The mounted Coverers or Horseholders m taken from either full Non-Commissioned Officers or the acting Bombardie whom 12 are allowed to be made, at the discretion of the officer commanding.

9-Pounder Field Battery, Royal Artillery.—Detail of CENTRE Division.

Key:
A = Number of Carriages.
B = N. C. Officers and Artificers.
C = Gunners.
D = Drivers.
E = Riding.
F = Draught.

H = Sets of Appointments.
I = Officers.
J = N. C. Officers.
L = Harness Sets Double.
M = Lead.
N = Wheel.

	Equipment.	No. 3 Sub-division.								
			Men.		Horses.		H		L	
A		B	C	D	E	F	I	J	N	M
2	24-Pr. Howitzers	.	10	4	.	8	.	.	1	3
5	How. Amm. Wag.	.	4	6	.	12	.	.	2	4
1	Spare Gun Carriage	.	.	3	.	6	.	.	1	2
1	Medicine Cart	.	.	.	.	.	.	.	1	.
1	Water Cart	.	.	1	.	2	.	1	.	.
.	Serjeants	2	.	.	1	.	.	.	.	.

.	Corporals	1	.	.	1	.	.	1	.	.
.	Bombardiers	1	.	.	.	.	.	.	.	.
.	Wheeler (senior)	1	.	.	.	.	.	.	.	.
.	Collar-maker	.	.	.	.	.	.	.	.	.
.	Shoeing-smith	1	.	.	.	.	.	.	.	.
.	For Officers	.	.	.	1	1	1	.	.	.
.	Spare	.	2	4	1	3	.	1	1	.
10	Total.	6	16	18	4	32	1	3	6	9

		No. 4 Sub-division.									
A	Equipment.	B	Men.		Horses.		H		L		Officers. { Junior Li (No. 3.)
			C	D	E	F	I	J	N	M	{ Assist.- Surgeon (No. 4.)
2	24-Pr. Howitzers	.	10	4	.	8	.	.	1	3	{ Serjeant
5	How. Amm. Wag.	.	6	9	.	18	.	.	3	6	Non-Comm- { Corpora
1	Spare Gun Carriage	.	.	.	.	.	.	.	.	.	issioned { Bombard
1	Medicine Cart	.	.	1	.	2	.	.	1	.	Officers { Gunners
1	Water Cart	.	.	.	.	.	.	.	.	.	and Men. { Drivers
.	Serjeants	2	.	.	1	.	.	1	.	.	{ Wheeler (senior)
.	Corporals	1	.	.	1	.	.	1	.	.	Artificers. { Collar-ma
.	Bombardiers	1	.	.	.	.	.	.	.	.	{ Shoeing- smiths
.	Wheeler (senior)	.	.	.	.	.	.	.	.	.	Horses. { Riding
.	Collar-maker	1	.	.	.	.	.	.	.	.	{ Draught
.	Shoeing-smith	1	.	.	1	.	.	1	.	.	Appointments. { Officers
.	For Officers	.	.	.	1	1	1	.	.	.	{ N. C. Officers
.	Spare	.	1	4	.	3	.	.	.	1	Harness. { Wheel
10	Total.	6	17	18	4	30	1	3	5	10	{ Lead

9-Pounder Field Battery, Royal Artillery.—Detail of the LEFT Division.

Key:
A = Number of Carriages.
B = N. C. Officers and Artificers.
C = Gunners.
D = Drivers.
E = Riding.
F = Draught.

H = Sets of Appointments.
I = Officers.
J = N. C. Officers.
L = Harness Sets Double.
M = Lead.
N = Wheel.

	Equipment.	No. 5 Sub-division.								
			Men.		Horses.		H		L	
A		B	C	D	E	F	I	J	N	M
2	9-Pounder Guns	.	10	4	.	8	.	.	1	3
3	Gun Amm. Wag.	.	4	6	.	12	.	.	2	4
1	Store Limber Wag.	.	.	.	.	.	.	.	.	.
1	Forage Waggon	.	.	2	.	4	.	.	1	1
1	Rocket Carriage	.	.	.	.	.	.	.	.	.
1	Water Cart	.	.	1	.	2	.	.	1	.

.	Staff Serjeant	1	.	.	1	.	.	1	.	.
.	Serjeant	1	.	.	1	.	.	1	.	.
.	Corporal	1	.	.	1	.	.	1	.	.
.	Bombardier	1	.	.	.	.	.	.	.	.
.	Wheeler	.	.	.	.	.	.	.	.	.
.	Collar-maker	1	.	.	.	.	.	.	.	.
.	Shoeing-smith	1	.	.	.	.	.	.	.	.
.	Trumpeters	.	.	.	.	.	.	.	.	.
.	For Officers	.	.	.	1	1	1	.	.	.
.	Spare	.	2	4	1	3	.	.	.	1
9	Total.	6	16	17	5	30	1	3	5	9

A	Equipment.	No. 6 Sub-division.								
		B	Men.		Horses.		H		L	
			C	D	E	F	I	J	N	M
2	9-Pounder Guns	.	10	4	.	8	.	.	1	3
3	Gun Amm. Wag.	.	2	3	.	6	.	.	1	2
1	Store Limber Wag.	.	.	3	.	6	.	.	1	2
1	Forage Waggon	.	.	.	.	.	.	.	.	.
1	Rocket Carriage	.	3	4	.	8	.	.	1	3
1	Water Cart	.	.	.	.	.	.	.	.	.
.	Staff Serjeant	.	.	.	.	.	.	.	.	.
.	Serjeant	1	.	.	1	.	.	1	.	.
.	Corporal	1	.	.	1	.	.	1	.	.
.	Bombardier	1	.	.	.	.	.	.	.	.
.	Wheeler	1	.	.	.	.	.	.	.	.
.	Collar-maker	.	.	.	.	.	.	.	.	.
.	Shoeing-smith	1	.	.	.	.	.	.	.	.
.	Trumpeters	1	.	.	1	.	.	1	.	.
.	For Officers	.	.	.	1	1	1	.	.	.
.	Spare	.	1	4	.	3	.	.	1	.

Officers. { 2nd Ca (No. 5)
{ 2nd Se Lieut. (
{ Staff Serjea
{ Serjea
Non-Comm- { Corpo
issioned { Bomba
Officers { Gunn
and Men. { Drive
{ Trump
{ Wheele
Artificers. { Col.-ma (sen.)
{ Shoeing smith
Horses. { Riding
{ Draug
Appointments. { Officers
{ N. C. Officer
Harness. { Whee

9	Total.	6	16	18	4	32	1	3	5	10 { Lead

Detail of an 18-Pounder Field Battery, Royal Artillery, for Active Service with the Army in the East.

Key:
A = Number of Carriages.
C = Gunners.
D = Drivers.
E = Riding.
F = Draught.
G = Total.

H = Sets of Appointments.
I = Officers.
J = N. C. Officers.
L = Harness Sets Double.
M = Lead.
N = Wheel.

A	Equipment.	Men.			Horses.			H		L		
		C and D		G	E	F	G	I	J	M	N	
4	18-Pounder Guns	56	24	80	.	48	48	.	.	16	8	
12	Gun Ammunition Waggons	24	36	60	.	72	72	.	.	24	12	
2	Store Limber Waggons	.	6	6	.	12	12	.	.	4	2	Officers.
1	Spare Gun Carriage	.	4	4	.	8	8	.	.	2	2	

1	Platform Waggon	.	4	4	.	8	8	.	.	2	2	
1	Forge	.	3	3	.	6	6	.	.	2	1	
1	Store Cart	.	1	1	.	2	2	.	.	.	1	
1	Medicine Cart	.	1	1	.	2	2	.	.	.	1	
2	Light Forage Waggons	.	4	4	.	8	8	.	.	2	2	Non-Comm-
3	Water Carts	.	3	3	.	6	6	.	.	.	3	issioned
.	For Staff-Serjeants and											Officers
	Non-Commissioned	.	.	.	10	.	10	.	10	.	.	and Men.
	Officers											
	Trumpeters	.	.	.	2	.	2	.	2	.	.	
	Farrier	.	.	.	1	.	1	.	1	.	.	
	Shoeing-Smith	.	.	.	1	.	1	.	1	.	.	Artificers
.	Spare Men, Officers'											
	Servants and Bâtmen,	15	24	39	2	20	22	.	1	3	3	
	&c., and Spare Horses											
.	Officers' Horses	.	.	.	6	.	6	6	.	.	.	
.	Bât Horses	.	.	.	.	6	6	.	.	.	.	
28	Total Carriages. Total	95	110	205	22	198	220	6	15	55	37	

Detail of a 32-Pounder Howitzer Field Battery, Royal Artillery, for Active Service with the Army in the East.

Key:
A = Number of Carriages.
C = Gunners.
D = Drivers.
E = Riding.
F = Draught.
G = Total.

H = Sets of Appointments.
I = Officers.
J = N. C. Officers.
L = Harness Sets Double.
M = Lead.
N = Wheel.

A	Equipment.	Men.			Horses.			H		L		
		C and D		G	E	F	G	I	J	M	N	
4	32 Pounder Howitzers	48	16	64	.	32	32	.	.	12	4	
12	Howitzer Ammunition Waggons	24	36	60	.	72	72	.	.	24	12	{ C
1	Store Limber Waggon	.	3	3	.	6	6	.	.	2	1	Officers. { S
1	Spare Howitzer Carriage	.	4	4	.	8	8	.	.	3	1	{ L

1	Forge	.	3	3	.	6	6	.	.	2	1	
1	Store Cart	.	1	1	.	2	2	.	.	.	1	
1	Medicine Cart	.	1	1	.	2	2	.	.	.	1	
2	Flanders Waggons	.	4	4	.	8	8	.	.	2	2	
3	Water Carts	.	3	3	.	6	6	.	.	.	3	Non-Comm-
.	For Staff Serjeants, and											issioned
	Mounted Non-Com.	.	.	.	10	.	10	.	10	.	.	Officers
	Officers											and Men.
	Trumpeters	.	.	.	2	.	2	.	2	.	.	
	Farrier	.	.	.	1	.	1	.	1	.	.	
	Shoeing-smith	.	.	.	1	.	1	.	1	.	.	
.	Spare Men, Officers'											Artificers.
	Servants and Bâtmen,	15	24	39	2	20	22	.	1	3	3	
	&c., and Spare Horses											
.	Officers' Horses	.	.	.	6	.	6	6	.	.	.	
.	Bât Horses	.	.	.	.	6	6	.	.	.	.	
26	Total Carriages. Total	87	95	182	22	168	190	6	15	48	29	

Detail of a Reserve of Gun and Small Arm Ammunition for Active Service with the Army in the East.

Key:
A = Number of Carriages.
C = Gunners.
D = Drivers.
E = Riding.
F = Draught.
G = Total.

H = Sets of Appointments.
I = Officers.
J = N. C. Officers.
L = Harness Sets Double.
M = Lead.
N = Wheel.

A	Equipment.		Men.			Horses.			H		L		
			C and D		G	E	F	G	I	J	M	N	
30	Ammunition { Gun	4	8	12	20	.	24	24	.	.	8	4	
	Waggons { Howitzer	2	4	6	10	.	12	12	.	.	4	2	
	{ Small arm	24	24	72	96	.	144	144	.	.	48	24	Officers
1	Store Limber Waggon		.	3	3	.	6	6	.	.	2	1	

1	Forge	.	3	3	.	6	6	.	.	2	1	
1	Store Cart	.	1	1	.	2	2	.	.	.	1	
1	Medicine Cart	.	1	1	.	2	2	.	.	.	1	
2	Light Forage Waggons	.	4	4	.	8	8	.	.	2	2	
3	Water Carts	.	3	3	.	6	6	.	.	.	3	Non-Comm-
.	For Staff-Serjeants and											issione
	Mounted Non-Com.	.	.	.	10	.	10	.	10	.	.	Office
	Officers											and Men.
	Trumpeters	.	.	.	2	.	2	.	2	.	.	
	Farrier	.	.	.	1	.	1	.	1	.	.	
	Shoeing-smith	.	.	.	1	.	1	.	1	.	.	
.	Spare Men, Officers'											Artifice
	Servants and Bâtmen,	12	27	39	2	18	20	.	1	2	1	
	&c., and Spare Horses											
.	Officers' Horses	.	.	.	6	.	6	6	.	.	.	
.	Bât Horses	.	.	.	.	6	6	.	.	.	.	
39	Total Carriages. Total	48	132	180	22	234	256	6	15	68	40	

Detail of a Gun Ammunition Reserve for Active Service, and to be attached to the Reserve Artillery with the Army in the East.

Key:
A = Number of Carriages.
C = Gunners.
D = Drivers.
E = Riding.
F = Draught.
G = Total.

H = Sets of Appointments.
I = Officers.
J = N. C. Officers.
L = Harness Sets Double.
M = Lead.
N = Wheel.

A	Equipment.	Men.			Horses.			H		L		
		C and D		G	E	F	G	I	J	M	N	
24	Ammunition { 16 Gun	32	48	80	.	96	96	.	.	32	16	
	Waggons { 8 Howitzer	16	24	40	.	48	48	.	.	16	8	
1	Store Limber Waggon	.	3	3	.	6	6	.	.	2	1	Officers
1	Forge	.	3	3	.	6	6	.	.	2	1	
1	Store Cart	.	1	1	.	2	2	.	.	.	1	

1	Medicine Cart	.	1	1	.	2	2	.	.	.	1	
2	Light Forage Waggons	.	4	4	.	8	8	.	.	2	2	
3	Water Carts	.	3	3	.	6	6	.	.	.	3	
2	Spare Gun Carriages—	.	6	6	.	12	12	.	.	4	2	Non-Comm-
	1 Gun and 1 Howitzer											issioned
.	For Staff-Serjeants and											Officers
	Mounted Non-Com.	.	.	.	14	.	14	.	10	.	.	and Men.
	Officers											
	Trumpeters	.	.	.	2	.	2	.	2	.	.	
	Farrier	.	.	.	1	.	1	.	1	.	.	
	Shoeing-smiths	.	.	.	2	.	2	.	2	.	.	Artifice
.	Spare Men, Officers'											
	Servants and Bâtmen,	15	30	45	2	20	22	.	1	2	1	
	&c., and Spare Horses											
.	Officers' Horses	.	.	.	6	.	6	6	.	.	.	
.	Bât Horses	.	.	.	.	6	6	.	.	.	.	
35	Total Carriages. Total	63	123	186	27	212	239	6	16	60	36	

Detail of a Small Arm Ammunition Reserve for Active Service, to be attached to the Reserve Artillery with the Army in the East.

Key:
A = Number of Carriages.
C = Gunners.
D = Drivers.
E = Riding.
F = Draught.
G = Total.

H = Sets of Appointments.
I = Officers.
J = N. C. Officers.
L = Harness Sets Double.
M = Lead.
N = Wheel.

A	Equipment.	Men.			Horses.			H		L		
		C and D		G	E	F	G	I	J	M	N	
36	Small Arm Ammunition Waggons	36	108	144	.	216	216	.	.	72	36	{
1	Store Limber Waggon	.	3	3	.	6	6	.	.	2	1	Officers. {
1	Forge	.	3	3	.	6	6	.	.	2	1	{
1	Store Cart	.	1	1	.	2	2	.	.	.	1	{
1	Medicine Cart	.	1	1	.	2	2	.	.	.	1	

2	Light Forage Waggons	.	4	4	.	8	8	.	.	2	2		{
3	Water Carts	.	3	3	.	6	6	.	.	.	3		{
.	For Staff-Serjeants and											Non-Comm-	{
	mounted Non-Com.	.	.	.	10	.	10	.	10	.	.	issioned	{
	Officers											Officers	{
	Trumpeters	.	.	.	2	.	2	.	2	.	.	and Men.	{
	Farrier	.	.	.	1	.	1	.	1	.	.		{
	Shoeing-smith	.	.	.	1	.	1	.	1	.	.		
.	Spare Men, Officers'												{
	Servants and Bâtmen,	30	31	61	4	20	24	.	2	4	2	Artificers.	{
	&c., and Spare Horses												{
.	Officers' Horses	.	.	.	6	.	6	6	.	.	.		{
.	Bât Horses	.	.	.	.	6	6	.	.	.	.		
45	Total Carriages. Total	66	154	220	24	272	296	6	16	82	47		

ON THE INTERIOR MANAGEMENT OF A BATTERY.

1. The greatest care should be paid to the fittings of the saddles and collars; extensive sore backs and galled shoulders arise chiefly from neglect on the march: and by prompt attention on the part of the officers, many horses may be preserved to the service, which would otherwise be disabled for months. The drivers should never be suffered to lounge in their saddles, or to sit uneven. A folded blanket under the saddle is found to be the best preventive of sore backs, as it adapts the shape of the saddle to any loss of flesh in the animal.

On long marches, the shaft horse should invariably be provided with a half blanket under the pad saddle; every driver should also have attached to his harness a pair of pads of basil leather, about six inches by four, stuffed with hair; and the moment any tenderness is perceived in a horse’s shoulder, the pressure should be relieved by placing the pads above and below the tender part.

2. On a march, there will always be an advanced and rear guard; the advanced guard of one day becoming the rear guard of the next. On arriving on the ground where the battery is to be parked, the advanced guard will immediately pitch their tent, and post sentinels. When the battery quits its ground, the non-commissioned officer of the guard is responsible that nothing be left behind.

3. When a battery is to march, the camp kettles, and everything that will not be required before morning, should be lashed on the carriages at sunset.

4. In parking guns, the usual interval is ten or twelve paces; but on a march, that everything may be better under the eye of the sentinels, the intervals may be diminished to three or four paces. The guns are to be in the first line, covered by their respective waggons; the spare ammunition and store carriages in the third line. The tents of the detachment are sometimes on the flanks of the battery, and sometimes in rear of their respective sub-divisions: the officers in rear of the battery. The horses are sometimes picketed in rear of the whole, and parallel to the line of guns, and sometimes perpendicular to this line, and on the flanks between the detachments, tents, and the carriages; but in general, the form of encamping will depend on the nature of the ground and local circumstances. In every situation the approach to the park, and the road by which the guns are brought out, should be kept clear and open.

5. If the battery is parked in hot weather, the naves of the wheels must be defended as much as possible from the effect of the sun, by sods or other covering.

6. When a battery arrives in camp, quarters, or cantonments, each non-commissioned officer will immediately examine every part of the carriages of his sub-division, especially the wheels, to the greasing of which he will attend. Any damages, to be repaired without delay, he will report to the officer of his division, who will report to the commander of the battery.

7. When a battery is in stationary quarters, there must be a weekly inspection of every part of the battery, and a parade in marching order, when circumstances will permit; at which parade, every part of the harness and appointments of gunners and

drivers is expected to be in the best order. Particular attention should be paid to the state of the ammunition, which should be frequently aired; and no fresh ammunition should ever be received without being gauged to the guns.

8. The drivers must immediately report any loss or breakage of their harness; and, on the instant, make known to the non-commissioned officer of the sub-division, any gall or other hurt which may have happened to the horses committed to their charge: any neglect on this point must be punished. Airing and beating with a knotted rope the stuffing of the collars and saddles is an important part of the driver's duty, which should never be omitted on continued marches. In camp, greasy heels are the most common disability which horses labour under; and as they proceed from cold, occasioning humours to settle, the best preventive is hand-rubbing and exercise, to keep up a circulation.

9. Unless for some particular purpose, the elevating screws should never be raised higher than the half of their length; on a march, they should be covered with a piece of canvas, or an old flannel cartridge, which will prevent their being clogged with dirt; and the travelling chain should be always applied. The pintail, and the trail plate eye, should be greased previous to marching.

10. After a field day, or an action, the bores of the guns should be washed, and then laid under metal.

11. If a wheel be so disabled as not to be worth repairing, the nave, if not damaged, should be at any rate saved. If the nave be good, a new wheel can easily be made from materials perhaps found on the spot, but it is very difficult to find a nave.

12. In marching in ordinary circumstances, the officer next for duty will always proceed in advance, to take up quarters, and to choose ground for parking, or encamping on; and the officer on duty for the day will always march in, and bring up the rear.

13. When a battery is to march, and "*Boot and saddle*" has been sounded, the officer of the day, the non-commissioned officers, drivers, and horses will turn out, and immediately proceed to the park and put-to; if encamped, tents to be struck, and lashed to the carriages. At the sound "*Turn out*," the whole of the officers, non-commissioned officers, and gunners, repair to the park; and when the usual inspections have been made, and the regular reports delivered to the commander, the battery will be marched off.

14. Feeding will always take place three times a day at the park, under the inspection of the officer of the day; when the nose-bags have been filled by the non-commissioned officer in charge of the forage, the trumpeter is to sound "*Feed*," the nose-bags are put on, and the drivers fall in, in front; after the feed, the nose-bags are rolled up and buckled on.

15. A non-commissioned officer is to have charge of and serve out the corn and forage, which for security will be deposited at the park guard; but on a march, when the corn is carried on the ammunition waggons, no more corn should be taken off the carriages than is likely to be wanted.

16. Buckets are provided for watering the horses on a march; by this means they can be watered from wells or places inaccessible to the animals, or at least to more than one or two of them at a time: but the operation is a long one. If on a march a small river or stream of water is to be forded, this opportunity of

watering them, or at any rate of giving them a mouthful of water in crossing it, should be seized: it saves much time. Should the stream, however, be very rapid, or deep, or should there be troops immediately in the rear, no halt should be made in fording it.

17. The *Serjeant-major* is to superintend all parades and drills, under the inspection of the officer on duty. The *Quartermaster serjeant* is to draw provisions and forage; he is to make out returns, and have charge of the spare stores.

18. The *Trumpeter* is always to be quartered in the nearest billet to the commanding officer; and the men and horses of each sub-division and division to be as near together as possible. A gunner from each sub-division, or a gunner of the guard, is to be made acquainted with the quarters of the commander of the battery, that in any emergency there may be no delay in finding him out: the same applies to the officers of divisions as far as their divisions are concerned.

19. The *Farrier* is to report every evening to the commanding officer the state of the sick animals; and on the ——, (the particular days to be mentioned) a return, in writing, of the number of horse (and mule, if any) shoes, and quantity of horse medicines expended.

20. The senior *Collar-maker*, the *Jobbing-smith*, and the *Wheeler*, to make similar reports of the stores expended in their several departments: these reports to be delivered to the serjeant-major, to be laid by him before the commander of the battery.

21. The *Artificers* are to work as near as possible to the park guard, the non-commissioned officer of

which is responsible that no work is done, or horse shod, except for the battery, without written permission from the commander.

22. The *Forge*, when employed, should be removed to a proper distance from the park. It should, at night, be brought back to its place, and everything arranged on it, so that, should the battery be suddenly ordered to march, there may be no delay.

LASSO.

Lasso harness consists of a brown leather surcingle, and one trace. The surcingle is rather wider than a common girth, and is composed of two pieces (joined together by rings), one of which is placed over the saddle, and the other round the belly of the horse. There are also rings at the end of the surcingle, which is drawn very firmly round the horse, and fastened tight by lapping a white leather thong (fixed at one end of the surcingle) through these rings. There are two descriptions of traces, one being 8, and the other 12 feet long. They have hooks at each end, and, when the lasso harness is made use of by cavalry, &c., to assist draught horses in moving very heavy carriages, or in dragging guns, &c., up steep hills, one of these hooks is fastened to a ring in the surcingle, and the other to the carriage, &c.

Lasso harness may be advantageously employed with all horses; even those unaccustomed to draught having been found perfectly tractable and efficient the first time they were required to draw by means of the lasso. When two horses are in draught, the traces must be inside, and each rider should keep his horse’s croup a little outwards.

EMBARKING, AND DISEMBARKING.

The following directions will be found applicable to nearly all the cases likely to occur: such as embarking, or disembarking from a beach; from a wharf; with, or without boats; in presence of an enemy, &c., &c.

Sec. 39.[17] Embarking Guns, and Carriages.

Preparations.

1. On the arrival of the battery at the place of embarkation, it is to be drawn up in as compact order as is consistent with the performance of the operations required. The horses are to be taken out; the harness taken off and packed in vats, and the stores in cases. When there are no vats and cases, the stores must be secured to the carriages or tied together: the intrenching tools may remain with the carriages. The non-commissioned officers in charge of sub-divisions will attach to their harness and stores, pieces of basil having the number of their sub-divisions written upon them. The harness for each carriage should be embarked with it.

2. The gun detachments will prepare the carriages for embarkation. They will take off the side arms and secure them together, take out the elevating screws, unkey the cap-squares, unlash the ammunition boxes, and coil up the lashing ropes. Each carriage, when called for, is to be run forward to the boat or crane; the gun is to be unlimbered and dismounted; the ammunition boxes, shafts, wheels, &c., to be taken off; the washers and linch-pins must be carefully put away in the slow match box, and in the small box between the limber boxes. Every article must be stowed away with the greatest care, and arranged so as to be got at without delay.

3. Those articles which will be the last required

when disembarking are the first to be embarked. The divisions, and everything belonging to them, should be kept together as much as possible. The first to be embarked are the spare carriages and forge, which are to be stowed forward, the left division next to them, and before the main hatchway; the centre abaft the hatchway; the right under the hatchway. The whole of the guns are put together, generally in the bottom of the hold, vents turned downwards, and a fid in them, to prevent their being choked.

4. When a battery is embarked in different vessels, every part should be complete, and a proportion of general stores be on board of each. If the voyage is likely to last some days, the cartouches with the ammunition must be taken out of the boxes, and stowed in the magazine. The ammunition must be so placed that whatever part belongs to any particular carriage may be got at without difficulty. When the cartouches are not taken out, the boxes must be stowed well aft in the hold, or between decks, and they should be well covered with wadmilltilts, or hair cloths.

5. In embarking from a beach, it may be necessary to erect small sheers, made of a couple of topgallant masts, previously prepared for the purpose. In embarking from a wharf, if there are cranes, they should be made use of. If boats are employed, the loads must be regulated by the state of the weather, and distance of the vessels.

Embarking the horses.

6. When the vessels can come alongside a wharf, the horses are hoisted in by means of tackle. The slings, made of canvas, should be minutely inspected, to see that they are secure. There must be a double

guy made fast to the horse's head, one end on shore, the other on board, to keep his head steady. A shoeing-smith should be in each ship, to receive the horses.

7. A horse requires at least four men besides the driver to sling him, one on each side, one at his breast, and one behind. One end of the sling is passed under his belly, and both ends made to meet over his back; one man passes his loop through the other, it is received by the man on the other side, who hauls it through, hooking the tackle to it, both men holding up the ends of the sling. The men at the breast and behind bring their ropes round, and make them fast to the grummets. The driver holds the horse's head, and makes fast the guys to it. The horse being previously blindfolded, the word "HOIST AWAY" is given, and he is hoisted on board. The sling is then taken off, and he is led to his place; the first horses being always placed forward or aft, as the ship fills; the stalls nearest the hatchway being reserved for the horses which are to be first landed.

8. The horses are to be embarked in the same order as the carriages, taking care that the officers' and non-commissioned officers' horses are on board with the divisions to which they belong. The farriers and shoeing-smiths should be distributed in different ships.

9. When horses are embarked in boats; sheers, or a derrick, are necessary. The head of the derrick must incline inwards when the horse is rising, but when he is high enough the head of the derrick or sheers must be forced out, to bring the horse over the boat. This applies to a beach, or wharf. Sand or straw should be put in the boats, to prevent the horses slipping. They should stand athwart, the head of one horse being on

the starboard, and the head of the next on the larboard side. The drivers sit on the gunwale, or stand between the horses.

10. When horses are embarked from an open beach without any appliances, they are to be led to the boat, and the halter given to one of the men in it. The horse must then be made to walk or leap into it, the gunwale of the boat being inclined towards the shore. A quiet horse should first be embarked, and the others will more readily follow.

11. In embarking in presence of an enemy, the horses and carriages, should first be embarked, the guns being retained to the last, to repel any attack. If the position be a mile or two from the place of embarkation, it may be necessary to retain a portion of the horses.

APPLICATION OF FIELD ARTILLERY.[18]

General remarks.

1. In a defensive position, the guns of the largest calibre should be posted on the weakest points of the line, and on those from whence the enemy can be discovered at the greatest distance. Those heights on which the enemy in advancing may rest his flanks, and those from whence he may be fired upon obliquely, must also be occupied by the largest calibres.

2. In an offensive position, the guns of the heaviest calibre should be placed in such situations as will render them available, without difficulty, for any operations in advance. In heavy ground, a nine or twelve pounder battery, when coming into action,

should reverse, when it will be only necessary to drop the trail, instead of carrying it round by hand.

3. The guns should be placed as much as possible under cover; this is easily done on heights, by keeping them so far back that the muzzles are only to be seen over them. By proper attention, advantage may be taken of many situations, such as banks, ditches, &c.

4. Artillery in the field should be concealed from the enemy till the very moment it is to open; the guns may be masked by being a little retired, or by being covered with troops, particularly by cavalry.

Ammunition waggons.

5. No positive rule can be laid down for all cases, with respect to the ammunition waggons in presence of an enemy: this must depend on a variety of circumstances; but in general it will be found expedient to place them under charge of an officer, who will conform to the movements of the main body, in such a manner and at such distance, as to enable him to supply the guns with ammunition, before that which is in the limbers is expended.

6. The spot selected for a battery should be one which does not present any obstacles to the ulterior movements.

7. The most elevated situations are not the best; the greatest effect may be produced at a distance of six hundred yards, from a height of thirty or forty yards; and at two hundred yards distance from a height of sixteen.

8. Round shot should be used from three hundred yards, upwards. The use of case should begin at three hundred, and the quickness of fire increase as the

range diminishes.

9. Double charges of case may be used at one hundred and fifty or one hundred and sixty yards. Shrapnell shells should not be used at a less range than six hundred and fifty yards.

10. The guns should never be abandoned till the last extremity; the last discharges are the most destructive.

On the march.

1. Intelligent non-commissioned officers should be sent to reconnoitre a road or ground that artillery is to pass over, and, when necessary, to report the state of it. When the march is connected with military operations, an officer should always be employed for this duty.

2. The officers of divisions should frequently halt, to see that their carriages are marching in proper order, and are well up.

3. The strictest attention should constantly be paid to the correct preservation of distances, the loss of which may be made up by small bodies of artillery; but when in large bodies, or when acting with infantry, the operation is attended with serious disadvantage, particularly to the latter; it is a point, therefore, which cannot be too strongly insisted upon, being one of most essential consequence.

Advanced Guard.

4. A battery marching by itself should always have an advanced guard. In a narrow road it should be considerably in front, to stop all carriages which might cause obstruction. In a hilly road, it should reconnoitre the top of every hill, and see that it is all

clear before the guns come up.

5. Parties should always be sent out on each flank.

6. When an accident happens to a carriage, either on the march, or manœuvring, those in its rear should pass it on the most convenient flank, and fill up its interval. It will resume its place as soon as the damage is repaired. A waggon belonging to a disabled gun should always remain with it; but a gun must not wait for its disabled waggon, but leave only a sufficient number of men to put it into a proper state.

Crossing fords.

1. Artillery can cross a river about three and a half feet deep, though much depends on the strength of the current. The ammunition boxes are so well made that the water will seldom penetrate through them, particularly if the river be narrow, and the guns pass quickly. The canvas cartouches afford additional protection, and they may be taken out if necessary.

2. When the water is deep, and the current strong, great attention must be paid in fording. The person conducting the column over a direct ford, should keep his eye steadily on an object on the opposite bank, which points out where the ford is: he must never look at the stream, which would deceive him, and would appear to carry him down, and he would endeavour to keep too high up the stream, and miss the ford.

3. All those in the rear should keep their eyes on those in front; every individual should wade rather against the stream, in order to resist its power.

4. Troops should always cross a ford with the largest possible front, for the same reason.

5. If the ford is not well known, and there is no guide, it should be previously examined, and the dangerous places marked. In fording, the horses should neither be allowed to trot, halt, or drink.

Passage of military bridges.

1. Great attention and caution are required in passing over pontoon bridges, the vibratory motion of which is very dangerous, and should be lessened by every possible means.

2. The troops, in passing, should not preserve an equal pace. There should be no halt on the bridge. As soon as the bridge is perceived to rock, the passage of the troops must be stopped.

3. The greatest precaution is necessary to prevent accidents in tide rivers at low water. Unless battens are nailed across the chesses on the slopes, the horses will have the greatest difficulty in keeping their feet, indeed if the chesses be wet it will be impossible; the men must therefore always assist; holding on when going down, and manning the wheels when going up.

4. The drivers must in some cases dismount, and an interval must be left between the carriages equal to their own length; they must be passed over gently. In wet weather over chesses, great care must be taken to prevent the horses slipping. It may sometimes be necessary, unless the bridge be strong, to pass the carriages and horses over separately.

5. In passing over a flying bridge, it may occasionally be advisable to take the horses out; and in boisterous weather, or at night, the wheels should be locked.

Crossing a bridge, and passing a defile.

1. The battery should always pass with the largest front possible.

2. The artillery must be previously posted to the right and left of the bridge; if it be flat, and that the other side can be seen, a gun or two should be placed on each side, and close to the road leading to it; these guns should cross first and come into action on the other side, the remaining guns continue in action and follow by degrees; they should be posted at such a distance from the bridge, that they may keep up a fire while the others are crossing and forming.

Advancing through a defile.

3. A defile should be passed as quickly as possible, as it is a much more hazardous operation than crossing a bridge. Artillery can seldom be made available till it has passed the defile; whereas it can generally be employed in clearing the opposite bank of a river, previous to the troops pushing across.

Over a bridge.

4. In retreating over a bridge, the artillery will gradually close in from the flanks of the troops, till all the guns are in line in front of the bridge. They will cross by degrees; the flank guns will generally cross under the protection of the centre ones; they may retire limbered up, taking up their position and coming into action to the right and left of the bridge, to protect the centre guns, which will retire with the prolonge and with the largest front possible. They may halt on the highest part, or middle of the bridge, and keep the enemy in check.

Retiring through a defile.

5. A battery should retire from one of its flanks

under the protection of the other; the covering guns retiring with the largest front possible.

6. Should the defile be wide, and there are any favourable situations in it, they should be taken advantage of, and guns posted to protect the retreat of the others. The situations must be such as the guns can retire from, and continue the retreat without difficulty.

7. When artillery is retiring along a road, or through a defile which is hilly, some of the guns should halt on the tops of the hills, and protect the retreat of those in the hollow. In these cases, round shot may be fired with safety to the troops retreating, and perhaps with good effect against an enemy.

8. The guns which are retreating, may pass those in position without halting; they will take up other positions, the whole retreating alternately.

9. In retreating towards a defile, the artillery may retire in line, or by half batteries, or by divisions; forming new lines and retreating again; or it may retreat alternately; or in echellon from either flank. This must depend on the nature of the ground, and the flank on which the enemy may be.

10. In these retrograde movements, the ammunition waggons must be sent to the rear. One or two may be kept nearer than the others, to supply ammunition.

Artillery, acting with other troops.

1. The artillery should always cover the troops when advancing, retiring, or deploying into line.

2. When the line retires by alternate companies,

wings, or battalions, the artillery must remain with that part of it which is nearest the enemy; retiring with the prolonge, and halting when it arrives at the halted part of the line.

In column.

3. When the troops are in column, the artillery should be on the flank.

4. When a line of troops wheels backward into column, the artillery break into column, and close to the reverse flank, so as not to interrupt the line of pivots.

ENCAMPING, AND PICKETING.

[19]*Sec. 29. First method.*

The battery being formed in line, at full intervals, the horses are picketed, and the tents pitched in rear.

Prepare to encamp, and picket.

At the word PREPARE TO ENCAMP, AND PICKET, the drivers dismount and unhook; the markers take up an alignment twelve yards in rear of the battery, and facing it, for the line of pickets; the marker of the centre division in the centre; the others extend from him the number of yards there are horses in each half battery. One staff serjeant ten yards in rear of the centre marker indicates the alignment for the men's tents. The second staff serjeant twenty yards in rear of the other, to mark the spot for the captain's marquee. Nos. 1 and 6 unlash tents; 4 and 5 of each sub-division are told off for the marquee; 2, 3, 7, and 8 take a picket each, 9 a maul, and the wheel drivers a picket line.

Encamp, and picket.

At the word ENCAMP, AND PICKET, the numbers with the pickets form on the centre marker, facing to the front, the numbers with the mauls in front of and facing them.

The start' officer gives OUTWARDS FACE—QUICK MARCH, when the men with pickets extend outwards, dividing themselves at equal distance along the alignment taken up by the markers.

The staff officer dresses them, and gives the word STEADY, when the numbers with the mauls commence to drive the pickets.

The markers dismount, and assist the wheel drivers in making fast the line from centre to flanks, taking two half hitches round each picket, above and below the hook.

The horses are then brought up, the marker's horse of the centre division in the centre, the spare horses on each side of him, the wheelers, centre horses, and the leaders of the centre waggon next, and the rest in succession; the officers' and N.C. officers' horses on the flanks of their respective divisions.

Fastening the horses.

The horses are fastened by the centre of the collar chains to the line, taking two half hitches round it; the T end being also passed through the diamond link.

Nos. 1 take up an alignment ten yards in rear of the pickets, for the men's tents. They are dressed by the staff serjeant.

The centre of the tent is indicated by a peg; they then drive four guy pegs to the front, rear, right, and

left, at three yards distance from the centre one. Nos. 6 spread out the tents, and fix the second cord from each side of the door to the front peg, the fifth cord on each side to the side pegs, and the rear cord to the rear peg. They then put the tent-pole into the canvas, lying on the ground.

Raising the tents.

As soon as all is ready, the commanding officer gives the word RAISE THE TENTS, which is done by Nos. 6. Nos. 1 and 6 then drive in their pegs, and fasten the remaining cords.

Preparing the marquee.

The second staff serjeant dismounts, and the position of the marquee is indicated by two pegs, driven at a distance equal to the length of the ridge pole, on the spot where his horse stood. Nos. 4 and 5 of each sub-division (being detailed for the marquee), fall in, and are told off by the second staff serjeant, from 1 to 12; as eight men only are required, the remainder are spare. 1, 2, 3, and 4 spread out the roof, the outside on the ground, the door to the rear; 5 and 7 double the lining, lay it on the roof, and put in the ridge pole; 6 and 8 put the standards together, and pass them through the lining; 5 and 7 fix the girthing and ridge pole on the spikes. The inside being thus arranged, half of the roof is turned over in order to prepare the outside. Nos. 1, 2, 3 and 4 fix the vases on the spikes, and take two half hitches round them with the centre of each guy.

The marquee is raised by 5, 6, 7 and 8, at the same time as the tents. Nos. 1, 2, 3 and 4 take a guy peg and a mallet each, stretch the guys, and fasten them to the pegs in such a manner that they cross each

other at each side, at the point of the dirk, which is painted on the roof; they then drive in the roof pegs, working round to their left, with their backs to the marquee; the pegs on the sides to be driven in a line parallel to the marquee, but at the ends in a half circle; 5 and 6 then hook on the wall from rear to front, overlapping two hooks at the rear, and peg it down; 7 and 8 hook on the lining, and peg it down; 5, 6, 7 and 8 also arrange the door. If there is a second marquee, it is fixed in the same manner.

As soon as the pickets are driven, Nos. 2 and 3 of each sub-division pitch the subalterns' tents, directed by the staff serjeant, ten yards in rear of the men's tents, in the centre of their division, the doors to the front; Nos. 7 pitch the guard tent, twenty yards in front of the centre of the battery, the door to the front.

Sec. 30. Second method.

The battery being formed in line, at half intervals, the horses are picketed, and the men's tents pitched on each flank; the officers' tents in rear.

At the word PREPARE TO ENCAMP, AND PICKET, the markers of the flank divisions mark twelve yards from the flanks of the battery for the line of pickets, facing to the rear.

At the word ENCAMP, AND PICKET, the picket numbers of each half battery form on the markers facing the battery; the numbers of the centre sub-divisions next the markers; they are faced to the rear, extended at equal distances, and dressed by the officers of the flank divisions; the distance they extend must be regulated by the number of horses in each half battery, allowing one yard for each horse.

The men's tents are ten yards outside of the line of pickets, facing the horses of their own sub-divisions, dressed by the staff serjeants.

The subalterns' tents ten yards in rear of the last line of carriages, and the commanding officer's marquee ten yards in rear of them.

The guard tent as in the first method.

All the duties of picketing the horses, pitching the tents and marquees, are performed by the same numbers as detailed in the first method.

Arrangement of the harness.

If the harness is to be taken off, it is placed in line, ten yards behind the horses. The traces, breeching, and collars are put inside the pad, which is laid inside the saddle; and the whole is kept compact by buckling the surcingle of the saddle tight round it; the bridles are laid over the cantles, which are towards the horses.

Sec. 31. To strike the Encampment.

The horses being harnessed and hooked in, at the word STRIKE TENTS, AND PICKETS, the pickets are struck at once; the tents and marquees prepared for striking by pulling up all the pegs except the guy ones. At the word DOWN, the whole are lowered together, and packed up as quick as possible.

With a brigade of batteries, the commanding officer's marquee would be pitched fifteen yards in centre, and in rear of the whole, door to the rear, by the spare marquee men of each battery. The pickets and tents of the whole brigade would be pitched in line, dressed by the adjutant, and serjeant-major.

WEIGHT, DIMENSIONS, ETC., OF TENTS.

CAPTAIN'S MARQUEE.

	ft.	in.			in.
Ridge pole, length	6	11	}		{ 2½
Standards, each	8	2	} in two pieces	diameter	{ 2½
Door standards	6	3	}		{ 1½

Mallets, 2. Pins—Large, 4; Small, 96.

Weight of Marquee complete, 142 lb.

SUBALTERN'S MARQUEE.

	ft.	in.			in.
Ridge pole, length	6	3	}		{ 2¼
Standards, each	8	0	} in two pieces	diameter	{ 2¼
Door standards	6	1	}		{ 1½

Mallets, 2. Pins—Large, 4; Small, 76.

Weight of Marquee complete, 132 lb.

BELL TENT, CIRCULAR.

	ft.	in.			in.
Standards, length	10	3	in two pieces	diameter	2

Pins, 40 Mallets, 2.

Weight of Tent complete, 60 lb.

LABORATORY TENT, CIRCULAR.

	ft.	in.				in.
Standards, length	16	3	{ in two pieces }	diameter	{ Top	3
					{ Bottom	5

Mallets, 2. Pins—Large, 4; Small, 100.

Weight of Tent complete, 2 cwt. 10 lb.

HORSES.

The average weight of artillery horses is 10 cwt. 2 qrs.

An allowance of 27 square feet is generally made for each horse standing at picket, or three feet in breadth, and nine feet in depth.[20] A horse should seldom be made to draw more than three cwt. besides the weight of the carriage. With great burthens, less weight must be allowed for each horse to draw than with medium burthens; as with a team of horses, the leaders cannot draw so much as the horses nearer the carriage, and the disadvantage must increase in proportion to the lengthening of the team.

{ 4	horses may each draw	6 cwt.	Total,	24 cwt.

A Team of {	6	do.	do.	5 do.	30 do.
{	8	do.	do.	4 do.	36 do.
{	12	do.	do.	4 do.	48 do.

These weights include the carriages. It is usual, however, in heavy carriages, to reckon all their weight exceeding twelve cwt. as part of the load.

The most useful mode of applying a horse's power is in draught, and the worst is in carrying a load. This is owing to the structure of the animal. It has been found that three men, carrying each 100 lb., will ascend a hill with greater rapidity than one horse carrying 300 lb. When a horse has a large draught in a waggon, however, it is found useful to load his back to a certain extent, this prevents him from inclining so much forward as he would otherwise do, and consequently frees him from the fatigue of great muscular action. The best disposition of the traces in draught is when they are perpendicular to the collar; when the horse stands at ease, the traces are then inclined to the horizon, at an angle of about 15°; but when he leans forward to draw, the traces should then become nearly parallel to the road. The most proper inclination, however, is determined from the relation which subsists between the friction, and the pressure, in every particular case.

When a horse is employed in moving a machine, by travelling in a circular path, the diameter of the path ought not to be less than twenty-five or thirty feet, and in most cases forty feet should be preferred: at all events, it must not be less than eighteen feet.

The following table shows the *maximum quantity of labour*, which a horse of average strength is capable

of performing at different velocities, on canals, railways, and turnpike roads; but in comparing this table with practice at the higher velocities, it is reckoned necessary to add one-third more than the useful effect for the total mass moved.

Velocities per hour.	Day's work.	Force of traction.	Useful effect per Day for a distance of one Mile on a		
			Canal.	Level railway.	Level road.
Miles.	Hours.	lb.	Tons.	Tons.	Tons.
2½	11·5	} {	520	115	14
3	8·	} {	243	92	12
3½	5·9	} {	153	82	10
4	4·5	} {	102	72	9
5	2·9	} 83⅓ {	52	57	7·2
6	2·	} {	30	48	6
7	1·5	} {	19	41	5·1
8	1·8	} {	12·8	36	4·5
9	·9	} {	9	32	4
10	·75	} {	6·6	28·8	3·6

Result of experiments with a light four-wheeled cart, weighing with its load 1000 lb., drawn upon different sorts of roads, (12½ lb. having been deducted from the force of traction for the friction at the axles, which were of wood).

Turnpike-road,	hard, dry	18	} Force of traction
Do.	dirty	26½	} required to move the

Do.	new gravelled	130½	} carriage, independent of
Loose sandy road		191½	} the friction at the axles.

Note.—An ox can draw about 4 cwt., and a pair of oxen 9 cwt., on a level road.

MANAGEMENT OF DRAUGHT HORSES.

Whatever the difficulties of a road or ground may be, ten horses are as many as can be harnessed with effect to one carriage. It is difficult for a greater number to act at the same instant, even if the pull be straight.

Before a carriage moves, the traces should be equally stretched out, that at the word "MARCH" every horse may act steadily at the same instant on the carriage, and not by jerks.

The distance of one horse's length between the carriages is always to be maintained on the best road, to prevent fatigue and unnecessary stoppage to the horses. In bad or difficult roads it may be necessary to increase the distance to double, or perhaps more, according to the nature of the ground.

After going up a short steep hill, the horses should be halted, but when that cannot be done, they ought to move slowly to recover their wind. Should the ascent be long, and steep, the road in a bad state, or when from any other cause the exertion is likely to be very great for the horses, a part of the carriages should halt, the leaders of them be hooked on to those in front, and when they arrive at the top, as many leaders sent back as may be necessary.

In going up a hill, a carriage may be halted to rest the horses, by bringing them across it, and locking the limber.

Whenever the ruts are very deep, the carriages must quarter the road, and if the road is narrow, and sunk between banks, the horses should be left to themselves, and not be hurried.

In passing over deep furrows, or small ditches or drains, the carriages should cross them obliquely: when they are crossed perpendicularly, the horses not only encounter greater difficulty, but they, as well as the harness, suffer much from the jerks. The former line of march should be resumed as soon as they are passed.

HORSE-SHOES.

NEW PATTERN.

There are three sizes of horse-shoes in the service, and also a smaller size made for mules.

	Size.		lb.	oz.
Weight	{ 1st	} (not including the weight of nails)	7	0¼
of	{ 2nd	} do. do.	6	4½
set.	{ 3rd	} do. do.	4	8½
	{ Mules	} do. do.	2	14

NAILS.

LENGTH, WEIGHT, NUMBER, ETC.

1st size.	{ No. of nails*	8	9	10 }	5½ oz.	}
Largest.	{ No. of each required	16	8	8 }		}
						} Weight
2nd size.	{ No. of nails*	7	8	9 }	4½ oz.	} of set.
	{ No. of each required	8	12	12 }		}
						} 32 Nails.
3rd size.	{ No. of nails*	5	6	7 }	3½ oz.	}
	{ No. of each required	8	8	16 }		}

No. of Nails.	Length of Nails.	Weight of 1000 Nails.
188	2¾ inches.	10 lb.
187	2½ —	9 —
186	2⅜ —	8 —
185	2¼ —	7 —
184	2⅛ —	6 —
183	2 —	5 —

**Note.*—These several nails are known by farriers according to their No.—viz., when they say shoes require nails, Nos. 8, 9, 10, this implies nails of 8, 9, and 10 pounds per thousand nails.

FORAGE.

Method observed in carrying one day's forage.

NON-COMMISSIONED OFFICERS, AND TRUMPETERS.—One feed of oats in the nose bag, and buckled to the near-ring of the saddle. Three feeds in the corn bag, and carried across the saddle. Twelve pounds of

hay twisted, and rolled up into two bundles, each nine inches long, carried at the ends of the kitt, and made fast with the forage cord, one end to pass in front, and the other in the rear of the kitt, making it fast by two hitches.

DRIVERS.—One feed of oats for each horse, carried in the nose-bags, and made fast to the rear staples of the off-horses' saddles. Three feeds for each horse (six feeds) in the corn bag, carried across the saddle of the near horse. The hay is twisted and rolled up into two bundles of twelve pounds, each eighteen inches long; carried on the off-horse at the ends of the kitt; the end of one forage cord passing in front of the kitt, the end of the other forage cord passing in rear of the kitt, both ends being made fast by two half hitches.

If a waggon accompanies the battery, the officers' horses' forage will be carried in it; if not, the oats are to be divided between the sub-divisions, and the hay carried on the foot board in front of the body of the waggon.

In heavy marching order, when forage is not ordered to be carried.

NON-COMMISSIONED OFFICERS, AND TRUMPETERS.—The nose bags are rolled up and buckled to the near-ring of the saddle. Forage cord, currycomb and brush, mane-comb, picker, and sponge, are made fast to the off-ring.

DAILY RATION FOR ONE HORSE.

Oats.	Hay or Grass.	Straw.

	lb.	lb.	lb.	lb.
In Quarters	8	18	..	6
In Barracks	10	12 or 36		8
A load of Hay, or Straw			36 trusses.	
A truss of Hay			56 lb.	
Ditto Straw			36 lb.	

VETERINARY DIRECTIONS.[21]

MASSES.

The ordinary dose of every Mass is One ounce (Avoirdupois).

No. I.—Cathartic Mass.

One ounce of this Mass made into a ball is a Dose of physic.

A Ball contains seven drams of Aloes, the remaining dram being made up with Ol. olivar, Ol. carui, and water.

Any horse to which a dose of physic is given, should be fed on bran mashes, in lieu of corn, until its operation has ceased. If there be no cause for its immediate administration, let ample bran mashes be given, by way of preparation, in lieu both of hay and corn, during one day, and the ball administered the following morning, after the horse is sufficiently watered, and a couple of hours at least before his bran mash be given him. Exercise also, during the day, is advisable. The following day, early in the morning, after the horse has had water, with the

chill taken off, offered him, till he refuses to drink more, let him be walked out briskly for one hour, unless he purge; in which case let him be returned to the stable, littered down, frequently watered, and plentifully supplied with bran mashes. But should the physic not operate at the expiration of his exercise, nor after he has remained four succeeding hours in the stable, let him be exercised for another hour; and he may be gently trotted at this time should he still show no signs of purging; let it be here understood, however, that in no case is a horse in physic to be galloped. To insure purgation, water is no less requisite than exercise.

Should the animal continue to purge on the third day, let his bran be eaten dry, and let him be kept short of water, and without exercise, until the physic be set. As soon as his dung shall have put on its natural appearance and consistence, the usual ration of provender may be restored, and he may return to duty.

If the horse has been lately taken up from grass, or be low in condition, or light-carcassed, six drams of the mass is generally a sufficient dose; but if he be of large size, and in high condition, even nine drams may be occasionally required.

Horses of a costive habit, whose dung-balls are small and not of their natural colour—whose coats are rough and skins tight upon their ribs, and who do not thrive, require physic. Purging balls are also given with benefit to horses that have mange, or itchy skins—swelled legs, or grease—fever in the feet —inflamed eyes—staggers—locked jaw—any swellings from blows or wounds, &c.

When a sick or lame horse requires physic, to

whom exercise would be injurious, let the dose be increased by one or two drams; and to him the ball may be given at any time—either day, or night—he may stand in need of it; in order that its operation may be as speedy as possible.

To a horse not labouring under active disease, a second dose of physic is not to be administered prior to the seventh day; but to a *sick* one, should the case be urgent, the dose may be repeated at the expiration of twenty-four hours.

Horses suffering from coughs, discharges from the nose, or inflammation of the lungs, are not to have full doses of purgative medicine given them, but the febrifuge, or sedative mass should be given.

No. II.—Febrifuge Mass.

A ball contains—Aloes one dram, Antim. tart. one dram, Nitre two drams, and Common Turpentine three drams.

In fever, also in cough or discharge from the nose in which fever is present, this mass is especially useful; and if the fever be violent, the horse ought to lose three or four quarts of blood before the ball is given. Let the animal be warmly clothed—a hood be worn in catarrh—be littered down, have bran mashes in lieu of corn, and be kept still and quiet in a well-ventilated box. The ball may be administered once or twice a day according to the symptoms; but it must be discontinued whenever it seems to affect the appetite, or should purging appear to be coming on. The appetite being restored, and the dung in balls again, should it be required, the ball may be repeated.

No. III.—Sedative Mass.

A ball contains—Digitalis one scruple, Antim. tart. one dram, Nitre two drams, Linseed meal three drams, and Treacle three drams.

In case of inflammation of the lungs, these balls are especially beneficial—a disease in which colds and coughs not unfrequently terminate. After having drawn four or five, or even six quarts of blood, according to the violence of the symptoms and the apparent strength of the animal, give a sedative ball three times a day at regular intervals. Let the sides of the chest be well rubbed with some of the blistering liquid, clothe warmly and hand-rub the legs, making use of the turpentine liniment from time to time until they become warm; and bandage them with flannel. Keep the stable well ventilated.

Should the symptoms continue unabated, four or five quarts more blood must be taken away at the expiration of four or five hours from the first bleeding, and the operation may be repeated again in six should the animal continue unrelieved.

Let the horse be littered down, and have bran mashes. No exercise.

No. IV.—Diuretic Mass.

A ball contains—Common Turpentine half an ounce, Nitre two drams, and Sulphur two drams.

Diuretic or urine balls may be given in all cases in which they may be required, one every third night: seldom is it necessary to administer one every other

night, and still more rarely every night.

Should the flow of urine prove abundant—the horse frequently making efforts to stale, and groaning in so doing; or if he cannot stale, but appear to experience pain about the loins and hips, and to be stiff in moving those parts, diuretic balls must on no account be given.

Diuretics are beneficial in recent swelled legs; linen bandages and walking exercise being had recourse to at the same time. They are also useful in watery farcy, dropsy, and puffy or watery swelling of all kinds.

No. V.—Alterative Mass.

A ball contains—Aloes one dram, Calomel a scruple, Sulphur half an ounce, and Treacle three drams.

To ill-conditioned horses that do not thrive, notwithstanding they eat and appear otherwise in health—to horses that rub themselves, or that have small lumps or bare places upon the skin (not mange), balls made up of this mass are serviceable; one may be given every day for a week, or every other day for a fortnight, unless the horse should purge, when they are to be omitted, and had recourse to again in the course of a week or ten days.

Bruised corn, hay cut into chaff, and frequent and full supplies of water, contribute to restore such horses to condition. Walking exercise once or twice a day, according to the strength and thrift of the horse, is also recommended.

No. VI.—Tonic Mass.

A ball contains—Blue Vitriol one dram, Verdigris half a dram, Linseed meal four drams, and Treacle two drams.

These balls may be administered with advantage to horses affected with farcy, or under suspicion of glanders, after the swelling and inflammation attendant upon those diseases have been abated by bleeding, purging, and diuretic medicines.

Not more than one ought to be given in the space of twenty-four hours; nor on any account should the dose be continued unless the horse's appetite is good; as soon as he refuses any part of his provender, or appears to be in any manner affected by the medicine, let the ball be omitted.

No. VII.—Anti-spasmodic Draught.

This draught is prepared for horses that become griped, after the following manner:—

Mix together two ounces of Spirits of Turpentine, and one ounce of Tincture of Opium, and add a pint and a half of warm water.

In mild cases of gripes this single draught will generally suffice; but in violent attacks, four or five quarts of blood ought to be immediately taken away, and the draught, after an interval of a couple of hours, repeated; also two or three ounces of the turpentine liniment should be well rubbed upon the surface of the belly. If no dung is passed, let the horse be raked, and have clysters of salt and water (about four ounces of salt dissolved in four quarts of water) thrown up every hour until the bowels be relaxed. When the horse continues to lie down and

rise in the stall, and to roll upon his back, relief will frequently be given by walking exercise for ten minutes.

Those cases, in which the symptoms do not intermit, and in which the pulse and breathing are much quickened, are not gripes, but *inflammation* of the bowels. Take away five or six quarts of blood without loss of time, and give a draught composed of eight or ten drams of aloes dissolved in a pint and a half of hot water,[22] with the addition of an ounce of tincture of opium, inject clysters frequently, rub a blister upon the belly, composed of equal parts of oil of turpentine and blistering liquid, wrap the legs in flannel bandages, making use of the turpentine liniment to the legs if cold, and clothe warmly. Water, with the chill taken off, should be plentifully given; or, what is better, water-gruel.

If the symptoms do not speedily subside, draw three or four quarts of blood again, and repeat the blister to the belly, and clysters and turpentine liniment to the legs if not warm.

No. VIII.—Vermifuge Powder.

Three drams of this powder, containing one dram of Calomel and two drams of Tartarized antimony, form a dose.

To be given in a bran mash at night to a horse having worms, and to be followed up by the administration of a dose of physic the following morning—paying attention to the directions already laid down under the head—Cathartic Mass. The powder and physic may be repeated in the course of a week or ten days.

No. IX.—Anti-purgation Powder.

This powder is composed of prepared Chalk half a pound, Cinnamon four ounces, Tormentil three ounces, Gum arabic three ounces, and Long pepper half an ounce, reduced to a fine powder, and mixed together, with the addition of Gum opium.

An ounce of the powder, which contains only a scruple of gum opium, may be administered in a quart of gruel, in cases of continued purging or scouring, every four or five hours, or as circumstances may require, but its use is to be discontinued when the purging is checked.

No. X.—Discutient Powders.

This powder is composed of Zinc vitriol three drams, and Bole armen. one dram.

A lotion, composed of half an ounce of this powder, and one quart of water, is a proper application to sore backs, and to recent swellings from blows or injuries of any kind.

Bandages may be used, wetted with this lotion, in sprains of the back sinews.

No. XI.—Astringent Powder.

This powder is composed of Linseed meal half an ounce, Powdered alum half an ounce, Blue vitriol half a dram, and Bole armen. two drams.

This powder is prepared principally for grease and thrushes, but it is also a good dressing for unhealthy

sores—or sores in which there is proud flesh.

In cases of grease, when the discharge is but little, and not very offensive, besprinkle the affected parts with this powder; let the horse be exercised in the morning and afternoon; and, if the legs be swollen, let a diuretic ball be occasionally administered.

But should the discharge be copious and fetid, apply to the heels, by means of pledgets of tow and linen bandages, a liniment composed of this powder and oil. This dressing ought to continue undisturbed for two or three days; during which time a dose of physic may be administered with considerable benefit. Let his food consist of bran mashes. As soon as the dressings shall have been removed, the animal ought to be exercised for two hours, the heels afterwards wiped dry, and the liniment again applied, unless the discharge have ceased; in which case the powder sprinkled upon the part, as above recommended, and a diuretic or two will complete the cure. Should the case require a repetition of the liniment, purging balls are preferable to diuretics.

Of horses that have thrushes, lower the heels, that the frog may be upon a level with the heels of the shoe, pare out the cleft with a small drawing-knife, so as to cut away the ragged parts of it, and introduce a little of the astringent powder daily, at the evening stable hour. If heat be perceptible in the foot, a dose of physic may be given at the same time.

No. XII.—Ophthalmic Powder.

This powder is composed of Sugar of lead two drams,
Turmeric half a dram.

So long as the eyes appear red and angry, nothing but cold water should be made use of to them, with which they ought to be continually wet. At the same time, if there be much inflammation, take four or five quarts of blood from that side of the neck corresponding to the affected eye, or from both sides, should both eyes be bad.

When the inflammation is abated, sponge the eyes and eyelids with a lotion, made by dissolving a quarter of an ounce of this powder in a quart of cold spring water, several times in the course of the day.

In every case in which it is found advisable to draw blood, a dose of physic is recommended.

No. XIII.—Blistering Liquid.

This liquid is composed of Cantharides four ounces, and Linseed oil a pint and a half.

For sore throat and *jugged* swellings, in glanders, or farcy—for inflammation of the lungs, and inflammation of the bowels, the blistering liquid is a proper application.

For spavins, splints, old strains, curbs, ringbones, windgalls, thoroughpins, and other enlargements of joints that have no heat in them, and swellings in general which will not yield to simple remedies, this liquid may likewise be used.

Let a small quantity of it be well rubbed in with the hand—without the hair being cut off—and let the same be repeated at the expiration of six hours, should it not have taken effect.

About one table spoonful of this mixture is

sufficient for the throat, two for the leg, three for the side or the chest, and so on.

No. XIV.—Turpentine Liniment.

This liniment is composed of equal parts of Spirits of turpentine, and Linseed oil.

In cases of sore throat and cough, this liniment will be found very useful, as well as in cases of inflammation of the lungs, and fever, where the legs are cold, making use at the same time of flannel bandages, and repeating the liniment every two or three hours, until they become warm.

Half an ounce will be found sufficient for a leg, or for the throat, and requires to be well rubbed in.

No. XV.—Turpentine Ointment.

It is composed of equal parts of Common turpentine, and Hog's lard.

This ointment is the best application that can be made use of in case of treads or wounds on the coronet, between hair and hoof; a small quantity is to be spread upon a pledget of tow, and bound on with a bandage. It is likewise a good dressing for broken knees, or cuts, and to promote the action of rowels.

No. XVI.—Black Oil.

It is composed of Olive oil one pint, Spirits of turpentine

half a pint, and Acid vitriol two drams.

In recent wounds, such as broken knees, or other lacerated wounds, this will be found a good dressing to promote healthy and speedy granulation. It may be applied to extensive wounds by means of a feather; and in cases of broken knees, a pledget of tow is to be bound on with a tail bandage. It is likewise a good application for sitfasts, produced by the pressure of the saddle.

No. XVII.—Hoof Ointment.

This ointment is composed of Tar, and Train oil, equal parts.

This ointment is intended for brittle feet, or such as have sand cracks.

By mixing one part of the ointment with two of train oil, it forms a good application for mange.

CONGREVE ROCKETS.

Rockets may be of great use when a disembarkation of troops takes place in presence of an enemy, since Rocket men can land with the first party of Infantry, and commence firing before any guns can be brought into position. Rockets will not only be useful against masses of Cavalry, and squares of Infantry, but, when guns cannot be brought up, may be of material benefit in dislodging an enemy from villages or houses, which could not be approached by Infantry alone without a considerable loss of men, and chance of failure. The larger rockets

are of great service in bombardments and sieges.

Congreve Rockets are of four different natures—viz., 24 pounders, 12 pounders, 6 pounders, and 3 pounders. The cases are of wrought iron, and the rockets are driven upon the same principle as Signal rockets. Congreve rockets may be used either as shot or shell-rockets, and the shell may be made to burst either at long or short ranges. Each rocket is fitted with a fuze screwed into the base of the shell; this fuze is as long as the size of the shell will admit of, so as to leave sufficient space between the end of it and the inner surface of the shell, for putting in the bursting powder, and the end of the fuze is capped to serve as a guide in the insertion of the boring-bit. There is a hole in the apex of the shell, secured by a screw metal plug, for putting in the bursting powder, and for boring, according to the different ranges at which it may be required to burst the shell.

ON FIRING ROCKETS.

If the Rocket is to be used as a Shot-rocket, the only thing to be attended to, is to take care that there is no powder in the shells, and that the plug is secured in the plug-hole. If the rocket is to be used as a shell-rocket at the longest range, the plug is to be taken out, and the shell filled, the fuze left at its full length, and the plug replaced. If at the shortest range, the fuze is to be entirely bored through, and the rocket composition bored to within an inch and a half of the top of the cone in the 24 pounder rocket, and to within one inch in the 12, 6, and 3 pounder rockets. The distances from the surface of the shell to the top of the cone, and from the surface of the shell to the end of the fuze, and also, the length of the fuze being fixed and known, the place on the boring-bit at which to screw the stopper, whether for

various lengths of fuzes, or lengths of rocket composition to be left over the cone, is easily determined; these distances are marked on the brass scales for each nature of rocket, and the length of rocket composition available for boring into, and the lengths of fuze, are also set off and subdivided into tenths of an inch.

ELEVATIONS, RANGES, AND LENGTHS OF FUZE.

The 24 pounder and 12 pounder rockets are very destructive against troops from 800 to 1000 yards; against buildings, &c., from 500 to 600 yards: with 6 pounders about 300 yards, and never at a greater range than 600 or 700 yards.

The range and elevation of a 12 pounder rocket is 10 degrees of elevation for 600 yards, and 1 degree more is given for each additional 100 yards, as far as 1250 yards, the elevation for which will be 16 degrees.

The range and elevation of a 6 pounder rocket is 7¾ degrees for 400 yards, and as far as 700 yards 1 degree for each 100 yards; and from 700 to 1250 yards, half a degree increases the range about 100 yards.

24 pounders.—If the whole length of fuze is left in the shell, the rocket may be expected to burst at from 3300 to 3700 yards; elevation, 47 degrees.

If the whole of the fuze composition is bored out, and the rocket composition left entire, the shell may be expected to burst at about 2000 yards; elevation, 27 degrees.

If the rocket composition be bored to within 1·5 inch of the top of the cone, the shell may be expected to burst at about 700 yards; elevation, 17 degrees.

12 pounders.—If the whole length of fuze be left in the shell, the rocket may be expected to burst at about 3000 yards; elevation, 40 degrees.

If the whole of the fuze composition is bored out, and the rocket composition left entire, the shell may be expected to burst at about 1300 yards; elevation, 15 degrees. If the rocket composition be bored to within one inch of the top of the cone, the shell may be expected to burst at about 500 yards; elevation, 9 degrees.

6 pounders.—If the whole length of the fuze be left in the shell, the rocket may be expected to burst at about 2300 yards; elevation, 37 degrees. If the whole of the fuze composition be bored out, and the rocket composition be left entire, the shell may be expected to burst at about 950 yards; elevation, 13¾ degrees. If the rocket composition be bored to within one inch of the top of the cone, the shell may be expected to burst at about 500 yards; elevation 9½ degrees.

3 pounders.—If the whole length of the fuze be left in the shell, the rocket may be expected to burst at about 1850 yards; elevation, 25 degrees. If the whole of the fuze composition be bored out, and the rocket composition be left entire, the shell may be expected to burst at about 750 yards; elevation, 10 degrees. If the rocket composition be bored to within one inch of the top of the cone, the shell may be expected to burst at about 500 yards; elevation, 8 degrees.

Ranges, and Elevation of Congreve rockets.

Ranges.	Elevation.			
	12 Pounder.		6 Pounder.	
Yards.	Degrees.	Minutes.	Degrees.	Minutes.

400			7	45
500			8	45
600	10	0	9	45
700	11	30	10	30
800	12	45	11	15
900	13	30	11	45
1000	14	0	12	30
1100	14	45	13	15
1200	15		14	0
1250	16		14	30

EXERCISE OF ROCKETS.[23]

The 24 pounder is used for siege purposes. The 12 and 6 pounders are for service in the field.

EXERCISE OF 12 AND 6 POUNDER, OR FIELD ROCKETS.

Telling off the Detachment.

The detachment falls in, in rear of and facing the carriage, and is told off as for gun exercise.

"FORM THE ORDER OF MARCH, LEFT FACE—QUICK MARCH."

Disposition and Duties of a Detachment of Seven Men, with a 12 and 6 pounder Rocket.

No. 1 stands one yard in rear of the tube, points, and commands.

3 stands on the left of the tube, in line with its centre, elevates,and traverses.	2 stands on the right of the tube, in line with its centre, elevates, and traverses.

5 stands on the left of the tube, in line with the rear of it, primes, and fires.	4 stands on the right of the tube, in line with the rear of it, brings up rockets, arranges the priming, and loads.
7 stands in rear of the carriage and prepares rockets. When firing shell-rockets, he bores out the composition, assisted by No. 6.	6 stands in rear of the carriage, assists No. 7 in preparing rockets. When firing shell rockets he puts in the bursting powder, &c.

The following is the proportion of Stores furnished with Field Carriages.

Two hundred and sixteen rockets with sticks.	} with
Two hundred and sixteen bursters.	} 6 pounder.
One hundred rockets with sticks.	} with
One hundred bursters.	} 12 pounder.
One rocket tube. One rocket frame, comprising two cheeks, a prypole, elevating bar, and tangent scale. Two funnels. One boring stock. Two boring bits. One brass scale fitted to bits. *Two turnscrew bits. One grease box. One tube pocket with tubes. One lanyard with hook* for friction tubes.	} with both natures.

To every other equipment not exceeding 144 Rockets.

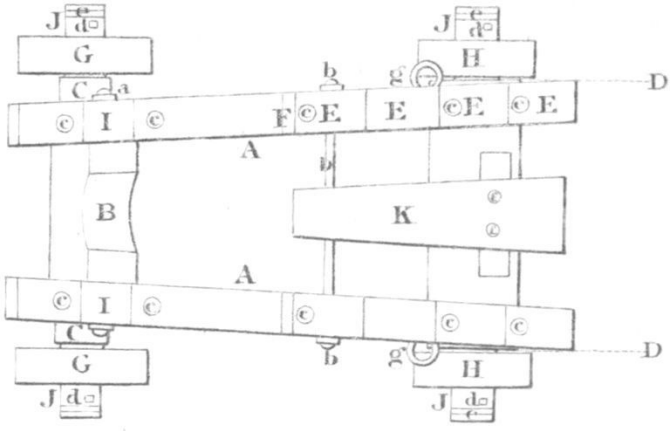
One rocket tube with frame. One stick for each rocket. One burster ditto. Two funnels. One boring stock. Two boring bits. One brass scale fitted to bits. *Two turnscrew bits. One grease box. One tube pocket with tubes. One lanyard with hook* for friction tubes.

One angle. One plummet with line. One elevating chain. Two guy ropes. Two additional pieces for the cheeks. } with 24 pounder.

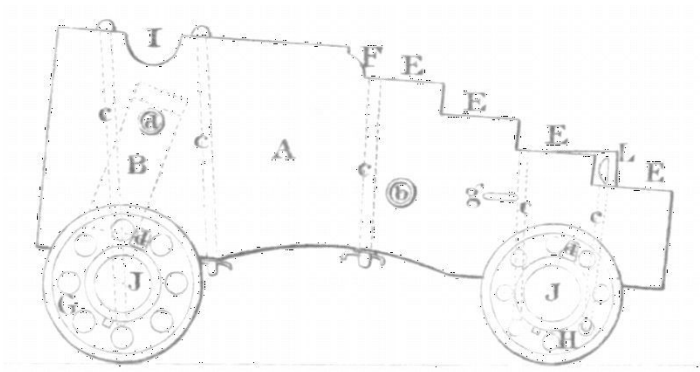
On field service the bursters are carried in the limber boxes, in canvas cartouches, similar to those in which the field ammunition is carried. The 12 pounder rocket carriage takes 50 bursters in each limber box, and the small stores in a box on the body of the carriage corresponding to the slow match box. The 6 pounder carriage takes 108 bursters in each limber box, and the small stores in a box which is between the limber boxes. In mountain equipments the bursters and small stores are carried in a box fitted to the pack saddle.

[24]ACTION FRONT, REAR, RIGHT, OR LEFT. DRIVE ON. LOAD. ELEVATE. LOWER. HALT. MUZZLE RIGHT, OR LEFT. HALT. Priming, and Firing, as at Field guns.

PLAN OF A GARRISON CARRIAGE.



A	*Sides or brackets*	K	*Stool bed*
B	*Transom*	L	*Quoin*
C	*Fore axletree*	a	*Transom bolt*
D	*Hind axletree*	b	*Bed bolt*
E	*Steps*	c	*Bracket bolts*
F	*Quarter round or ovolo*	d	*Linch-pins*
G	*Fore truck*	e	*Axletree hoops*
H	*Hind truck*	f	*Stool bed bolts*
I	*Trunnion hole*	g	*Eye or loop bolts*
J	*Axletree arm*		



ELEVATION OF A GARRISON CARRIAGE.

EXERCISE OF 24 POUNDER, OR SIEGE ROCKET.

Disposition, and duties with seven men.

When the detachment is in action, the disposition and duties of the numbers are the same as at the lighter natures.

PUT THE FRAME TOGETHER AT LOW ORDER. RAISE THE FRAME. REEVE THE GUYS. SLING THE ROCKET TUBE, AND fiX THE ANGLE. ADJUST THE FRAME. LOAD. TRAVERSE, when necessary, MUZZLE RIGHT, MUZZLE LEFT. If greater alteration be required, than can be given by means of the guys, the cheeks of the rocket frame are moved in the named direction, CHEEKS TO THE RIGHT, OR LEFT. ELEVATE, when necessary. Priming, and Firing, as directed for Field guns. When the frame is fixed at *Low order*, the prypole forms an angle of 30 degrees with the horizon. If greater elevation than this be required, the frame must be raised to *High order*—45 degrees elevation; or higher still—50 degrees elevation.

PREPARE TO RAISE THE FRAME TO HIGH ORDER.

Join the cheeks. Raise the frame. Adjust the frame. Load, etc. Prepare to strike the frame. Strike the frame.

PART VII.

REPOSITORY COURSE.

SERVING, AND WORKING HEAVY ORDNANCE.[25]

PART I.—*Article 1.—Telling off the Detachments.*

The men fall in two deep, and are told off on the same principle as for field guns. No. 1 always commands his detachment.

A gun detachment being drawn up in line, two deep, No. 1 is the right hand man of the front rank; No. 2 is the right hand man of the rear rank; and No. 3 his front rank man; and so on.

The men must go through every part of the exercise in turn. At the word "*Change round*" when there are seven men in a detachment,

No. 2	becomes	4	No. 1	becomes	7
4	”	6	7	”	5
6	”	1	5	”	3
			3	”	2

No. 3 shifting in front of the muzzle.

When there are only six men in a detachment,

No. 4	becomes	1
1	”	6

6 ” 5

the rest as above.

The detachments are told off on their private parades, and marched to the battery. Arrived there, they are halted a few paces in rear of the platforms, to the left of their respective guns, so as to be covered by the merlons, and facing the parapet.

The commander then gives the caution, “*Take post under cover of the merlon*;” and immediately afterwards the executive word, “*To the right face*,” No. 1 after facing takes an oblique pace to the rear, on the left of 3. At the word *quick march*, the detachments step off except No. 1, who at first marks time until the detachment has past him, and then follows in rear of 6. When the detachments are opposite to the left corner of the platforms, the ranks open out on each side of the guns, the rear ranks on the right, the front ranks on the left—the whole outside of the platforms. Nos. 2 and 3 halt next to the embrasure, as soon as they arrive at the parapet; 4, 6, and 1 halt in succession on the right of 2; 5 and 7 on the left of 3. When all the numbers have arrived at the parapet in the order here detailed, the commander gives the word, “*Right about face*.”

The detachments are now in the position, which they should always occupy in action, in a battery, unless actively employed in their duties at the guns.

When there is no parapet, the command is given to “*Take post at the guns*;” Nos. 2 and 3 halt in line with the muzzle of the piece; 4 and 5 in line with the trunnions; 6 and 7 with the vent; 1 the trail: the whole outside of the platform and in echellon. The numbers should never cover if they can avoid doing so.

The following general detail of duties for a detachment of seven men is applicable to all natures of guns, from 18-pounders and upwards, on any description of carriage whatever.

No. 1 commands, points, and primes.

3 loads, assists to ram home shot and wad, runs up, and elevates.	2 searches, spunges, rams home, runs up, and elevates.
5 supplies 3 with shot and wad, runs up, and traverses.	4 clears the vent, serves it, pricks the cartridge, runs up, and traverses.
7 supplies 3 with cartridge, double-man's his handspike, serves 1 with tubes, and fires.	6 supplies 2 with side arms, double-man's his handspike, replaces 1's handspike, and supplies 7 with cartridges, (and 3 with shell when required.)

The following general detail of duties for a detachment of six men, is applicable to all natures of guns below 18-pounder, on any description of carriage whatever.

No. 1 commands, supplies 2 with side arms, points, and primes.

3 loads, assists to ram home shot and wad, runs up, and elevates.	2 searches, spunges, rams home, runs up, and elevates.
5 supplies 3 with cartridge, shot, and wad, runs up, and traverses.	4 clears the vent, serves it, pricks the cartridge, runs up, and traverses.
6 supplies 5 with cartridge, replaces 1's handspike, serves him with tubes, and fires.	

Besides the men told off to each gun, there must be some at the magazine, to fill and issue cartridges. When shells are fired, some men must be appointed to fill them, and to cut and fix fuzes; No. 6 brings up shells to 3, who uncaps the fuze.

Guns are always laid under metal, *i. e.*, at an angle of depression, after exercise.

The following is a list of stores required for the service of heavy ordnance in batteries:—

One spunge	{	to be placed on the right of the gun outside of 4, resting against the parapet; the spunge head, rammer head, and the worm uppermost, and just below the interior crest.
One rammer	{	
One wadhook	{	

When there is no parapet the side arms must be laid on the ground in the order above detailed, about two paces from the gun, and parallel to it; the spunge and rammer heads to the front, and supported to keep them free from gravel.

Five handspikes.—Two of these are placed on each side of the platform close to the edge of it, the points towards the parapet; the points of the front handspikes about two feet from the hurter, the points of the rear ones overlapping inside to about the middle of the front ones; the front handspikes for the use of 2 and 3, the rear ones for the use of 4 and 5. The fifth handspike is placed close to the rear of the middle of the platform, small end to the right, for the use of 1. All bevelled handspikes are to be laid bevelled side upwards.

One set of priming irons	{	For the use of No. 4. The priming irons to be placed in the loop on the right of the carriage.
One thumbstall	{	

One leather pocket with tubes.—The tube pocket must be strapped on the left side of No. 7, who will keep it close shut.

One lanyard with hook for friction tubes in charge of No. 7, who attaches it to the waist belt of the tube pocket; or, one hammer with lanyard likewise in charge of 7, who fixes it to the gun, assisted by 1.

Shot, piled on the left of the gun, close to the front of the platform.

Wads, (if necessary,) close to the shot.

Broom, shovel, one or two for each battery.

Spade, pick, one per battery if thought necessary.

Guns on dwarf and casemate traversing platforms require nearly the same stores.

Two shod levers, in place of three common handspikes, and in addition,

Two truck levers. Two scotches. One preventive rope.

Two luff tackles. With 8-inch guns and all above that calibre, the tackles should consist of double blocks.

Guns on common traversing platforms require nearly the same stores as those on dwarf platforms. When the four trucks are on, two shod levers to be substituted for two truck levers.

Article 3.

TO SHIFT A GUN FROM THE FIRING TO THE TRAVELLING, OR FROM THE TRAVELLING TO THE FIRING TRUNNION HOLES.

The wheels of the gun carriage and those of the limber should, if possible, always be on a level and scotched. In shifting the gun either way, it should only be lifted so high, as to keep the under side of the trunnions clear of the cheeks of the carriage.

When the gun is in the travelling holes, the screw must be taken out to prevent its being damaged; it is lodged in a place for it between the cheeks. The gun roller is strapped to the hind part of the centre transom.

Heavy guns on travelling carriages require the following number of men for their service in the field:—

24-pounder	18 men	}	besides non-commissioned officers,
18 ”	14 ”	}	
12 ”	12 ”	}	

being necessary on the march for extricating them out of difficulties, taking up positions, laying temporary platforms, placing planks under the wheels and trail, to facilitate the working of the gun, &c., &c.

PREPARE TO SHIFT THE GUN. BEAR DOWN. LOWER. LIFT, AND HEAVE. HALT, LOWER THE MUZZLE. BEAR DOWN. LOWER. STRAP ON THE SIDE ARMS AND HANDSPIKES.

Article 4.

EXERCISE OF GUNS, ON SIEGE CARRIAGES.

The disposition, and duties of the detachments are the same as detailed for guns on standing carriages;

with the exception of the application of the handspikes.

In addition to the stores, and side arms for the service of the gun, a heavy gun in the field requires men's harness, and dragropes, a lifting jack, a set of intrenching tools, and three planks of a foot wide, and ten or twelve feet long. There should be a lever, and fulcrums, and prop, for every two guns; besides a gyn, rollers, tackles, and ropes for every four guns. The side arms, handspikes, and planks are strapped on the cheek; the gyn, rollers, tackles, &c., are carried on a platform waggon.

Planks for temporary platform. When the ground is not very hard, it will be found very necessary to lay planks under the wheels and trail for the carriage to recoil on.

Article 5.

EXERCISE OF GUNS ON DWARF, AND CASEMATE TRAVERSING PLATFORMS.

The disposition, and duties of the detachments are the same as at page 174, with the following additions, viz., No. 1 guides the levers whilst the gun is running back; Nos. 1, and 7 hold on the preventer rope, and 4, and 5 guide the levers, whilst it is running up; Nos. 2, 3, 4, and 5 manage the truck levers, reeve the tackles, hook, and unhook them.

[26]PREPARE FOR ACTION. REEVE THE TACKLE, AND fiX THE PREVENTER ROPE. HOOK THE TACKLES. LOAD. RUN THE GUN UP. EASE OFf. HALT. *After Pointing, Laying, Priming, and Firing*——RUN THE GUN BACK. HEAVE. HALT. UNREEVE THE TACKLE, AND

TAKE Off THE PREVENTER ROPE.

Article 6.

EXERCISE OF GUNS ON COMMON TRAVERSING PLATFORMS.

The disposition, and duties of the detachments, as at page 174.

LOAD. RUN THE GUN UP. HEAVE. Elevating, Traversing, Priming, Firing, and Running back, as detailed for guns on dwarf, and casemate traversing platforms.

Article 7.

DISPOSITION, AND DUTIES OF FIRING HOT SHOT, WITH SEVEN MEN.

No. 1. commands, supplies 2 with side arms, points, and primes.

3 loads, puts a dry wad over the cartridge, then a damp one, (and a dry wad over the shot if necessary,) assists No. 2 to ram home the dry wads, runs up, and elevates.	2 searches, spunges, rams home, assists to put in the shot, runs up, and elevates.
5 supplies 3 with cartridges and wads, runs up, and traverses.	4 clears the vent, serves it, pricks the cartridge, runs up, and traverses.
7 brings shot from the furnace, and assists to put them in, double-mans 3's handspike, supplies 1 with tubes, and fires.	6 assists 7 to bring shot from the furnace, double-mans 2's handspike, and supplies 5 with cartridge, and wads.

With all kinds of traversing platforms, No. 3 receives the bearer from 6 and 7, and assists 2 to put in the shot.

The gun is spunged in the ordinary manner, but the spunge must be wetted, and the gun frequently cooled with it.

The same stores are required as for the service of heavy guns with cold shot. Junk wads are indispensable, and those which are used wet should be made of a low gauge.

Utensils required for the Shot.

One furnace or grate.	*One poker.*
One moving tool.	*One rake.*
One scraper.	*One shovel.*
One pair of tongs.	

One stand on which to place the shot, in order to scrape them.

One shot bearer per gun. *Two tubs* full of water, to soak wads, cool tongs, &c. *Two or three water buckets.*

The furnace may be heated either with wood, or coals, or a mixture of coal and coke, according to circumstances.

There should never be less than three men to attend the furnace, even when the shot and wood are close at hand, and four will generally be required, viz., one non-commissioned officer, or steady man in charge to see that the reddest shot are served out and replaced by cold ones, and to keep up such a fire as he may judge necessary.

One man to light and attend the fire, and supply fresh fuel when required.

One to take out shot, lay them on the stand, scrape them, and afterwards place them on a bearer.

One to supply the furnace with cold shot, and to bring fuel.

Loading.

The powder must be in a good flannel cartridge, which must undergo the strictest examination, to see that there are no holes in it, lest in setting it home any grains should fall out. The gun must be elevated, in order that the shot may roll freely along the bore.

LOAD. PREPARE TO LOAD. LOAD.

ADDISON'S SHOT FURNACE.

This furnace will contain in three rows, alongside of each other, fifteen 32-pounder, or eighteen 24-pounder, or twenty-one 18-pounder shot.

To heat the furnace.

To heat the furnace, it takes of coals ½ a bushel, of coke 2½ bushels, and shavings for lighting it. It should be allowed twenty minutes to light properly.

To heat the shot.

Fifteen 32-pounder shot being then put in, are heated in forty minutes.

Order of using the shot.

The shot should be taken equally out of each row from the rear of the furnace, and replaced by cold ones from the front.

After the furnace has been thoroughly heated, it will supply a new batch of shot every twenty minutes.

The furnace should be placed to leeward, and as near the battery as may be convenient, carefully selecting an open space, with as great a draught as can be found. The draught-hole should be to windward, and the furnace perfectly horizontal.

Article 8.

EXERCISE OF CARRONADES, 68-POUNDER, SEVEN MEN.

The disposition and duties are the same as detailed for the service of heavy guns with seven men, in Articles 1 and 2. But as the spunge stave is short, No. 2 receives it with his right hand at the rammer head, and left near the spunge head, pushes it up to the bottom of the chamber at once, spunges out, and proceeds as directed for guns.

The shot weighing above ½ cwt. No. 2 assists 3 to put it into the bore by means of a shot bearer, which they raise to the muzzle with their outward hands, backs down, and their inward hands, backs up.

24 and 12-Pounders, Six men.

The disposition, and duties are the same as detailed for the service of heavy guns with six men. See Articles 1, and 2.

Article 9.

EXERCISE OF GUNS, AND CARRONADES ON SHIP

CARRIAGES, WITH SEVEN MEN.

The disposition, and duties are the same as in the gun and carronade exercises, but a few additional men are necessary for manning the tackles.

The same stores as for guns on common traversing platforms, with the exception of the four levers, and in addition, three handspikes, and a breeching.

FIX THE BREECHING. HOOK THE TACKLES. RUN THE GUN IN. HEAVE. HALT. Spunge, and load, *as detailed for guns on standing carriages*. RUN THE GUN OUT. HEAVE. HALT. Elevating, Traversing, Priming and Firing, *as directed in Article 2*.

Article 10.

GUNS, AND CARRONADES ON DEPRESSING CARRIAGES.

When, after being fired, the piece is to be loaded, it must be brought to such a position that the spunge may be clear of the ground, or sill of the embrasure. Short pieces, such as carronades, and howitzers, are superior to guns for great depression, as they are easily managed and quickly loaded.

Article 11.

EXERCISE OF 10 AND 8-INCH HOWITZERS, ON STANDING AND SIEGE CARRIAGES, WITH SEVEN MEN.

No. 1 commands, supplies 2 with side arms, points, and primes.

3 loads, runs up, and elevates.	2 spunges, wipes the shell, uncaps the fuze, puts the shell up, runs up, and elevates.
5 supplies 3 with cartridge, runs up, and traverses.	4 clears the vent, serves it, pricks the cartridge, runs up, and traverses.
7 prepares and brings up shells, assists to put them in, double-mans 3's handspike, supplies 1 with tubes, cuts and fixes fuzes, and fires.	6 prepares and brings up shells, assists to put them in, double-mans 2's handspike, replaces 1's handspike, supplies 5 with cartridges, cuts and fixes fuzes.

The same stores are required for the service of howitzers as for that of guns, (substituting shells for shot,) and, in addition, a shell bearer, a sheepskin, and a pair of setting up pincers.

The detachments take post as directed for guns.

LOAD. SHELL. The howitzers are run up, elevated, traversed, primed, and fired, *as detailed for guns*.

Article 12.

EXERCISE OF MORTARS.

The detachments are told off and numbered as detailed in Article 1. When they are to take post the commander gives the word, "*Take post at the mortars, to the right face*." No. 1, after facing, takes an oblique pace to the rear on the left of No. 3. At the word "*Quick march*," the ranks open out and march on each side of the mortars, as directed for guns. Nos. 2 and 3 halt in line with the muzzle; 4 and 5 with the trunnions; 6 and 7 with the rear of the bed; the whole outside of the platform, and in echellon, except No. 1, who takes post in rear of the platform.

Disposition, and Duties of Detachments, for 13 and 10-inch Mortars, with Seven men.

No. 1 commands, hands the spunge to 2, points, and primes.

3 runs up, puts in the cartridge, assists to put in the shell, and traverses.	2 runs up, spunges, wipes the bottom of the shell, uncaps the fuze, assists to put the shell in, and traverses.
5 runs up, supplies 3 with cartridge, and traverses.	4 runs up, clears the vent, serves it, pricks the cartridge, and traverses.

7 double-mans 3's handspike, prepares and brings up shells, assists to put them in, cuts and fixes fuzes, supplies 1 with tubes, and fires.

6 double-mans 2's handspike, prepares and brings up shells, assists to put them in, supplies 5 with cartridges, cuts and fixes fuzes.

At 10-inch mortars, Nos. 2 and 3 are sufficient to put in the shell.

Disposition, and Duties of Detachments, for 8, 5½, and 4⅖-inch Mortars, with Five men.

No. 1 commands, hands the spunge to 2, points, and primes.

3 runs up, puts in the cartridge, puts in shell, and traverses.

2 runs up, spunges, wipes the bottom of the shell, uncaps the fuze, and traverses.

5 prepares and brings up shells, cuts and fixes fuzes, supplies 1 with tubes, and fires.	4 clears the vent, serves it, pricks the cartridge, supplies 3 with cartridges, cuts and fixes fuzes.

The shells ought always to be deposited behind traverses raised for the purpose, or in other sheltered places, and one or two men, according to circumstances, should be appointed to scrape and clean the inside of them, and prepare them for the powder and fuzes. There must also be men to weigh or measure out the charges of powder, according to the directions of No. 1.

The following stores are required for the service of mortars:—

One spunge to be placed on the right of the mortar, the spunge head to the front, and supported to keep it free from gravel.

One scraper for two mortars.

One cartridge case, for bringing up the cartridge; or a paper or leather case, for loading when the powder is loose.

One beam hook, for 13-inch; *One pair of hand hooks*, for 10-inch.

One new pattern hand hook, or piece of cord, for 8-

inch.

Four handspikes. Two on each side of the platform, as directed for guns.

Two pointing rods, or pickets.

One plummet with line, in charge of No. 1.

A piece of sheepskin, or an empty sand-bag for wiping the bottom of the shell; to be placed on the right of the spunge.

One quadrant, One perpendicular, One fuze engine, for every four or five mortars. *One tube pocket. One lanyard with hook*, for friction tubes. *One set of priming irons. One filling funnel. One cork screw. One mallet. Two setters. Tow, or flax. Shells. Pound shot, or stones. Bottoms* for ditto. *Valenciennes composition. Fuzes. Carcasses. Light balls.*

At the Magazine.

One budge barrel.	*One set of powder measures.*
One set of weights and scales.	

PREPARE FOR ACTION. PLANT THE POINTING RODS. HALT. PLANT THE ROD. Pointing rods are sometimes fixed in two and a half or three inch planks, about seven or eight feet in length, prepared for this purpose.

Mortars are run up by the same numbers, and in the same manner, as guns on standing carriages, the handspikes being applied under the running up bolts. LOAD. PUT IN THE SHELL. TRAVERSE. MUZZLE RIGHT. HEAVE. HALT. MUZZLE LEFT. HEAVE. HALT. *If necessary*—CROSS LIFT THE MORTAR TO THE RIGHT, (or LEFT). HEAVE. DOWN. Priming, and Firing, as

detailed for guns, except that No. 2, at the word "READY," takes the sheepskin out of the mortar, and as well as No. 3 takes an oblique pace to the rear, to be clear of the explosion.

Article 13.

FIRING BY NIGHT.

To insure as accurate a fire as possible during the night, the following expedients have been adopted:—

For guns on standing carriages.—A directing bar, or piece of timber, about a foot or eighteen inches longer than the platform and four inches by six in thickness, is used. It has a hole at one end, through which a bolt is passed into the platform close to the hurter, and in the object line. On this bolt the bar traverses. At equal distances from the axis or middle line of the carriage, two cleats are bolted under each axletree, at a distance from each other equal to the breadth of the bar, and the bar is passed under the carriage and fitted between these cleats. Holes are bored at the tail of the platform, for the reception of bolts, at distances from each other to suit the size of the bar. The gun is laid for the object during the day, and should the bar fall exactly between two holes, the bolts are put in, and the bar remains fixed. When however the bar covers a hole, the bolts are put into the nearest holes on each side, and small wedges driven in between them and the bar, in order to keep it in its place. The gun now requires nothing more after each round than to be loaded, run up, and fired; operations which are as easily performed by night as by day.

For guns on travelling carriages.—The gun having

been properly laid during the day, a bead or piece of timber of a proper scantling is nailed or screwed to the platform, inside the felloe of each wheel, and parallel to the object line, and two shorter pieces are fastened in like manner outside of the cheeks of the carriage, at the trail.

By a proper application of scotches, the Madras and every description of traversing platform can be made available for night firing.

When the foregoing expedients cannot be resorted to, the platform and the carriage should be chalked in different places, and when the gun is run up, these chalk-marks should be made to correspond. A lantern, in this case, is always required.

For Mortars.

After the mortar has been accurately laid, a plank, thin enough to go under the running-up bolts without touching them, is placed against the outside of one of the cheeks of the bed, and nailed or screwed to the platform, and the mortar after every round, run up to it. If a suitable piece of plank cannot be procured the platform must be chalked close to the mortar bed.

Article 14.

FIRING AT MOVING OBJECTS.

For firing at moving objects a garrison carriage may be fitted with a directing bar, as for night firing, and traversed by means of tackles hooked to eye-bolts in the rear end of the bar. If the rear end be shaped for about ten inches like an axletree arm, and fitted with a truck, the operation of traversing will be

greatly facilitated. This method is peculiarly applicable to coast batteries, where the guns are mounted *en barbette* and where vessels under sail are the objects to be fired at. The gun is elevated and primed, and the proper tackle being then hauled upon, No. 1 gives the word "*Fire*," without any caution to the traversing numbers.

PART 2.—*Article 1.*

LEVER, AND HANDSPIKE.

The lever is of essential use in the service of artillery. When it is 6 feet long, and 3½ inches square at the large end, called *the point*, it is termed a handspike. The greater the length of the lever the greater is its power.[27]

Slewing.

To slew a gun, or mortar, strictly speaking, is to turn it on its axis without moving it from the spot on which it rests.

Pinching.

Pinching is the operation of moving a gun, or mortar, by small heaves of the handspike, without allowing it to turn on its axis. It is moved little by little, and never raised in its progress, but rubs against the skid on which it rests.

Cross-lifting.

To cross-lift a gun, or carriage, is to move it in a direction nearly perpendicular to its axis. Heavy guns, mounted, or dismounted, require a long lever,

and a fulcrum, for cross-lifting. Guns of medium weight may be cross-lifted by means of handspikes.

Article 2.

FULCRUMS, AND PROPS.

Any piece of strong timber of suitable dimensions may serve for a fulcrum, or a prop. It is called a fulcrum when used to support a lever, and a prop when used as a temporary support for anything else.

Fulcrums.

The distance of the fulcrum from the weight which is to be raised should be such that, when the lever rests upon the top of it, the point may be put under the weight, and the lever form such an angle with the horizon that, when it is heaved down, and the small end nearly touches the ground, the weight may be raised to the required height.

Except with very heavy bodies, care must be taken, in placing a fulcrum, that it is inclined in a small degree towards the body, so that when the lever acts it may bring the fulcrum into a vertical position.

Props.

There cannot be a better prop than a quoin, when it is long enough, or a piece of wood of that shape, of proportionate size.

If the wheels of a carriage are to be taken off, and the carriage propped, the trail should be first secured from slipping.

The props are placed under each cheek, or under the shoulder of the axletree, with a slight inclination

towards the carriage.

When one wheel only is to be taken off, and the other scotched, the props may be placed vertically; but practice alone will point out the proper position of props in all situations.

The point of the lever must not be withdrawn, until it is evident that the prop is well placed.

Article 3.

LIFTING JACK.

The lifting jack forms part of the equipment of every battery, and battering train. It may be applied to many of the purposes for which a long lever is used; but it is commonly employed to raise the wheels of carriages from the ground when they are to be greased, or exchanged, and to extricate them from ruts and holes.

The wheel opposite to that which is to be raised must be scotched.

On soft ground a piece of board must be placed under the foot of the jack, to prevent its sinking.

There are three kinds of lifting jacks in the service —

1st. *The common lifting jack* is used for field carriages only. The arm, which may be adjusted, within certain limits, to any required height, is a lever of the first kind, and is applied accordingly. The body of the jack is the support on which it works.

2nd. *The tooth and pinion jack* is of greater power

than the common jack, and is used for heavy carriages. It is applied vertically under the carriage, which is raised by turning the winch of the jack.

3rd. *The screw jack* is an elevating screw of large dimensions, and is of greater power than either of the other two. Like the tooth and pinion jack, it is applied vertically under the body, which is raised, like the breech of a gun, by turning up the screw. The foot of it is furnished with three spikes, to prevent its slipping when the screw is turned.

If a wheel is to be extricated from a rut, into which it has sunk so far that the lifting jack cannot be applied in the ordinary manner, the jack is placed as close to the wheel as possible, on the outside of it. A piece of rope, passed under the nave, is made fast to the extremity of the arm, if the common jack is used, or to the fork, if either of the other kinds be employed. The jack is then worked as usual, and stones or other hard substances are thrown under the wheel, to prevent its sinking, as often as it may be necessary to take fresh purchases.

The tooth and pinion and screw jacks may be employed to move bodies horizontally a few inches, provided a good abutment or support can be found for the foot of the stock. By the application of two jacks, in opposite directions, bodies may be brought together to be spliced, riveted, &c.

Article 4.

ROLLERS.

Rollers are solid cylinders of wood, used in mounting guns upon their carriages, in shifting them

from carriage to carriage, and in moving them through passages too narrow to admit of the use of the ordinary means of transport. Their dimensions vary, according to the nature of the service for which they are intended.

They can be used with advantage, only on a perfectly level plane surface.

When a cylindrical body is moved on rollers, they must be perfectly horizontal, or it will roll off them; and even when the rollers are horizontal, steadying handspikes should, if possible, be applied, to guard still further against such an accident.

The rollers must be placed at right angles to the direction in which they are intended to move, projecting equally on each side of the axis of the gun, or other body, which they support.

A gun laid upon rollers may be moved, either by hauling upon it with ropes, or by means of levers. In the last case, two holes crossing each other at right angles, are pierced near each end of the several rollers, and in them are inserted the points of iron levers, by means of which the rollers are turned in the required direction.

In order that rollers may be used with the greatest effect, and that there may be as little necessity as possible for shifting them during the course of an operation, it must be borne in mind,—

1st. That a roller moves in a direction perpendicular to its own axis.

2nd. That it moves over half the space only which is traversed by the body it supports.

Article 5.

CRAB CAPSTAN.

A crab capstan consists of a barrel, (in shape, a frustum of a cone,) and of a framework of wood and iron by which the barrel is supported in a vertical position with its largest diameter next the ground. It is furnished with two levers, called capstan bars, which are passed through mortices in the upper part of the barrel, and by means of which the barrel may be turned about on its axis. By means of the crab capstan, a few men, acting at the levers, can move weights which would be far beyond their strength, if applied in the ordinary manner; and it may, therefore, be used with advantage in many situations, in which it may be either difficult to command labour, or desirable to economise it.

One end of a rope is made fast to the weight which is to be moved, and is called the *standing end*. The other, called the running end, is passed two or three times round the lower part of the barrel, the loose or running end being kept above the turns, and stretched taught by the man who passed it round. As the barrel is turned, the standing end of the rope winds round it, forces the turns up the barrel, and clears itself. As fast as the running end comes off the barrel, it is coiled by a man appointed to that duty.

The capstan, when used, is secured by ropes to pickets, driven on the opposite side of it to that on which the strain acts upon it. Three men at each end of both bars—*i. e.*, twelve men in all—is the greatest number that can be employed at the capstan with advantage; and two men are required for the running end of the fall, as previously described. The levers are twelve feet in length, and the power of twelve

men, acting upon them, is about equivalent to that of 132 men acting at the end of a taught rope.

If a crab capstan cannot be procured, the windlass of a gyn may be used as a substitute, the cheeks being laid on the ground and secured with pickets; or a temporary capstan may be rigged, by lashing four handspikes to the spokes and felloe of a limber wheel, which is turned upon the pintail of the dismounted limber.

Article 12.

SLING CART.

The sling cart weighs about 15 cwt., and is employed for moving heavy ordnance. It is capable of carrying 65 cwt.

One non-commissioned officer and six men are required, numbered as usual; but it can be worked by one non-commissioned officer and four men.

Articles required:—

One sling of six-inch white rope, two fathoms long, with an eye-splice at each end.

One sling tye, of one-inch tarred rope, two feet long.

One prypole.

One prypole rope, 2½-inch, three fathoms long.

Two levers, six feet nine inches long.

Two lever ropes, of two-inch tarred rope, each two fathoms.

Two pawls.

Two common handspikes.

Two pieces of short skidding, about 4½ feet long, and five or six inches square.

The detachment is drawn up in rear of and facing the cart, the command is given, "*Form the order of exercise—to the right face—quick march.*" The detachment wheels to the left, and the ranks open out. Nos. 2 and 3 halt one pace in rear of and covering the wheels. The whole one pace from each other, and covering.

Disposition, and duties of the Men.

No. 1 attends to the pawl, and commands.

Left side.	*Right side.*
3 has charge of the left lever, and skids the gun when necessary.	2 has charge of the right lever, and skids the gun when necessary.
5 has charge of a handspike, assists 3 at the lever, and skidding, and raises the weight when it is to be lashed.	4 has charge of a handspike, assists 2 at the lever, and skidding, and raises the weight when it is to be lashed.

7 assists 3 at the lever, slings, and unslings the gun, and lashes it to the prypole.	6 assists 2 at the lever, slings, and unslings the gun, and lashes it to the prypole.

FORM THE ORDER OF MARCH. QUICK MARCH. If the gun be not on skids, a piece of skidding is placed under it, a little in front of the trunnions, to make room for the sling to be passed under the piece. Before the piece is slung, the trunnions are brought vertical, or nearly so, either by the ordinary method of slewing, or by means of the sling cart, as follows: —

BACK THE CART OVER THE GUN. SCOTCH THE WHEELS. FORM THE ORDER OF EXERCISE. QUICK MARCH. UNLASH THE PRYPOLE, LEVERS, AND HANDSPIKES. FIX THE SLING TO THE RIGHT OF THE WINDLASS. OVERHAUL THE SLING. PREPARE TO RAISE THE RIGHT TRUNNION. HEAVE IN THE SLACK. TAKE UP LEVERS. RIGHT LEVER TAKE PURCHASE. HEAVE. LEFT LEVER TAKE PURCHASE. RIGHT LEVER FETCH. LEFT LEVER HEAVE. RIGHT LEVER TAKE PURCHASE. LEFT LEVER FETCH. HALT. OUT LEVERS. SLING THE GUN. HEAVE IN THE SLACK. MAN THE LEVERS. HEAVE. LEFT LEVER HOLD ON. RIGHT LEVER FETCH. Alternately to the lever numbers—HOLD ON, and FETCH, until the gun is close to the axletree, HALT. PREPARE TO RAISE THE BREECH. RAISE THE BREECH. (If necessary, TAKE A FRESH PURCHASE. HEAVE.) HALT, LASH THE BREECH. LASH LEVERS, AND HANDSPIKES.

Unslinging the Gun.

UNLASH LEVERS, AND HANDSPIKES. UNLASH THE PRYPOLE. MAN THE LEVERS. EASE OFF. LEFT LEVER HOLD ON. RIGHT LEVER FETCH. RIGHT LEVER HOLD ON. LEFT LEVER FETCH. OUT LEVERS.

Slinging a Howitzer.

A howitzer is slung, and unslung according to the foregoing details.

Slinging a Mortar.

A mortar is slung with the muzzle towards the rear. For a 13-inch mortar, the wheels of the sling waggon ought to be used for the sling cart, and a double-barrelled windlass, if procurable.

Unslinging a Mortar.

See "Unslinging a Gun."

Slinging a Mortar bed.

The windlass for raising Mortar beds is of a different construction from that of guns, being square in the middle, and cylindrical at each end. The bed is slung with the front part towards the rear of the cart.

SLING THE BED. LASH THE BED.

Unslinging a Mortar bed.

Unslinging a mortar bed is just the reverse of slinging, each number undoing what he had previously done.

Article 13.

SLING WAGGON.

The sling waggon weighs about 29 cwt., and is employed for moving heavy ordnance, and their standing carriages. It requires a detachment of 1 non-commissioned officer and 8 men; but 1 non-commissioned officer and 6 men can sling any weight below a 24-pounder.

The following articles are required:—

One sling of five-inch white rope, 2½ fathoms long, and having an eye-splice at each end.

One sling tye of one-inch tarred rope, two feet long.

One breech rope, or carriage sling, of 2½-inch tarred rope, 6 fathoms long.

Two levers, six feet nine inches long.

Two lever ropes, of two-inch tarred rope, 2½ fathoms each.

Two pawls.

Four common handspikes.

Two pieces of skidding, about four feet long, and six or seven inches square.

One pair of strong dragropes.

The detachment is numbered in the usual manner, and takes post for exercise, as at the sling cart.

Disposition, and duties of the men.

No. 1 attends to the pawls, and commands.

Left side.	*Right side.*

3 has charge of the left lever, and skidding, scotches the wheels in rear, assists in unlimbering, and limbering up.

2 has charge of the right lever, and skidding, scotches the wheels in rear, assists in unlimbering, and limbering up.

5 has charge of a handspike, assists 3 at the lever, scotches the wheels in front, fixes the carriage sling, and assists in unlimbering, and limbering up.

4 has charge of a handspike, assists 2 at the lever, scotches the wheels in front, fixes the carriage sling, and assists in unlimbering, and limbering up.

7 assists 3 at the lever, slings, and unslings the gun, lashes the breech, handspikes, and levers, and assists in unlimbering, and limbering up.	6 assists 2 at the lever, slings, and unslings the gun, lashes the breech, handspikes, and levers, and assists in unlimbering, and limbering up.
9 assists in unlimbering, and limbering up, keys, and unkeys the limber chain, and fixes the breech rope.	8 assists in unlimbering, and limbering up, keys, and unkeys the draught chain, and fixes the breech rope.

Bringing the stores.—If the stores are not with the waggon, Nos. 2 and 3 bring a lever each, and 4 and 5 two handspikes each; 6 the gun sling, and 7 the carriage sling or breech rope; 8 and 9 the skids and drag ropes.

The gun is supposed to be lying on skids, and its carriage on one side, with its breast nearly in line with the breech.

FORM THE ORDER OF MARCH. QUICK MARCH. BACK THE WAGGON OVER THE GUN. PREPARE TO UNLIMBER. UNLIMBER. OUT LEVERS. PREPARE TO

TURN THE GUN CARRIAGE OVER. TURN THE GUN CARRIAGE OVER—HEAVE. TAKE OFF THE TRUCKS. PREPARE TO LIFT THE CARRIAGE TO THE CROSS-BAR. LIFT THE CARRIAGE TO THE CROSS-BAR. FIX THE CARRIAGE SLING. TAKE UP LEVERS. RIGHT LEVER TAKE A PURCHASE—HEAVE. OUT LEVERS—OFF SLING. PREPARE TO LIMBER UP. LIMBER UP. PREPARE TO BACK THE WAGGON. BACK THE WAGGON. SCOTCH THE HIND WHEELS. PUT ON THE TRUCKS. FORM THE ORDER OF EXERCISE. QUICK MARCH. PREPARE TO RAISE THE TRUNNION ON THE RIGHT. HEAVE IN THE SLACK. TAKE UP LEVERS. RIGHT LEVER TAKE A PURCHASE—HEAVE. LEFT LEVER TAKE A PURCHASE. RIGHT LEVER FETCH. LEFT LEVER HEAVE. OUT LEVERS. SLING THE GUN. MAN THE LEVERS. LEFT LEVER HOLD ON—RIGHT LEVER FETCH. PREPARE TO RAISE THE BREECH. RAISE THE BREECH. FRAP AND MAKE FAST. PLACE STOOL BED, AND QUOIN. LASH UP LEVERS, AND HANDSPIKES.

Dismounting the Gun, and Carriage.

PLACE SKIDS, UNLASH, AND SCOTCH THE WHEELS. UNLASH THE BREECH. FORM THE ORDER OF EXERCISE. QUICK MARCH. LEVERS TAKE A PURCHASE TO LOWER THE GUN. BEAR DOWN. EASE OFF. RIGHT LEVER HOLD ON. LEFT LEVER FETCH. LEFT LEVER HOLD ON. RIGHT LEVER FETCH. EASE OFF.

Slinging Howitzers.

A howitzer is slung in the same manner as a gun.

Slinging Mortars.

A 13-inch mortar and its bed require each a waggon for itself; but a 10 or 8-inch mortar can be conveyed on its bed, by one waggon.

LIMBER UP. UNSCOTCH THE WHEELS. RUN THE WAGGON BACK. PREPARE TO LASH UP THE MUZZLE. HEAVE. RUN THE WAGGON FORWARD.

Article 15.

TRIANGLE GYNS.

There are two patterns of triangle gyn, the small and the large.

The small gyn has legs sixteen feet long, weighs about 8½ cwt., including the tackle, and is capable of raising with safety 65 cwt. It is principally used for mounting guns and howitzers on their carriages, and for dismounting them; and for placing ordnance of every description on platform waggons.

The large gyn has legs twenty feet long, weighs about 11½ cwt., including the tackle, and is also capable of raising with safety 65 cwt. It is principally used for mounting guns upon traversing platforms, and for dismounting them.

The rear of the gyn is the part where the windlass is fixed. The front of the gyn is the prypole.

Strength of Gyn Detachments.

One non-commissioned officer and ten men are allowed to raise and work the gyn, numbered as for gun drill.

The same number is sufficient to carry the small gyn. The large one should be drawn to the place where it is to be used in a hand cart.

At exercise the even numbers are on the right, and the odd numbers on the left.

The following is the list of stores required for the service of gyns:—

One fall, of 3½-inch white rope, seventy-two feet long, for the small gyn.

One fall, of 3½ inch white rope, ninety-six feet long. }

One staple, fixed in the top of the prypole. } For

One four-inch block for whip. } the large

One whip fall, of 1½-inch rope, thirty feet long. } gyn.

Four lashing ropes, each nine feet long. }

Two levers and lever ropes. }

One triple block. }

One double block. }

One sling, of six-inch white rope, of a length to suit the dimension of the gun or other object which is to be slung. }

One single lashing rope, 2½-inch, for slinging mortars. }

One piece of spun yarn, three-stranded, 1½ fathom long, for seizing the clinch of the fall. }

One ditto, one fathom long, for stoppering the fall. } With

One fid, (for which a couple of handspikes may be substituted,) for slinging the gun; or,— } both patterns.

One short piece of skidding, for the same purpose,
for slinging mortars and howitzers. }

One hammer. }

Three trucks, or *small pieces of board*, four inches thick,
with a hole in the centre of each, to receive the spikes of
the feet of the gyn on soft ground. Handspikes laid upon the
ground, and on each side of the several spikes, will answer
this purpose. }

One pair of dragropes. }

Disposition, and duties of the Men.

No. 1 commands.

Left side.	*Right side.*
3 carries the foot of the left cheek, has charge of the left lever, keys and unkeys the left capsquare, runs the carriage up, or back.	2 carries the foot of the right cheek, has charge of the right lever, keys and unkeys the right capsquare, runs the carriage up or back.

5 carries the top of the left cheek, assists 3 at the lever, runs the carriage up, or back.

4 carries the top of the right cheek, assists 2 at the lever, runs the carriage up or back.

7 carries the levers and handspikes, assists 6 to pass the fall round the windlass, holds on next to him.

6 carries the windlass, passes the fall round it, holds on the fall and makes it fast, eases off the fall, and lowers the gun.

9 carries the top of the prypole with sling, fid, trucks, &c., holds on the fall behind 7, and coils it up.

8 carries the foot of the prypole with sling, fid, trucks, &c., holds on the fall behind 6. xx

11 assists in carrying the blocks, and fall, reeves, and unreeves the triple block, assists in slinging the gun, and steadies it on his own side.	10 assists in carrying the blocks and fall, reeves, and unreeves the double block, assists in slinging the gun, and steadies it on his own side.

PUT THE GYN TOGETHER, AND REEVE THE TACKLE. PLACE THE WINDLASS.

To raise, and place a Gyn.

PREPARE TO RAISE THE GYN. At a small gyn the tackle is hooked before the gyn is raised; at a large gyn it is not hooked until after the operation has been performed. *At the Small gyn*, HOOK THE TACKLE. RAISE THE GYN. HALT. PREPARE TO PLACE THE GYN, either pattern. LIFT THE CHEEKS IN, OUT, TO THE RIGHT, OR TO THE LEFT. *At the Large gyn*, PREPARE TO HOOK THE TACKLE. HOIST THE TACKLE.

To raise a Gun, or other object, and to mount and dismount a Gun or Howitzer on, and from a standing carriage; or to shift it from one carriage to another.

POST YOURSELVES. PASS THE FALL ROUND THE WINDLASS. PUT ON THE SLING, AND HOOK THE BLOCK. FIX THE SLING, to a gun, or howitzer without dolphins. Or, FIX THE LASHING, to a mortar, or other piece of ordnance with dolphins. FIX THE SLING, to a

mortar bed. SHIFT THE FALL TO THE RIGHT OF THE WINDLASS. HAUL TAUGHT. Everything being prepared for raising the piece, &c., which has been slung, WORK THE LEVERS. HEAVE. FETCH. HEAVE, FETCH, alternately until the piece, &c., is high enough. HIGH ENOUGH. MAKE FAST THE FALL. If a gun, or howitzer is to be dismounted, the carriage is run from under by Nos. 2, 3, 4, 5, and the piece is lowered to the ground—PREPARE TO LOWER THE PIECE. LOWER. The piece is unslung, and the sling removed by the same numbers that slung it. Before striking the large gyn, the tackle must be unhooked; an operation exactly the reverse of hooking. PREPARE TO STRIKE THE GYN. STRIKE THE GYN. TAKE THE GYN TO PIECES.

To mount a Gun, and Carriage, upon a platform waggon, by means of a triangle gyn.

The gyn is placed over the gun in the usual manner, and the platform waggon is brought to the side of the gyn, with its rear towards the muzzle of the gun. The gun is then raised, by means of the gyn; and, when high enough, and the fall made fast, the carriage is run back by Nos. 2, 3, 4, 5. PREPARE TO BACK THE WAGGON. BACK THE WAGGON. LOWER THE GUN. The sling is then removed, and the waggon is run forward. The gun carriage is next brought under the gyn, and turned bottom upwards—LIFT. FIX THE CARRIAGE SLING. The carriage is now raised by means of the gyn, and is lowered upon the piece. LASH THE CARRIAGE.

Article 16.

GIBRALTAR GYN.

The Gibraltar gyn is principally used for mounting, and dismounting guns, and howitzers on, and from standing carriages. It weighs 10¾ cwt., and can support three tons with safety.

The following stores are required for the service of the gyn:—

One fall, of 3½-inch white rope, eight fathoms long.

Two lashings for slinging the gun, of 2½-inch tarred rope, each twenty feet long.

One stopper, about 5½ feet long, of 2½-inch tarred rope, more than one half plaited as a gasket.

One iron triple block, with brass sheaves, to which is attached a bar of iron 2½ feet long, for suspending the gun, its ends turned up to prevent the slings slipping off.

Four common handspikes. Two dragropes.

One non-commissioned officer and six men are allowed for working the gyn, numbered as usual.

The gyn is moved by means of dragropes hooked to the staples of the front, or rear axletrees by Nos. 6 and 7. It can be drawn over hard level ground by the working detachment of six men. On ground of an unfavourable nature, a greater number than this is necessary.

The rear of the gyn is the part where the windlass is fixed.

The detachment being formed a few paces in rear of the gyn, No. 1 gives the word, "TAKE POST FOR EXERCISE—TO THE RIGHT FACE—QUICK MARCH." The detachment wheels to the left, and the ranks

open out. Nos. 2 and 3 halt one pace in rear of their respective axletree arms. The whole one pace from each other, and covering.

Disposition, and Duties of the Detachment.

No. 1 commands.

Left side.	*Right side.*
3 runs the carriage up, or back, heaves round the windlass, assists 7 to sling the gun.	2 runs the carriage up, or back, heaves round the windlass, assists 6 to sling the gun.
5 runs the carriage up, or back, assists to hold on the fall, stoppers, and unstoppers it.	4 runs the carriage up, or back, holds on the fall, makes it fast, and lowers the gun.

7 reeves the tackle, slings, and unslings the gun at the chase, and steadies it. xx	6 reeves the tackle, slings, and unslings the gun near the first reinforce, steadies the gun, and overhauls the tackle.

PREPARE TO PLACE THE GYN. PLACE THE GYN BY HAND, (or BY CROSSLIFTING). REEVE THE TACKLE. PREPARE TO SLING THE PIECE. SLING THE PIECE. HAUL IN THE SLACK. HEAVE ROUND THE WINDLASS. HALT. STOPPER THE FALL. SHIFT THE FALL. HALT. The carriage having been run under the piece, or away from it, as may be required, the piece is lowered, and cast loose, each number reversing the operations which he performed in lashing; and raising it.

PART VIII.

GUNNERY.

By the Parabolic Theory, the greatest range is when the angle of elevation is 45˚, or half a right angle; and the ranges are equal at angles, equally above, and below 45˚. In projectiles, moving with velocities not exceeding 300 or 400 feet per second of time, the Parabolic theory will resolve cases tolerably near the truth; but in cases of great projectile velocities, that theory is quite inadequate, without the aid of data, drawn from good experiments; for so great is the effect of the resistance of the air to projectiles of considerable velocity, that some of those, which in the air range only two or three miles, would, in vacuo, range between twenty and thirty miles. The effects of this resistance are also various, according to the velocity, the diameter, and the weight of the shot.

By experiments it will be found that the greatest range (instead of being constantly that at an elevation of 45˚, as in the Parabolic theory), will be at all intermediate degrees between 45˚ and 30˚ (with ordinary charges about 42˚), being more, or less, both according to the velocity, and the weight of the projectile; the smaller velocities, and larger shells ranging farthest when projected almost at an elevation of 45˚; while the greatest velocities, especially with the smaller shells, range farthest with an elevation of about 30˚. However, as sufficient

experiments have not yet been made to establish true rules for practical gunnery, independent of the Parabolic theory, we must at present content ourselves with the data of some one certain experimental range, and time of flight at a given angle of elevation, and then, by help of these, and the Parabolic theory, we can determine the like circumstances for other elevations that are not greatly different from the former, assisted by the following rules:—

PRACTICAL RULES IN GUNNERY.

1.—*To find the Velocity of any shot, or shell.*

It has been found by experiments, that with shot of mean windage, and powder of mean strength, a charge of one-third of the weight of the ball gives an initial velocity of about 1600 feet per second: therefore, *to find the velocity given by any other charge*, divide three times the weight of the charge by the weight of the ball, and multiply the square root of the quotient by 1600, the product will be the velocity in feet, or the space the shot passes over in the first second.[28]

2. *The first graze, with given elevation, and charge, being known, to determine the charge for any other first graze, and elevation.*

Multiply the known charge, and elevation into the proposed first graze, also the proposed elevation into the known first graze, and divide the first product by the last, for the charge required in ounces.

3. *Given the range for one charge, to find the range for another charge, or the charge for another range.*

The ranges have the same proportion as the charges; that is, as one range is to its charge, so is any other range to its charge, the elevation of the piece being the same in both cases.

Table of Velocities, &c., of shells.

Nature of shells, in inches	13	10	8	5½	4⅖
Their weight (loaded) in pounds	200	92	46	16	8
Charge of powder (land service) do.	5	3	2	1	½
The velocities	436	500	629	693	693

From Experiments on the velocities of shot, the following results have been obtained:—

1. *The time of a ball's flight is nearly as the range*, the gun, and elevation being the same.

2. *The velocities decrease as the distances increase* (arising from the resistance of the air, which opposes the progress of the shot,) in a proportion somewhat higher than the squares of the velocities throughout, and subject only to a small variation.

3. *Very little advantage is gained, in point of range, by increasing the charge* more than is necessary to attain the object, the velocities given by large charges being very soon reduced to those by moderate charges; those, for instance, given by half the shot's weight are reduced to an equality with those by one-third, after passing through a space of only 200 feet. (*Vide* 8.)

4. *Very little benefit is derived from increasing the length of guns*, the velocity given by long guns of 22

calibres being reduced to an equality with that of short guns of 15½ calibres with similar charges, after passing through the following spaces—viz.:—

With	½	the shot's	weight, about	285
”	⅓	do.	do.	200
”	¼	do.	do.	150
”	⅙	do.	do.	115

5. *The resistance of the air* against balls of different diameters with equal velocities, is very nearly in the proportion of the squares of their diameters, or as their surfaces.

6. *A very great increase of velocity may be acquired by a decrease of windage*, from ⅓ to ¼ being lost by the windage of ½0 the diameter of the bore.

7. *By firing the charge in different parts* (separately, or simultaneously), by compressing the charge, by the use of wads, by varying the weight of the gun to lessen the recoil, or even by stopping the recoil entirely, no sensible change is produced in the velocity of the ball.

8. *The velocity increases with the charge*, to a certain point, peculiar to each gun; but, by further increasing the charge, the velocity gradually diminishes; yet the recoil is always increased by an increase of charge. (*Vide* 3.)

9. *The velocities of balls fired with equal charges* increase to a certain point, when the gun is longer, in a proportion which is nearly the middle ratio between the square and cube roots of the length of the bore.

10. *When shot of different weights are fired with the*

same charges of powder, the velocities communicated to them are nearly in the inverse ratio of the square roots of their weights. Therefore, shot which are of different weights, and impelled by the firing of different charges of powder, acquire velocities which are directly as the square roots of the charges of powder, and inversely as the square roots of the weights of the shot. By making use of shot of a heavier metal than iron (lead for instance) the momentum of the shot discharged with the same charge of powder would be increased in the ratio of the square root of the shot's weight, which would both augment the force of the blow with which it would strike, and also the extent of the range.

Compound-shot, or shells filled with lead, fired with charges increased ⅛th, will increase the power of range considerably.

11. *With common shells at 45° elevation, the time of flight* is nearly equal to the square root of the range in feet, divided by 4; or, more nearly, equal to the square root of the quotient of the range in feet, divided by 16-1/12.

12. *The range at 45° elevation* is nearly equal to the square of the time of flight in seconds, multiplied by 16-1/12 feet. The range at 15° will be about half that at 45°.

13. *Upon inclined planes, at any elevation*, there are always two elevations with which any range may be obtained.

The elevation which gives the greatest range, on a given ascent, is equal to half the sum of 90° added to the ascent.

The elevations which give equal ranges on a given

ascent, are the complements of each other added to the ascent.

The elevation which gives the greatest range on a descent, is equal to half the complement of the descent.

14. *The depths penetrated by balls of the same size into wood*, with different velocities, or charges, are nearly as the squares of the velocities. Balls of different sizes will penetrate to depths proportionate to their diameters; therefore a greater ball will not only make a larger hole, but will also penetrate farther than a small one with the same velocity.

15. By experiments at a mean range, it has been ascertained that in common earth, dug up and well rammed, a musket ball buries itself nearly 1½ foot; a 6-pounder from 3½ feet to 4½ feet; 9-pounder from 6½ feet to 7 feet; 12-pounder from 8½ feet to 10 feet; 18, and 24-pounders from 11½ feet to 13 feet.

THEORY, AND PRACTICE OF GUNNERY,

APPLICABLE ESPECIALLY TO THE SERVICE OF NAVAL ORDNANCE. [29]

Double Shotting.

"Double shotting may be used with all 32-pounder guns above those of 32 cwt., at distances not exceeding 400 or 500 yards; but the most efficient practice with two shot is at 300 yards. The 32-pounders of 32 cwt. and 25 cwt. should not, however, be so used beyond 200 and 250 yards.

"With double loadings of round shot and grape, when the shot is put in first, the projectiles range more together than when the reverse process is used; such loading requires, however, more elevation to be

given to the gun than when single shot are used, on account of the grape shot impeding the flight of the round shot. A double load of grape from the same gun ranges tolerably well together for 300 yards. With a double load of case shot, even with half a degree more elevation than when a single load is used, a great many balls will not range above 100 yards to the first graze; within this extent they lose much of their velocity, and few reach an object at 200 yards. A 32-pounder gun of 56, or of 50 cwt., double shotted with charges of 6 lb., requires at 400 yards 1½ degree of elevation; at 300 yards 1 degree; and at 200 yards half a degree; and, in general, half a degree must be added, with any double loading, to the elevation required with single shot.

"For round, and grape, at 400 yards, there is required 1½ degree of elevation; and at 200 yards half a degree. These projectiles range well together at a target, but they should not be used at a greater distance than 150 yards on account of their dispersion, and the differences of their striking velocities, and penetrating forces.

"With a single load of grape at 400 yards, the elevation required is 1 degree, a full charge of powder being used. With a double load of grape at 400 yards, and the reduced charge, the elevation required is 3½ degrees; at that distance, however, double grape scatters so much as to make very bad practice."

The effects of wads.

"Experience has proved that different degrees of ramming, or different dimensions of wads, make no sensible alteration in the velocities of the ball as determined by the vibrations of the suspended gun.

Stout firm junk wads, so tight as with difficulty to be rammed into the gun, have been used; sometimes they were placed between the powder and ball, sometimes over both, but no difference was discovered in the velocity of the ball. Different degrees of ramming were also tried without wads. The charge was sometimes set home without being compressed; sometimes rammed with different numbers of strokes, or pushed up with various degrees of force; but the velocity of the ball remained the same. With great windage, the vibrations of the pendulum were much reduced, although tight wads under the shot were used; so that wads do not prevent the escape of the inflamed powder by the windage, nor under any circumstances occasion any sensible difference in the velocity of the ball.[30]

"From experiments made on board the 'Excellent,' in 1847, it was found that a grummet wad is more efficient than one of junk, in preventing the cartridge from shifting its place in the bore when the guns were run out with a strong jerk.

"With respect to small arms, it is found that wads of different kinds have different effects upon the projectile, by modifying the action of the charge; and from experiments which have been made in the United States with a musket pendulum, the following results have been obtained: With a charge equal to 77 grains, a musket ball, wrapped in cartridge paper, and the paper crumpled into a wad, the velocity of the ball was 1342 feet; and when two felt wads, cut from a hat, were placed on the powder, with one on the ball, the velocity was 1482 feet. With a charge equal to 140 grains, two felt wads being placed on the powder, and one on the ball, the velocity was

1525 feet; when cartridge paper was used, crumpled into a wad, the velocity was 1575 feet; and when one wad of pasteboard was placed over the powder, with another on the ball, it was 1599 feet. These results seem to indicate that wads made of the stiffest materials are the most advantageous."

Penetration of Shot.

"Experiments were made in 1848 on board H.M.S. 'Excellent,' by firing both solid and hollow shot against the 'Prince George' hulk, which was moored at the distance of 1200 yards. The guns were laid at small angles of elevation, generally between two and three degrees; and the following is a brief statement of some of the most remarkable effects which were produced, the depth penetrated being expressed by the sum of the distances in solid wood which the shot passed through, or deeply furrowed. Several 18-pr. shot, with charges of 6 lb. of powder, penetrated to depths varying from 21 to 33 inches, according to the state of the wood, and there stuck. With charges of 8 lb., the 32-pr. shot penetrated to depths varying from 22 to 48 inches. A 68-pr. shot (solid), with a charge of 10 lb. of powder, made a total penetration of 46 inches. Many hollow shot were fired with remarkable effects from 68-pr. guns, making penetrations which varied from 25 to 56 inches. One of these, with a charge of 8 lb., penetrated the side of the hulk, passing through 28 inches of good wood, tore out the iron hook, which holds the port-hinge, and fractured the after-side of the port, driving the splinters about the deck. It rent away the end of a beam, grazed the deck, passing through two planks, and cutting down a stanchion 8 inches square, making several large splinters; it then struck against the opposite side of the ship, whence it rebounded

against that which it entered.

“At 800 yards, with heavy guns, a charge of one quarter of the weight of shot may always be used; at 500 yards, the charge may be reduced to one-sixth; and within 400 yards, two shot at once may be used with advantage.

“Hollow shot from a 68-pounder carronade, with a charge of 5 lb. 8 oz., penetrated to depths varying from 28 to 31 inches.

“In order to ascertain if shot reflected from water would damage a ship, shots from a 32-pounder gun, with a charge of 10 lb. and a depression equal to 7 degrees, were fired, and the following are some of the effects produced:—

“At the distance of 16 yards, the shot struck the water at 4 feet from the ship’s side; and in one experiment it lodged in the cut-water; in another, it indented the ship’s side; and in both cases it struck at 18 inches below the water-line. At the distance of 36 yards, with a depression of 5 degrees, the shot struck the water at distances from the ship’s side varying from 2 to 15 feet; and, ricocheting, entered the ship at distances above the water-line varying from 2 inches to 3 feet. In consequence of the loss of force which the balls sustained by striking the water, it has been inferred, that if a shot be fired with such a depression as a ship’s gun will bear, it will not penetrate into water more than 2 feet; and, consequently, it will be impossible to injure a ship materially by firing at her under water.

“From experiments made at Metz, in 1834, it appears that masses of cast iron, above one yard square and thirteen inches thick, do not resist the shock of balls fired against them with even moderate

velocities, having been fractured not only at the point of contact, but also at points considerably distant from thence. It was found, also, that the side of a traversing gun carriage of iron was broken by an 8-pounder ball, having a velocity of 492 feet; which proves that carriages of this nature would, if struck, be rendered unserviceable: and that a collision, which, with a wooden carriage, would have damaged only an accessory part, without requiring its being replaced, would, with a cast-iron carriage, have a more fatal effect. Not only is the object struck destroyed, but the fragments scattered in different directions are highly dangerous.

"During the year 1850, various experiments were made on board the 'Excellent,' at Portsmouth, in order to ascertain the effects which might be produced on iron vessels by shot, both solid and hollow, with various charges of powder; for which purpose a double target, ⅝ of an inch thick, consisting of iron ribs and plates, resembling the opposite sides of a strongly-built iron steamer, was constructed, at the distance of about 450 yards from the ship. The general effect was, that the target was always pierced by the shot, and that numerous splinters were detached from it in every direction, which could not fail to be most destructive to the crew of a vessel of this description; the shot was, besides, almost always split in pieces by the shock. One 32-pounder shot broke into thirty-four fragments. Some experiments were made with grape-shot, fired from a 32-pounder, with charges of 3 lb. and 6 lb., when the shot passed through a plate, making a clean hole 3 inches in diameter, and knocking out some rivets. The effects produced by 6-inch shells were not greater than those produced by shot. Two of these being filled with powder, and

having the fuze holes plugged up, broke on passing through the plate; the powder, however, did not explode, but was seen to go away in a cloud like dust.

"From the above-mentioned experiments, it may be concluded, that the splinters detached from the side of an iron ship, and the fragments of the shot themselves, would as effectually clear her quarters as the explosions of shells; in either case the effect would be more serious than any that could be produced by like means on a ship constructed of timber, incendiary effects excepted. With both raking, and diagonal firing, the effect is described as being most formidable; the holes, which were very irregular, were in all cases larger than the shot.

"In 1838, experiments were made at Gavre with two solid balls fired at once against a butt of oak timber, in order to determine the different penetrations of the shot, and the distances between their centres at different distances from the piece. Three different natures of ordnance were used: a long 30-pounder gun, a cannon obusier of 30, and a 30-pounder carronade. One ball was in contact with the charge, and the other in contact with the former. From these experiments it was evident that the ball which was in contact with the charge had the least velocity, and the least penetrating power. It is further remarkable that, at distances beyond 200 yards, the vertical dispersion greatly exceeds the horizontal dispersion."

Excentric spherical shot.

"Experiments with these projectiles were carried on at Metz in 1841; the following were the effects observed:—When the centre of gravity was above the

centre of the figure, the ranges were the longest, and when below, the shortest; when to the right, or left hand, the deviations were also to the right, or left. The mean range of a 12-pounder brass gun, which, with the usual shot, was 1640 yards, was, with the shot whose centres of gravity and of figure were not coincident, the centre of gravity being upwards, equal to 2140 yards, being an increase of 500 yards.

"When the centre of gravity is not coincident with that of figure, the projectile is made to revolve, *ab initio*, on the former centre, thus occasioning a compound motion in the flight of the projectile. When the centre of gravity is below the axis of the bore, the front must turn from below upwards, and a rotation in this direction continuing, the range will be diminished. In like manner, when the centre of gravity is placed on the right, or left hand of the axis of the bore, the shot will turn on a vertical axis, and produce deviations to the right, or left hand respectively. Experiments were carried on at Portsmouth, and at Shoebury Ness, in the year 1850, to ascertain whether the deviations of excentric projectiles were so regular as to admit of being allowed for in pointing the gun; and whether any result might appear to disprove the maxim, that spherical and homogeneous projectiles are the truest in their flight.

Nature of Ordnance.	Charge.	Elevation.	Nature of Projectile.	Greatest Range.	Deviation.
AT PORTSMOUTH.					
	lb.	Deg.		Yards.	Yards.
{	8	2⅛	{Common Shot	1200	2 to 6
{			{Excentric	1450	2 to 7

32 Pr.	{	10	2½	{Common	1654	2
	{			{Excentric	2108	6 to 27
	{	12	12	{Common	3100	10 to 58
	{			{Excentric	3710	10 to 150
	{	10	2½	{Common	1035	2 to 3
	{			{Excentric	1181	2 to 7
8 inch	{	10	5	{Common	1750	2 to 4
	{			{Excentric	1980	9 to 21
	{	10	10	{Common	2800	2 to 25
	{			{Excentric	3230	6 to 54
AT SHOEBURY NESS.						
	{	8	2½	{Common	1296	8⅖
	{			{Excentric	1750	16
32 Pr.	{	10	2½	{Common	1404	6¼
	{			{Excentric	1776	⅓ to 5⅔
	{	10	12	{Common	3068	68
	{			{Excentric	3498	186
	{	10	5	{Common	1820	16⅖
8 inch.	{			{Excentric	2207	19⅓
	{	10	10	{Common	2703	35
	{			{Excentric	2339	141

"The preceding table presents, in an abstracted form, the results of the experiments at Portsmouth, and Shoebury Ness. It will be observed that the ordnance used were 32-pounders, and 8-inch guns; from both of which natures were fired the ordinary solid shot, and also shot rendered excentric by the removal of certain quantities of metal. Thus, in the Portsmouth experiments, 1 lb. of metal was taken from each 32 lb. shot, and 3 lb. from each 68 lb. shot; in those at Shoebury Ness, 1 lb. or 2 lb. were taken from the 32 lb. shot, and 4 lb. from the 68 lb. shot.

"On analyzing the experiments, both at Portsmouth, and Shoebury Ness, it appears that the flight of the ordinary solid shot was the most true, the lateral deflections being frequently but one-half, sometimes one-third, or one-fourth only of the deflections of the excentric shot; that these last deflections were always in the direction in which the centres of gravity of the shot were placed in the gun; and that the increases, or diminutions of range caused by the vertical deviations were produced respectively, as the centres of gravity of the shot were placed upwards, or downwards. It appears, also, that the lateral deviations, though in general constant in direction, were very variable in amount. The results above stated prove decisively the correctness of the deductions from theory, and of the practical maxim, that errors in sphericity and homogeneity in a shot are causes of its deviation from a correct path; and it follows that spherical and homogeneous projectiles, being the most simple, and quite indifferent to the position in which they are placed in the gun and rolled home, as well as to that in which they pass through the atmosphere, are decidedly to be preferred to the others.

"The results of these very curious, and instructive experiments fully explain the extraordinary anomalies, as they have hitherto been considered, in length of range, and in the lateral deviations: these have been attributed to changes in the state of the air, or the direction of the wind, to differences in the strength of the gunpowder, and to inequalities in the degrees of windage. All these causes are, no doubt, productive of errors in practice; but it is now clear that those errors are chiefly occasioned by the excentricity, and non-homogeneity of the shot, and the accidental positions of the centre of gravity of the projectile with respect to the axis of the bore.

"The whole of these experiments furnish decisive proof of the necessity of paying the most scrupulous attention to the figure, and homogeneity of solid shot, and the concentricity of shells; and they exhibit the remarkable fact, that a very considerable increase of range may be obtained without an increase in the charge, or elevation of the gun."

Resistance of iron plates, oak plank, &c., against musketry, canister, grape shot, hollow, and solid shot.

"From experiments in November, 1849, the following results were obtained:—

"*Marine percussion musket*—Charge, 4½ drams; distance, 40 yards.

"Iron plates,	⅛	inch }	All passed through.
Oak plank,	1	" }	
Iron plates,	2/8	" }	4 in 6 passed through.
Oak plank,	2	" }	
Iron plates,	⅜	" }	Both musket proof.
Oak plank,	3	" }	

Canister—Charge, 6 lb.; distance, 100 yards.

Iron plates,	⅜	inch }	Passed through.
Oak plank,	3	” }	
Iron plates,	4/8	” }	Canister proof.
Oak plank,	4	” }	

Grape—Charge, 6 lb.; distance, 200 yards.

Iron plates,	4/8	inch }	
”	⅝	” }	All passed through.
”	6/8	” }	
Oak plank,	4	inch }	All passed through.
”	5	” }	
”	6	”	Generally passed through.

“Experiments were made in June, 1850, against two sections of the ‘Simoom,’ ⅝ inch thick, placed 35 feet apart; the guns, and charges were those used in all steam vessels. The result made evident that two, or three shot, or sometimes even a single one, striking near the water-line of an iron vessel, must endanger the ship. Another most serious evil is, that the shot breaks, on striking, into innumerable pieces, which pass into the ship with such force, as to range afterwards to a distance of 400 or 500 yards; and that the effect on men at their quarters would be more destructive than canister shot, supposing them to pass through a ship’s side; as when the plates are only ⅜ inch thick.

“Experiments were made in July, 1850, against an iron section similar to the ‘Simoom;’ it was filled in and made solid with 5½ inch oak timber between the iron ribs, and 4½ inch oak planking above the water-ways, which were 1 foot thick, and with 3 inch fir above the portsills; these were strongly secured to

the iron plates by bolts. The results were as follows:—The holes made by the shot were not so irregular as on the former occasion, but as clear and open; all parts of the shot passed right through the iron and timber, and then split, and spread abroad with considerable velocity. With low charges, the shot did not split into so many pieces as before. With high charges, the splinters from the shot were as numerous and as severe as before, with the addition, in this, and the former case, of the evil to which other vessels are subject—that of the splinters torn from the timbers.

"In August, 1850, an iron section similar to the 'Simoom' was prepared with a covering of fir plank on the outside, of the thickness of 2, 3, and 4 inches, in different parts. The result of this experiment was similar to the last, when the wood was on the inside; with the exception of the splinters from the wood. The holes made by the shot were regular, of the full size of the shot, and open; every shot split on passing through—those between the ribs into a few pieces only, those that struck on the ribs into a great number; in both cases, when combined with the splinters of the iron side, the effect must prove highly destructive.

"A comparison as to the effect of shot on iron, and timber, was made by firing 8-inch hollow shot, and 32-pound solid shot, at a butt built for experimental shell-firing, with timber having 6-inch plank on the outside, and 4-inch within; the result was, that the splinters from the wood were trifling when compared with those from the iron.

"The general result of all the foregoing, and consecutive experiments for the same purpose, clearly demonstrates that the destructive effects of

the impacts of shot on iron cannot be prevented. If the iron sides are of the thickness required to give adequate strength to the ship (⅝, or at least 4/8 of an inch), the shot will be broken by the impact; if the iron plates be thin enough to let the shot pass into the ship without breaking, the vessel will be deficient in strength; the shot will do its work, particularly in oblique or raking fire, more effectively than its splinters, and, in passing out, make apertures more difficult to plug or stop, than in passing in. When a clean hole is made by a shot penetrating an iron plate, the whole of the disc struck out by the shot is broken into numerous small pieces, which are driven into the ship with very destructive effects; and if the plate be so thick (viz., upwards of 4/8 of an inch) as to cause the shot to break on striking, the fragments will nevertheless pass into the ship, as in the case of a percussion, or concussion shell, and so produce a terrific compound effect by the fragments of both.

"The expedient of combining wood, and iron, either by substituting timber for the iron ribs, or the reverse, outside planking for the iron plates—makes the matter worse. The pieces of ribs struck off, sometimes of great length, pass on with the shot, to produce more extensive ravages elsewhere."

NAVAL GUNNERY.

"In firing into masses of timber, or any solid substance, *that velocity which can but just penetrate* will occasion the greatest shake, and tear off the greatest number of and largest splinters; consequently, in close actions, shot discharged with the full quantity of powder tear off fewer splinters than balls fired from the same nature of guns with reduced charges.

"*In naval actions*, shot intended to take effect upon the hull of an enemy should rather be discharged with a falling than with a rising side; but such pieces as may be appointed specially to act against the masts and rigging should be fired, on the contrary, with the rising motion, the aim being taken low.

"*In all close actions*, the great object should be to strike as often as possible the enemy's hull. One or two 24-lb. shot taking effect just below the water-line, and perhaps perforating both sides of a small vessel, will in general either force her to surrender, or send her to the bottom; and such an injury is much more likely to be occasioned by firing with a falling than with a rising side.

"*To estimate the distance between vessels.*[31]

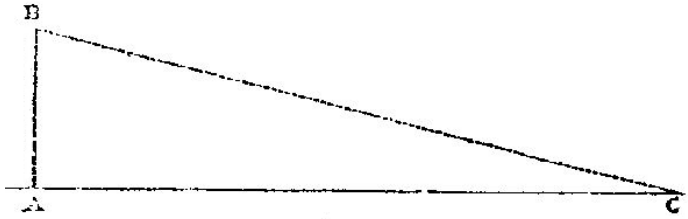
"Measure with a sextant, or quadrant, the angular height of the enemy's mast, and by referring *to Table B*, the corresponding distance may be taken out.

"*In Table A*, the height of the masts to the head of the maintopgallant rigging, and likewise to the maintopmast crosstrees above the surface of the water at low water mark, are given for every rate, and class of vessel.

"The distances in English yards, corresponding to the angles subtended by the masts, are given in the first column *of Table B*.

"*Table B* may also be applied to the important purpose of determining distances, making use of the ship's own mast as the given height or side of the triangle, by marking upon it any of the heights expressed in the table, and placing an observer there when required to measure the angle A B C (*vide fig.*) formed by the mast when most perpendicular, and

the line of sight B C.



"*The Tangent practice Tables* C, D, and E will frequently be found useful in pointing ordnance, when the distance is known; for by referring to that distance in the column of the table belonging to the corresponding nature of gun, the part, that should be aimed at, will be ascertained."

TABLE A.

Heights above the water of the different parts of French ships of War,
and their masts, according to the following Rates:

	Line of battle Ships.										Frigates.			
	Guns. 120.		Guns. 100.		Guns. 90.		Guns. 86.		Guns. 82.		Guns. 60.		Gu 4	
	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft	
Port-sills:														
Of lower deck	5	3	7	10	6	7	5	8	5	8				
Middle	13	1												
Upper	19	4	15	1	14	9	12	9	12	9	6	6¾	6	
Quarter	25	7	21	3	19	8	19	2	19	2	13	9	13	
After-part:														
Of poop plank sheer	35	5	29	2	29	6	25	4	25	4				
Mainmast:														
Upper side of mainyard	79	0	77	1	76	5	71	0	66	0	67	0	59	
Under side of maintop	93	6	91	10	90	2	84	0	78	0	79	0	70	
Upper side of cap to mainmast	109	6	109	10	108	3	101	0	94	0	95	0	84	
Upper side of maintopsail-yard	148	7	140	9	141	0	139	0	130	0	131	0	114	
” Crosstrees to maintopmast	158	5	150	11	150	11	148	0	138	0	139	0	121	
” Cap to maintopmast	166	4	161	8	158	9	156	0	147	0	148	0	128	
Head of topgallant rigging	190	7	185	4	185	4	183	0	170	0	171	0	151	
Truck	219	9	212	7	201	9	205	0	192	5	187	9	168	
Foremast:														

Upper side of foreyard	72	10	72	2	71	2	64	0	61	0	67	0	51
Under side of foretop	86	7	84	11	83	7	77	0	72	0	73	0	63
Upper side of cap to foremast	103	0	101	8	100	0	92	0	87	0	88	0	76
” Foretopsail-yard	136	5	128	11	129	7	128	0	117	0	118	0	101
” Crosstrees to foretopmast	145	8	139	1	137	9	136	0	126	0	127	0	109
” Cap to foretopmast	153	6	148	11	145	0	144	0	135	0	136	0	116
Head to topgallant rigging	173	10	170	3	169	7	168	0	156	0	157	0	136
Truck	200	1	194	10	184	8	188	0	176	0	172	1	152
Mizenmast:													
Upper side of crossjack-yard	73	1	71	10	70	2	64	0	61	0	62	0	52
Under side of mizentop	83	4	83	7	81	4	75	0	71	0	72	0	62
Upper side of cap to mizenmast	93	6	96	5	93	9	85	0	82	0	83	0	71
” Mizentopsail-yard	121	4	116	9	117	1	110	0	107	0	108	0	94
” Crosstrees to mizentopmast	127	11	125	11	122	4	117	0	112	0	113	0	99
Head of topgallant rigging	154	2	150	11	145	8	143	0	136	0	137	0	120
Truck	177	9	171	7	158	9	160	0	153	0	150	0	133

TABLE B.

Angles subtended by the Mainmasts of French ships of war, between the water-line and the truck, also between the water-line and the crosstrees, at distances in yards, and in cables' length; the eye of the observer being twenty feet above the water.

DISTANCES.		LINE OF BATTLE SHIPS.					
		120 Guns.		90 Guns.		82 Guns.	
		ft. in. 219 9	ft. in. 158 5	ft. in. 201 9	ft. in. 150 11	ft. in. 192 5	ft. in. 138 0
Yards.	Cables' length.	Truck of main-mast.	Main-topmast cross-trees.	Truck of main-mast.	Main-topmast cross-trees.	Truck of main-mast.	Main-topmast cross-trees.
		° ′	° ′	° ′	° ′	° ′	° ′
120	½	32 14	24 13	29 59	23 3	28 47	21 11
240	1	17 7	12 29	15 46	11 50	15 4	10 54
360	1½	11 33	8 22	10 37	7 56	10 8	7 38
480	2	8 42	6 17	7 59	5 57	7 38	5 29
600	2½	6 59	5 2	6 24	4 46	6 7	4 23
720	3	5 49	4 12	5 20	3 59	5 6	3 39
840	3½	4 59	3 36	4 35	3 24	4 22	3 8
960	4	4 22	3 9	4 1	2 59	3 49	2 44
1080	4½	3 53	2 48	3 34	2 42	3 24	2 26
1200	5	3 30	2 31	3 21	2 23	3 4	2 12
1320	5½	3 11	2 17	2 55	2 10	2 47	2 0
1440	6	2 55	2 6	2 40	1 59	2 33	1 50

Part 2 of 2

DISTANCES.		FRIGATES.				CORVETTES.		
		60 Guns.		44 Guns.		24 Guns.		1
		ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft.
		187 9	139 0	168 6	121 0	120 7	85 0	112
Yards.	Cables' length.	Truck of main-mast.	Main-topmast cross-trees.	Truck of main-mast.	Main-topmast cross-trees.	Truck of main-mast.	Main-topmast cross-trees.	Truc of mai mas
		° ′	° ′	° ′	° ′	° ′	° ′	°
120	½	28 11	21 12	25 37	18 51	18 50	13 25	17
240	1	14 43	10 55	13 15	9 35	9 34	6 45	8
360	1½	9 54	7 19	8 54	6 24	6 24	4 30	5
480	2	7 27	5 30	6 41	4 48	4 48	3 23	4
600	2½	5 58	4 23	5 21	3 51	3 51	2 42	3
720	3	4 58	3 39	4 28	3 13	3 13	2 15	2
840	3½	4 16	3 8	3 50	2 45	2 45	1 56	2
960	4	3 44	2 44	3 21	2 24	2 24	1 41	2
1080	4½	3 19	2 26	2 59	2 9	2 9	1 30	1
1200	5	2 59	2 12	2 41	1 55	1 55	1 21	1
1320	5½	2 43	2 0	2 26	1 45	1 45	1 14	1
1440	6	2 29	1 50	2 14	1 36	1 36	1 8	1

TABLE C.

Tangent practice with 8-inch Guns, weighing 65, and 60 cwt., carrying a single shot weighing 56 lb., or a shell weighing 56 lb., and charged with 10 lb. of powder. The line of sight is parallel to the axis of the bore, and the gun is 5 feet 4 inches above the level of the water.

Elevations.	Distances.	Heights of part aimed at above the water.	The Points aimed at	
			In a Line of battle ship of 82 guns.	In a 44 Gun frigate.
° ′ ″	yards.	ft. in.		
0 22 20	330	11 10	1 foot below the portsills of the main deck.	1½ foot below the portsills of the quarter deck.
0 35 0	435	18 7	7 inches below the portsills of the quarterdeck, and forecastle.	5 feet above ditto.
0 47 30	535	27 6	2 feet above the afterpart of poop plank sheer.	Twice the height from the water to ditto.
1 0 0	630	38 4	About midway between the water-line, and the under side of the maintop.	Three times ditto.
1 20 0	756	58 0	3 feet below the upper side of the foreyard.	Upper side of the mainyard.

1 40 0	879	82 0	Upper side of cap to mizenmast; or, 4 feet above the under side of the maintop.	2 ft. below the upper side of the cap of the mainmast.
2 0 0	1000	110 0	2 feet below the crosstrees of the mizentopmast.	1 ft. above the upper side of crosstrees of foretopmast.
2 20 0	1078	137 0	1 foot below the crosstrees of the maintopmast.	1 ft. above the head of the topgallant rigging foremast.
2 40 0	1153	166 0	4 feet below the head of topgallant rigging.	2 feet below the truck of the mainmast.
3 0 0	1225	198 0	6 feet above the truck of mainmast.	

Tangent practice with 32-pounder Gun, weighing 56 cwt., carrying one solid shot, charge 10 lb. The line of sight parallel to the axis of the bore, and the Gun 5 feet 4 inches above the water.

0 15 0	343	9 10	3 feet below the portsills of the upper deck.	3 feet above the portsills of the upper deck.
0 30 0	435	16 9	4 feet above ditto.	3 feet above the portsills of the quarter deck.
0 41 0	525	24 0	1 foot below the afterpart of poop plank sheer.	About midway between the water, and the under side of foreyard.
0 52 0	613	33 0	Midway between the water & upper side of mainyard.	One-third of distance from the water to the crosstrees of mizentopmast.

1 0 0	700	42	0	About midway between the water and the upper side of the cap of the mizenmast.	Midway between the water, and cap of mainmast.
1 20 0	835	63	8	About 2 feet below the upper side of the mainyard.	The under side of foretop.
1 40 0	968	90	0	4 feet below the upper side of the cap of mainmast.	4 feet under the mizentopsail-yard.
2 0 0	1100	120	0	3 feet above the upper side of foretopsail-yard.	1 ft. below the upper side of crosstrees of maintopmast.
2 20 0	1240	157	0	1 foot above the head of topgallant rigging, foremast.	5 feet above the truck of foremast.
2 40 0	1378	198	0	5 feet above the truck of mainmast.	

Vide—Tables of Practice, &c., pages 74, 75, 77, 79.

TABLE D.

Tangent practice with a long 24-Pr. Gun with 1 solid shot and a charge of 8 lb. of powder, or with a long 18-Pr. charge 6 lb., from the maindeck of a Frigate of the first class; the height of the Gun above the surface of the water being 9 ft.

Distance in yards.	Take aim.	Height of parts aimed at.	Point at the undermentioned parts of Frigates of 44 guns.
297	P. B.	..	At part intended to hit.
By using sight parallel to bore.			
402		14 ft.	At the level of the quarterdeck, gangway, and forecastle.
508		22	At bulwark rail of quarterdeck, gangway, and forecastle.
614		33	At 4 feet below the centre of mainmast, reckoning from the deck to the mainyard; centre of foremast; 20 feet below crossjack-yard.
720		47	At 13 feet below mainyard; 5 feet below foreyard; 6 feet below crossjack-yard.
790		61	At under part of mainyard; 3 feet below foretop; 2 feet below mizentop.
860		77	At rail of maintop-bulwark; forecap; 5 feet over mizencap.
930		..	Point at part intended to hit.
*By using the line of metal.			

1000		35	At 2 feet below half-way from deck to mainyard; 2 feet above half-way from deck to foreyard; centre of mizenmast.
1060		51	At 9 feet below mainyard; under part of foreyard; 1 foot below crossjack-yard.
1120		68	At 3 feet under maintop; rather better than half-way between foretop and forecap; half-way between mizentop and mizencap.
1180		86	At cap of mainmast; 8 feet over forecap; 3 feet under half-way from mizencap to topsail-yard (hoisted).
1240		106	At centre-way between maincap and topmast-crosstrees; 4 feet over foretopsail-yard (hoisted); cap of mizentopmast.
1299		130	At maintopmast cap; 7 feet under head of foretopgallant rigging.

With 2 shot the elevation must be nearly double that which, with 1 shot, and the same charge of powder, produces the same range.

The angles of elevation, corresponding to the ranges, increase, by quarter degrees, from point blank.

*The reason for transferring the sight to the line-of-metal is, obviously, to use the dispart elevation for the purpose of getting a more direct view.

Vide Tables of Practice, &c., pages 74, 75.

TABLE E.

Tangent practice with short 24, and 18-Prs., with 1 solid shot and a charge of ¼th the shot's weight, from the maindeck of a 2nd class Frigate; the height of the Gun above the surface of the water being 7 feet 6 inches.

Distance in yards.	Take aim.	Height of parts aimed at.	Point at the undermentioned parts of Frigates of 44 guns.
221	P. B.	. .	Point at part intended to hit.
By sight parallel to axis of bore.			
312		11 ft. 6 in.	At 2 feet below the level of the quarterdeck, gangway, and forecastle.
403		18 6	At bulwark rail of quarterdeck, gangway, and forecastle.
494		26 6	At 6 feet over the upper part of hammocks stowed in quarterdeck, gangway, &c.
582		37 6	At 2 feet under centre of mainmast, reckoning from top of hammocks to mainyard: 2 feet over corresponding mark in foremast.
644		50	At 8 feet under mainyard; 1 foot under foreyard; crossjack-yard.

706		62		At 2 feet under half-way from mainyard to maintop; 1 foot under foretop; mizentop.
768		78		At half-way from maintop to maincap; 2 feet over forecap; 7 feet over mizencap.
832		94		At 10 feet over maincap or one-third up to the topmast, reckoning from cap to topsail-yard, (hoisted); 6 feet under foretopsail-yard, hoisted; mizentopsail-yard.
907	..	.	.	Point at part intended to hit.
*By the line of metal.				
			6	At upper part of the hammocks stowed in
982		20		quarterdeck, forecastle, nettings, &c.
			6	At 4 feet under centre of mainmast,
1057		35		reckoning from top of hammocks to mainyard; centre of foremast.
1133		51		At 7 feet under mainyard; foreyard; crossjack-yard.
1177		69		At 1 foot under maintop; centre between foretop and forecap; 2 feet under mizencap.

1221		87	At 3 feet over maincap; 1 foot under centre between maincap and topsail-yards (hoisted up); 4 feet under centre of mizentop-sail.
1265		106	At 8 feet under maintopsail-yard (hoisted); 3 feet under foretopmast crosstrees; 1 foot over mizentopmast cap.
1308		127	At 1 foot under maintopmast cap; 9 feet under the head of foretopgallant-rigging; 7 feet over the head of mizentopgallant-rigging.

With 2 shot the elevation must be nearly double that which, with 1 shot, and the same charge of powder, produces the same range.

The angles of elevation, corresponding to the ranges, increase, by quarter degrees, from point blank.

*The reason for transferring the sight to the line-of-metal is, obviously, to use the dispart elevation for getting a more direct view.

Vide Tables of Practice, &c., pages 74, 75.

INSTRUCTIONS FOR THE EXERCISE, AND SERVICE OF GREAT GUNS, AND SHELLS ON BOARD HER MAJESTY'S SHIPS.

POSITIONS. (*Vide Plate.*)

Before loading. Loading. Training.

Gun Numbers.
1, 2, 3, 4, 5, 6.

Auxiliaries.
7, 8, 9, 10, 11, 12, 13, &c.

Handspike-men.
9, 10.

Rear-men.
12, The right rear-man. 13, The left rear-man, or the two highest numbers.

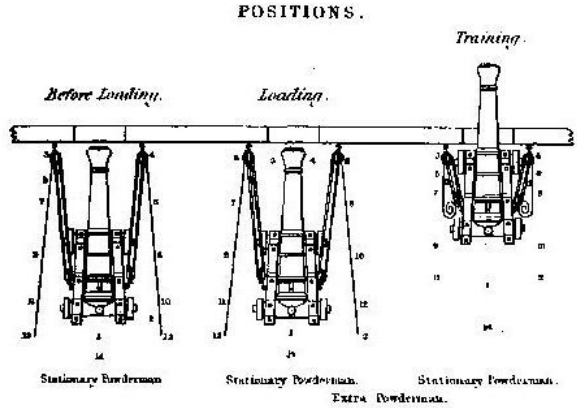
Words of command.

"Prime."—"Point."—"Elevate."—"Ready."—"Fire."—"Stop the vent."—"Sponge."—"Load."—"Run out."

Number of Men allowed to the following Broadside guns.

Nature of Gun.	Weight.	Length.	Number of men.	Carriage.
	cwt.	Feet.		
8-inch.	65	9	14	}
{	56	9½	13	} These guns
{	50	9	12	} are mounted on common carriages.

32 Pounder.	{	45	8½	11	}
	{	42	8	10	}
	{	32	6½	9	}Mounted on
	{	25	6	8	} Hardy's carriages.
32 Pr. Carronade		17	4	7	}



POSITIONS. *J. W. Lowry, sc.*

Before Loading. Loading. Training.

Stationary Powderman Stationary Powderman Stationary Powderman

Extra Powderman

EXERCISE WITH 13 MEN, *to a Lower deck gun.*

No.

1. The Captain;—commands, attends the breeching, bed, and quoin, primes, points, fires, and stops the vent.

2. The second Captain;—assists No. 1, casts loose, hauls up the port, runs out, attends the apron,

and port tackle-fall, and cocks the lock.

3. Takes out the tompeon, bears out the port, loads, rams home, runs out, and trains.

4. Takes out the tompeon, bears out the port, worms, sponges, rams home, runs out, and trains.

5. Casts loose, hauls up the port, gives shot and wad to No. 3, runs out, trains, and spans the breeching.

7, and 8. Cast loose, run out, and train.

9, and 10. Cast loose, run out, and attend handspikes.

11. Casts loose, runs out, and trains.

12. Casts loose, and attends train tackle.

13. Casts loose, runs out, trains, and fires with a hammer, or match.

Note.—The duties of No. 2 for upper, or main deck guns will be the same as that for lower deck guns, omitting the words "haul up the port," and "attends port tackle-fall." The duties likewise of Nos. 3, and 4 will be the same, substituting the words "takes off the upper half-port," "lets down the lower one," or "takes out the port" (as the case may be) for "bears out the port." The duties also of Nos. 5, and 6 will be the same, omitting the words "hauls up the port."

Handspike-men with	5, 6, or 7 men	Nos. 5, and 6
" "	8 or 9 men	" 7, and 8
" "	10 or 11 men	" 7, and 8
and assistant handspike-men		" 9, and 2
Handspike-men with all Nos. above 11		" 9, and 10

and assistant handspike-men " 11, and 2

With light guns it may be advantageous, in some cases, to double man the handspikes.

The left rear-man will always fire with a hammer, or match; and the right rear-man will attend the train tackle, except when he is handspikeman (when No. 2 will attend it), and in lower deck exercise (when the left rear-man will attend it).

At the word "*Man both sides*," each watch will repair to its respective side, the odd numbers standing to the left of the left guns; even numbers to the right of the right guns.

"MAN BOTH SIDES."

Left guns.—No. 3 remains 3; 5 becomes 4; 7—6; 9—5; 11—2; 13—7; 1 remains 1.

Right guns.—No. 4 remains 4; 6 becomes 3; 8—6; 10—5; 12—2; 2—1.

Note.—The left guns are odd starboard, and even port. The right guns are even starboard, and odd port. The odd numbered guns' crews are taken from the starboard watch; the even numbered from the port watch.

Guns' crews always man, and powder boys always supply adjacent guns, when clearing for action, or when fighting both sides.

Note.—With a crew of 11 men, and upwards, and both sides manned, No. 2 is *always* to attend the train tackle.

When casualties occur at the guns, those holding the highest numbers, or those *last* placed, will be the first to move to fill up the vacancies, excepting that

where both captains are removed, the officer will name the most fitting person to become No. 1, filling up the vacancy as above. For instance; if there should be 13 men at the gun, and Nos. 3, 6, and 9, are ordered to "fall out," Nos. 5, and 7, move up, becoming Nos. 3, and 5; No. 11, moves up, and becomes No. 7; No. 13,—No. 9; No. 8 moves up, and becomes No. 6; No. 10,—No. 8; and No. 12,—No. 10. [32]

EXERCISE WITH 7 MEN, *to a 32-pounder carronade.*

No.

1. The Captain; commands, attends the breeching, primes, points, fires, and stops the vent.
2. The second Captain; assists No. 1, casts loose, runs out, attends the apron, and elevating screw, cocks the lock, and attends train-tackle.
3. Takes out the tompeon, takes off the upper half-port, lets down the lower one, loads, rams home, runs out, and trains.
4. Takes out the tompeon, takes off the upper half-port, lets down the lower one, worms, sponges, rams home, runs out, trains, and attends compressor, when the gun is out.
5. Casts loose, gives shot, and wad to No. 3, runs out, trains, and spans the breeching.
6. Casts loose, gives sponge, rammer, and worm to No. 4, runs out, trains, spans the breeching, and attends compressor, when the gun is in.
7. Casts loose, runs out, trains, and fires with a hammer, or match.

Note.—Handspikes are used with all guns, and sometimes with carronades.

The duties with 9 men at the 32 cwt., and 8 men at the 25 cwt. guns are the same as with the 32-pounder carronade, except that No. 8 attends the compressor, instead of No. 6.

Arrangement for Fighting both sides.

When ordered to quarters, each watch will take its respective side; when the crew will assume the Nos. to which the several duties, prescribed for working the guns, are assigned.

In the event of being attacked on both sides, at the same time, the following distribution is to be made, where 6 men, and upwards, besides the powderman, can be allowed to each gun, and its opposite, viz.:—

Fighting both sides.

With 6 men, and powderman.		With 8 men, and powderman.		With 10 men, and powderman.		With 12 m powderr	
3 □ 4	3 □ 4	3 □ 4	3 □ 4	3 □ 4	3 □ 4	3 □ 4	
□	□	□	□	□	□	□	
‖□‖	‖□‖	‖□‖ 6	‖□‖ 6	5 ‖□‖ 6	5 ‖□‖ 6	5 ‖□‖ 6	5
□	□	□	□	□	□	□	
‖□‖	‖□‖	‖□‖	‖□‖	‖□‖	‖□‖	‖□‖ 2	
1	1	1	1	1	1	1	
Powder-man.	Powder-man.	Powder-man.	Powder-man.	Powder-man.	Powder-man.	Powder-man.	P
1	1	1	1	1	1	1	
‖□‖	‖□‖	‖□‖	‖□‖	‖□‖	2 ‖□‖	2 ‖□‖	2
□	□	□	□	□	□	□	
‖□‖	6 ‖□‖	6 ‖□‖	6 ‖□‖ 5	6 ‖□‖ 5	6 ‖□‖ 5	6 ‖□‖ 5	6

□ 4 □ 3	□ 4 □ 3	□ 4 □ 3	□ 4 □ 3	□ 4 □ 3	□ 4 □ 3	□ 4 □ 3
With 7 men, and powderman.		With 9 men, and powderman.		With 11 men, and powderman.		With 13 m powder

The guns are to be worked in pairs, commencing from forward; Nos. 1, and 2 guns on each side will be pairs, and so on, up to the highest even numbered gun on the deck; but the aftermost (if it should be an odd numbered gun) must be worked by its own crew passing from side to side, as necessary. When exercising, until the crews are perfect, and steady, the orders should be given by the officer, who is in charge of the quarters, and the left guns should be fired first. But when the men are perfect, the guns, which are first ready, should be first fired, and the exercise should be conducted by the captains of the guns, having reference to the movements of the other gun of their pairs, in order to approximate the exercise, as nearly as possible, to action with an enemy. All shot practice at targets, with both sides manned, is to be conducted on this plan.

Words of command for FIGHTING BOTH SIDES.

"Man both sides."—"Prime."—"Point."—"Muzzle to the right."—"Muzzle to the left."—"Elevate."—"Ready."—(*Left guns.*) —"Fire."—"Sponge, and load."—(*Right guns.*) —"Fire."—"Sponge, and load."—(*Left guns.*)—"Run out."—"Fire."—"Sponge, and load."—(*Right guns.*) —"Run out."—"Fire."—"Cease firing."

When ordered to "cease firing," the guns are to be loaded, and run out.[33]

EXERCISE FOR THE 10-INCH, OR OTHER REVOLVING

GUN, *with a crew of 17 men.*

The crew are assembled as in the established Gun exercise; then—

Gun.—Nos. 1, 2, 3, 4, 5, 6.

Auxiliaries.—Nos. 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17.

Traversing tackle-men.—Nos. 7, 8.

Handspike-men.—Nos. 9, 10. Assistant handspike-men.—Nos. 11, 12.

Compressor men, Nos. 13, 14.

Rear-men.—No. 16, the right rear-man. No. 17, the left rear-man.

No. 1. The Captain.	No. 4. Sponger.
” 2. Second Captain.	” 5. Assistant loader.
” 3. Loader.	” 6. Assistant sponger.

Words of command.

“Traverse.”[34]
—“Prime.”—“Point.”—“Elevate.”—“Ready.”—“Fire.”—“Stop the vent.”—“Sponge.”—“Load.”—“Run out.”

Exercise with 17 men.

No.

1. The Captain; commands, attends the breeching, bed, and quoin, primes, points, fires, and stops the vent.

2. Second Captain; assists No. 1, casts loose, runs out, attends the apron, cocks the lock, and attends

rear bolt.

3. Takes out the tompeon, loads, rams home, runs out, attends fighting bolt, shackles, and unshackles breeching, if necessary.

4. Takes out the tompeon, worms, sponges, rams home, runs out, attends stop-handspike, shackles, and unshackles breeching, if necessary.

5. Casts loose, runs out, traverses, and spans the breeching.

6. Casts loose, gives sponge, rammer, and worm to No. 4, runs out, traverses, and spans the breeching.

7, and 8. Cast loose, run out, attend traversing tackles, and shift side tackles.

9, 10, 11, and 12. Cast loose, run out, and attend handspikes.

13, and 14. Cast loose, run out, traverse, and attend compressors.

15. Casts loose, runs out, and traverses.

16. Casts loose, traverses, shifts traversing-tackle, brings up shot, or shell, attends stop-handspike, and train-tackle.

17. Casts loose, traverses, shifts traversing-tackle, brings up shot, or shell, fires with a hammer, or match, and attends train tackle.

N.B. These numbers will be reduced for lighter guns, as may be necessary, when Nos. 11, and 12, will attend compressors, and the rear-men will do the duties of No. 16, and 17. When slide-guns are fitted with Ferguson’s Compressor, No. 6 is to attend to it.

On coming to the gun, one, or other of these orders will follow; viz.,—“Action on the rear bolt,” or “Action on the fighting bolt required.”

No. 2, attends the rear, No. 3, the fighting bolt, No. 1 gives the word “Right, or left traverse;” and when bearing on the object, or when on the fighting bolt required “Well:” the gun is then to be wormed, sponged, loaded, and run out, without further orders.

MORTAR EXERCISE.

Mortars—	13-inch Land service —	Nos. 1, 2, 3, 4, 5, 6.
”	10-inch ” ”	” 1, - 3, 4, 5, 6.
”	8-inch ” ”	” 1, - 3, 4, - 6.

Words of command.

“Point.”—“Run the mortar up.”—“Cross lift the mortar to the right.”—“Cross lift the mortar to the left.”—“Muzzle to the right.”—“Muzzle to the left.”—“Down.”—“Load.”—“Prime.”—“Fire.”

13-inch Land service Mortar.

Duties.—No. 1. Commands, points, and serves the vent.

2. Serves ammunition.

3. Loads, assists to put in the shell, runs up, and trains.

4. Sponges, wipes the bottom of the shell, uncaps the fuse, puts in shell, runs up, trains, and attends sheepskin.

5. Assists to bring up shell, runs up, trains, and fires.

6. Brings up shell, guides it into the mortar, runs up, trains, and primes.

10-inch Land service Mortar.

Duties.—No. 1. Commands, points, and serves the vent.

3. Serves ammunition, loads, assists to put in shell, runs up, and trains.

4. Sponges, wipes the bottom of the shell, uncaps the fuze, puts in shell, runs up, trains, and attends sheepskin.

5. Assists to bring up shell, runs up, trains, and fires.

6. Brings up shell, runs up, trains, and primes.

8-inch Land service Mortar.

Duties.—No. 1. Commands, primes, points, and serves the vent.

3. Serves ammunition, loads, runs up, and trains.

4. Sponges, wipes the bottom of the shell, uncaps the fuze, puts in shell, runs up, trains, and attends sheepskin.

6. Brings up shell, and fires.

TO DISMOUNT A 13-INCH LAND SERVICE MORTAR, with any number of men, not less than 14.

Duties.—No. 1. Commands.

2. Assists No. 1, and lashes handspikes.

3, and 4. Unlash the quoin, and place handspikes in the mortar.

5, and 6. Bring up a drag-rope each, and place the loop ends over the handspikes.

All the Nos. man the dragropes, except Nos. 3, and 4, who attend with their handspikes, and raise the mortar perpendicular; then Nos. 3, and 4 steady the mortar, place the dragropes round the body of the mortar, and take out the handspikes and quoin; Nos. 5, 6, 7, and 8 unscrew, and take out the cap-squares. All the numbers man the dragropes, except Nos. 3 and 4, and throw the mortar to the rear. If it does not fall on its face, Nos. 3, and 4 place their handspikes under the trunnions (Nos. 5, and 6 the bight of the dragropes under the trunnions) and raise the mortar on its face; then Nos. 3, and 4 place their handspikes on the trunnions; Nos. 5, and 6 place the loop ends round the handspikes, and trunnions; even Nos. go to the front, and odd Nos. to the rear, and turn the mortar round. Nos. 5, and 6 place their dragropes over the opposite bolts of the mortar bed; Nos. 3, and 4 assist with their handspikes. All the Nos., at right angles to each other, turn the mortar bed round, and run it close up to the mortar.

To mount the Mortar.

Nos. 3, and 4 place their handspikes under the trunnions, and on the top steps of the mortar bed; Nos. 5, and 6 place their dragropes round the trunnions, and throw the mortar into the trunnion boxes: the mortar is raised perpendicular, as before. All the Nos. will do what they have undone; even Nos. go to the front, odd Nos. to the rear, and ease the mortar down.

N.B. The cap-squares are not to be shifted over till the mortar is raised perpendicular.

INSTRUCTIONS FOR LANDING SEAMEN, AND MARINES, WITH FIELD PIECES.

For Exercise, or Service on shore.

1. The boats should be formed in divisions, according to the seniority of the Captains of their respective ships, numbering from No. 1, on the right. The seamen, and marines should be told off in companies previous to leaving their ships, and on landing they will form immediately in the same order.

2. Each division of boats should have a distinguishing flag. Launches will carry two scaling ladders, intrenching tools, &c.; barges, and pinnaces, one ladder each.

3. The boats will always land a boat's length apart. Before leaving the ships, two boat keepers for each boat, and an officer in charge of each division of boats are to be told off, and are on no account to leave them.

A fast-pulling boat with medical officers will attend in rear of the line.

4. Should the distance from the point of landing be considerable, the boats of each division, in tow of each other, commencing with the lightest boats, will pull in,—the leading boat of each division abreast, leaving space for the whole to form line abreast when ordered.

The boats will be dressed in line, as well as circumstances will admit. The officer in command will commence firing from the gun-boats when he thinks fit, but no shells, Shrapnell shells, or musketry are to be fired without orders.

5. When the commanding officer perceives the beach to be cleared (or when he considers it proper) he will order the boats to advance; they will pull in immediately, and land their crews, and field pieces, the latter will be formed on the flanks of their own division, or in batteries, according to orders; the scaling ladders in the rear until required for service.

6. The launches' crews may be employed in throwing up a breast-work, and placing their guns in it, to cover their re-embarkation, should it become necessary.

7. Should the boats be employed for the disembarkation of troops, the same arrangement as to the divisions of boats should remain. It will then be desirable that every boat should carry a flag similar to that of the commanding officer of its division, and, when in large numbers, the boats should also be painted according to the colours of the flags, that the troops may readily know their own boats.

On these occasions, the launches, barges, and pinnaces will form a front line, so as to clear the beach; the light boats will tow troop boats, paddle box boats, &c., and be ready to succour any boats that may be damaged by the enemy's fire.

The orders, as to the firing of musketry, should be strictly enjoined, as before, with the seamen, and marines. It would be better that no musket should be loaded, and no knapsacks taken.

Proportion of Charges, Spare powder, &c., for a 51 Gun, screw, steam Frigate; and 50 Gun Frigate.

KEY:

A = Number.
B = Proportion for each Gun.
C = Total number of Cartridges.
D = Number in each case.
E = Number of cases.

51 Gun, screw, steam Frigate.								
Nature of Ordnance.	A	Charge.	B	C	D	E	Spare powder.	Remarks.
68 Pr. 95 cwt.	1	Distant 16 lb. Full 10 lb.	120	120	6	20	20 rounds per gun, full charges, as spare; amounting to 200 lb.	This spare powder would amount to 5560 pounds, and would be packed in 15 pound bags, 8 in a case, and would stow in 47 cases.
8 in. Gun 65 cwt.	12	Reduced 5 lb. Full 8 lb. Distant 10 lb.	60	60	11	7	20 rounds per gun, reduced charges, as spare; amounting to 1200 lb.	
			20	240	15	16		
			40	480	14	34½		
32 Pr. 58 cwt.	18	Reduced 6 lb. Full 8 lb. Distant 10 lb.	20	240	11	22	20 rounds per gun, reduced charges, as spare; amounting to 2160 lb.	
			40	720	19	38		
			20	360	14	26		
32 Pr. 45 cwt.	20	Reduced 5 lb. Full 7 lb.	20	360	11	33	20 rounds per gun, reduced charges, as spare; amounting to 2000 lb.	
			30	600	22	27½		
			50	1000	16	62½		

24 Pr. Howitzer 12½ cwt.	2	2½ lb.	174	348	20*	17†	2 half-cases of bursters, (10 oz., 6 oz., 5½ oz., and 4½ oz.,) and two half-cases of fuses.
12 Pr. Howitzer 6 cwt.	2	1¼ lb.	174	348	40*	9‡	

* In a half-case. † Half-cases, and a quarter-case. ‡ Half-cases.

KEY:
A = Number.
B = Proportion for each Gun.
C = Total number of Cartridges.
D = Number in each case.
E = Number of cases.

50 Gun Frigate.							
Nature of Ordnance.	A	Charge.	B	C	D	E	Spare powder.
8 in. Gun 65 cwt.	8	Reduced 5 lb.	20	160	15	11	20 rounds per gun, reduced charges, as spare; amounting to 800 lb.
		Full 8 lb.	40	320	14	23	
		Distant 10 lb.					
32 Pr. 56 cwt.	22		20	160	11	15	20 rounds per gun, reduced charges, as spare; amounting to 2640 lb.
		Reduced 6 lb.	40	880	19	46	
		Full 8 lb.	20	440	14	32	
		Distant 10 lb.					
32 Pr.	20		20	440	11	40	20 rounds per gun, reduced charges, as spare;
		Reduced 5 lb.	30	600	22	27½	

			50	1000	16	62½	
24 Pr. Howitzer 12½ cwt.	2	2½ lb.	174	348	20*	17†	2 half-cases of bursters, (10 oz., 6 oz., 5½ oz., and 4½ oz.,) and two half-cases of fuses.
12 Pr. Howitzer 6 cwt.	2	1¼ lb.	174	348	40*	9‡	

* In a half-case. † Half-cases, and a quarter-case. ‡ Half-cases.

ON NAVAL BOMBARDMENTS.[35]

"The attack of fortresses, and powerful land batteries with a naval force only, must ever be a hazardous, and perhaps desperate undertaking. But if skilfully combined with a military force sufficiently strong to make good its landing, to invest the place, or the batteries on the land side, to take the defences in reverse, and so open the way to the attack by sea, the object of the attack will in general be successful. But this mode of proceeding can only be applied when the place to be attacked occupies a position, insular or otherwise, of such extent as to admit of being attacked by land as well as by sea. When the place, fortress, or arsenal to be attacked is covered and protected by isolated points of defence, mutually protecting each other, and when no previous military operation can be made, those points or outposts should be attacked in detail, and successively reduced; after which the fleet may arrive at, and

attack the main position. This must evidently be a protracted and difficult process, even with such means: with ships alone, it cannot be effected without severe loss, and damages: and it should always be remembered that many of the attacking ships would be severely injured, probably disabled, in the attempt, whilst the enemy's fleet would remain untouched, and in reserve. It would, therefore, follow that the attacking fleet must be exposed to a very disadvantageous action with the enemy, in the event of the latter subsequently leaving his place of shelter.

"When the fortress, or arsenal to be attacked is situated on a coast which may be approached from the open sea in any direction, steam-ships may avoid the danger of a direct attack, end-on, or oblique, by approaching the place on either, or perhaps on both sides; and, having gained the proper proximity, clear of raking, or diagonal fire, range quickly up in parallel order, to attack the place in line, or lines; as in steam warfare, ship against ship, or fleet against fleet, direct advances upon the broadside batteries of ships, may, upon the same principle be avoided, and the enemy attacked in parallel order, by ranging up to him, and forced to fight if the attacking ships are superior in speed.

"But when the fortress, arsenal, or place to be attacked is only approachable by a narrow and intricate channel, through which ships can only pass singly, or nearly so, there can be no manœuvering for position. There is no way of avoiding being met by direct, then oblique, and ultimately raking fire from the batteries that defend the channel, and steam can only perform its office of propulsion into or through those intricacies under these

disadvantageous, and hazardous circumstances. Steam-ships might, indeed, run past advanced, or covering batteries at full speed, without being much damaged; but it would be extremely perilous to leave such forts unsilenced in their rear, and, unless the daring enterprise should succeed, like Nelson's, at Copenhagen, to produce a cessation of hostilities, the fleet, or at least any disabled ships, could never get out again.

"However successful a naval attack of a fortress, or arsenal may be, the work of destruction can never be effectually accomplished by ships. The sea defences may be silenced, guns dismounted, parapets ruined, magazines blown up by mortar shells, and habitations devastated by the cruel process of bombardment; but no substantial demolition of the defences, or material destruction of public works and property, can be effected, unless the partial and rather temporary than permanent damages inflicted by the attacks of ships be followed up and completed, by having actual possession of the captured place for a sufficient time to ruin it entirely. No naval operation, however skilfully planned, and gallantly executed, can, in this way, reap the fruits of its own victory.

"In the desultory operations of small active steamers employed to shell, with their pivot guns, open towns, roadsteads, harbours, and slender buildings, magazines, stores, &c., &c., or to shell bodies of troops on shore, the attacking vessels should never anchor, but having given their end-on fire, go off at speed to reload, and prepare to take up the fire in turn with others, whenever they regain a favourable position for a good effect. To hit a steamer running with speed across a line of fire is no

easy matter (Arts. 331, 341); and when in the end-on position, she presents but a small target to hit at a long range."

PART IX.

BATTERIES, AND FORTIFICATION.

BATTERIES.

A battery, in respect to its profile, may be either elevated, half sunken, or sunken; and it is usually reveted with gabions, fascines, sand-bags, &c.

An elevated battery has its whole parapet raised above the natural surface of the ground, and, to procure the mass of earth required, a ditch is usually dug directly in front of the parapet.

A half-sunken battery has its interior space, or terreplein, sunk some inches below the natural surface, and its parapet is composed of the earth thus obtained, and of that taken from a narrow ditch in front.

A sunken battery has the whole of the earth taken from the interior space to form the parapet; and it must therefore be lowered from 2 feet to 3 feet 6 inches, according to the height of the gun carriages to be used.

The half-sunken battery is constructed the quickest, as the diggers can work both in front and rear, at the same time. In a sunken battery, the diggers are as much crowded as in an elevated one, but, since the mass of parapet to be raised is smaller, it may be

completed in much less time.

Casemates, or vaulted batteries, are made bomb-proof, and the embrazures are cut through the revetment.

Barbet batteries have no embrazures, the guns being placed on traversing platforms to enable them to fire over the parapet.

A direct fire from a battery is when the line of fire is perpendicular to the parapet, and an *oblique fire* when it is oblique. The direct fire being preferable, the battery should be placed parallel to the object against which the fire is to be directed.

The line of fire is an imaginary line drawn through the centre of an embrazure, in the direction of the object against which a battery is constructed.

Embrazures are openings cut through parapets, flanks of bastions, &c., for guns to fire through.

The neck of the embrazure is the inward, or narrowest part of it.

The mouth of the embrazure is the outward, or widest part of it.

The sole of the embrazure is the bottom, or space, between the cheeks or sides.

The sill is the front of the sole.

The genouillere is that part of the parapet which is immediately beneath the embrazures.

The merlon is the portion of the parapet contained between two embrazures.

The following dimensions are requisite to be proof,

Against musketry.—	3 feet	when of	earth.
	6 inches	”	stone.
	12 inches	”	fir.
	5 inches	”	oak.
	9 inches	”	brick.

Against cannon.— 4 feet, when of wood, or brick.

6	feet against	6-pounders,	when of earth.
9	”	9-pounders,	ditto.
14	”	12-pounders,	ditto.
18	”	18 & 24-pounders,	ditto.

Note.—A 6-pounder shot, with a charge of one pound, will penetrate a *mass of ice* to the depth of 4½ feet, at the distance of twenty-one yards.

GENERAL DIMENSIONS OF AN ELEVATED GUN BATTERY,

reveted with fascines.

	ft.	in.
Space from the centre of one embrazure to that of the next, without traverses	18	0
Ditto, with traverses	22	0
Slope of the interior revetment, per foot (one-fourth its height)	—	3
Fall of the superior slope, ditto (one-twelfth, ditto)	—	1
Interior width of embrazures, measured on the sill	2	0
Exterior ditto, measured on the sole, at 12 feet from the sill	7	0
Slope of the cheeks of embrazures at the neck, per foot, (one-sixth of their height)	—	2
Ditto, at the mouth, per foot (one-fourth their height)	—	3

Distance from the centre of an embrazure to the foot of the slope of an adjoining traverse	7	6
Distance from the centre of an embrazure to the foot of the slope of an adjoining epaulment	5	0
Height of the sill about	3	0

DIRECTIONS FOR TRACING A BATTERY.

Batteries at sieges are generally traced in the dusk of the evening.

Detail of men, and tools required:

Tracers.—1 non-commissioned officer, and 2 privates.

Tools.—1 ground-square. 1 measuring tape.

1 white tracing-line. 2 ten-feet rods. 1 bundle of pickets. 1 mallet.

Directions.—The tracing-pickets, and mallet, are carried in a sand-bag, and a few long pickets are necessary to mark the embrazures. A line should be stretched about 40 feet in the direction of the object against which the battery is to be erected; this will show *the line of fire*. By means of a ground-square, a line may be laid down at right angles to the former, touching the first placed picket. This will be the interior base line. Another line must be placed parallel to this, at a distance equal to the sum of the breadth of the base of the parapet, breadth of the berm (if any), and breadth of the slope of the ditch (viz., about 27 feet), which line will represent the reverse slope of the ditch. A picket is then driven in on the interior base line, where it is intended to have one extremity of the battery, and as many long pickets (18 feet apart), measuring from this end, as there are guns, which will mark the centre of the embrazures. Then one more picket, 18 feet distant from the last, will show the other extremity. For the

embrazures, drive in a picket at the distance of one foot on each side of the centre of the embrazures, for the width of the neck. Set off, and drive in pickets 3 feet 6 inches on each side of, and perpendicular to the line of fire, for the width of the mouth.

WORKING PARTY; TOOLS; AND MATERIALS REQUIRED

for each gun; mortar; traverse; or epaulment; in an elevated fascine battery.

2 sappers, with 6 assistants, to revet the work.

12 infantry, to excavate the ditch, and form the parapet.

9 pickaxes, 15 shovels, or spades, 14 fascines, 18 feet long, 1 bundle of 50 pickets to 6 fascines, 3 mauls, 3 rammers, 1 saw to every two guns, *1 hatchet* per gun, *1 bill-hook, 1 field-service level, 1 six-feet rod, 1 bundle of matches* to every three guns, *1 lantern*, do., 1 lb. *of candles*, do., *1 bundle of gads* to each gun, *1 tape of 50 feet in length* per battery.

A battery will seldom be completed in less than 24 hours, when executed by inexperienced workmen; but by those inured to hard labour, and with proper reliefs, in about 10 hours. In light soil, that can be easily dug without the aid of a pickaxe, a man can, in 8 hours, load from 19 to 20 cubic yards of earth on barrows. If a pickaxe be required, 2 men will do the same quantity of work. A man can wheel 20 cubic yards of earth per day to a distance of 30 yards on level ground, or 20 yards on a ramp. Twenty cubic yards of earth will fill 500 wheelbarrows. When near the surface, in soil requiring but little the use of the pickaxe, an excavation of 6 cubic yards in a day of 8 hours would be a fair task for a soldier, who in general is little accustomed to working with

the pickaxe and shovel.

SHELTER FROM AN ENEMY'S FIRE.[36]

The following method of sheltering the workmen from the enemy's fire was used with great success during the construction of the batteries. It was towards the end of the siege that Lieutenant Néandre received orders to construct a battery 130 paces from the counterscarp, the covered way being strongly occupied by the enemy. Foreseeing the difficulties that would occur, Lieutenant Néandre provided 120 common platform planks, and, when the gabions were in their places, arranged the planks outside them, in such a manner as to present an inclined plane, (one end of the plank being supported on the gabion, and the other end resting on the ground towards the enemy): the gabions were then half filled with earth, and the pickets driven in. At this moment the enemy threw some fire balls, and fired a few shot, all of which went over. Soon after, the workmen were assailed with a well-sustained fire of musketry; but, on the balls striking the epaulment, they ricocheted and passed over the workmen, so that not a single man was hit. The battery was finished in a few hours, when the planks were drawn in, and used for the platforms.

A portable framework might be rapidly made, and used instead of the gabions, to obtain immediate cover from musketry fire; and, for sapping, the framework, with the planks fixed thereon, might be readily moved on trucks, as a substitute for the present sap roller.

EPAULMENTS.

Batteries at sieges are generally secured on one flank at least, by a parapet called an epaulment,

forming an obtuse angle with that of the battery. Their use is to secure the reverse of the terreplein from any flanking fire, and they are not in general made so thick as the parapet, being seldom subject to a direct fire.

ELEVATED SAND-BAG BATTERIES.

The base of the interior slope of a battery reveted with sand-bags is rather broader than that of one reveted with fascines, being about one-third the height of the parapet. *Bushel sand-bags* are now the only kind in use, and *when filled are of the following dimensions*:

Length 20 inches, breadth 10 inches, depth 5 inches.

Number required per gun,—for the interior revetment	262
Ditto Ditto for the cheeks	360
Total	622

Sand-bags are laid *header*, and *stretcher*, as in masonry; the ends which are tied being always hid. As the sand-bags near the neck of the embrazure would be destroyed after a few hours' firing, and constantly require repairing, gabions, or casks should be substituted for them.

Howitzer batteries are similar to those for guns, except that the interior openings of the embrazures are 2 feet 6 inches, and the soles are raised, towards the front, about 10°, in order to cover the gunners as much as possible.

Mortar batteries are constructed with the same dimensions as gun batteries (the parapet being generally 8 feet high, and from 18 to 22 feet thick), but, as they have not embrazures, the ditch of

elevated batteries is made two feet deeper to obtain the requisite quantity of earth. A preference would in general be given to the sunken, or half-sunken profile for a mortar battery, on account of its requiring less time for its construction, and it being of no consequence whether the platforms are sunken, or otherwise. Mortars are placed at the distance of 15 feet from centre to centre of each other, where no traverses intervene; and the parapet has the same profile as a gun, or howitzer battery.

When fired at	45°	they are placed	12	feet from the revetment.
Ditto	30°	ditto	13	ditto
Ditto	20°	ditto	21	ditto
Ditto	15°	ditto	30	ditto
Ditto	10°	ditto	40	ditto

HALF-SUNKEN BATTERIES.

The sill is about half its total height above the natural surface of the ground; the most convenient depth to which the terreplein may be sunk is 2 feet. The height of a sill for a travelling carriage will be 18 inches, and for a garrison carriage one foot above the natural level. The profile of the parapet is the same as in an elevated battery.

Number of sand-bags required for reveting one merlon	180
Ditto ditto for cheeks of embrazures	360
Total	540

In forming the epaulment of a half-sunken battery, the earth is taken from a ditch in front, six feet wide, and about five feet deep.

SUNKEN GUN BATTERIES.

The soles of the embrazures are on a level with the natural ground, therefore the terreplein is sunk a sufficient depth for the solid, and, the merlons are formed of the excavated earth. The height of the solid depends on the nature of gun carriage to be used. The first operation is to trace out the embrazures. The profile is the same as in the elevated battery. Should there be traverses, all the earth excavated from the interior will be required; if not, the overplus may be scattered in the rear.

RICOCHET BATTERIES.

Ricochet firing is the art of projecting shot, or shell, with a certain velocity, and in such a direction as to ensure its striking the ground at any spot that may be required; afterwards making several grazes upon the earth, and destroying, or striking all that may oppose its progress. The piece of ordnance is loaded with a diminished charge of powder, and the elevation is from 3° to 10°, which causes the shot to bound or hop along the ground. The smaller the angle under which the shot is made to ricochet, the longer it will preserve its force, and have effect, as it will sink in the same proportion so much less into the ground on which it bounds. In the ricochet of a fortress, or field work, the elevation should seldom exceed 10° to throw the shot over the crest of the parapet; but in the field, the objects to be fired at being principally infantry, and cavalry, the guns need seldom be elevated above 3°; as, under greater angles, the shot would be apt to bound too high, thereby defeating its intended purpose.

Ricochet batteries should, if possible, be at a distance of 400 yards, or not exceeding 600 yards;

as, from the uncertainty of the fire at a greater distance, at least two-thirds of the ammunition might be expended without producing any good effect.

The best elevation to enfilade a work being from 6° to 9° measured above the parapet, the charge should be regulated accordingly, which varies from one-half, to one-tenth the service charge.

Ricochet firing is very efficacious in dismounting the guns on the faces, or flanks of bastions, &c., the batteries for this purpose being erected on the prolongation of these works, and as nearly as possible perpendicular thereto, by which their whole length will be exposed to the effects of plunging, and destructive ricochet fire.

Vide Tables of Ricochet practice, pages 73, 79, 80.

FASCINES.

Fascines are bundles of wood of various lengths, according to the purposes to which they are to be applied.

Fascines for a revetment should be strong, and well bound. When small brushwood is used, *they are made 6 feet long, and 7 inches in diameter*, and are firmly bound with four or five withes, or gads.

The gads are made of tough twigs, first twisted until the fibres separate, the smaller end is then turned round, so as to form a loop, or noose. To make a fascine 6 feet long, the workmen set up three fascine horses on the same level, and in a right line.

(*A fascine horse* is formed with two pickets, each 5 feet long, driven about 1 foot obliquely into the ground, so as to cross each other at right angles 2 feet above the surface of the earth; and they are

fastened together at their point of meeting, with cord, three or four-thread spun yarn, or gads.) The brushwood, stripped of all its leaves and smaller branches, and which should be from half to one inch in diameter, and 5 or 6 feet long, is then laid on the fascine horses, the thick ends being placed alternately at each end. The large stuff must be used to form the exterior, and the smaller twigs the interior of the fascine. Before binding the fascine, it must be compressed with a *fascine choaker*, which consists of a cord, or chain, equal in length to one and a half times the circumference of the fascine, fastened at one end to a lever 5 feet long and 2½ inches in diameter, with a loop at the other end, into which, after passing the chain round the fascine near the part to be bound, a lever, similar to the one already described, is inserted, and the brushwood is squeezed tightly together until the gad is tied. The fascine must be compressed in a similar manner before each gad is fastened. *The weight of the fascine* is about 33 lb. *Three men can make a 6 feet fascine in twenty minutes.* Two of the workmen place the brushwood, while the third prepares the gads. If large brushwood can be procured, the fascines should be 18 feet long, the strength of the revetment being materially increased by diminishing the number of joints. *When the fascines are 18 feet long*, they are made nine inches in diameter, and the gads are placed 18 inches apart, the fascine horses being one yard apart. *This fascine weighs* about 2 cwt. *Four men can make an 18 feet fascine in two hours*, or, if the wood be cut and brought to them, they can make four fascines in that time. *They require 3 bill-hooks, 1 saw, 1 fascine choaker (each lever about 6 feet long), and 6 fascine horses.* Three men prepare the brushwood, and lay it on the horses, while the fourth

makes the gads.

The revetment is formed in proportion as the parapet is raised, the first fascine being half buried in the banquette, with three pickets driven vertically through it, each picket being from 3 to 4 feet long, and from 1¼ to 1½ inches in diameter at the thickest end. The second row of fascines is then laid a little in front of the first, so as to form the required slope, and three pickets are driven through each fascine; the extreme pickets through the fascine previously laid in the direction of the slope, the other perpendicular to the slope.

The joints of the different rows of fascines should be so broken, that no two adjoining joints may be in the same line, and the ends of the fascines at the angles should alternately be flush with, and be inserted in the parapet; care being taken to lay the fascines so that the ties of the gads may be concealed in the parapets. Six rows of large fascines are sufficient to form the revetment of a parapet, the upper row being covered with a layer of sods, the grass upwards. When fascines of seven inches in diameter are used, eight rows are required.

GABIONS.

Gabions are cylindrical baskets open at both ends, and are very commonly used to revet parapets. For the interior of parapets they should be *3 feet in height, and diameter. The common gabions are 2 feet in diameter, and 2 feet 9 inches high.*

To make them.—A directing circle consisting of two hoops, kept apart by bits of wood, to which both the hoops are secured with packthread, is first made. The diameter of the hoops must be such as to permit of the pickets for the gabion being driven between the

exterior of the one, and the interior of the other. The directing circle is then laid on a level piece of ground, and from seven to twelve pickets are driven at equal distances apart, between the hoops; the number of pickets depending on the size of the rods, or brushwood with which the basket-work is to be made. The circle is then raised, and fastened to the middle of the pickets, and the web is made above it, two or three rods being used at the same time; the workman twisting them round each other while he interlaces them with the pickets, striking down the web from time to time with a stick. The *randing*, or *basket-work*, is continued to near the top of the pickets, where it is secured with four gads, each one passed round one of the pickets and four or five of the rods, which should be from 8 to 10 feet long, and not more than half an inch in diameter. The gabion is then pulled up, the finished end is placed on the ground, and the directing circle being removed, the remainder of the web is completed and secured as before described.

Two men can make a gabion in three quarters of an hour, using about 80 rods for each gabion.

In forming the revetment, the gabions are placed touching each other with a slope of one quarter the height; the first row is surmounted with two rows of fascines side by side, and a second row of gabions rests on them.

SOD, OR TURF.

A revetment is sometimes made with sods of unequal sizes, called *headers*, and *stretchers*.

The headers are 1 foot 6 inches long, 1 foot wide, and about 4½ inches thick.

The stretchers are 1 foot wide, and long, and about 4½ inches thick.

Sometimes the sods are first cut all of the same dimensions—viz., 1½ foot long and 1 foot wide; this sod is then cut diagonally, across, so as to form two, and they are then all laid as headers. This saves nearly half the turf, and labour. The sods should be cut from good meadow land, previously mown, and watered; but the sods should not be laid or built when wet, because they would shrink in dry weather, and all the joints would open. The sod-work is laid with the grass downwards, either alternately headers, and stretchers, or two stretchers to one header; care being taken that the joints of no two rows fall immediately over one another, which is termed breaking joint. If the layers of sods are laid perpendicular to the slope, they will answer better than if laid horizontally. Each sod should have two or three pegs driven through it, to secure it to the work beneath. When the revetment is completed, the whole should be cut off smooth to the proper slope; a pair of hedge-clippers, or a cutting knife, will answer well for this purpose.

One man can lay 19 square yards of sod-work in eight hours, when the sods are brought to the spot, and require no previous trimming.

PLATFORMS.

To facilitate the working of a gun, it must be placed on a platform of stone, or timber and plank: but, as a temporary measure, when required to fire only in one direction, timbers to take the wheels will suffice. The usual inclination given to platforms, from the rear to the front, is half an inch per foot. Platforms on barbettes should be perfectly level, and

their dimensions must depend on the extent of the lateral range which may be required.

In laying a gun platform, the first thing to be done is to fix the *hurter*, which may be a piece of timber 7 or 8 feet long, and 7 inches square, or a strong fascine 9 feet in length may be advantageously used. The hurter is intended to take the wheels, or trucks of the carriage when the gun is run out, and to prevent their damaging the interior slope of the parapet. The position of the hurter necessarily depends therefore on the steepness of the interior slope. The hurter should be placed perpendicular to the axis, or central line of the embrazure. Three, four, or five sleepers of from 6 to 8 inches square, are then laid, their upper surface on a level with the bottom of the hurter, and they are covered with two-inch planks, nailed down when three sleepers are used; but if there be four or five sleepers, the planks may be confined by two *ribbands* (which are pieces of wood of the same length, but weaker scantling than the sleepers) and the platform racked down with *rack lashings* at the proper intervals.

A rack lashing consists of a piece of 2-inch rope about 9 feet long, which is fastened to a stick 15 inches long, 2 inches wide at the head, with a hole in it to receive the lashing, and tapering to a blunt point: it is passed round the timber, and sleeper beneath, then twice round itself. The end of the stick is then put into the loose gromet so formed, and twisted round until the whole is firmly secured, when the stick is turned flat on the upper piece of scantling.

The gun, and mortar platforms for sieges are now made rectangular: the dimensions of the former are 15 feet long by 10 feet 6 inches broad; those of a

mortar platform are 7 feet 6 inches long by 6 feet 6 inches broad. Mortar platforms are laid exactly horizontal, the front part being placed 5 feet within the foot of the interior slope of the parapet.

Madras platforms consist of two stout planks about 12 feet long; they are supported on two sleepers, having a transom in front. The planks are secured with a moveable bolt, or pivot to the front transom, slide freely on the sleepers, and are connected together in rear by two cross pieces parallel to the rear sleeper, one in front, and the other in rear of it. To the centre of these two cross pieces is bolted another 12-feet plank, called the trail-piece, of a width equal to the distance between the cheeks of a siege-carriage, which is supported on a sleeper in the rear. When the gun is to be traversed, the whole platform is moved on the sleepers on the pivots in front. These platforms are chiefly intended for a direct fire. Two wedges are required for this platform to form inclined planes for the wheels, in running the gun on, or off the platform. Each wedge is of elm, 3 inches thick, 2½ feet long, and 1 foot wide, with a block to give the requisite height, the block being 12 inches long, 4 thick, and 7 in extreme height.

Alderson's platform.

The platform invented by Colonel Alderson, R.E., is 15 feet long, by 9 feet wide; and is composed of 46 similar pieces of timber (baulks) each measuring 9 feet × 5 inches × 3½ inches. Of these, ten are used as sleepers, and the remainder as planking. The weight of the platform (when 15 feet long and 9 feet wide) for guns is 15 cwt. 2 qrs. 14 lb. By addition of the small beams, this platform may easily be extended from 15 to 18 feet.

Dimensions, and weight of Platforms, for Guns, &c.

Nature of Platform, and articles required.	Number.	Length.	Breadth.	Thickness.	Weight.
		ft. in.	ft. in.	ft. in.	cwt. qr. lb.
GUN, AND HOWITZER.					
Sleepers	5	15	5	5	4 2 1
Planks	20	10 6	9	2	7 3 22
Ribbands	2	15	4	4	1 0 18
Rack-sticks, and lashings					10
Total weight					13 2 23
MORTAR. *Covered with oak planks.*					
Sleepers	7	7 6	6	6	3 3 7
Planks	10	6 6	9	3	5 1 22
Ribbands	2	7 6	4	4	2 10
Rack-sticks	10	1 3			15
Total weight					9 3 26
Made entirely of fir.					
Sleepers	7	7 6	6	6	3 3 7
Planks	8	6 6	11¼	4	4 2 18
Ribbands	2	7 6	4	4	2 10

Rack-sticks	8								12
Total weight							9	0	19
MADRAS.									
Wood work.									
Side-pieces	2	12	6	1	0	4	3	0	18
Trail-piece	1	12		1	4	4	1	1	3
Fore transom	1	7			6	6		2	19
Hind transoms	2	6	6		9	3		2	20
Sleepers	3	9			6	6	2	0	16
Wedges	2							2	7
Iron work.									
Long bolts, ⅞in. diameter	2		11½						6
Short bolts, ditto	6		7½						11
Total weight							8	2	16

GUN, AND HOWITZER PLATFORM.

For carrying this platform, two men are required for each sleeper; one man for each plank, and ribband. The non-commissioned officer carries the rack-sticks.

A platform may be laid down in an hour by expert men, and may be dismantled in three minutes.

MORTAR PLATFORM.

Detailed as above. One non-commissioned officer, and seventeen men carry the platform. *Time required for laying down, and dismantling*, similar to the above.

MADRAS PLATFORM.

In an elevated battery, the platform may be laid down by expert men in half an hour, *and may be dismantled* in three minutes.

BREACH.

The best place for making a breach, in ravelins, bastions, &c., is about thirty yards from their salient angles. The batteries should commence by marking out by their fire the extent of the breach intended to be made, first by striking out a horizontal line as near the bottom of the revetment as possible, and afterwards two others perpendicular to, and at the extremities of this line. Should the breach be required to be extensive, it will be necessary to form intermediate lines. Then, by continuing to deepen these two or more cuts, and occasionally firing salvoes at the part to be brought down, the wall will

give way in a mass. The guns must, however, at first fire low, and gradually advance upwards until the breach is effected; and when the wall has given way, the firing should be continued until the slope of the breach is made practicable.

TO BURST OPEN GATES OF FORTRESSES, ETC.

A leathern bag, containing about 50 lb. of powder, should be hooked upon the gate, as near the centre as possible (or be laid on the ground, close to the bottom of the gate, and tamped with sods, &c.), and be fired by means of a piece of portfire, or match, passed through a hole in the bottom of the bag.

FORTIFICATION.

Offensive fortification is the art of conducting a siege.

Defensive fortification comprehends military architecture, and is the art of securing, or protecting a place by works, to resist a siege.

Natural fortification consists of obstacles, such as marshes, mountain passes, &c., which are found in some countries, and should be taken advantage of to impede the approaches of an enemy.

Artificial fortification comprises those works which are constructed to defend a place.

Permanent fortification is the art of putting towns, &c., into such a state as at all times to be prepared to resist the attack of an enemy.

Field fortification is the method of fortifying a camp, or position, buildings, &c., and it includes the construction of redoubts, entrenchments, &c. Works

of this nature are considered as temporary.

Irregular fortification is the art of fortifying a place of an irregular figure, situated where the country does not admit of giving to the several works their due proportion according to rule.

A Command is the vertical elevation of one work above another, or above the country.

A Command in front is when an eminence is directly facing the work which it commands.

A Command in the rear, or reverse, is when any eminence is directly behind the work which it commands.

A Command by enfilade is when an eminence is situated in the prolongation of any line of a work, and a considerable part of it may be seen from thence; this line will be subject to enfilade, and such a command is the most dangerous.

The Rampart (A T R) is an elevation of earth, obtained from the excavation of the ditch; and is that part of the fortification which is situated between the ditch, and the town, consisting of an interior slope, terreplein, banquette, parapet, and exterior slope or escarp.—(*Vide* *Plate.*)

The Interior slope (A) is the inclination of earth nearest to the town.

The Terreplein (T) is the upper part of the rampart, which remains after having constructed the parapet.

The Parapet (R) is a mass of earth elevated on the terreplein of the rampart, on the side towards the country; being from 18 to 22 feet thick, and from 6 to 8 feet high. The top is formed with a slight declivity towards the country, which is called the

superior slope.

The Banquette is an elevation of earth, or step, on which the soldiers stand to fire over the parapet.

The Revetment is the masonry which retains the earth of the rampart on its exterior side. It is about 5 feet thick at the top, and its slope is one-fifth, or one-sixth its height.

The Berm is a space, or path, sometimes left between the exterior slope of the rampart, and the ditch. It serves as a communication round the works, and prevents the earth falling into the ditch.

The Tablette is a flat coping-stone, on the exterior of the top of the escarp of whole revetment.

The Cordon is a semicircular projection of stone, whose diameter is about one foot, placed at the top of the slope of the revetment of the escarp.

The Escarp (a) is the exterior slope, or wall of the rampart.

The Counterscarp (b) is the wall, or slope of the ditch, opposite to the escarp.

The Faces of a work (p q) are those parts which form a salient angle, projecting towards the country.

The Flank (q G) is the part of a work so disposed as to defend another; joining the face of a bastion to the curtain, &c.

The Bastion (M L) is a work composed of two faces, and two flanks. Bastions are joined by curtains, and are constructed salient, and with flanks, in order that the whole escarp may be seen, and that a reciprocal defence may be obtained.

Bastions are of various kinds—viz., full (M), empty

(L), also flat, detached, demi, and tower bastions.

A Full bastion (M) is when the terreplein occupies all the interior space of the bastion. From the description of this bastion, that of all the others may be ascertained.

The Curtain (G R H) is that part of the rampart which lies between two bastions, and joins the flanks thereof.

A Front of fortification consists of two half bastions, and a curtain.

The Ditch (B) is an excavation from 12 to 24 feet deep, and from 90 to 150 feet broad, surrounding the rampart. The side of the ditch nearest the place forms the escarp (a); and the opposite part, the counterscarp (b) is made circular opposite to the salient angles of the works.

The Covered way (V) is a space of about 30 feet broad, extending round the counterscarp of the ditch, being covered by a parapet from 7 to 9 feet high, with a banquette.

The Glacis (X) is the superior part of the parapet of the covered way, forming a gentle slope towards the country, and terminating at from 120 to 180 feet; it covers the revetment of the body of the place.

The Places of arms of the covered way are spaces contrived in the salient, and re-entering angles of it; those (c) in the re-entering angles flank the branches of it, and contain troops for sallies, and its defence; and those (P) in the salient angles serve for assembling the Troops destined for the defence of the covered way.

The Sally-ports are openings cut in the glacis, at the faces of the re-entering places of arms, and at the

branches of the covered way. They are used in making sallies from the covered way.

The Traverses (n) in the covered way, are parapets which cross the breadth of it at the salient, and re-entering places of arms, &c. They cover the troops who are drawn up behind the parapet of the covered way, from the enfilade fire of the enemy. There are passages cut in the parapet of the covered way, close to the traverses, in order to form a communication from one part of the covered way to another: these passages are about 6 feet wide, and are provided with gates.

A Citadel is a fortress joined to the works of a place, and is fortified both towards the town, and country. It should always be situated on the most commanding ground, serving to keep the inhabitants in awe, and, should the town be taken, it becomes a retreat for the garrison.

The Esplanade is a space of even ground, clear of buildings, situated between the town, and citadel.

The Body of the place (or *Enceinte*) consists of the works next to, and surrounding the town, in the form of a polygon, whether regular, or irregular.

Outworks are those works which are constructed beyond the body of the place, such as tenailles, ravelins, &c.

The Tenaille (D) consists of two faces, and a small curtain. It is constructed between the flanks of the bastions in front of the curtain, and has a terreplein, parapet, and banquette.

The Ravelin (P) is constructed opposite the curtain, (in front of the tenaille,) is composed of two faces, which form a salient angle towards the country, and

of two demi-gorges formed by the counterscarp.

A Horn-work is composed of two half bastions, and a curtain, with two long sides directed upon the faces of the bastions, or ravelins, so as to be defended from them.

A Crown-work is composed of a bastion between two curtains, which are terminated by half bastions. It is joined to the body of the place by two long sides.

Lunettes, and *Tenaillons* are works constructed on each side of ravelins, consisting of two faces.

A Flèche, or Arrow, is constructed along the foot of the glacis before the re-entering, and salient places of arms. It consists of a parapet, whose faces form a salient angle, and are about 120 feet long, and it has a communication with the covered way, cut through the glacis.

The Caponiere (Y) is a work intended to cover a passage across the ditch. That from the tenaille to the gorge of the ravelin is a road about 30 feet wide, covered on each side by a parapet 7½ feet high, its superior slope terminating in a glacis about 60 feet wide.

A Cunette is a small ditch made in the middle of a dry ditch, to drain off the water from the place, &c.

A Batardeau (e) is a solid piece of masonry, 7 or 8 feet thick, crossing the whole breadth of the ditch opposite the flanked angles of the bastions. It retains the water in those parts of the ditch which require to be inundated.

A Ramp (t) is a road cut in the interior slope of the rampart, forming a communication from the town, &c., to the terreplein.

A Cavalier is a work constructed upon the terreplein of a full bastion, being from 8 to 12 feet above the rampart, with a parapet 6 feet high. Its use is to command some rising ground within cannon-shot, and to serve as a traverse for preventing the neighbouring curtains from being enfiladed.

Parallels, or Places of arms, thrown up at sieges, are trenches formed to connect together the several approaches to a besieged place.

Zig-zags, or Boyeaux of communication, are trenches made for the approaches from the parallels to the besieged place. They are generally 3 feet deep, and have a parapet, and banquette.

A Redan consists of two faces forming a salient angle (which should not be less than 60°) with parapet, &c.[37]

A Lunette has two faces, similar to the redan, and also two flanks.[37]

A Redoubt is a square, polygonal, or circular field fort.[37]

A Star fort consists of a succession of salient, and re-entering angles, formed on the sides of a polygon. These forts are usually constructed on a triangle (when they have six salient points), or a square (having eight salient points).[37]

Têtes de pont, or Bridge heads, consist of redans, &c., which are constructed upon the banks of rivers, to protect the passage across them.[37]

Lines are formed for the entrenchment of armies, and are composed of a succession of redans, &c., joined by curtains, which should not be more than 120 yards distant from each other, to afford mutual protection, and defence.[37]

An Epaulment is an elevation of earth thrown up to cover troops from a flanking fire.

Loop-holes are oblong holes, from 15 to 18 inches long, 6 inches wide within, and 2 or 3 without. They are cut through timber, or masonry, for the services of small arms.

Palisades are stakes of strong wood, 8 or 9 feet long, and 6 inches thick, fixed about 3 feet in the ground, and 3 or 4 inches asunder.

Fraises are a kind of palisades, placed horizontally, or obliquely in the exterior slope of ramparts.

Chevaux de frise consist of a piece of timber from 9 to 12 feet long, and about six inches in diameter, into which staves are inserted cross-ways, about 9 inches asunder, about 2 inches thick, 6 feet long, and pointed at the end, if not shod with iron. Their use is to stop up a breach, defend a passage, or form an entrenchment against cavalry. Chevaux de frise are sometimes made entirely of iron.

Abattis consist of trees with their branches shortened, and sharpened at the ends; they are used instead of chevaux de frise on an emergency.

Hurdles are about 3 feet high, and 2 broad, and are used in sieges to stop up breaches, &c.

Trous de loup are holes dug in the ground in the form of an inverted cone, about 6 feet deep, and 4½ in diameter at the top, having a picket fixed in the centre of the bottom, 6 feet long, and 4 or 6 inches square, the point being on a level with the upper surface of the ground. These pits are used to prevent the approach of bodies of cavalry.

PERMANENT FORTIFICATION.

Remarks, and general rules.

The ground plan, and relief of bastioned fortifications are mutually dependent on each other; and, as a variety of causes occur to influence both according to the various sites occupied, it is impossible to give them any fixed arrangement, and dimensions, applicable under all circumstances. However, under the supposition that the site to be fortified is a horizontal plane, a great number, and variety of systems have been proposed at different times; almost every author, who has treated of fortification, having invented one, at least, of his own. Notwithstanding this diversity of opinion, as to the best system, all agree that the following general principles should not be lost sight of in the construction of fortifications.

1. Salient angles should be as large as possible, and never less than 60°. The larger they are the smaller will be the space in front undefended by direct fire. If less than 60°, the salients of earth are too acute to stand firmly for any length of time; and the angles of masonry are easily damaged; besides which the space within the parapets becomes too restricted to admit of a gun being worked near the angle.

2. Angles of defence should be right angles, or slightly obtuse. If less than right angles, the fire from the flanking works might injure the defenders of the works they flank; as troops generally, and more particularly at night, fire in a direction perpendicular to the parapet; and if too obtuse the fire might be directed wide of its object. Besides, embrazures should be cut as direct as possible; as the more they are oblique, the more they weaken the parapet.

3. The length of the lines of defence shall be such,

that the works defended may be within the effective range of the projectiles used.

4. The works should be so disposed that the assailants may not be able to obtain cover in any part of the exterior, within range of the projectiles of the defenders.

5. The escarps of the body of the place should be of such height, or construction, as to be secure against escalade.

6. The masonry should be sufficiently covered from the view of the enemy, to prevent his making a practicable breach from a distance.

7. The interior of every work should be completely covered from the view of an enemy outside it; so that he may not be able to fire directly into any part of it. Interior works should therefore have a command over those in front of them, at least equal to the height which a besieger can give to the parapets of his lodgments, and which is seldom less than 3 feet.

8. Every opportunity should be seized of so directing the faces of works that an enemy may not have it in his power to enfilade them by ricochet fire.

9. In the general construction of fortifications the salients should be few, and sufficiently prominent to force the besieger to take them before he can attack the re-entering parts. The object of this is to reduce the number of points of attack, as, the fewer they are, the less advantage an assailant derives from his numerical superiority.

10. Permanent fortifications must be considered very incomplete without a sufficiency of casemated cover for the sick, and wounded, and for the portion of the garrison off duty. The magazines of

ammunition and provisions, should also be secure from the effects of shells; and the supply of water ample, and certain.

11. Small enclosed works, in which the defenders must be crowded, without cover from vertical fire, should never be employed in permanent fortification. The strength they impart can never make up for the loss the garrison must suffer by them.

12. Outworks, and detached works should have easy communications with the main work, to admit of their garrisons receiving reinforcements, or supplies, when necessary; and to enable them to retreat, when the works are no longer tenable.

13. Every enclosed defensive work of importance should, if possible, be provided with a keep, or citadel, or interior retrenchment, to which the garrison may retire when the main enclosure (or enceinte) is forced.

14. Outworks, and detached works near the body of the place, should be so constructed that the enemy, when he has taken them, may not be able to use them as defensive works.

15. Outworks, and detached works, should always be of sufficient strength to force the enemy to make *regular* attacks on them. Advanced works of a weak construction are likely to do more harm than good; for the troops of the garrison seeing them taken with comparative facility, would naturally lose confidence in the strength of their remaining defences, while that of the assailants would be increased by early success.

16. All fortifications should be provided with means of egress, and ingress, to enable the garrison

to assume the offensive, whenever opportunities offer; and to admit reinforcements into the fortress.

17. There are very few fortified places that agree with any published system, though some resemble one or other of the systems, or consist of combinations, or modifications of them. The systems which have been wholly, or partly carried into execution are, of course, the most interesting, and form valuable subjects of study. A knowledge of their advantages, and defects, and the best methods of attacking, and defending them, will enable the military student properly to appreciate works which have been, or are to be constructed; and the operations by which fortresses have been, or may be captured.

VAUBAN'S FIRST SYSTEM.[38]

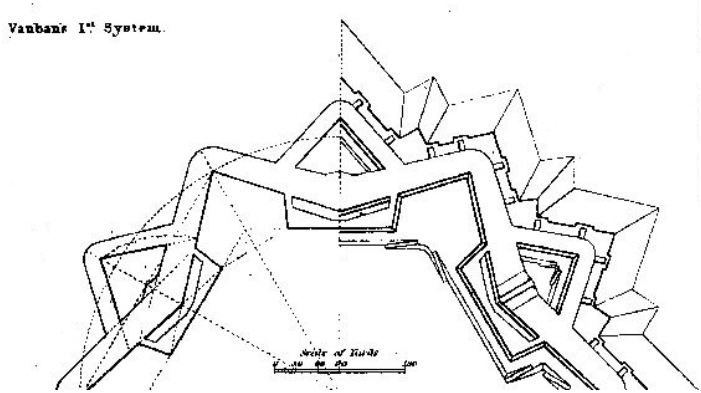
To describe three Fronts of fortification, on a hexagon.—Vide Plate.

With a radius of 360 yards, the length of the exterior side of the fortification (taken from a scale of equal parts), describe a semicircle, which divide into three equal parts, and draw lines to the points of division; thus forming *three exterior sides*. Bisect each of these by perpendiculars drawn to the centre of the polygon, on which set off ⅙th of the exterior side, (if a hexagon,)[39] through which points draw *the Lines of defence*; on these set off 2/7ths of the exterior side, from the angles of the circumference, for the length of the faces of the bastions; with radius of the distance between the two faces describe arcs joining the lines of defence, and draw the cord of these arcs for *the flanks of the bastions*; a line joining the interior extremities of the flanks will give the length of *the*

curtains.

Or, to describe one Front of fortification.

For the exterior side, draw a line 360 yards in length, at the ends of which, lines are to be directed to the centre of the polygon, at the angle required; (*vide* PRACTICAL GEOMETRY *—To find the angles at the centre, and circumference of a regular polygon*,) then bisect the exterior side, and draw the perpendicular, &c., &c., as described for the construction on a hexagon.



Vauban's 1st System.

J. W. Lowry, sc.

Main ditch.

From the salient angles of the bastions, with 38 yards as a radius, describe arcs, to which draw tangents, directed to the angles of the shoulders of the bastions.

The Tenaille.

Draw lines parallel to the lines of defence, at the distance of 16 yards, for the faces of the work; its flanks, and curtain are constructed parallel to the flanks of the bastions, and curtain, at the distance of 11 yards.

The Ravelin.

From the re-entering angle of the counterscarp, make the capital of the ravelin 80 yards in length, and from its summit draw lines to points, on the faces of the bastions, 11 yards from the angle of the shoulder; the junction of these lines, and the counterscarp of the main ditch will determine the length of the faces of the ravelin. The gorge is formed by drawing lines 24 yards from the re-entering angle of the counterscarp to the intersection of the perpendicular, and the exterior side. From the salient angle of the ravelin, with a radius of 24 yards, describe an arc, to which draw tangents parallel to the faces, for the breadth of the ditch.

From the outline of the works draw the following parallels inwards:—

Rampart.

1. At the distance of 6 yards, for the thickness of the parapet.
2. From which 12 yards, for the breadth of the terreplein.
3. From which 6 yards, for the breadth of the interior slope.

Tenaille.

Draw lines parallel to the faces, at the distance of

6 yards, for the parapet.

Ravelin.

To the faces of the work draw the following parallels:—

1. At the distance of 6 yards, for the parapet.
2. From which 8 yards, for the terreplein.
3. From which 5 yards, for the interior slope.

Covered way.

Draw lines parallel to the counterscarp, at the distance of 11 yards, for the breadth of the covered way.

Salient places of arms.

These are formed by the salients of the branches of the covered way.

Re-entering places of arms.

Set off 40 yards on each side of the re-entering angle of the counterscarp for their demi-gorges, from which points draw their faces at an angle of 100 degrees.

Glacis.

For its breadth, draw parallels to the branches of the covered way, and the re-entering places of arms, at the distance of 50 yards.

Traverses.

Those at the re-entering places of arms are erected perpendicular to the covered way; those at the salient places of arms are formed on the prolongation of the faces of the bastions, and ravelins, across the

covered way; all the traverses are 6 yards thick at the top. The passages, cut out of the glacis, to enable the troops to pass round the traverses, are 4 yards wide.

Ramps.

Flank of the empty bastion.—Set off 42 yards, from the angle of the flank of the interior slope, diagonally along the slope, for the length of the ramp, to which draw a parallel line 5 yards distant, for their breadth, which mark by a perpendicular, prolonging it, and setting off 6 yards for the interior slope; to which point, from the end of the ramp, draw a line; and also from the same point draw another line parallel to the side of the ramp, and joining the interior slope of the face of the bastion.

Flanked angle of the empty bastion.—From the angle of the interior slope set off 16 yards on each side, from which points draw lines 42 yards in length diagonally along the interior slope for the length of the ramps; to which draw parallels, 4 yards distant, for their breadth; erect perpendiculars from the points (16 yards from the angle) until they intersect each other, from which point as a centre, with radius of the distance between the ramps, describe an arc joining the head of the ramps of the two faces; concentric to which, with a radius 6 yards less than the former, describe another arc, to which draw tangents from the termination of the ramps, representing their slopes.

Gorge of the full bastion.—From the angle of the interior slope, set off 16 yards on each side, from which points draw lines 42 yards in length diagonally along the interior slope; draw parallels to these at the distance of 5 yards, for the breadth of the ramps; erect perpendiculars at their head, from

the intersection of which as a centre, with radius of the distance between them, describe an arc, parallel to which, with radius 6 yards less, describe another arc, to which draw tangents, completing the interior slope of the ramps.

Ravelin.—From the angle of the interior slope, set off 12 yards on each side; from these points draw lines 30 yards in length, diagonally along the interior slope, for the length of the ramps; to which draw parallels 4 yards distant for their breadth; erect perpendiculars at the commencement of the ramps, and from their intersection, as a centre, with radius of the distance from the ramps, describe an arc joining the two ramps; also from the junction of the perpendiculars draw lines to the termination of the ramps, for their slopes.

Caponniere.

Make the passage of this work 30 feet wide, including the banquette on each side; the superior slope of each parapet terminates at 20 yards' distance.

Bridges, and communications.

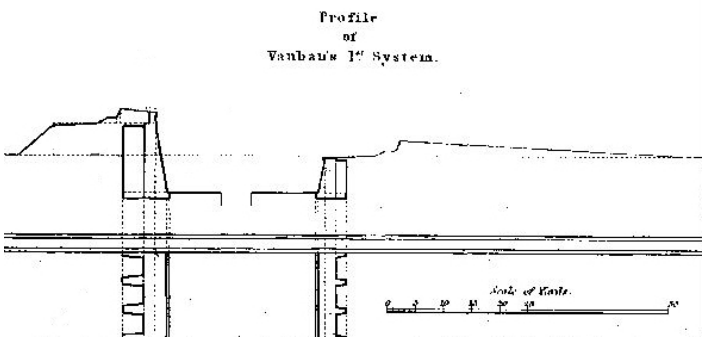
These are about 14 feet wide.

Stairs, or Pas de souris.

These steps of masonry are made at the gorges of the several works, and at the salient, and re-entering angles of the counterscarp. Those at the salients are generally 24 feet long, and at the re-entering angles 30 feet; they are 5 feet wide, and their steps 1 foot distant from each other.

Sally-ports.

These passages, cut through the glacis, are about 12 feet wide, and 18 feet long.



Profile of Vauban's 1st System.

J. W. Lowry, sc.

PROFILE, OR SECTION OF VAUBAN'S FIRST SYSTEM.

Construction.

The interior slope of the rampart has a base of 18 feet, and a perpendicular height of 17 feet 6 inches.

The terreplein has a breadth of 25½ feet, its height being 18 feet sloping to 17 feet 6 inches, the height of the interior slope.

The banquette is 3 feet in height, the tread 4 feet wide, and the slope 5 feet wide.

The parapet is 4 feet 6 inches higher than the banquette, its interior slope is 18 inches, its thickness 18 feet, and its superior slope has a declivity of 3 feet; the revetment is 3 feet thick.

The escarp has a perpendicular height of 36 feet, measuring from the cordon to the bottom of the

ditch.

The tablette, or coping-stone, at the top of the revetment, has a projection of 6 inches square.

The cordon is semicircular, its radius being 6 inches.

The slope of the escarp is 6 feet, the thickness of its revetment at the top 5 feet, and at the bottom 11 feet.

The counterfort joins the escarp; it is 1 foot lower than the top of it, 9 feet wide, and it extends to the bottom of the foundation, which is 3 feet below the bottom of the escarp; the retreat, or lessening, has a width of 1 foot.

The ditch is 38 yards wide, from the salient angle of the bastion.

The counterscarp is 17 feet 6 inches in perpendicular height, its slope being 3 feet, and its thickness at top 3 feet, the bottom, therefore, having a thickness of 6 feet; the foundation is 3 feet; and the retreat 1 foot.

The terreplein of the covered way is 20½ feet wide, and its slope is 6 inches. The banquette is 3 feet high, its tread 5 feet, and its slope 6 feet. The parapet is 4 feet 6 inches above the banquette, and its interior slope is 18 inches. The glacis, which forms the superior slope of the parapet of the covered way, is 50 yards in breadth.

The counterfort of the counterscarp is 5 feet in thickness, being 1 foot lower than the top of the counterscarp, and extending as low as the foundation of it.

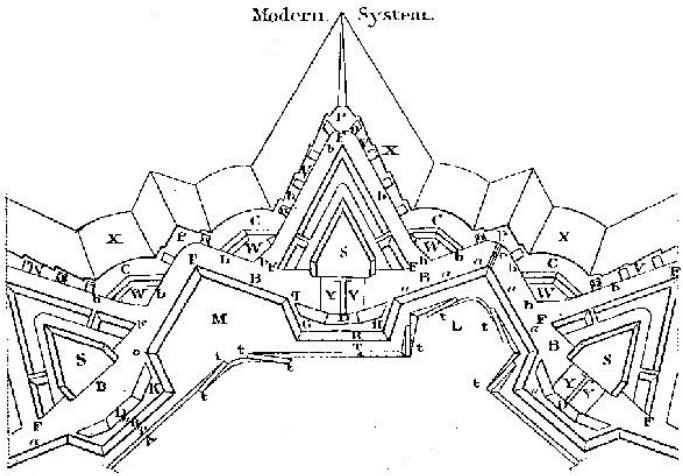
The counterforts of the escarp, and counterscarp

are 15 feet distant from centre to centre of each other, those of the escarp being at the end adjoining it 5 feet 6 inches, and at the termination 3 feet 8 inches thick; those of the counterscarp being in thickness at the larger part 3 feet 6 inches, and at the smaller 2 feet 4 inches.

Vide Plate.

MODERN SYSTEM.

A	Interior slope.	p q	Face of bastion.
T	Terreplein of rampart.	q G	Flank of bastion.
R	Parapet of rampart.	K o p q G	Outline of bastion.
A T R	Rampart.	G H	Curtain.
a a a a	Escarp, or exterior slope	t	Ramps.
	of rampart.	B	Ditch.
M	Full bastion.	D	Tenaille.
L	Empty bastion.	Y	Caponniere.
e	Batardeau.	c	Re-entering places of arms.
F F F	Ravelin.	W	Redoubt in ditto.
S	Redoubt in ravelin.	P	Salient places of arms.
b	Counterscarp.	V	Covered way.
n	Traverses in covered way.	X	Glacis.



FORTIFICATION.
Modern System.

FIELD FORTIFICATION.

REMARKS, AND GENERAL RULES.

1. The size of a work depends in general upon the number of men who are to defend it. If labour is the sole object of attention, the advantage must necessarily be the greater in proportion as the size of the work is less; but if the accommodation of the troops is only to be considered, the advantage depends greatly upon occupying much ground.

2. The form of the work should be such as to contain the greatest surface with the least perimeter. By an adherence to this maxim, we obtain the greatest accommodation for the troops with the least labour. The form of a field work seldom depends upon choice, but generally upon the spot where it is to be raised, the purposes for which it is to be constructed, and the nature of the ground in the

vicinity.

3. The interior of the work ought to be so covered by the parapet, that the men within, except when on the banquette, may not be seen from any part without, at the distance of cannon-shot.

4. The circumjacent ground (to as great a distance as possible) ought to be cleared, that the enemy may not conceal, or shelter himself against the fire from behind the parapet. The nearer to the work that the enemy can find cover, the more advantageously he can form his dispositions; and, as his attacks may consequently be made with greater vigour, and be more readily supported, the success will be the more probable.

5. The flanking parts ought to be sufficiently capacious to contain all the men required for the defence of the flanked portions of the work.

6. The flanking parts ought to have nearly a direct view of those flanked; that is, the defence should be nearly at right angles, the most advantageous angle being 100 degrees.

7. The parts flanked ought to be within musket fire of their flanking parts.

8. The fire ought to be equally distributed, that every part of the work may be equally defended.

9. The work ought to be equally strong in all its parts, that it may everywhere equally resist the assaults of the enemy; and the parapet should be thick enough to withstand the shot fired against it.

10. The dimensions of the parapet should not only be sufficient to secure, and cover the troops within the work, but ought also to be of such a form as to afford a full view of the enemy in his approach; and

at the same time discover, as little as possible, the men employed for its defence.

Capacity of Field works.

The perimeter of a work, and the number of men to defend it, should bear a just proportion to each other, one yard being allowed for each man, or for each file of men, according to the nature, and object of the work.

In calculating the area of enclosed field works, 10 square feet may generally be estimated for each man, and 324 square feet for each gun, and its stores.

Content of Field works.

In square redoubts, or works having salient angles, if the areas of the sections of the parapet, and ditch, are made nearly equal, there will be too much earth; were the angles of the plan re-entering, instead of salient, the result would be reversed. Bearing this in mind, previous to commencing the excavation of the ditch, a correct calculation must be made to prevent any excess, or deficiency of earth for the parapet, and banquette.

Rules.

1. *To find the quantity of earth* required for the parapet, and banquette of a field work, &c.

Divide the parapet, and banquette into trapezoids, and triangles; compute the contents of each separately (*by the rules in* MENSURATION OF PLANES) and the sum of them will be the superficial content of a section of the parapet, and banquette. Multiply this by the length of the periphery of the redoubt, battery, &c., for the solid content of the parapet, and banquette.

2. *To find, rapidly*, the quantity of earth required for a parapet, and banquette.

Multiply the height of the crest of the parapet, into the sum of the bases of the superior, and exterior slopes; which will give the superficial content, very nearly.

3. *To compute the superficial content of the ditch.*

Multiply the depth into the breadth at bottom, to which product add the areas of the escarp, and counterscarp, for the content required.

4. *To find the breadth of the ditch*, of the usual form.

Divide the area of the section of the parapet by the intended depth of the ditch, and the quotient will be the mean breadth of the ditch; to this add half the sum of the bases of the slopes of the escarp, and counterscarp, for the breadth at top, and deduct the same for the breadth at bottom.

5. *To find the breadth of the ditch*, having a triangular section.

Divide the area of the section of the parapet by half the given depth of the ditch, and the quotient will be the required breadth at the top.

Construction of Field works.—Vide Plate.

Fig. 1. The redan.

Draw a base line, 60 yards, from the centre of which erect a perpendicular, 40 yards; join the terminations of the base, and perpendicular, which will form the crest of the parapet of the work.

Fig. 2. The lunette.

Construct a redan (*vide No. 1*), base 80 yards,

perpendicular 50 yards: make the faces of the lunette 45 yards in length, and draw the flanks to points on the base line, 30 yards, from the perpendicular.

Fig. 3. The square redoubt.

Construct a square, each side 40 yards (*vide* PRACTICAL GEOMETRY). To form additional faces when required, bisect the side of the square, draw perpendiculars inwards equal to ⅛th of the side, and join the termination of the perpendiculars, and the sides of the square, thus forming a double number of faces.

Fig. 4. The pentagonal redoubt.

Describe a circle, radius 30 yards, and construct a pentagon in the circle (*vide* PRACTICAL GEOMETRY), thus forming the crest of the parapet of the redoubt.

Fig. 5. The hexagonal redoubt.

Describe a circle, radius 30 yards, and construct a hexagon within it (*vide* PRACTICAL GEOMETRY); the sides of which form the crest of the parapet of the work.

Fig. 6. The circular redoubt.

Describe a circle, radius 30 yards, which will form the crest of the parapet of the redoubt.

Fig. 7. The star fort, with six points.

Construct an equilateral triangle, and divide each side, 75 yards, into three equal parts, form also an equilateral triangle on the central portion of each side, 25 yards, and the crest of the parapet of the fort will be traced.

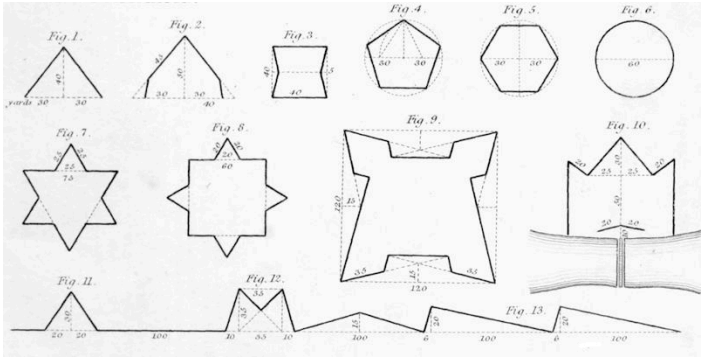
Fig. 8. The star fort, with eight points.

Construct a square: divide each side, 60 yards, into

three equal parts, and on the central portion, 20 yards, describe an equilateral triangle: the periphery of the fort will thus be obtained.

Fig. 9. The field fort, with bastions, and half bastions.

Construct a square; from the centre of each side, 120 yards, drop a perpendicular equal to one-eighth of the side, through the extremity of which, from the angles of the square, draw the lines of defence; make the faces of the bastions, and half bastions, two-sevenths of the exterior side, and draw the flanks perpendicular to their respective lines of defence.



FIELD FORTIFICATION.

J. W. Lowry, sc.

Fig. 10. The bridge head, or tête du pont.

Construct a redan, base 50 yards, perpendicular 30 yards, at an appropriate distance from the bridge, 50 yards; draw flanks, 20 yards, perpendicular to the faces, and from their termination draw lines to the river parallel to the capital of the work. To strengthen the defence of the tête du pont, construct a flèche, faces 20 yards each, and 10 yards in front of

the bridge, 4 yards wide.

In the construction of bridge heads, the foregoing Figures may be employed when expedient; the simplest form, the redan, being for light bridges, and the more perfect defence, the bastioned front, or fronts, for bridges of material consequence.

Fig. 11, 12, 13. Lines.—Vide Plate.

Fig. 11. Construct a redan, base 40 yards, perpendicular 30 yards; which join by a curtain 100 yards, to a queue d'aronde.

Fig. 12. Side of square, 35 yards, and lines drawn from summit to points on the curtains 10 yards. To increase the defence of the next curtain, 100 yards, bisect it by a perpendicular, 15 yards, and draw the two faces. Lengthen the lines by cremaillères.

Fig. 13. Base 100 yards; crochet, base 5 yards; perpendicular 20 yards.

Lines, continuous, are formed by a modification of redans, lunettes, curtains, &c., dependent on the nature of the ground, and the means of defence.

Lines, with intervals, are formed by detached redans, lunettes, &c., within range of each other; the rear works flanking those in front.

Bridges, and passages into field works are from 6 feet, to 12 feet wide, according to the requirements.

Traverses are placed about 9 feet from the slope of the banquette, their length being so regulated as to exclude from the view of the enemy the interior of the field work.

The nature, and form of the field work, or lines, required for the defence of a post, &c., &c., having been determined, the perimeter may be laid down, in

conformity to the construction detailed in the foregoing figures: after which the requisite dimensions of the parapet, ditch, &c., (dependent, of course, on the nature of the enemy's ordnance) must be taken into consideration, and the quantity of earthwork computed by the *Rules*, page 245, or by those in PRACTICAL GEOMETRY. The following Table will, however, in many cases be found useful; and, by a judicious adaptation of it, much time may be saved in the computation, and construction of field works.

TABLE,

showing the dimensions, in feet; and the superficial content of earth of banquettes, parapets, and ditches, of field works.

Key:
A = Number.
B = Base of slope.
C = Tread.
D = Height.
E = Base.
F = Superficial content.
G = Berm.
H = Breadth at top.
I = Escarp slope.
J = Counterscarp slope.
K = Depth.

	BANQUETTE.				PARAPET.								DITCH		
					Interior slope.		Superior slope.		Exterior slope.						
A	B	C	D	F	D	E	D	E	D	E	F	G	H	I	J
1	6	5	3	24	7½	1½	7½	15	5½	5½	120½	3	26	3	3
2	6	4	3	21	7½	1½	7½	15	5	5	113⅞	3	20	4	4
3	6	5	3	24	7½	1½	7½	12	5½	5½	101	3	23	3	3
4	6	4	3	21	7½	1½	7½	12	5	5	98⅜	3	17	4	4
5	6	4	3	21	7½	1½	7½	9	5½	5½	81½	3	19	3	3
6	6	4	3	21	7½	1½	7½	9	5½	5½	81½	3	16	4	4
7	5	4	3	19½	7½	1½	7½	6	6	6	66⅜	2	18	3	3
8	5	4	3	19½	6	1	6	6	4½	4½	44 6/8	2	15	10	5
9					8	1½	8	12	5½	5½	102⅛	3	19	3	3
10					7½	1	7½	9	5½	5½	78	2	16	4	4

11					6	1	6	6	4½	4½	44⅝	2	12	4	3
12					6	1	6	3	5¼	5¼	33 15/16	2	9	6	3
13	4	4	3	18	7½	1	7½	4	5½	5½	44¾	2	15	10	5

SIMPLE METHODS OF TRACING FIELD WORKS, ON THE GROUND.

1. Square redoubt.

Place pickets in a line (in length conformable to the side of the intended work), at each end of which erect perpendiculars equal in length to the side first marked out, and join the termination of these lines; which will complete the perimeter of the redoubt.

Note.—A perpendicular is raised on a given line, with a chain or cord, by forming a right-angled triangle from the numbers 3, 4, and 5, or any multiples thereof, and extending the cord, &c., so that the base may correspond with the base line of the pickets, and the perpendicular be in the direction of the side required.—*Vide* PRACTICAL GEOMETRY.

2. Pentagonal redoubt.

With a chain, tape, or cord, construct, and lay down with pickets five similar, and contiguous triangles, having their bases, which form the sides of the pentagon, in the proportion of 47 to the other two equal sides, the length of each of these being 40.

3. Hexagonal redoubt.

From a central point with a chain, or line, construct, and lay down with pickets six equilateral, and contiguous triangles, the bases of which will form the required hexagon.

4. Octagonal redoubt.

Construct a square (*vide* No. 1), from the centre of each side of which erect perpendiculars outwards, in length proportional to the side as 13 to 60 (nearly 1 to 5); join the extremities, or termination of the perpendiculars, to the angles of the square, which will determine the sides of the octagon.

Note 1.—The directions for the construction of the pentagonal, and hexagonal redoubts are on a small scale; but the redoubts may be increased by the equal extension of the interior sides of the triangles, until the bases are sufficiently long for the periphery of the work required.

Note 2.—By means of the pocket sextant, prismatic compass, or reconnoitring protractor, the pentagonal, hexagonal, and octagonal redoubt may be thus traced on the ground. From a central point place pickets at the requisite distance from each other, and in the direction of lines drawn from the angle of the centre of the intended work. (*Vide* PRACTICAL GEOMETRY. *To find the angles at the centre, and circumference of a polygon.*) Extend these radii equally until the relative distances between them are of the length required to form the sides of the proposed equilateral redoubt.

5. Front of fortification, for a Field fort.

Place pickets in a straight line, of the length required for the front of the proposed field work; from the centre of which drop a perpendicular inwards, making it for a square, pentagon, hexagon, or octagon, respectively one-eighth, one-fifth, one-fourth, or one-third of the exterior side. Direct the lines of defence from the termination of the exterior side to the end of the perpendicular, making the

faces of the bastions two-sevenths of the exterior side, and constructing the flanks perpendicular to, and joining the lines of defence. Other fronts are traced by laying down the exterior sides, at the angle of the circumference of the intended polygon (*Vide* PRACTICAL GEOMETRY) by means of the prismatic compass, &c., and then proceeding as directed for the former front.

PART X.

BRIDGES, AND PONTOONS.

BRIDGES.

To find the number of planks required to form a float, to support a given weight.

1st. Find the content of one plank (*vide Practical Geometry, Part 12*), and multiply it by the specific gravity of the wood; the product will be the *weight of the timber*.

2nd. Multiply the same solid content by the specific gravity of water: the product will be the *weight of an equal bulk of water*.

Then take the difference of these two products, or weight, and it will be the weight one piece of timber will support without sinking. *Hence by Proportion*, the number required to support the given weight may be found.

To find the number of casks required to form a raft to support a given weight.

1st. Find the solid content of one cask in cubic inches (*vide Practical Geometry*), and multiply it by the specific gravity of water; the product will be the weight of a quantity of water of equal bulk with the cask.

2nd. From this product, or weight, subtract the weight of the cask, and the remainder will be the weight it will support without sinking. *Then by Proportion*, the number required for the formation of the raft may be found.

To find the number of boats, or pontoons, required to support a given weight.

The burthen a boat, or pontoon, will support without sinking beyond a given depth (the form of the boat, or pontoon being known) must first be found, thus—

1st. Find the solid content of the part to be sunk, in cubic feet (*vide Practical Geometry, Part 12*), and multiply it by the specific gravity of water (*vide Gravity, Part 12*).

2nd. Subtract this product from the weight of the boat, or pontoon, and the remainder will be the burthen it will support without sinking beyond the required depth.

Then by Proportion, the number required to support the given weight may be computed.

Note.—In the construction of bridges, should a rope require to be extended across a rapid river, the coil should be placed in the boat (instead of on shore) and be paid out as the boat advances.

PONTOONS.

Those called Blanshard's (from their inventor, Colonel Blanshard, Royal Engineers) are of two descriptions.

1.—LARGE PONTOONS.

Displacement of water, 97½ cubic feet, equals 6088 lb., or 54½ cwt.

The buoyant power of a raft of two pontoons, its own weight deducted, is 77 cwt., about one-half of which is a safe load. Each raft, or one carriage load, forms 2 bays, or 20 ft. 8 in. of bridge: its own weight will sink it about 7 or 8 inches. The crew of a raft consists of 6 rowers, and 1 steersman.

At open order the bridge will pass cavalry, field artillery, or infantry, with closed files.

At close order the bridge will pass any part of a heavy train.

Dimensions, and weight of cylindrical pontoons, manufactured in the arsenal at Woolwich.

	Extreme length.		Diameter.		Weight.
	ft.	in.	ft.	in.	cwt.
LARGE PONTOON, with hemispherical ends	22	3	2	8	4
SMALL PONTOON, with conical ends	15	0	1	8	1¼

ONE CARRIAGE LOAD.

	Number.	Dimensions.						Weigl	
		Length.*		Breadth.		Depth.			
		ft.	in.	ft.	in.	ft.	in.	cwt.	qrs
Pontoons	2	22		2	7	2	7	9	1
Baulks	12	14	2		5		3	5	1
Chesses	8	12		1	2		1½	1	3
Half-chesses	4	11	5				1½	1	3
Gunnels	2	12		1	2		4	1	3
Side-pieces	5	10	4		5		2½	1	1
Anchor	1								3
Buoy	1								
Cable (20 fathoms)	1	168			3		3		1
Oars	7	14							3
Boat-hook	1	14							
{ Body	3	8	9		4				
Lashings{ Gunnel	4	15			1		1	}	
{ Carriage	4	22			1		1	}	
Rack-sticks, and lashings	8								
Buoy-line	1	60			1½		1½		
Breast-line	1	60			1½		1½		
								31	1
Weight of Carriage	1							13	3
Total								45	0

* The length includes the hemispherical ends.

2.—SMALL PONTOONS.

Five pontoons, with their appurtenances, form the load of one carriage. Length, 15 feet; diameter, 1 foot 7 inches; displacement, 27½ cubic feet; buoyancy, 1718 lb., or 15¼ cwt., from which deduct 2 cwt. for the weight of pontoon, and share of superstructure. A bridge of this nature is so light that it may be made on shore, and carried by hand entire. It will support as many men as can be placed on it, and, by removing the chesses over the gunnels, it may be bent so as to be passed without difficulty down a steep bank, or counterscarp.

ONE CARRIAGE LOAD.

	Number.	Dimensions.						Weight.		
		Length.*		Breadth.		Depth.				
		ft.	in.	ft.	in.	ft.	in.	cwt.	qrs.	lb.
Pontoons	5	15		1	7	1	7	5	0	0
Gunnels	5	8	4		9		3		3	12
Baulks	30	6	6		3		1½	1	1	9
Chesses	20	8		1	4		1½	4	0	20
Paddles, used as side-pieces	5								1	27
Rack-sticks, and lashings	10									6
Carriage lashings	2									5
Anchor, and cable	1								2	0
								12	1	23

Weight of the Carriage	1				9	0	0
Total					21	1	23

* The length includes the ends.

SCALING LADDERS.

Scaling ladders are made in portions, 12 feet, and 7½ feet long; which are joined together by placing the end of one portion into staples at the end of another, and securing them together with a lashing of rope. Four men are sufficient to carry an 18 feet scaling ladder.

PART XI.

FIREWORKS.

CANDLES, ROMAN.

When the case has been properly finished, and the end secured with strong twine, ram in a little dry clay, then put in a small quantity of corned powder, and over this a small piece of paper; after which as much of the composition is to be put in as will, when rammed down, fill the case about one-sixth of the length. Over this a piece of paper is placed, covering about two-thirds of the diameter, on which a little powder is laid, and then a ball, or star. Some more composition is then poured in, and pressed lightly down till the case is about one-third full, when it is to be rammed down by gentle strokes; after which, put in another small piece of paper, powder, and star, over which pour in some more composition, ram down gently, and continue thus until the case is filled, when it will contain about five stars; after which it is capped, and primed. Roman candles should be placed in rows on a stand, some of them being perpendicular, and others at angles, not, however, exceeding 45 degrees.

Compositions.

1. Mealed powder, ½ lb. Sulphur, ½ lb. Saltpetre, 2½ lb. Glass dust, ½ lb.

2. Mealed powder, 1 lb. Charcoal, ½ lb.

3. Signal rocket composition.

CANDLES, BLUE.

Saltpetre, ¼ oz. Powder, ½ oz. Sulphur, 1 oz.

CRACKERS.

The case is made of cartridge paper, the dimensions required being 15 inches by 3½ inches. First fold down one edge, about ¾ of an inch broad, then turn down the double edge about ¼ of an inch, and bend back the single edge over the double fold, so as to form within a channel, which is to be filled with mealed powder, not ground very fine; the powder is then to be covered by the folds on each side, and the whole is to be pressed by a flat ruler; and the part containing the powder is to be folded into the remainder of the paper, every fold being pressed down. The cracker is then doubled backwards, and forwards in folds about 2¼ inches, which are pressed quite close, and a piece of twine is passed twice round the middle across the folds, and the joinings secured by causing the twine to take a turn round the middle at each fold successively; one of the ends of the folds may be doubled short under, which will produce an extra report; the other must project a little beyond the rest for the purpose of being primed.

EARTHQUAKE, ARTIFICIAL.

Mix together four pounds of iron sand, and four pounds of sulphur; and after making it into a paste with water, bury it a little depth in the ground. In ten or twelve hours, if the weather be warm, the earth will swell up, and burst; flames will also issue out, scattering around a yellow and black dust.

FIRES OF VARIOUS COLOURS.

White fire is made by mixing powder with iron sand, or filings.

Red fire is made by mixing powder with iron sand of the first order.

Silver colour is made by introducing raspings of ivory.

Pale white colour is made by mixing camphor with the composition.

Lemon colour is produced from raspings of yellow amber.

Russet colour is produced from crude antimony.

Red flame, inclining to brown, is produced by Greek pitch.

Dusky flame is produced by black pitch.

Bluish flame is produced by introducing sulphur in a moderate quantity.

Green flame is made from the introduction of sal ammoniac, and verdigris.

White flame: saltpetre, sulphur, mealed powder, and camphor; the saltpetre must be the chief part.

WILDFIRE, WHICH BURNS UNDER WATER.

Mix well together equal quantities of sulphur, naphtha, bitumen, pitch, and gum.

GERBES.

Gerbes consist of strong cylindrical cases of thick paper, filled with brilliant composition, and sometimes with balls, or stars. Gerbes throw up into the air luminous and sparkling jets of fire; and when

arranged in a circular manner, as the radii of a circle, they form what is called a fixed sun. The thickness of the cases for brilliant fire must be a fourth part of the diameter, and for Chinese fire a sixth part. The case is loaded on a nipple, having a point equal in length to the same diameter, and in thickness to a fourth part of it; but as it generally happens that the mouth of the jet becomes larger than is necessary for the effect of the fire, the case should be first charged by filling it to a height equal to a fourth part of the diameter, with clay, which must be rammed down. When the charge is completed with the composition, the case should be closed with a tompeon of wood, and then choked. The train, or match, must be of the same composition as that employed for loading, otherwise the jet would be subject to burst. Charged cases may be pierced with two holes near the neck, in order to have three jets; or, if a top pierced with a number of holes be added to them, they will imitate a bubbling fountain. Jets intended for representing sheets of fire ought not to be choked. They must be placed in a horizontal position, or inclining a little downwards.

Composition for Gerbes, or jets of fire.

Key:
S = Saltpetre.
P = Pulverized powder.
Su = Sulphur.
C = Charcoal.

JETS.	S	P	Su	C	Iron sand, or filings.
	lb. oz.	lb. oz.	oz.	oz.	oz.
{ Chinese fire ·4 of an	1	1	8	2	

	{ White fire	1			8	3	2	Sand, 1st order	8
·5 to 1 inch diameter	{ Brilliant fire			1				Filings	5
	{ White fire	1				8	2		
	{ Chinese fire	1	4			5	5	Sand, 3rd order	12
1·1 to 1·5 diameter	{	1	4			7	5	Mixed sand	12
	{			1	8		5		
	{	2		2			8		

The saltpetre, powder, and charcoal, are three times sifted through a hair sieve; the iron sand is besprinkled with sulphur, after being moistened with spirits of wine, that the sulphur may adhere to it, and they are then mixed together. The sulphuretted sand is then spread over the first mixture, and the whole is mixed with a ladle only, for if a sieve were employed, it would separate the sand from the other materials.

When sand larger than the 2nd order is used, the composition is moistened with spirits of wine, so that it forms itself into balls, and the jets are then loaded with them.

IRON FILINGS.

These filings must be quite clean, and free from rust. They must be thoroughly mixed with the

compositions of which they form one of the ingredients; which, however, will not afterwards keep in good order longer than a week, as the moisture contracted by saltpetre rusts the filings, and destroys the effect they are intended to produce.

IRON SAND, OR POUNDED IRON.

Having broken a cast-iron plate, or iron pot, to pieces, on an anvil, pulverize the fragments till the grains are not larger than radish seed, then sift them through six graduated sieves to separate the different sizes; and preserve these six different kinds in a very dry place, in closely-corked bottles. The grains which pass through the first or finest sieve, are called *Sand of the 1st order*, and those that pass through the second sieve, *Sand of the 2nd order*, &c. Compositions into which iron filings, or sand, are introduced, must not be driven hard, for fear of accidents by explosion.

LEADERS, OR PIPES OF COMMUNICATION.

These are small tubes of paper, of lengths adapted to the distances to which they are to extend. The paper is cut into slips two or three inches broad, or sufficient to go four times round the formers, which are about one-fourth of an inch diameter. Brass wire formers are the best, and should be oiled to prevent the paper sticking. Quick match is inserted in these tubes, but must be made to go in easily. The quick match should project an inch beyond each end of the leader, and should be inserted into the mouths of the cases of the fireworks with a small quantity of mealed powder. The leaders must not be placed too near, or cross each other so as to touch, as it may happen that the fire from one may communicate to another, and destroy thereby the intended

arrangements.

MARROONS.

Marroons are boxes containing from 1 to 6 ounces of powder. They are made either on a square, or round former, and the ends of the paper are pasted down, and well welded round with kitted twine worked over cross-ways. A hole is bored into the case, and a match inserted.

MEALING GUNPOWDER.

A small quantity of powder being placed on a table with a rim round it, is rubbed down with a scored wooden mealer until all the grains are broken, and it becomes sufficiently fine to pass through a lawn sieve.

PASTE FOR REPRESENTING ANIMALS, ETC., IN FIRE.

Reduce sulphur to an impalpable powder, and having formed it into a paste with starch, cover with it the figure intended to be represented on fire, which must, however, have been previously coated over with clay, to prevent it from being burnt. When covered with the paste, besprinkle it, while still moist, with mealed powder; and when perfectly dry, arrange some matches on the principal parts, so that fire may be speedily communicated to every part of it. The same paste may be employed to form festoons, garlands, &c., the flowers of which might be imitated by fires of different colours, and could be formed on the frieze of a piece of architecture, covered with clay to preserve the stone, or wood from the effect of the fire. The Chinese imitate grapes exceedingly well, by mixing powdered sulphur with the pulp of the jejube, instead of flour-paste or starch.

PORTFIRES FOR ILLUMINATIONS.

The cases are made of three or four rounds of thin paper, the last round being pasted; they are from two to five-eighths of an inch in diameter, and from two to six inches long; they are pinched close at one end, and left open at the other. In filling them, a small quantity of the composition must be put in at a time, ramming it lightly, so as not to break the case.

Compositions.

1. Saltpetre, 1 lb.; sulphur, 8 oz.; mealed powder, 6 oz.
2. *Amber lights*: Mealed powder, 9 oz.; amber, 3 oz.
3. Saltpetre, 2 lb.; sulphur, 3 lb.; antimony, 1 lb.
4. Saltpetre, 3½ lb.; sulphur, 2½ lb.; mealed powder, 1 lb.; antimony, ½ lb.; glass dust, 4 oz.; brass dust, 1 oz.

Note.—Compositions No. 3, and 4, driven 1¼ inch in a one ounce case, will burn one minute.

RAIN, GOLD, AND SILVER.

Fill small paper cases, or goose quills, with the composition, and place upon the mouth of each some moist powder, both to keep in the composition, and to serve as a match. If the head of a rocket be loaded with these cases or quills, a shower of fiery rain will be produced at the extreme range of the rocket.

Compositions.

Gold rain.

1. Saltpetre, 1 lb.; mealed powder, 4 oz.; sulphur, 4 oz.; brass dust, 1 oz.; sawdust, 2¼ oz.; glass dust, 6 drs.

2. Mealed powder, 12 oz; saltpetre, 2 oz.; charcoal, 4 oz.

3. Saltpetre, 8 oz.; sulphur, 2 oz.; glass dust, 1 oz.; antimony, ¾ oz.; brass dust, ¼ oz.; sawdust, 12 drs.

Silver rain.

1. Saltpetre, 4 oz.; sulphur, mealed powder, and antimony, each 2 oz.; sal prunella, ½ oz.

2. Saltpetre, 8 oz.; sulphur, 2 oz.; charcoal, 4 oz.

3. Saltpetre, 1 lb.; antimony, 6 oz.; sulphur, 4 oz.

4. Saltpetre, 4 oz.; sulphur, 1 oz.; powder, 2 oz.; steel dust, ¾ oz.

ROCKETS, LINE.

Any rocket which is not very large, may be made to run along an extended rope. For this purpose affix to the rocket an empty case, and introduce therein the rope which is to carry it, placing the head of the rocket towards that side to which it is intended to move. Two rockets with an empty case may be similarly used, and may be made to move in a retrograde direction by placing them with their heads reversed, and a leader to communicate from the head of the rocket to be first ignited to the tail of the second.

ROCKETS, SIGNAL.

Composition.

Pulverized saltpetre, 4 lb.; sublimated sulphur, 1 lb.; dogwood charcoal, 1 lb. 8 oz.

The charcoal is first pounded fine enough to pass through a wire sieve (No. 3). The saltpetre and

sulphur are each separately passed through a fine hair sieve, then mixed well together with a copper slice, and passed three times through the hair sieve. The charcoal is then spread on a tray, and the saltpetre and sulphur sifted a fourth time on it, and the whole being carefully mixed with a hard brush, is afterwards passed four times through the wire sieve.

To each ladleful of composition, 25 blows are given for the pound, and 21 for the half-pound rocket.

Twenty-eight ladlesful of composition (7½ oz.) are required to complete the pound, and twenty-five (5 oz.) the half-pound rocket.

To prevent accidents in driving rockets, &c., the workman should keep his body erect, the drift being well cleaned after each ladleful; and while driving, it should be moved backward, and forward by a pair of holders.

Rockets are driven 3½ calibres hollow, 1 calibre solid, and ½ calibre with clay.

Moulds.

		Length.	Diameter.
1 Pounder	Exterior	14 inches	3·9
	Interior	10·5 ”	1·7
½ Pounder	Exterior	11·6 ”	2·3
	Interior	8·5 ”	1·3

Spindles.

	Diameter.			
	Top.	Middle.	Bottom.	Length.
1 Pounder	·2	·35	·5	6·4

½ Pounder	·2	·3	·4	5·2

Drifts.

	Length.	Diameter.	Hollowed.	No.
1 Pounder	12·1 inches	1·1	6·5	1
	10 ”	1·1	5·7	2
	7·3 ”	1·1	2·5	3
	6·8 ”	1·1	Solid	4
½ Pounder	9·3 ”	·9	5·4	1
	7·1 ”	·9	2·3	2
	4 ”	·9	Solid	3

The rocket is primed with mealed powder, and spirits of wine.

When complete, the length of the pound rocket is 15½ inches; and the half-pound 12 inches; the weight of the pound rocket and stick is 1¾ lb.; and the half-pound, 13 oz.

Length of sticks for rockets.

1-Pounder rocket	8 feet.	Half-pounder	6 feet 4 inches.

Star compositions.

No. 1.

Saltpetre, pulverized	8 lb.	Isinglass, dissolved	3½ oz.
Sulphur, sublimated	2 lb.	Vinegar	1 quart.
Antimony, pounded	2 lb.	Spirits of wine	1 pint.

2. *White stars.* Mealed powder, 4 oz.; saltpetre, 12 oz.; sulphur vivum, 6 oz.; oil of spike, 2 oz.; camphor, 5 oz.

3. *Blue stars.* Mealed powder, 8 oz.; saltpetre, 4 oz.; sulphur, 2 oz.; spirits of wine, 2 oz.; oil of spike, 2 oz.

4. *Coloured, or variegated stars.* Mealed powder, 8 drs.; rockpetre, 4 oz.; sulphur vivum, 2 oz.; camphor, 2 oz.

5. *Brilliant stars.* Saltpetre, 3½ oz.; sulphur, 1½ oz.; mealed powder, ¾ oz., worked up with spirits of wine.

6. *Common stars.* Saltpetre, 1 lb.; sulphur, 4 oz.; antimony, 4¾ oz.; isinglass, ½ oz.; camphor, ½ oz.; spirits of wine, ¾ oz.

7. *Tailed stars.* Mealed powder, 3 oz.; sulphur, 2 oz.; saltpetre, 1 oz.; charcoal, coarsely ground, ¾ oz.

8. *Drove stars.* No. 1. Saltpetre, 3 lb.; sulphur, 1 lb.; brass dust, 12 oz.; antimony, 3 oz.

No. 2. Saltpetre, 1 lb.; antimony, 4 oz.; sulphur, 8 oz.

9. *Fixed pointed stars.* Saltpetre, 8½ oz.; sulphur, 2 oz.; antimony, 1 oz. 10 drs.

10. *Stars of a fine colour.* Sulphur, 1 oz.; mealed powder, 1 oz.; saltpetre, 1 oz.; camphor, 4 drs.; oil of turpentine, 4 drs.

The dry ingredients are well mixed, and sifted through a hair sieve: the isinglass dissolved over a fire with vinegar, and the spirits of wine afterwards added, and with which the dry composition is thoroughly mixed. It is then formed on moulds, and

a hole is left in the middle to assist its ignition. Thirty-six stars are put in a 1-pounder, and twenty-two in a half-pounder rocket.

A great variety of figures may be represented in the air by attaching to a large rocket several small rockets, or small cases filled with the composition; or serpents may be attached to the rocket by means of packthread.

SALTPETRE, PULVERIZED.

Sixteen pounds of refined lakepetre are put into a copper vessel, to which four quarts of water are added. It is placed over a charcoal fire to boil; as the water evaporates it is well stirred with copper-shod spatulas or paddles, occasionally taking it off the fire, until the evaporation ceases; and when brought to a fine powder it is sifted through a hair sieve, and spread on paper to cool.

To extract saltpetre from damaged gunpowder.

Dissolve the powder in warm water, filter the solution through fine linen bags, and then evaporate the water by boiling it, until the solution is of sufficient strength to crystallize.

SERPENTS, OR SQUIBS.

The case is made by rolling stout cartridge paper in slips of 6 or 8 inches in breadth three times round a former, and pasting down the last fold. The case, having been choked at one end, is filled about two-thirds with the composition, and a small piece of paper is inserted, over which powder is placed, and this end is secured with twine. At the other extremity, moist powder with touch-paper is inserted. To introduce the composition into the case,

a quill, cut into the form of a spoon, may be employed, and the composition must be rammed down by a few strokes of a mallet on an iron rod tipped with brass.

Composition.

1.	lb. oz.	2.	lb. oz.
Mealed powder	1		1
	8		0
Charcoal	4		1
Sulphur	1		0
Saltpetre	3		1¾

SHELLS, OR AERIAL GLOBES.

These globes are made of wood, and their thickness is equal to about a twelfth part of their diameters. The usual charge is an ounce of powder for a shell of 4 lb. weight, and 2 ounces for a shell of 8 lb. They may be fired from any mortars that have not a chamber.

To form the shell.

Two wooden hemispheres (with a fuze hole) are joined firmly together, enclosing stars, squibs, rain, &c. A small quantity of powder is inserted to explode the shell, by means of a fuze.

SHOWERS OF FIRE.

To form a shower of fire, mould small paper cases on an iron rod, two-tenths of an inch in diameter, and 2½ inches in length. They must not be choked, as it will be sufficient to twist the end of the case, and having put the rod into it, beat it to make it

assume its form. When the cases are filled (which is done by immersing them in the composition) fold down the other end, and then apply a match. They must be fixed on a frame with leaders, to be fired simultaneously.

Compositions.

Chinese fire. Mealed powder, 1 lb.; sulphur, 2 oz.; iron filings, 5 oz.

Ancient fire. Mealed powder, 1 lb.; charcoal, 2 oz.

Brilliant fire. Mealed powder, 1 lb.; iron filings, 4 oz.

The Chinese fire is the best of the above compositions.

SPECKIE.

Brilliant, and diversified displays of fireworks may be readily exhibited by means of speckie, or lances. Illuminated designs of figures, &c., are represented by affixing on a black board small cases filled with various coloured compositions, to which leaders must be attached. The cases are fastened on with glue, and red lead mixed together.

Compositions.

	White.		Yellow.		Blue.		Yellow.		Yellow.	
	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.
Saltpetre	2	4		8	1	2	1			2
Sulphur		8	1			4		8		½
Mealed powder		4		12				10		8
Antimony, crude		4								

Gum Succum		8				
Antimony, prepared			8			
Basket salt				6		
Gamboge					3	

Stars, crosses, revolving suns, &c., being fixed on the wooden frame with the speckie, will form a brilliant display.

SPUR FIRE.

Composition.

1.	lb.	oz.	2.	lb.	oz.
Saltpetre	4	8		1	
Sulphur	2				8
Lamp black	1				4
		8		quarts.	

The saltpetre and sulphur must be first sifted together, and then put into a marble mortar with the lamp black. These ingredients must be thoroughly mixed with a wooden pestle. The composition, if rubbed too much, will be too fierce, and hardly show any stars; and on the contrary, when not mixed enough, will be too weak, and throw out an obscure smoke, and lumps of dross without any stars. This composition is generally rammed in 1, or 2 ounce cases, about five, or six inches long, but not driven very hard. Cases filled with spur fire may be used in rooms without any danger of setting fire to the furniture, &c., and some of them being placed round a transparent pyramid of paper, and fired in a large room, make a very pretty appearance.

SUNS, OR WHEELS, FIXED, AND MOVEABLE.

None of the pyrotechnic inventions can be applied with so much success in artificial fireworks, as suns, or wheels, of which there are two kinds, fixed, and revolving.

FIXED SUNS.

Construct a circular piece of wood, into the circumference of which screw 12 or 15 pieces in the form of radii, and to these attach jets of fire, the mouth of each of which must be towards the circumference of the frame; and leaders being affixed to all the jets, they will, when ignited, produce the appearance of a radiated sun. The wheel is fixed vertically. The jets may be arranged so as to cross each other in an angular manner, in which case a *star*, or *cross of Malta* will be formed. To produce a very brilliant effect, these suns may be made with several rows of jets.

REVOLVING SUNS.

Provide a wooden wheel of the requisite size, and bring it into perfect equilibrium around its centre, in order that the least effort may make it turn round. Attach to the circumference of it jets placed in the direction of the circumference; and affix leaders of match to communicate the fire from jet to jet, according as may be required. When fire is applied to one of the jets, the recoil will immediately cause the wheel to revolve, unless it should be too ponderous or large: therefore, when these suns are intended to be of a considerable size, that is, when they consist of twenty jets, fire must be communicated at the same time to the 1st, 6th, 11th, and 16th, from which it will proceed to the 2nd, 7th, 12th, and 17th, and so on. Four jets will thus make the wheel revolve

rapidly. If two similar suns be placed one behind the other, and made to turn round in a contrary direction, they will produce a very brilliant cross fire.

For a sun 5 feet in diameter, the cases should be 8 oz., filled about 10 inches in length with composition.

Compositions.

Slow fire.	oz.
Saltpetre	4
Sulphur	2
Mealed powder	1½

Dead fire.	oz.
Saltpetre	1¼
Sulphur	¼
Lapis Calemanaris	¼
Antimony	⅛

Brilliant fire.	lb.	oz.
Mealed powder	6	0
Saltpetre		8
Sulphur		2
Iron Sand		12

Illumination fire.	lb.	oz.
Saltpetre	1	0
Sulphur		8
Mealed powder		6

Golden colour.	lb.	oz.
Mealed powder	1	0
Charcoal, very good		2

Red Chinese fire.	lb.	oz.
Mealed powder	1	0
Saltpetre	1	0

Charcoal	4
Sulphur	4
Iron sand 2nd and 3rd order	14

White Chinese fire.		
	lb.	oz.
Mealed powder	1	0
Saltpetre	1	0
Sulphur		8
Iron sand, 2nd & 3rd order		14

Grey colour.		
	lb.	oz.
Mealed powder	1	0
Saltpetre		4
Sulphur		2
Charcoal		1¼

Four ounce cases will be required for wheels of 14, or 16 inches; if the wheels are larger, 8 oz., 1 lb., or even 2 lb. cases will be required.

The Chinese compositions are intended for cases of nine-tenths of an inch interior diameter, but they will be found to answer for cases as low as four ounces.

TOUCH PAPER.

Dissolve saltpetre in spirits of wine, or water, more or less of the saltpetre, according as the paper is to burn fast, or slow: then dip into the solution blue paper, which, when well saturated, take out, and dry for use. The touch-paper must be cut into slips, placed once round the mouth of the firework, and the end of the paper outside the case should be twisted to a point.

WHEELS, PIN, OR CATHERINE.

The pipe or case is made on a long wire former, about three-sixteenths of an inch in diameter, into which the composition is poured through a funnel, and shaken down. The case is then rolled round a small circle of wood about one inch in diameter, and not more than half an inch thick, with a hole through the centre of it for a nail, or pin. One end of the case is to be pasted round the wood, and each half turn of it secured with sealing-wax, or a strip of paper pasted across the wheel. The end is then primed.

Composition.

Mealed powder, 12 oz.; saltpetre, 3 oz.; sulphur, 1½ oz.

Two ounces of iron sand, or camphor, may be added, but it keeps better without either.

PART XII.

MATHEMATICS.

Mathematics is the science which treats of all kinds of quantity whatever, that can be numbered, or measured.

Arithmetic is that part which treats of numbering.

Fractions treat of broken numbers, or parts of numbers.

Algebra is the art of computing by symbols.

In this science, quantities of all kinds are represented by the letters of the alphabet.

Geometry is the science relating to measurement. By the assistance of geometry, engineers, &c., conduct all their works, take the distances of places, and the measure of inaccessible objects, &c.

Characters, marks, or signs,

which are used in arithmetic, and algebra, to denote several of the operations, and propositions:

\+ *signifies* plus, or addition,
\- minus, or subtraction,
× multiplication,
÷ division,
: :: : proportion,
= equality,
√ square root,
∛ cube root,

4^2 *denotes that* 4 is to be squared.
4^3 *denotes that* 4 is to be cubed.

ARITHMETIC.

REDUCTION.

Reduction is the method of converting numbers from one name, or denomination to another: or the method of finding the value of a quantity in terms of some other higher, or lower quantity.

To reduce from a higher to a lower denomination.

Rule.—Multiply the given number by as many of the lower denomination as make one of the greater; [40] adding to the product as many of the lower denomination as are expressed in the given sum.

Example.—In £6 15*s.* 5*d.*, how many pence?

£.	*s.*	*d.*	
6	15	5	
20			
135			
12			
1625			*Answer.*

To convert from a lower to a higher denomination.

Rule.—Divide the given number by as many of the lower denomination as are required to make one of the greater.[41] Should there be any remainder, it will be of the same denomination as the dividend.

Example.—Convert 1625 pence into pounds, shillings, and pence.

12) 1625 pence

20) 135 5

£6 15*s.* 5*d.* *Answer.*

THE RULE OF THREE, OR SIMPLE PROPORTION.

It is called the *Rule of Three* because three numbers are given to find a fourth. It is also called *Simple Proportion*, because the 1st term bears the same proportion to the 2nd, as the 3rd does to the 4th. Of the three given numbers, two of them are always of the same kind, or name, and are to be the 1st, and 2nd terms of the question; the 3rd number is always of the same name, or kind as the 4th, or answer sought; and in stating the question it is always to be made the 3rd term. If the answer will be *greater* than the 3rd term, place the least of the other two given quantities for the 1st term; but if the answer will be *less* than the 3rd term, put the greater of the two numbers, or quantities, for the 1st term.

Rule.—State the question according to the above directions, and multiply the 2nd and 3rd terms together, and divide this product by the 1st, for the 4th term, or answer sought.

If the 1st and 2nd terms are not of the same denomination, they must be reduced to it; and if the third term is a compound number, it must be reduced to its lowest denomination before the multiplication, or division of the term takes place.

Note 1.—The operation may frequently be considerably abridged, by dividing the 1st and 2nd, or the 1st and 3rd terms, by any number which will

exactly divide them, afterwards using the quotients, instead of the numbers themselves.*

Example.—If 2 tons of iron for ordnance cost £40, how many tons may be bought for £360?

As £40 : £360 :: 2 tons : 18 tons.
(Thus 360 × 2) ÷ 40 = 18. The answer.
* Or thus, 9 × 2 = 18. The answer.

Note 2.—A concise method of ascertaining the annual amount of a daily sum of money.

Rule.—Bring the daily sum into pence, and then add together as many pounds, half pounds, groats, and pence, as there are pence in the daily sum, for the amount required. For leap year, add the rate for one day.

Example.—Required the annual amount of 2*s.* 6*d.* per diem.

2*s.* 6*d.* = 30*d.*

30 pounds.
15 = 30 half pounds.
10*s.* = 30 groats.
2*s.* 6*d.* = 30 pence.

Annual amount (365 days) ... £45 12*s.* 6*d.*

Note 3.—To find the amount of any number of days' pay, the daily rate (under twenty shillings) being given.

The price of any article being given, the value of any number may be ascertained in a similar manner.

Rule 1. When the rate (or price) is an even number, multiply the given number by half of the rate, doubling the first figure to the right hand for the shillings, the remainder of the product will be pounds.

Example. Required the amount of 243 days' pay, at 4*s.* per diem.

4/2 = 2

243
2
£48 *Ans.*
12*s.*

Rule 2. When the price is an odd number, find for the greatest number as before, to which add one-twentieth of the given number for the odd shilling.

Example. What is the price of 566 pairs of shoes, at 7*s.* per pair.

566
3
169 16*s.*
28 6
£198 2*s.* *Ans.*

2/0) 56/6
28 6

FRACTIONS.

A fraction is a quantity which expresses a part, or parts of a unit, or integer. It is denoted by two numbers placed with a line between them.

A Simple fraction consists of two numbers, called the numerator, and denominator; thus,

$\frac{3}{5}$ 3 numerator,
5 denominator.

The Denominator is placed below the numerator, and expresses the number of equal parts into which the integer is divided.

The Numerator expresses the number of parts of the

broken unit, or integer; or shows how many of the parts of the unit are expressed by the fraction.

A Compound fraction is a fraction of a fraction, as ⅔ of ⅘.

A Mixed number consists of a whole number with a fraction annexed to it, as 4⅖.

An Improper fraction has the numerator greater than the denominator, as $^{6}/_{5}$.

REDUCTION OF FRACTIONS.

is bringing them from one denomination to another.

To reduce a fraction to its lowest terms.

Rule.—Divide the numerator, and the denominator, by any number that exactly divides them, and the quotients by any other number, till they can be no longer divided by any whole number, when the fraction will be in its lowest terms.

Example.—Reduce

$$\frac{4032}{6048}$$

to its lowest terms.

Thus,

$$\frac{4}{4032}{6048} = \frac{12}{1008}{1512} = \frac{6}{84}{126} = \frac{7}{14}$$

$$= \frac{21}{2}$$

3.

Answer.

To reduce an improper fraction to a whole, or mixed number.

Rule.—Divide the numerator by the denominator, the quotient will be the whole number; and the remainder (if any) the numerator of the fraction, having the divisor for the denominator.

Example.—Reduce $\frac{114}{12}$ to a whole, or mixed number.

12) 114

9 *Answer.*

6

12

To reduce a mixed number to an improper fraction.

Rule.—Multiply the whole number by the denominator, and add the numerator to the product, under which place the given denominator.

Example.—Reduce 17⅝ to an improper fraction.

17⅝

8

141

8 *Answer.*

To reduce a compound fraction to a simple fraction.

Rule.—Multiply all the numerators together for the numerator, and all the denominators for the

denominator.

Example.—Reduce ⅜ of ⅙ of ½ of 9 to a simple fraction.

Numerators	3	×	1	=		=		*Answer.*
	×		×		27		9	
	1		9					
Denominators	8	×	2		96		32	
	×		×					
	6		1					

To reduce fractions of different denominators to equivalent fractions, having a common denominator.

Rule.—Multiply each numerator by all the denominators except its own for the new numerators, and multiply all the denominators together for a common denominator.[42]

Example.—Reduce ⅜, ⅔, and ⅘ to fractions having a common denominator.

$$3 \times 3 \times 5 = 45$$
$$2 \times 8 \times 4 = 80$$
$$4 \times 8 \times 3 = 96$$
$$8 \times 3 \times 5 = 120$$

Answer, $\frac{45}{120}$, $\frac{80}{120}$, $\frac{96}{120}$.

ADDITION OF FRACTIONS.

Rule.—Bring compound fractions to simple fractions; reduce all the fractions to a common

denominator, then add all the numerators together, and place their sum over the common denominator. When mixed numbers are given, find the sum of the fractions, to which add the whole numbers.

Example.—Add together ⅝, ¾, and 6½.

$5 \times 4 \times 2 = 40$

$$\begin{array}{r} 40 \\ 48 \end{array}$$

$+$

$$\begin{array}{r} 36 \\ 48 \end{array}$$

$+$

$$\begin{array}{r} 24 \\ 48 \end{array}$$

$+ 6 = 8$

$$\begin{array}{r} 4 \\ 48 \end{array}$$

.

$3 \times 6 \times 2 = 36$

$1 \times 6 \times 4 = 24$ or, by cancelling, and dividing,[43]

$6 \times 4 \times 2 = 48$

$$\begin{array}{r} 10 \\ 12 \end{array}$$

$+$

$$\begin{array}{r} 9 \\ 12 \end{array}$$

$+$

$$\begin{array}{r} 6 \\ 12 \end{array}$$

$+ 6 = 8$

$$\begin{array}{r} 1 \\ 12 \end{array}$$

Answer.

SUBTRACTION OF FRACTIONS.

Rule.—Prepare the quantities, as in addition of fractions. Place the less quantity under the greater. Then, if possible, subtract the lower numerator from the upper; under the remainder write the common

denominator, and, if there be whole numbers, find their difference as in simple subtraction. But if the lower numerator exceed the upper, subtract it from the common denominator, and to the remainder add the upper numerator; write the common denominator under this sum, and carry 1 to the whole number in the lower line.

Example.—

From 54
5
6
or 54
25
30

Take 25
5
15
or 25
10
30

——
29
15
30
Answer.

MULTIPLICATION OF FRACTIONS.

Rule.—Reduce mixed numbers to equivalent fractions; then multiply all the numerators together for a numerator, and all the denominators together for a denominator, which will give the product required.

Example.—Multiply ⅝, ⅜, and 2½ together.

⅝ × ⅜ × (2½ or)

$$= \frac{5}{2} \times \frac{75}{96}$$

Answer.

DIVISION OF FRACTIONS.

Rule.—Prepare the fractions, as for multiplication; then divide the numerator by the numerator, and the denominator by the denominator, if they will exactly divide; but if they will not do so, then invert the terms of the divisor, and multiply the dividend by it, as in multiplication.

Example.—Divide $\frac{9}{16}$ by 4½.

$$\frac{9}{16} \div (4\tfrac{1}{2} \text{ or}) \frac{9}{2}$$

$= \frac{1}{8}$ *Answer.*

RULE OF THREE IN FRACTIONS.

Rule.—State the terms, as directed in “Simple proportion;” reduce them (if necessary) to improper, or simple fractions, and the *two first* to the same denomination. Then multiply together the second and third terms, and the first with its parts inverted, as in division, for the answer.

Example.—If 4⅕ cwt. of sugar cost £19⅞, how much may be bought for £59⅝?

As 19⅞ : 59⅝ :: 4⅕
Or,

$$\frac{\frac{159}{8}}{\frac{477}{8}} :: \frac{21}{5} : 12\tfrac{3}{5} \quad \textit{Answer.}$$

$$\frac{159}{8} \times \frac{477}{8} \times \frac{21}{5} = \frac{80136}{6360} = 12\tfrac{3}{5} \text{ cwt.}$$

DECIMALS.

A decimal fraction is that which has for its denominator an unit (1), with as many ciphers annexed as the numerator has places; and it is usually expressed by setting down the numerator only, with a point before it, on the left hand. Thus,

$$\frac{5}{10}$$

is ·5;

$$\frac{25}{100}$$

is ·25;

$$\frac{25}{1000}$$

is ·025; ciphers being *prefixed*, to make up as many places as are required by the ciphers in the denominator.

A mixed number is made up of a whole number

with some decimal fraction, the one being separated from the other by a point, thus 3·25 is the same as 3 $\frac{25}{100}$ or $\frac{325}{100}$.

Ciphers on the right hand of decimals make no alteration in their value; for ·5, ·50, ·500 are decimals having all the same value, each being = $\frac{5}{10}$. But when they are placed on the left hand, they decrease the value in a tenfold proportion; thus, ·5 is $\frac{5}{10}$; but ·05 is $\frac{5}{100}$.

ADDITION OF DECIMALS.

Rule.—Set the numbers under each other, according to the value of their places, in which state the decimal separating points will all stand exactly under each other. Then beginning at the right hand, add up all the columns of numbers as in integers, and point off as many places for decimals as are in the greatest number of decimal places in any of the lines that are added; or place the point directly below all the other points.

Example.—Required the sum of 29·0146, 3146·5, 14·16, and 165.

29·0146
3146·5

	14·16
	165·
Answer	3354·6746

SUBTRACTION OF DECIMALS.

Rule.—Place the numbers under each other according to the value of their places. Then, beginning at the right hand, subtract as in whole numbers, and point off the decimals, as in addition.

Example.—Subtract 4·90142 from 214·81.

	214·81
	4·90142
Answer	209·90858

MULTIPLICATION OF DECIMALS.

Rule.—Place the factors, and multiply them together, the same as if they were whole numbers. Then point off in the product just as many places of decimals as there are decimals in both the factors. But, if there be not so many figures in the product, prefix ciphers to supply the deficiency.[44]

Example.—Multiply 32·108 by 2·5.

32·108	
2·5	
160540	
64216	
80·2700	*Answer.*

DIVISION OF DECIMALS.

Rule.—Divide as in whole numbers, and point off

in the quotient as many places for decimals as the decimal places in the dividend exceed those in the divisor. When the decimal places of the quotient are not so many as the above rule requires, the deficiency is to be supplied by prefixing ciphers. When there is a remainder after the division, or when the decimal places in the divisor are more than those in the dividend, then ciphers may be annexed to the dividend, and the quotient carried on as far as required.

Example.—Divide 234·7052 by 64·25.

64·25) 234·7052 (3·65 *Answer.*
19275
41955
38550
34052
32125
1927 *Remainder.*

REDUCTION OF DECIMALS.

To reduce a vulgar fraction to its equivalent decimal.

Rule.—Divide the numerator by the denominator, as in Division of Decimals, annexing ciphers to the numerator as far as necessary: and the quotient will be the decimal required.

Example.—Reduce

$$\frac{7}{24}$$

to a decimal.

24 = 4 × 6. Then 4) 7·

6) 1·75

·291666, &c.

To find the value of a decimal, in terms of the inferior denominations.

Rule.—Multiply the decimal by the number of parts in the next lower denomination, and cut off as many places to the right hand for a remainder, as there are places in the given decimal. Multiply that remainder by the parts in the next lower denomination, again cutting off for another remainder as before. Proceed in the same manner through all the parts of the integer; then the several denominations, separated on the left hand, will make up the answer.

Example.—What is the value of ·775 pounds sterling.

	·775	
	20	
Shillings	15·500	
	12	
Pence	6·000	*Answer* 15*s.* 6*d.*

To convert integers, or decimals to equivalent decimals of higher denominations.

Rule.—Divide by the number of parts in the next higher denomination, continuing the operation to as many higher denominations as may be necessary.

When there are several numbers, all to be converted to the decimal of the highest—

Set the given numbers directly under each other

for dividends, proceeding from the lowest to the highest; opposite to each dividend, on the left hand, place such a number for a divisor as will bring it to the next higher name. Begin at the uppermost, and perform all the divisions, placing the quotient of each division, as decimal parts, on the right hand of the dividend next below it; so shall the last quotient be the decimal required.

Example.—Convert 15*s.* 9¾*d.* to the decimal of a pound sterling.

4	3·
12	9·75
20	15·8125
	£·790625 *Answer.*

Example.—Convert 1 dwt. to the decimal of a pound, Troy weight.

20)	1
12)	·05 oz.
	·004166 lb., &c., *Answer.*

RULE OF THREE IN DECIMALS.

Rule.—Prepare the terms, by reducing the fractions to decimals; compound numbers to decimals of the higher denominations, or integers of the lower; also the first, and second terms to the same name. Then multiply, and divide, as in the Rule of Three, in whole numbers.

Example.—If ⅜ of a yard of cloth cost £⅖, what will

$$\frac{5}{16}$$

of a yard cost?

	yd.	yd.	£.		*s.*
					d.
⅜ = ·375	As	·3125	:: 4 :	·333	or 6
	·375			&c.	
	:				8
		4			
⅖ = ·4	·375)	·12500	(·3333	&c.	
		1125	20		
5/16 = ·3215		1250*s.*	6·666	&c.	
		1125	12		
Answer, 6*s.* 8*d.*		125*d.*	7·999	&c. nearly 8*d.*	

DUODECIMALS.

By Duodecimals, artificers, &c., compute the content of their works.

Rule.—Set down the two dimensions to be multiplied together one under the other, so that feet may stand under feet, inches under inches, &c.

Multiply each term in the multiplicand, beginning at the lowest, by the feet in the multiplier, and set the result of each straight under its corresponding term, observing to carry 1 for every 12, from the inches to the feet. In like manner multiply all the multiplicand by the inches, and parts of the multiplier, and set the result of each term one place removed to the right hand of those in the multiplicand: omitting, however, what is below parts of inches, only carrying to these the proper number of units from the lowest denominations. Or, instead of multiplying by the inches, take such part of the

multiplicand as those are of a foot.

Then add the two lines together for the content required.

Example.—Multiply 14 feet 9 inches, by 4 feet 6 inches.

ft.	in.	
14	9	
4	6	
59	0	
7	4½	
66	4½	*Answer.*

TABLES OF WEIGHTS, AND MEASURES.

TROY WEIGHT.

24	grains	1	pennyweight.				
480		20		1	ounce.		
5760		240		12		1	pound.

AVOIRDUPOIS WEIGHT.

16	drams	1	ounce.				
256		16		1	pound.		
7168		448		28		1	qua
28672		1792		112		4	
573440		35840		2240		80	

Note.—

1 lb.	Avoirdupois weight equals 14 oz.	11 dwts.	15½ grs. Troy.
1 oz.	ditto	18 dwts.	5½ do.
1 dr.	ditto	27·34375	do.

APOTHECARIES' WEIGHT.

20	grains	1	scruple.					
60		3		1	dram.			
480		24		8		1	ounce.	
5760		288		96		12		1

WEIGHTS.

To find the weight, for tonnage.

Cattle—

Divide the number by 3, for weight in tons.

Sheep Average 60 lb. each.

Divide by 33, for weight in tons.

Pigs Average 80 lb.

Divide by 15, for tons.

Beer, or Ale—

Barrel 3¼ cwt.

Hogshead 5¼ cwt.

Oats Sack—24 stone.

Divide quarters by 5, for tons.

Rum—

Divide gallons by 224, for tons.

Wine Cask—12 cwt.

Rule for ascertaining the weight of Hay.

Measure the length and breadth of the stack; then take its height from the ground to the eaves, and add

to this last one-third of the height from the eaves to the top: Multiply the length by the breadth, and the product by the height, all expressed in feet; divide the amount by 27, to find the cubic yards, which multiply by the number of stones supposed to be in a cubic yard (viz., in a stack of new hay, six stones; if the stack has stood a considerable time, eight stones; and if old hay, nine stones), and you have the weight in stones. For example, suppose a stack to be 60 feet in length, 30 in breadth, 12 in height from the ground to the eaves, and 9 (the third of which is three) from the eaves to the top; then 60 × 30 × 15 = 27000; 27000 ÷ 27 = 1000; and 1000 × 9 = 9000 stones of old hay.

LONG MEASURE.

12 inches	1 foot.			
36	3	1 yard.		
198	16½	5½	1	pole, perch, or rod.
7920	660	220	40	1 furlong.
63360	5280	1760	320	8 1 mile.

LAND MEASURE (*Length*).

7·92 inches	1 link.
100 links, or 22 yards	1 chain.
80 chains	1 mile.
69·121 miles	1 geographical degree.

LAND MEASURE (*Surface, or Superficial*).

62·7264 square inches	1 square link.

625	square links	1 square pole, or perch.
10000	square links	1 square chain.
2500	square links	1 square rood, or pole.
10	square chains	1 square acre.
100000	square links	1 square acre.

NAUTICAL MEASURE.

1	nautical mile	6082·66 feet.
3	miles	1 league.
20	leagues	1 degree.
360	degrees	the earth's circumference.

SQUARE MEASURE.

144	s. inches	1	s. foot		
1296		9		1	s. yard.
39204		272¼		30¼	1 s. pole.
1568160		10890		1210	40 1 r
6272640		43560		4840	160 4

CUBIC MEASURE (*Measure of solidity*).

1728	cubic inches	1 cubic foot.
27	cubic feet	1 cubic yard.

Note.—A cubic foot is equal to 2200 cylindrical inches, or 3300 spherical inches, or 6600 conical inches.

Timber.

40 feet of round, and 50 feet of hewn timber make 1 *Ton*; 16 cubic feet make 1 *Foot* of wood; 8 feet of

wood make 1 *Cord*.

Water.

Maximum density 42 deg. Fahrenheit.

1 cubic foot of water		6¼ imperial gallons.
1 cylindric foot do.	about	5 do.
1 cubic foot	weighs	62·5 lb. avoirdupois.
1 cylindric do.	do.	49·1
1 lineal do. (1 in. square)	do.	·434
12·2 imperial gallons	weigh	1 cwt.
224 do.	do.	1 ton.
1·8 cubic feet	do.	1 cwt.
35·84 do.	do.	1 ton.

MEASURES OF CAPACITY.

69⅓	cubic in	2	pints	1	quart.			
277¼		8		4		1	gallon.	
554½		16		8		2		1 peck
2218⅕		64		32		8		4
10¼	cubic ft.	512		256		64		32

FRENCH MEASURES.

	English cubic inches.		English feet.
		Metre	3·281
Millilitre	·06103	” French feet, 3·07844	

Centilitre	·61028	Millimetre.	·03937
Decilitre	6·10279	Centimetre	·39371
Litre, or cubic decimetre	61·02791	Decimetre	3·93708
Decalitre	610·27900	Metre	39·37079
Hectolitre	6102·79000	Decametre	393·70790
Kylolitre	61027·90000	Hectometre	3937·07900
Myrialitre	610279·00000	Kilometre	39370·79000
1 litre is nearly 2⅛ wine pints.		Myriametre	393707·90000
1 kilolitre 1 tun 12¾ wine gallons.		8 kilometres are nearly 5 miles.	
1 stere, or cubic metre	35·3171	1 inch is ·0254 metre.	
		100 feet are nearly 30·5 metres.	

INVOLUTION.

Involution is the raising of powers from any given number, as a root.

A *Power* is a quantity produced by multiplying any given number, called the *Root*, a certain number of times continually by itself. Thus, $2 \times 2 = 4$, the 2nd power, or square of 2, expressed thus, 2^2.

The index, or exponent of a power is the number denoting the height, or degree of that power. Thus, 2 is the index of the 2nd power.

Powers that are to be raised, are usually denoted by placing the index above the root, or first power.

Thus $2^2 = 4$, the 2nd power of 2.

Example.—What is the 2nd power of 45?

$45 \times 45 = 2025$ *Answer.*

EVOLUTION.

Evolution is the reverse of Involution, being the extracting, or finding the roots of any given powers, or numbers.

The Root of any number, or power, is such a number as being multiplied into itself a certain number of times, will produce that power.

Thus, 2 is the square root, or 2nd root of 4, because, $2^2 = 2 \times 2 = 4$; and 3 is the cube root, or third root of 27. But there are many numbers of which a proposed root can never be exactly found; by means of decimals, however, the root may be very nearly ascertained.

Any power of a given number, or root, may be found exactly by multiplying the number continually into itself.

Those roots which only approximate are called *Surd-roots*; but those which can be found, quite exactly, are called *Rational-roots*. Thus, the square root of 3 is a surd root, but the square root of 4 is a rational root, being equal to 2; also the cube root of 8 is rational, being equal to 2, but the cube root of 9 is surd, or irrational. Roots are sometimes denoted by writing the character √ before the power with the index of the root against it. Thus, the 3rd, or cube root of 20 is expressed by $\sqrt[3]{20}$. When the power is expressed by several numbers with the sign + or - between them, a line is drawn from the top of the sign over all the parts of it; thus the cube (or third) root of 45 - 12 is $\sqrt[3]{45} - 12$ or thus $\sqrt[3]{(45 - 12)}$.

TO EXTRACT THE SQUARE ROOT.

Rule.—Divide the given number into periods of

two figures each, by setting a point over the place of units, and another over the place of hundreds, and so on over every second figure, both to the left hand in integers, and right hand in decimals. Find the greatest square in the first period on the left hand, and set its root on the right hand of the given number, after the manner of the quotient figure in division. Subtract the square thus found from the said period, and to the remainder annex the two figures of the next following period for a dividend. Double[45] the root above-mentioned for a divisor, and find how often it is contained in the said dividend, exclusive of its right-hand figure; and set that quotient figure both in the quotient, and divisor. Multiply the whole augmented divisor by this last quotient figure, and subtract the product from the said dividend, bringing down to it the next period of the given number, for a new dividend. Repeat the same process over again—viz., find another new divisor, by doubling all the figures now found in the root; from which, and the last dividend find the next figure of the root as before; and so on through all the periods to the last.

To extract the square root of a fraction, or mixed number.

Reduce the fraction to a decimal, and extract its root.

Mixed numbers may be either reduced to improper fractions, and the root extracted; or the fraction may be reduced to a decimal, then joined to the integer, and the root of the whole extracted.

Example.—To find the square root of 29506624.

29506624 (5432 The Root.

	25
104	450
4	416
1083	3466
3	3249
10862	21724
2	21724

TO EXTRACT THE CUBE ROOT.

Rule 1.—By trials, or by the table of roots (*vide page* 280), take the nearest rational cube to the given number, whether it be greater, or less, and call it the assumed cube.

2.—Then (*by the Rule of Three*),

As the sum of the given number, and double the assumed cube, is to the sum of the assumed cube, and double the given number, so is the root of the assumed cube, to the root required, nearly.

3.—Or as the first sum,
is to the difference of the given, and assumed cube,
so is the assumed root,
to the difference of the roots, nearly.

4.—Again, by using, in like manner, the cube of the root last found as a new assumed cube, another root will be obtained still nearer. Repeat this operation as often as necessary, using always the cube of the last-found root, for the assumed root.

Example.—To find the cube root of 21035·8.

By trials it will be found *first*, that the root lies between 20, and 30; and, *secondly*, between 27, and

28. Taking, therefore, 27, its cube is 19683, which will be the assumed cube. Then by No. 2 of the Rule

	19683		21035·8				
	2		2				
	39366		42071·6				
	21035·8		19683·				
As	60401·8	:	61754·6	::	27	: 27·6047	the Root, nearly.

Again for a second operation, the cube of this root is 21035·318645155832, and the process by No. 3 of the Rule will be

	21035·318645,		&c.				
	2						
	42070·637290		21035·8				
	21035·8		21035·318645, &c.				
As	63106·43729	:	diff. ·481355	::	27·6047 :		
			: the diff.		·000210560		
	consequently the root required is				27·604910560		

TABLE OF SQUARES, CUBES, AND ROOTS.

No.	Sqr.	Cube.	Sqr. root.	Cube root.	No.	Sqr.	Cube.	Sqr. root.
1	1	1	1·0000000	1·000000	51	2601	132651	7·1414284
2	4	8	1·4142136	1·259921	52	2704	140608	7·2111026
3	9	27	1·7320508	1·442250	53	2809	148877	7·2801099
4	16	64	2·0000000	1·587401	54	2916	157464	7·3484692
5	25	125	2·2360680	1·709976	55	3025	166375	7·4161985
6	36	216	2·4494897	1·817121	56	3136	175616	7·4893148
7	49	343	2·6457513	1·912933	57	3249	185193	7·5498344
8	64	512	2·8284271	2·000000	58	3364	195112	7·6157731
9	81	729	3·0000000	2·080084	59	3481	205379	7·6811457
10	100	1000	3·1622777	2·154435	60	3600	216000	7·7459667
11	121	1331	3·3166248	2·223980	61	3721	226981	7·8102497
12	144	1728	3·4641016	2·289428	62	3844	238328	7·8740079
13	169	2197	3·6055513	2·351335	63	3969	250047	7·9372539
14	196	2744	3·7416574	2·410142	64	4096	262144	8·0000000
15	225	3375	3·8729833	2·466212	65	4225	274625	8·0622577
16	256	4096	4·0000000	2·519842	66	4356	287496	8·1240384
17	289	4913	4·1231056	2·571282	67	4489	300763	8·1853528
18	324	5832	4·2426407	2·620741	68	4624	314432	8·2462113
19	361	6859	4·3588989	2·668402	69	4761	328509	8·3066239
20	400	8000	4·4721360	2·714418	70	4900	343000	8·3666003
21	441	9261	4·5825757	2·758923	71	5041	357911	8·4261498
22	484	10648	4·6904158	2·802039	72	5184	373248	8·4852814
23	529	12167	4·7958315	2·843867	73	5329	389017	8·5440037
24	576	13824	4·8989795	2·884499	74	5476	405224	8·6023253
25	625	15625	5·0000000	2·924018	75	5625	421875	8·6602540
26	676	17576	5·0990195	2·962496	76	5776	438976	8·7177979
27	729	19683	5·1961524	3·000000	77	5929	456533	8·7749644
28	784	21952	5·2915026	3·036589	78	6084	474552	8·8317609
29	841	24389	5·3851648	3·072317	79	6241	493039	8·8881944
30	900	27000	5·4772256	3·107232	80	6400	512000	8·9442719
31	961	29791	5·5677644	3·141381	81	6561	531441	9·0000000

32	1024	32768	5·6568542	3·174802	82	6724	551368	9·0553851
33	1089	35937	5·7445626	3·207534	83	6889	571787	9·1104336
34	1156	39304	5·8309519	3·239612	84	7056	592704	9·1651514
35	1225	42875	5·9160798	3·271066	85	7225	614125	9·2195445
36	1296	46656	6·0000000	3·301927	86	7396	636056	9·2736185
37	1369	50653	6·0827625	3·332222	87	7569	658503	9·3273791
38	1444	54872	6·1644140	3·361975	88	7744	681472	9·3808315
39	1521	59319	6·2449980	3·391211	89	7921	704969	9·4339811
40	1600	64000	6·3245553	3·419952	90	8100	729000	9·4868330
41	1681	68921	6·4031242	3·448217	91	8281	753571	9·5393920
42	1764	74088	6·4807407	3·476027	92	8464	778688	9·5916630
43	1849	79507	6·5574385	3·503398	93	8649	804357	9·6436508
44	1936	85184	6·6332496	3·530348	94	8836	830584	9·6953597
45	2025	91125	6·7082039	3·556893	95	9025	857375	9·7467943
46	2116	97336	6·7823300	3·583048	96	9216	884736	9·7979590
47	2209	103823	6·8556546	3·608826	97	9409	912673	9·8488578
48	2304	110592	6·9282032	3·634241	98	9604	941192	9·8994949
49	2401	117649	7·0000000	3·659306	99	9801	970299	9·9498744
50	2500	125000	7·0170678	3·684031	100	10000	1000000	10·0000000

PILING OF SHOT, AND SHELL.

Shot, and shells, are usually piled in horizontal courses, the base being either an equilateral triangle, a square, or a rectangle. The triangular, and square piles terminate each in a single ball, but the rectangular pile finishes in a row of balls.

To find the number of balls in a complete pile.

Rule.—Add the three parallel edges together; then one-third of the product of that sum, and of the number of balls in the triangular face, will be the number sought.

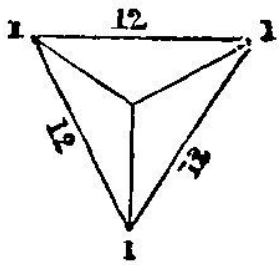
Note 1.—The parallel edges in a *rectangular pile* are the two rows in length at the base, and the upper ridge. In the *square pile* the same, except that the

upper row is only a single ball. In the *triangular pile*, one side of the base, the single ball at top, and that at the back, are considered the parallel edges.

Note 2.—The number of balls in the triangular face is found by multiplying half the number in the breadth at the base, by the number in the breadth at the base *plus* 1.

Note 3.—In all piles the breadth of the bottom is equal to the number of courses. In the oblong pile, the top row is one more than the difference between the length, and breadth of the bottom.

Example.—To find the shot in a triangular pile, the bottom row consisting of 12 shot.



Parallel
{
12

edges.
{
1

12 ÷ 2
= 6

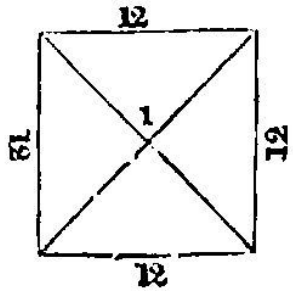
{

1
12 + 1
= 13

Triangular face
78
3)
14
4⅔
4⅔
312
52

Answer
364

Example.—To find the shot in a square pile, the bottom row consisting of 12 shot.



12

1

12 ÷ 2

= 6

1

12 + 1

= 13

78

3)

25

8⅓

8⅓

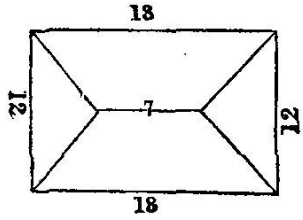
624

26

Answer

650

Example.—To find the shot in an oblong pile, whose base consists of 18 shot in length, and 12 in breadth.



18

18 - 12
= 6

18

1

7

7

3)
43

14⅓

12 ÷ 2
= 6

12 + 1
= 13

78

14⅓

312

78

26

Answer

1118

Triangular pile.

Rule.—Multiply the base by the base *plus* 1, this product by the base *plus* 2, and divide by 6.

Square pile.

Rule.—Multiply the bottom row by the bottom row *plus* 1, and this product by twice the bottom row *plus* 1, and divide by 6.

Rectangular, or oblong pile.

Rule.—Multiply the breadth of the base by itself *plus* 1; and this product by three times the length of the base *plus* 1, *minus* the breadth of the base, and divide by 6.

In the following formulæ let the letter (L) *denote the number in the bottom row, or the length; and* (B) *the breadth of the lowest course.*

Triangular pile	$\frac{L \times (L + 1) \times (L + 2)}{6}$
Square pile	$\frac{L \times (L + 1) \times (2L + 1)}{6}$
Oblong pile	$\frac{B \times (B + 1) \times (3L + 1 - B)}{6}$

The number of shot in any pile,

(whose base does not exceed 21) may readily be ascertained by referring to *the following Table,* *page*

284.

For the square pile.—Look for the number of shot in the base, in the first vertical column on the left hand, and also in the diagonal column; and at their angle of meeting will be found the content required.

Thus 20 base gives 2870.

For the triangular pile.—Look for the number in the base row in the diagonal column, and opposite to it will be found the content.

Thus 18 base gives 1140.

For the oblong pile.—Look for the number in the length of the base in the vertical column, and the breadth of the base in the diagonal column, and at their angle of meeting will be found the content required.

Thus 17 length, and 12 breadth, gives 1040.

To find the number of balls in an incomplete pile.

Compute the number in the pile considered as complete; also the number in the upper pile, or part wanting; and the difference between the two piles thus found will be the number in the frustrum, or incomplete pile.

Table for computing the Content of any Pile, whose base row does not

1	2	4														
2	5	3	10													
3	8	14	4	20												
4	11	20	30	5	35											
5	14	26	40	55	6	56										
6	17	32	50	70	91	7	84									
7	20	38	60	85	112	140	8	120								
8	23	44	70	100	133	168	204	9	165							
9	26	50	80	115	154	196	240	285	10	220						
10	29	56	90	130	175	224	276	330	385	11	286					
11	32	62	100	145	196	252	312	375	440	506	12	364				
12	35	68	110	160	217	280	348	420	495	572	650	13	455			
13	38	74	120	175	238	308	384	465	550	638	728	819	14	560		
14	41	80	130	190	259	336	420	510	605	704	806	910	1015	15	680	
15	44	86	140	205	280	364	456	555	660	770	884	1001	1120	1240	16	816
16	47	92	150	220	301	392	492	600	715	836	962	1092	1225	1360	1496	17
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
19	56	110	180	265	364	476	600	735	880	1034	1196	1365	1540	1720	1904	2091
20	59	116	190	280	385	504	636	780	935	1100	1274	1456	1645	1840	2040	2244
21	62	122	200	295	406	532	672	825	990	1166	1352	1547	1750	1960	2176	2397

CORDAGE.

Ropes, *cables*, and all other descriptions of cordage are distinguished by their circumference, thus a two-inch rope means a rope two inches in circumference.

To find the weight of a rope.

First method.—Multiply the length in fathoms by the square of the circumference, and divide the product by 480 for the weight in cwts.

Example.—Required the weight of 110 fathoms of 3-inch rope.

$3 \times 3 \times 110 = 990$, which divided by 480, gives 2 cwt. 7 lb. Weight required.

Second method.—Divide the square of the circumference by 4, the quotient will give the weight, in pounds, per fathom.

Example.—What is the weight of a 3-inch rope per fathom?

$3^2 \div 4 = 2¼$ lb. Weight required.

To find the strength of a rope, or the weight it will support.

First method.—Square the circumference, and divide by 5, for the number of tons which it will bear suspended from it.[46]

Example.—What weight will 3-inch rope of the best description support?

$$\frac{(3 \times 3)}{5}$$

$= 9/5 = 1⅘$ ton, or 4030 lb. Weight required.

Second method.—Multiply the square of the circumference by 2, the product will give the *practical weight in cwts*. that may be lifted by it, or about half the breaking weight.

Example.—What number of cwts. may be lifted by a 3-inch rope?

$3^2 \times 2 = 18$ cwts. Weight required.

The	in	*a*	*will bear*	$= \text{girt}^2$	nearly.
strain,	pounds,	*rope*	*safely*	$\times 200\}$	
”	”	*a*	” ”	$= \text{girt}^2$	
		cable		$\times 120\}$	

CHAINS.

To find the weight of chains.

The square of the diameter of the link, measured in eighths of inches, will give the weight of the chain, per fathom, in pounds.

Example.—What is the weight per fathom of a ¾-inch chain?

¾-inch = $\frac{6}{8}$; $6^2 = 36$ lb. Weight per fathom.

Or, the weight per foot of the chain, multiplied by 24, will give the weight per fathom of the chain, *nearly*. A chain cable with a stay across the links will weigh about one-twelfth more than the foregoing examples.

To find the weight that may be safely lifted by a chain.

Divide the square of the diameter of the links, taken in eighths of an inch by 8, and the quotient will give the number of tons that may be lifted by the chain.

Example.—What number of tons will a chain made of ¾-inch iron carry with safety?

¾-inch = $\frac{6}{8}$

$6^2 = 36$

$\frac{36}{8}$

= 4½ tons. Weight required.

The safe strain is equal to about 8 tons, per square inch, of the iron of which the chain is made.

The stay across the link of a chain increases its strength about one-sixth.

When the chain is of great length, a deduction, from the above rules, must be allowed for the weight of it.

IRON RODS.

To find the weight of round iron rods.

Divide the square of the diameter, in quarter inches, by 2, and the quotient will give the weight in pounds, per yard.

Example.—What is the weight of a yard of 1-inch round iron.

1 inch = 4 quarters $4^2 = 16$

16

2

= 8 lb. Weight required.

To find the weight of square rods.

The weight of round rods, of similar diameter, divided by ·7854 will give the weight of the square rods.

To find the weight that may be sustained, or lifted by round iron rods.

Find the weight in pounds, per yard; two-thirds of which will give the safe load, in tons.

A round iron rod of average quality of iron, one inch in diameter, will be torn asunder by 16 tons; it will be perceptibly damaged by half this strain, or 8 tons; its safe load will be one-third, or 5·33 tons.

TIMBER.

To find the area, or superficial content of a plank.

Multiply the length by the mean breadth.[47]

Example.—Required the content of a board whose length is 11 feet 2 inches, and breadth 1 foot 10 inches

ft. in.			ft. in.			ft. in.	
11	2	×	1	10	=	20	Content
						5.	required.

To find the solid content of squared, or four-sided timber.

Multiply the mean breadth by the mean thickness, and the product by the length, for the content, nearly.

Note 1.—If the tree taper regularly from the one end to the other, either take the mean breadth, and thickness in the middle, or take the dimensions at the two ends, and half their sum will be the mean dimensions; which, multiplied as by the above rule, will give the content, nearly.

Note 2.—If the piece do not taper regularly, take several different dimensions, add them all together, and divide their sum by the number of them, for the mean dimensions.

Example.—Required the content of a piece of timber 16 feet long, and side of square 14 inches.

ft. in.			ft. in.			ft.	ft. in.	
1	2	×	1	2	×	=	21	Content
			16				9.	required.

To find the solidity of round, or unsquared timber.

1. Multiply the square of the quarter girt (or the square of ¼ of the mean circumference), by the

length, for the content.

Note.—When the tree is tapering, take the mean dimensions, either by girting it in the middle for the mean girt, or at the two ends, taking half the sum of the two; or by girting it in several places, then adding all the girts together, and dividing the sum by the number of them for the mean girt. But when the tree is very irregular, divide it into several lengths, and find the content of each part separately.

Example.—Required the content of a tree, whose mean girt is 3·15 feet, and length 14½ feet.

$$\begin{array}{rr} & 3.15 \\ & 4 \\ = \cdot 7875 & \cdot 7875 \times \cdot 7875 = \cdot 62015625. \end{array}$$

$\cdot 62015 \times 14 \cdot 5 = 8 \cdot 9922$ feet of solid timber. The content required.

2. Find the mean area of a round tree, and multiply it by the length for the content.

To find the weight of a tree.

Find its content in feet, and multiply that by the specific gravity of the wood.

(*Vide* GRAVITY, *and Table of Specific Gravities*. *Page 318.*)

Example.—Required the weight of an elm-tree; whose mean girt is 5 feet, and length 60 feet.

$$\begin{array}{rr} & 5 \\ & 4 \\ = 1 \cdot 25 & 1 \cdot 25 \times 1 \cdot 25 = 1 \cdot 5625. \end{array}$$

$1 \cdot 5625 \times 60 = 93 \cdot 75.$ Content in feet.

TONNAGE.

Table of Tonnage, and Weight of *one* of the following Carriages, Carts, Waggons, Gyns, &c., used in land service.

Carriages.			Tonnage.	Weight.	
			Tons. ft.	Cwt. qrs. lb.	
	{ 24 pounder		6 0	34 0 22	With bullock
	{ 8 inch		6 0	34 2 12	pole and
*For Iron	{ 18 pounder		4 39	27 2 9	chain,
Ordnance.	{ 12 ”	21 cwt.	4 7	18 3 24	weighing
	{ Howitzer	{ 10 inch	6 17	39 0 9	2 qrs. 19 lb.
		{ 8 ”	5 37	33 2 0	
	{ 12 pounder		5 33	22 0 10	
	{ 9 ”		5 1	20 2 14	
*For Brass	{ 6 ”		4 21	17 3 5	
Ordnance.	{	{ 32 pr.	5 29	23 3 13	
	{ Howitzer	{ 24 ”	5 6	21 0 17	
	{	{ 12 ”	4 21	18 3 14	
*Ammunition waggon			5 36	20 0 3	For all natures.

*Forge		5	38	19	1	0	
*Store-waggon (without spare wheel)		5	11	18	1	10	
*Small arm ammunition waggon		4	36	14	2	16	
*Rocket	{ 12 pounder	7	33	20	2	8	
	{ 6 ”	5	17	20	1	20	
*Pontoon	{ Large	3	30	42	2	13	
	{ Small			22	2	5	
Garrison, wood, common standing for 32 pounder of 25 cwt.		1	8	8	0	7	

* Travelling complete.

		Tons.	f.	Cwt.	qrs.	lb.	
Capstan, crab		0	31	3	3	26	
	{ Forge, cavalry	4	32	11	2	3	
	{ Hand	1	10	4	3	4	
	{ Hospital, conveyance	3	16	10	2	20	
Carts	{ Sling	3	38	16	1	17	
	{ Store	3	16	9	1	0	
	{ French	1	32	5	2	13	
Drugs	{ Large	2	7	17	1	24	
	{ Small	0	29	5	0	4	
Gyns,	{ Large	1	23	9	2	22	
Triangle	{ Small	1	2	7	3	3	
{ Madras	{ For 32 pounder garrison carriage	0	26	6	0	12	Fir.
Platform. { Madras	{ For traversing carriage with tail-piece	1	23	14	2	0	Teak.

{ Mortar, Alderson's pattern	0	30	8	1	4	
Portable forge, and pack saddle, in wooden case	0	17	2	1	3	
Waggons { Flanders	5	0	16	1	25	
Waggons { Platform	3	16	21	3	18	
Waggons { Sling	8	11	31	3	26	
Waggons, hospital, Mr. Holmes' {Large pattern	9	10	21	0	0	
{Small.	6	30	18	0	4	

The calculation of tonnage for baggage, stores, &c., is by measurement: *a Ton*, consisting of 40 cubic feet; but metals, and very heavy articles are estimated by actual weight, without reference to bulk.

To ascertain the tonnage of sailing vessels, the hold being clear.

Rule.—Divide the length of the upper deck between the afterpart of the stem, and the forepart of the stern-post, into six equal parts.

Depths.—At the foremost, the middle, and the aftermost of those points of division, measure in feet, and decimal parts of a foot, the depth from the under side of the upper deck to the ceiling at the limber strake. In the case of a break in the upper deck the depths are to be measured from a line stretched in a continuation of the deck.

Breadths.—Divide each of those three depths into five equal parts, and measure the inside breadths at the following points—viz., at one-fifth, and at four-fifths from the upper deck of the foremost, and

aftermost depths, and at two-fifths, and four-fifths from the upper deck of the midship depth.

Length.—At half the midship depth measure the length of the vessel from the afterpart of the stem to the forepart of the stern-post; then to twice the midship depth add the foremost, and the aftermost depths for the sum of the depths; add together the upper, and lower breadths at the foremost division, three times the upper breadth, and the lower breadth at the midship division, and the upper, and twice the lower breadth at the after division, for the sum of the breadths: then multiply the sum of the depths by the sum of the breadths, and this product by the length, and divide the final product by 3500, which will give the number of tons for register.

If the vessel have a poop, or half deck, or a break in the upper deck, measure the inside mean length, breadth, and height of such part thereof as may be included within the bulkhead; multiply these three measurements together, and dividing the product by 92·4, the quotient will be the number of tons to be added to the result as above found.

In order to ascertain the tonnage of open vessels, the depths are to be measured from the upper edge of the upper strake.

To ascertain the tonnage of steam vessels.

Rule.—In addition to the foregoing rules, when applied for the purpose of ascertaining the tonnage of any ship or vessel propelled by steam, the tonnage due to the cubical content of the engine-room must be deducted from the total tonnage of the vessel, as determined by either of the rules aforesaid, and the remainder will be the true register tonnage of the said ship or vessel.

To determine the tonnage due to the cubical content of the engine-room.

Rule.—Measure the inside length of the engine-room in feet and decimal parts of a foot, from the foremost to the aftermost bulkhead, then multiply the said length by the depth of the ship or vessel at the midship division as aforesaid, and the product by the inside breadth of the same division at two-fifths of the depth from the deck, taken aforesaid, and divide the last product by 92·4, and the quotient will be the tonnage due to the cubical content of the engine-room.

To ascertain the tonnage of vessels when laden.

Rule.—Measure, *first*, the length on the upper deck between the afterpart of the stem, and the forepart of the stern-post; *secondly*, the inside breadth on the under side of the upper deck, at the middle point of the length; and, *thirdly*, the depth from the under side of the upper deck down the pump-well to the sink; multiply these three dimensions together, and divide the product by 130, and the quotient will be the amount of the register tonnage of such ships.

MECHANICS.

Mechanics is the science of forces, and the effects they produce when applied to machines in the motion of bodies.

Machine, or engine, is any mechanical instrument contrived to move bodies.

Equilibrium is an equality of action, or force, between two or more powers, or weights, acting against each other, by which they destroy each

other's effects, and remain at rest.

The centre of motion is the fixed point about which a body moves.

The axis of motion is the fixed line about which it moves.

The centre of gravity is a certain point on which a body (being freely suspended) will rest, in any position.

The whole momentum or quantity of force of a moving body, is the result of the quantity of matter multiplied by the velocity with which it is moved.

THE MECHANICAL POWERS.

Power is compounded of the weight, or expansive force of a moving body multiplied into its velocity.

The power of a body, which weighs 40 lb., and moves with the velocity of 50 feet in a second, is the same as that of another body which weighs 80 lb., and moves with the velocity of 25 feet in a second: for the products of the respective weights, and velocities are the same.

$$40 \times 50 = 2000; \text{ and } 80 \times 25 = 2000.$$

Power cannot be increased by mechanical means.

Power is applied to mechanical purposes—

1. By the lever;
2. By the wheel, and axle;
3. By the pulley;
4. By the inclined plane;
5. By the wedge;
6. By the screw;

which are the simple elements of all machines.

The whole theory of these elements consists simply in causing the weight, which is to be raised, to pass through a greater or a less space than the power which raises it; for, as power is compounded of the weight, or mass of a moving body, multiplied into its velocity, a weight passing through a certain space may be made to raise, through a less space, a weight heavier than itself.

THE LEVER.

The lever is the most simple of all machines, being only a straight bar of iron, wood, &c., supported on, and moveable round a prop, called the *fulcrum*.

Case 1.—When the fulcrum of the lever is between the power, and the weight.

Rule.—Divide the weight to be raised by the power to be applied; the quotient will give the difference of leverage necessary to support the weight in equilibrio. Hence, a small addition either of leverage, or weight, will cause the power to preponderate.

Example 1.—A ball weighing 3 tons is to be raised by 4 men, who can exert a force of 12 cwt.; required the proportionate length of lever?

$$3 \text{ tons} = 60 \text{ cwt.}; \quad \text{and} \quad \frac{60}{12} = 5$$

In this example, the proportionate lengths of the lever to maintain the weight in equilibrio, are as 5 to 1. If, therefore, an additional pound be added to the power, the power side of the lever will preponderate, and the weight will be raised. But, although the ball is raised by a force of only one-fifth of its weight, no power is gained, for the weight passes through only

one-fifth of the space. The products, therefore, arising from the multiplication of the respective weights, and velocities are the same.

Example 2.—A weight of 1 ton is to be raised with a lever 8 feet in length, by a man who can exert, for a short time, a force of rather more than 4 cwt.; required at what part of the lever the fulcrum must be placed?

$$\frac{\text{20 cwt.}}{\text{4 cwt.}}$$

= 5; that is, the weight is to the power as 5 to 1, therefore,

$$\frac{8}{5 + 1}$$

= 1 foot and a third, from the weight.

Example 3.—A weight of 40 lb. is placed 1 foot from the fulcrum of a lever; required the power to raise the same, when the length of the lever on the other side of the fulcrum is 5 feet?

$$\frac{40 \times 1}{5}$$

= 8 lb. *Ans.*

Case 2.—When the fulcrum is at one extremity of the lever, and the power at the other.

Rule.—As the distance between the power, and the fulcrum is to the distance between the weight, and the fulcrum, so is the effect to the power.

Example 1.—Required the power necessary to raise 120 lb., when the weight is placed 6 feet from the power, and 2 feet from the fulcrum?

As 8 : 2 :: 120 : 30 lb. *Ans.*

Example 2.—A beam, 20 feet in length, and supported at both ends, bears a weight of 2 tons at

the distance of eight feet from one end; required the weight on each support?

$$\frac{40 \text{ cwt.} \times 8 \text{ feet}}{20 \text{ feet}}$$

= 16 cwt. on the support that is furthest from the weight; and

$$\frac{40 \times 12}{20 \text{ feet}}$$

= 24 cwt. on the support nearest to the weight.

Case 3.—When the weight to be raised is at one end of the lever, the fulcrum at the other, and the power is applied between them.

Rule.—As the distance between the power, and the fulcrum, is to the length of the lever, so is the weight, to the power.

Example.—The length of the lever being 8 feet, and the weight at its extremity 60 lb., required the power to be applied 6 feet from the fulcrum to raise it?

As 6 : 8 :: 60 : 80 lb. *Ans.*

Velocity is gained at the expense of power by the lever, and wheel, and axle.

Note 1.—When two men are carrying a load on a pole between them, the strongest man should have the weight placed nearer to him than the other man.

Note 2.—*To carry guns, &c.*—If the burden can be carried by four men; after having made it fast to the middle of a large lever, fix the extremities of this lever on two shorter levers, and place a man at each of the points, C, D, E, F. *Vide plate, Mechanics, Fig. 1.* In *Fig. 2*, the weight is equally divided between eight men, and in *Fig. 3*, between sixteen men.

THE WHEEL, AND AXLE.

The advantage gained is in proportion as the circumference of the wheel exceeds that of the axle; therefore, the larger the wheel, and the smaller the axle, the stronger is the power of this machine, but then the weight will rise proportionally slower. A winch may be used instead of a wheel, for in turning the winch the hand will describe a circle, and there is no difference in the result, whether an entire wheel be turned, or a single spoke which the winch as a lever represents.

Rule.—As the radius of the wheel is to the radius of the axle, so is the effect, to the power.

Example.—A weight of 50 lb. is exerted on the periphery of a wheel, whose radius is 10 feet; required the weight raised at the extremity of a cord wound round the axle, the radius being 20 inches.

$$\frac{50 \text{ lb.} \times 10 \text{ feet} \times 12 \text{ inches}}{20 \text{ inches}}$$

$= 300$ lb. *Ans.*

THE PULLEY.

The pulley consists of a grooved wheel, called *a sheave*, moveable on an axis, or gudgeon, and enclosed in a frame, or case, called a *block*. By passing a cord over the pulley, a man will be enabled *to draw up* a weight equal to that which his own body supplies in pulling downwards.

By combining a number of pulleys, as many assistants are obtained as there are wheels: thus, two pulleys will have double the power of one, because half the weight is sustained by the frame to which one end of the cord is attached; but then it requires *double the time* to do the work. As the *friction of the pulley* is very great, particular attention must be paid

that all the turns or kinks of a rope be taken out, before it is made use of, and it should enter easily into the grooves of the sheaves.

Rule.—Divide the weight to be raised by twice the number of pulleys in the lower block; the quotient will give the power necessary to raise the weight.

Example.—What power is required to raise 600 lb., when the lower block contains six pulleys?

$$\frac{600}{6 \times 2} = 50 \text{ lb.} \quad \textit{Ans.}$$

TACKLES.

Tackles are indispensable in the service of the artillery.

The fall is the rope of which the tackle is composed; that end of it which is fixed to the block is called *the standing part*, or *end*; the other, which is pulled, or hauled on by the men, is called *the running part*, or *end*; and the parts which pass from one block to the other are called the *returns of the fall*.

In all operations with tackles, the following directions should be attended to:—

1st. Make fastenings stronger than appears *actually* necessary.

2nd. Examine the straps, and hooks of the blocks carefully.

3rd. Consider whether the cordage is new, half-worn, or almost worn out.

4th. Attend to the seizings of the clinches, the sheet bends, the *proper* stoppering of the fall, the belaying the fall with two half hitches.

5th. Be very distrustful of selvages applied on smooth worn rope.

6th. Do not allow ropes to be struck, or trampled on, when the weight is suspended.

7th. The men should *stand as safe* as the proper performance of the various duties will permit.

8th. In pulling a rope, the men ought to place themselves in a right line, and haul together. The most advantageous position for pulling is down a slope, or in a descending position.

COMBINATION OF PULLEYS.

A leading block is a fixed pulley, which alters the direction of the power, but does not increase it: Power = Weight. On account of friction the power must exceed the weight a little, in order to raise it.

Vide plate, Mechanics, Fig. 1.

A whip is one moveable pulley, which increases the power without altering the direction.

Power = ½ weight (or 2 to 1).—*Vide* Fig. 2.

A whip upon whip will afford the same purchase as a tackle having a single and double block, and with much less friction.

A gun tackle consists of two single blocks with fall fixed to the one, then rove through the other, and then through the first. Power = ½ weight (or 2 to 1): or Power = ⅓ weight (or 3 to 1). *Vide* Fig. 3, and 4.

Two double blocks are generally used for very heavy guns.

A luff tackle, or half watch tackle, consists of one double and one single block: the fall is fixed to the single, then rove through first sheave of the double, then through sheave of single, and lastly through second sheave of double block. Power = ⅓ weight (3 to 1): or Power = ¼ weight (4 to 1). *Vide Fig. 5, and 6.*

A runner tackle is the same as a luff tackle, applied to the end of a large rope, called a runner, which is rove through a single block attached to a fixed point, or to a body that is to be moved, or raised; the standing end of the runner being secured to another point.

Power is either 6 to 1, or 7 to 1, or 8 to 1.

A gyn tackle consists of one triple and one double block: the fall is fixed to the double, then rove through first sheave of triple, then through first sheave of double, then through second sheave of triple, then through second sheave of double, and lastly through third sheave of triple block.

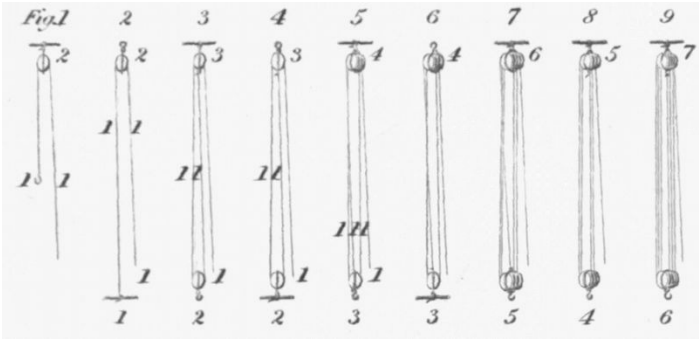
Power = ⅕ weight (5 to 1): or Power = ⅙ weight (6 to 1). *Vide Fig. 7.*

If the moveable block of a tackle be strapped with a tail, it is called a *tail*, or *jigger block*: and the tackle a *tail*, or *jigger tackle*: a block with a hook strapped to it, and attached to a selvage, answers the same purpose.

Two double blocks, with fall fixed to one of them, and then rove through the sheaves of both blocks, will either give Power = ¼ weight (4 to 1): or Power = ⅕ weight (5 to 1). *Fig. 8.*

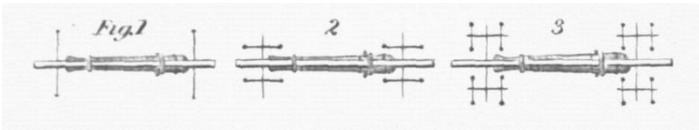
Two triple blocks, with fall fixed to one of them, then rove through sheaves of both blocks, will either

give power = ⅛ weight (6 to 1): or Power = ⅐ weight (7 to 1). *Fig. 9.*



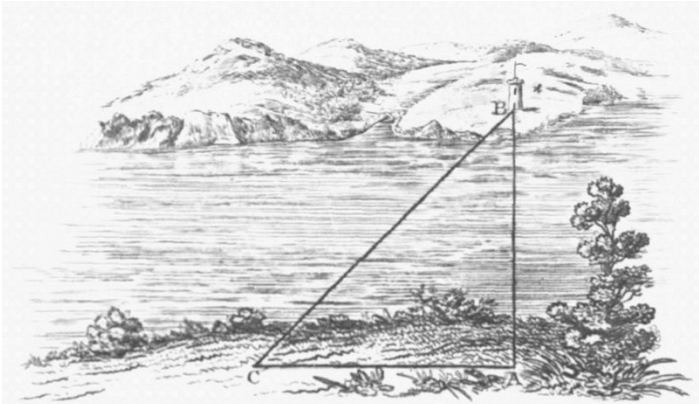
System of Pullies.

Fig. 1 2 3 4 5 6 7 8 9



To carry Guns &c.

Fig. 1 2 3



In the system of pulleys (*vide plate, Mechanics*) the Power is shown at the hooks of the moveable blocks, which are to be applied to the bodies, or weights, requiring to be moved or raised. The strain is also shown at the fixed blocks.

In Fig. 3, there are *three parts of the rope engaged* in supporting the weight—*viz.*, *the parts marked 1, 1, 1*. Each of them, hence, sustains *one-third* of it, and the fall of the rope to which the power is to be attached requires the Power = 1, if weight = 3. The same principle of calculation is applicable to all systems of pulleys having one fixed block, any number of moveable wheels, and a single rope over all the wheels. Hence, in such a system of pulleys, gravity being applied, there will be an equilibrium, when the weight is as many times the power as there are portions of the rope employed in sustaining the weight. *For example*, in a system consisting of six moveable sheaves, the same rope going over them all, there will be 12 portions of the rope engaged; and to produce an equilibrium the power must be equivalent to 1/12 the weight, no allowance being made for friction.

From the foregoing observations, and by referring to the plate, it will be seen that *each tackle has two applications*, differing in power one from the other; *for example*, if the double block of a luff tackle is fixed to a weight to be moved, and the single block to a picket, or other fastening, *Fig. 6*, then, if *one man* haul on the fall, the power of *four men* will be applied to the weight (4 to 1), and the power of *three men* to the picket; but if the double block be fixed to the picket, *Fig. 5*, and the single, block to the weight,

then the force of only *three men* will be applied to the weight (3 to 1), and a power of *four men* to the picket, or fastening.

When the moveable block of one tackle is fixed to the fall of another tackle, their respective powers are to be multiplied into each other for the power of the combination: thus, if one luff tackle is fixed to the fall of another luff tackle (the double blocks of both tackles being moveable), the power will be $4 \times 4 = 16$ (16 to 1): in this, the men haul through 16 feet to move the weight one foot; therefore if the combination be increased until the men haul through 100 feet to move the weight one foot, then the power would be 100 to 1.

The foregoing powers are, however, only true in theory, and are, therefore, called *theoretical powers*: for owing to the great friction of the pulleys, the stiffness of the ropes, &c., the actual *practical powers* are far less; so much so, that with a combination giving a power of 48 to 1, a 24-pr. (2½ tons weight) suspended, can scarcely overhaul the fall, the friction being so very great.

THE INCLINED PLANE.

The inclined plane forms simply a gradual and sloping instead of a sudden and perpendicular ascent, by which heavy bodies may be raised to certain heights. The power necessary for raising a weight depends on the difference between the length of the plane and the height to be ascended. If the height be one-third of the length, then one pound will lift three pounds. The force with which a rolling body descends on an inclined plane is to the force of its absolute gravity, as the height of the plane is to its length.

Parbuckling a gun on skids unites the advantage of one moveable pulley with that of the inclined plane.

Rule.—As the length of the plane is to its height, so is the weight to the power.

Example.—Required the power necessary to raise 540 lb. up an inclined plane, five feet long, and two feet high.

As 5 : 2 :: 540 : 216 lb. *Ans.*

THE WEDGE.

The wedge may be considered as two equally inclined planes joined together at their bases. It has a great advantage over all the other powers, arising from the force of percussion, or blow, with which the back is struck; which is a force incomparably greater than any dead weight, or pressure, such as is employed in other machines. The largest masses of timber may by this means be riven, and vessels of war, weighing many thousand tons, are lifted from their supports by the power of a few men, exerted by blows of mallets on wedges inserted for that purpose.

The power of the wedge increases in proportion as its angle is acute. In tools intended for cutting wood the angle is commonly about 30°; for iron from 50° to 60°; and for brass from 80° to 90°.

Case 1.—When two bodies are forced from one another, by means of a wedge, in a direction parallel to its back.

Rule.—As the length of the wedge is to half its back, or head, so is the resistance, to the power.

Example.—The breadth of the back, or head of the wedge, being three inches, and the length of either of

its inclined sides 10 inches, required the power necessary to separate two substances, with a force of 150 lb.

As 10 : 1½ :: 150 : 22½ lb. *Ans.*

Case 2.—When only one of the bodies is moveable.

Rule.—As the length of the wedge, is to its back, or head, so is the resistance, to the power.

Example.—The breadth, length, and force, the same as in the last example.

As 10 : 3 :: 150 : 45 lb. *Ans.*

THE SCREW.

The screw is a spiral thread or groove cut round a cylinder, and everywhere making the same angle with the length of it. The force of a power applied to turn a screw round is to the force with which it presses upward, or downward, setting aside the friction, as the distance between two threads is to the circumference where the power is applied; or the advantage gained is as much as the circumference of a circle described by the handle of the winch exceeds the interval, or distance, between the spirals of the screw. Hence the force of any machine turned by a screw can readily be computed; for instance, in a press driven by a screw, whose threads are each a quarter of an inch asunder, and with a handle, to turn the screw, four feet long; then, if the natural force of a man, by which he can lift, pull, or draw, be 150 lb., and it is required to determine with what force the screw will press when the man turns the handle with his whole force; the diameter of the handle (*power*) being 4 feet, or 48 inches, its circumference is 48 × 3·1416, or 150⅘ nearly; and

the distance of the threads being one-fourth of an inch, therefore the power is to the pressure as 1 to (150⅘ × 4) = 603⅕, but the power is equal to 150 lb., therefore as 1 : 603⅕ :: 150 : 90480, and consequently the pressure is equal to a weight of 90480 lb. independent of friction.

COMPOUND MACHINES.

Though each of the mechanical powers is capable of overcoming the greatest possible resistance in theory, yet in practice, if used singly for producing very great effects, they would frequently be so unwieldy and unmanageable as to render it impossible to apply them. For this reason it is generally found more advantageous to combine them together, by which means the power is more easily applied, and many other advantages are obtained. In all the mechanical powers, and their combinations, and in all machines, simple as well as compound, *what is gained in power is lost in time or velocity*; and *vice versâ*, or in other words, the product of the power, and the space through which it moves, is equal to the product of the weight, and the space through which it moves in the same plane. Suppose that a man, by means of a fixed pulley, raises a beam to the top of a house in two minutes, it is clear that he will be able to raise six beams in twelve minutes; but by means of a tackle with three lower pulleys, he will raise the six beams at once with the same ease as he before raised one, but then he will be six times as long about it, that is, twelve minutes; thus the work is performed in the same time whether the mechanical power is used, or not. But the convenience gained by the power is very great; for if the six beams are joined in one, they may be raised by the tackle, though it would be impossible to move

them by the unassisted strength of one man. No real gain of force is obtained by mechanical contrivances; on the contrary, from friction and other causes, force is always lost; but by machines a more convenient direction can be given to the moving power, and so modify its energy as to obtain effects which it could not otherwise produce.

FRICTION.

Friction arises from the irregularities of the surfaces which move upon one another. The surfaces of bodies of the same nature are moved with more facility over each other than those of a dissimilar nature. In proportion as the surfaces which are to be moved upon one another are rough, a greater force is requisite to produce motion. The same surfaces when under a greater pressure, are subject to still further friction. A double pressure doubles the amount of friction, a treble pressure trebles, and so on in nearly the same proportion. When surfaces are moving along each other in the direction of their grains, the friction is greater than when the direction of the grains is at right angles. Friction is little influenced by the velocity with which bodies move upon one another. Friction may be diminished in various ways, as will appear by the result of the following experiment with a block of square stone weighing 1080 lb.:—

	lb.
1. In order to drag this stone along the floor of a quarry roughly chiselled, it required a force equal to	758
2. Over a floor of planks, ditto	652
3. Placed on a platform of wood, and dragged over a floor of planks	606

4. After soaping the two surfaces of wood, which slide over each other	182
5. Placed on rollers of three inches diameter, and moved along the floor of the quarry	34
6. To drag it on these rollers over a wooden floor	28
7. Mounted on a wooden platform, and the same rollers placed between the platform, and a plank floor	22

One of the most remarkable instances of the application of rollers is the transport of the rock which now serves as the pedestal of the equestrian statue of Peter the Great at St. Petersburg. This rock is a single block of granite weighing 1217 tons. A railway was formed, consisting of two lines of timber, furnished with hard metal grooves; similar, and corresponding metal grooves were fixed to the under side of the sledge, or frame, on which the stone was laid, and between these grooves were placed spheres of hard brass, about six inches in diameter. On these spheres the frame with its enormous load was easily moved by sixty men working at capstans with triple purchase blocks.

UNGUENTS.

Mr. G. Rennie found, from a mean of experiments, with different unguents, on axles in motion, and under different pressures, that, with the unguent tallow under a pressure of from 1 to 5 cwt., the friction did not exceed

$$\frac{1}{39}$$

th of the whole pressure; when soft soap was applied, it became

$$1$$

th; and with the softer unguents applied, such as oil, hogs' lard, &c., the ratio of the friction to the pressure increased; but with the harder unguents, as soft soap, tallow, and anti-attrition composition, the friction considerably diminished; consequently, to render an unguent of proper efficiency, the nature of the unguent must be measured by the pressure, or weight, tending to force the surfaces together.

TRANSVERSE STRENGTH OF MATERIALS.

When a beam, of any material, is loaded, the surface in contact with the load is *compressed*, and the opposite surface *extended*; and there is a line between these, which is neither compressed, nor extended, called *the neutral line*.

If the depth of a beam be doubled, the breadth, and length between supports remaining the same, *its strength will be increased four times*.

If its breadth be doubled, the other dimensions being as above, *its strength will be doubled*.

By increasing the distance between the supports of any beam, its strength is decreased in the same ratio; twice the distance between the supports will weaken the beam one-half; half the distance between the supports will enable it to bear twice the load.[48]

The same beam will bear twice the load, if, instead of being concentrated in the middle, it be equally distributed over the whole length of the beam.

If the load on a beam be placed near to one of the supports, instead of in the middle, its effect will decrease in the ratio of its proximity to the support.

Let S s represent the beam, W the load or weight in

the middle, w the weight near s; then the load which the beam will carry at the point where w is placed will be found by the following proportion:—

$$\text{As} \quad S\,w \times w\,s : S\,W \times W\,s :: W : w.$$

A beam, fixed at one end, and loaded at the other, will bear half the weight of one of the same length supported at each end.

If the end of a beam, instead of being only supported, be *fixed*, its strength will be in the proportion of 3 to 2.

From the foregoing results it will be seen that the strength of a rectangular beam varies, as the breadth multiplied by the depth squared, divided by the length,

$$\frac{b \times d^2}{1}$$

and if the breaking weight of any material, 1 inch square, and 1 foot long, be found, it will represent a *constant multiplier* for the above equation.

Thus the breaking weight of a beam of Riga fir, 1 inch square, and 1 foot long (*vide following* TABLE), is ·164 of a ton; and to find the breaking weight of a beam of any other dimensions, the rule is simply

$$W = \frac{b \times d^2}{1} \times \cdot 164.$$

Example.—What will be the breaking weight of a beam of Riga fir, 8 inches broad, 12 inches deep, and 20 feet long?

$$\frac{8 \times 12^2}{20} = 57{\cdot}6 \qquad 57{\cdot}6 \times \cdot 164 = 9{\cdot}44 \text{ tons, breaking weight.}$$

Table of constants, for beams of different materials, being the breaking weights of such beams, 1 inch square, and 1 foot long.

Riga fir	·164	of a ton.	English oak	·248	of a ton.
Red pine	·199	”	Canadian do.	·261	”
Pitch pine	·242	”	Dantzic do.	·219	”
Beech	·231	”	Teak	·366	”
Elm	·150	”	Cast iron, mean.	1·000	”
Ash	·301	”	Wrought do.	1·083	”

From the foregoing rules

$$\text{Length} = \frac{b\,d^2}{W} \times \text{constant.}$$

$$\text{Breadth} = \frac{1\,W}{d^2} \times \text{constant.}$$

$$\text{Depth} = \sqrt{\frac{1\,W}{b}} \times \text{constant.}$$

The practical weight that a beam will carry *with safety*, permanently, should only be taken at one-fourth of the above computations.

ADHESION OF NAILS, AND SCREWS.

The percussive force required to drive the common sixpenny nail (73 to the pound) to the depth of an inch and a half into deal, with a weight of six pounds

and a quarter, is four blows, or strokes, falling freely the space of one foot; and *the steady pressure* to produce the same effect is four hundred pounds. A *sixpenny nail* driven into dry elm to the depth of one inch across the grain requires a force of 327 pounds to extract it; and the same nail, driven into the same wood endways, or longitudinally, can be extracted with a force of 257 pounds.

To extract a sixpenny nail from a depth of one inch out of dry oak requires 507 pounds, and out of dry beech 667 pounds. A sixpenny nail driven two inches into dry oak would require a steady force of more than half a ton to extract it.

A common screw of one-fifth of an inch diameter has an adhesive force of about three times that of a sixpenny nail.

TRIGONOMETRY.

Plane trigonometry treats of the relations, and calculations of the sides, and angles of plane triangles.

The measure of an angle is an arc of any circle contained between the two lines which form that angle, the angular point being the centre; and it is estimated by the number of degrees contained in that arc. Hence a right angle being measured by a quadrant, or quarter of a circle, is an angle of 90 degrees. The sum of the three angles of every triangle is equal to 180 degrees, or two right angles; therefore, in a right-angled triangle, taking one of the acute angles from 90 degrees, leaves the other acute angle; and the sum of the two angles in any triangle, taken from 180 degrees, leaves the third

angle; or one angle being taken from 180 degrees leaves the sum of the other two angles.

Definitions.

The sine of an arc is the line drawn from one extremity of the arc perpendicular to the diameter of the circle which passes through the other extremity.

The supplement of an arc is the difference, in degrees, between the arc, and a semicircle, or 180 degrees.

The complement of an arc is the difference, in degrees, between the arc, and a quadrant, or 90 degrees.

The tangent of an arc is a line touching the circle in one extremity of that arc, continued from thence to meet a line drawn from the centre through the other extremity; which last line is called *the secant* of the same arc.

The *cosine*, *cotangent*, and *cosecant* of an arc are the sine, tangent, and secant of the complement of that arc, *the co* being only a contraction of the word complement.

The sine, tangent, or secant of an angle is the sine, tangent, or secant of the arc by which the angle is measured, or of the degrees, &c., in the same arc, or angle. *Vide also* *Definitions*, PRACTICAL GEOMETRY.

There are two Methods of resolving triangles, or the cases of trigonometry—viz., *Construction*, and *Computation*.

1st method.—The triangle is constructed by making the sides from a scale of equal parts, and laying down the angles from the protractor. Then, by measuring the unknown parts by the same scale, the

solution will be obtained.

2nd method.—Having stated the terms of the proposition, resolve it like any other proportion, in which a fourth term is to be found from three given terms, by multiplying the second and third terms together, and dividing the product by the first.

Note.—Every triangle has six parts—viz., three sides, and three angles; and, in every case in trigonometry, there must be given three of these parts to find the other three. Also of the three parts that are given, one of them at least must be a side; because, with the same angles, the sides may be greater, or less, in any proportion.

Computation.

Case 1.—When a side and its opposite angle are two of the given parts.

The sides of any triangle having the same proportion to each other, as the sines of their opposite angles; then—

As any one side, is to the sine of its opposite angle; so is any other side, to the sine of its opposite angle.

To find an angle, begin the proportion with a side, opposite to a given angle; and, *to find a side*, begin with an angle opposite to a given side.

Case 2.—When the three sides of a triangle are given, to find the angles.

Let fall a perpendicular from the greatest angle, on the opposite side, or base, dividing it into two segments; and the whole triangle into two right-angled triangles: then the proportion will be—

As the base or sum of the segments, is to the sum

of the other two sides; so is the difference of those sides, to the difference of the segment of the bases: then add half the difference of the segments to the half sum, or the half base, for the greater segment; and subtract the same for the less segment. Hence, in each of the two right-angled triangles, there will be known two sides, and the right angle opposite to one of them, consequently the other angle will be found by the method in *Case 1*.

USEFUL THEOREMS, AND COROLLARIES.

1. When one line meets another, the angles, which it makes on the same side of the other, are together equal to two right angles.

2. All the angles, which can be made at any point (by any number of lines), on the same side of a right line, are, when taken all together, equal to two right angles: and, as all the angles that can be made, on the other side of the line, are also equal to two right angles; therefore all the angles that can be made quite round a point, by any number of lines, are equal to four right angles. Hence also the whole circumference of a circle, being the sum of all the angles that can be made about the centre, is the measure of four right angles.

3. When two lines intersect each other, the opposite angles are equal.

4. When one side of a triangle is produced, or extended, the outward angle is equal to the sum of the two inward opposite angles.

5. In any triangle, the sum of all the three angles is equal to two right angles (180˚). Hence, if one angle of a triangle be a right angle, the sum of the other two angles will be equal to a right angle (90˚).

6. In any quadrilateral, the sum of all the four inward angles is equal to four right angles.

7. In any right-angled triangle, the square of the hypothenuse (or side opposite to the right angle) is equal to the sum of the squares of the other two sides. Therefore, *to find the hypothenuse*, add together the squares of the other two sides, and extract the square root of that sum: and *to find one of the other sides*, subtract from the square of the hypothenuse the square of the other given side, and extract the square root of the remainder for the side required.

Or hypothenuse = $\sqrt{\text{base}^2 + \text{perpendicular}^2}$

Base = $\sqrt{(\text{hypoth.} + \text{perpend.}) \times (\text{hypoth.} - \text{perpend.})}$

Perpendicular = $\sqrt{(\text{hypoth.} + \text{base}) \times (\text{hypoth.} - \text{base.})}$

TRIGONOMETRY, WITHOUT LOGARITHMS.[49]

“In all the more elaborate, and refined operations of trigonometry, it is not only desirable, but necessary to employ some of the larger logarithmic tables, both to save time, and to ensure the requisite accuracy in the results. But in the more ordinary operations, as in those of common surveying, ascertaining inaccessible heights, and distances, reconnoitring, &c., where it is not very usual to measure a distance nearer than within about its thousandth part, or to ascertain an angle nearer than within two or three minutes, it is quite a useless labour to aim at greater accuracy in a numerical result. Why compute the length of a line to the fourth, or fifth place of decimals, when it must depend upon another line, whose accuracy cannot be ensured beyond the unit’s place? Or, why compute

an angle to seconds, when the instrument employed does not ensure the angles in the data beyond the nearest minute? In the following Table are brought together the *natural sines, and cosines*, to every degree in the quadrant, and this table will be found sufficiently extensive, and correct for the various practical purposes above alluded to. The requisite proportions must, it is true, be worked by multiplication, and division, instead of by logarithms. Yet this by no means involves such a disadvantage as might seem, at first sight. For when the measured lines are expressed by three, or at most, four figures, the multiplications, and divisions are performed nearly as quick, and in some cases quicker, than by logarithms. Then as to accuracy, even in cases where the computer will have to take proportional parts for the minutes of a degree, the result may usually, if not always, be relied upon to within about a minute."

TRIGONOMETRIC RATIOS.

Natural sines, and cosines to every degree in the quadrant, radius being 1·000000.

Deg.	Sines.	Cosines.		Deg.	Sines.	Cosines.	
0	·00000	1·00000	90				
1	·01745	·99985	89	26	·43837	·89879	64
2	·03490	·99939	88	27	·45399	·89101	63
3	·05234	·99863	87	28	·46947	·88295	62
4	·06976	·99756	86	29	·48481	·87462	61
5	·08716	·99619	85	30	·50000	·86603	60
6	·10453	·99452	84	31	·51504	·85717	59
7	·12187	·99255	83	32	·52992	·84805	58

8	·13917	·99027	82	33	·54464	·83867	57
9	·15643	·98769	81	34	·55919	·82904	56
10	·17365	·98481	80	35	·57358	·81915	55
11	·19081	·98163	79	36	·58778	·80902	54
12	·20791	·97815	78	37	·60181	·79863	53
13	·22495	·97437	77	38	·61566	·78801	52
14	·24192	·97030	76	39	·62932	·77715	51
15	·25882	·96593	75	40	·64279	·76604	50
16	·27564	·96126	74	41	·65606	·75471	49
17	·29237	·95630	73	42	·66913	·74314	48
18	·30902	·95106	72	43	·68200	·73135	47
19	·32557	·94552	71	44	·69466	·71934	46
20	·34202	·93969	70	45	·70711	·70711	45
21	·35837	·93358	69				
22	·37461	·92718	68				
23	·39073	·92050	67				
24	·40674	·91355	66				
25	·42262	·90631	65				
	Cosines.	Sines.	Deg.		Cosines.	Sines.	Deg.

“The preceding table is so arranged that for angles not exceeding 45 degrees, the sine, and cosine for any number of degrees will be found opposite to the proposed number in the left hand column, and in the column under the appropriate word. When the number of degrees in the arc, or angle, exceeds 45 degrees, that number must be found in the right hand column, and opposite to it in the column indicated by the appropriate word at the bottom of the table. Thus, the sine, and cosine of 36 degrees are ·58778 and ·80902 respectively, the radius of the table being unity, or 1. The taking of proportional parts for minutes can only be done correctly in those parts of the table where the differences between the

successive sines, &c., run pretty uniformly. Suppose we want the natural sine of 20° 16′. The sine of 21 degrees is ·35837, that of 20 degrees is ·34202; their difference is ·1635. This divided by 60 gives 27·25 for the proportional part due to 1 minute, and that again multiplied by 16 gives 436 for the proportional part for 16 minutes. Hence the sum of ·34202 and 436, or ·34638, is very nearly the sine of 20° 16′. But the operation may often be contracted by recollecting that 10 minutes are ⅙, 15 minutes are ¼, 40 minutes are ⅔ of a degree, and so on. Observe, also, that for cosines the results of the operations for proportional parts are to be *deducted* from the value of the required trigonometrical quantity in the preceding degree."

APPLICATION OF TRIGONOMETRY, WITHOUT LOGARITHMS, to the determination of Heights, and Distances.

Example 1.—Having measured a distance of 200 feet in a direct horizontal line from the bottom of a steeple, the angle of elevation of its top, taken at that distance, was found to be 47° 30′, from hence it is required to find the height of the steeple?

By deducting 47° 30′ from 90°, the angle opposite the given side will be found (42° 30′).

Then by *Case 1*. TRIGONOMETRY:—

As	sine ∠ 42° 30′	: 200	:: sine ∠ 47° 30′:
Or	·67556	: 200	:: ·73723 : 208·2, &c., height required.

By construction—

The triangle is constructed by making the side from a scale of equal parts, and laying down the

angles from the protractor. Then by measuring the unknown parts by the same scale, the solution will be obtained.

Example 2.—Being on the side of a river, and requiring the distance to a house on the other side, 200 yards were measured in a straight line by the side of the river, and at each end of this base line the angles with the house were 68° 2′, and 73° 15′—required the distance from each end of the base line to the house?

The sum of the given angles (68° 2′ + 73° 15′) subtracted from 180° will give the third angle (38° 43′).

Then by *Case 1*. TRIGONOMETRY:—

As sine ∠ 38° 43′	: 200	:: sine ∠ 68° 2′
·62544	: 200	:: ·92739 : 296·5 first distance required.
As sine ∠ 38° 43′	: 200	:: sine ∠ 73° 15′
·62544	: 200	:: ·95753 : 306·1 second distance required.

Similarly to the preceding examples, HEIGHTS, AND DISTANCES may be rapidly (and for military purposes, sufficiently accurately) computed in the field, by means of the foregoing trigonometrical table, if proper attention is paid to the principles by which the unknown angles of triangles may be ascertained: a base line, and requisite angle, or angles, having been given.

It will, however, be necessary to use advantageously the methods in Cases 1, 2 (*vide* Trigonometry), and also the properties in the

subsequent theorems, and corollaries.[50]

TABLE,

Showing the reduction in feet, and decimals upon 100 feet, for the following angles of elevation, and depression.

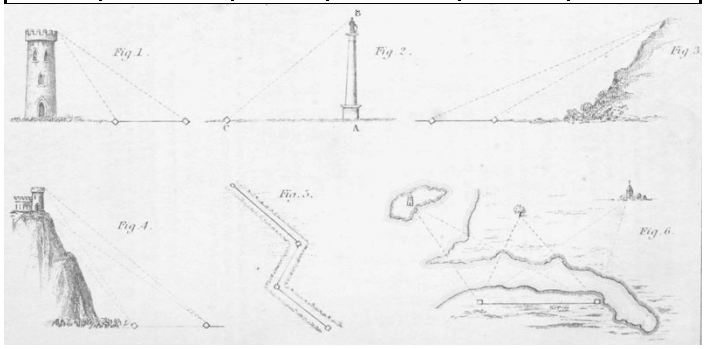
Angle.		Reduction.	Angle.		Reduction.	Angle.		Reduction.
°	′		°	′		°	′	
3	0	·14	9	0	1·22	15	0	3·40
			9	30	1·38	15	30	3·64
4	0	·25	10	0	1·52	16	0	3·88
			10	30	1·68	16	30	4·12
5	0	·38	11	0	1·84	17	0	4·37
			11	30	2·01	17	30	4·63
6	0	·55	12	0	2·19	18	0	4·90
6	30	·65	12	30	2·37	18	30	5·17
7	0	·76	13	0	2·56	19	0	5·44
7	30	·86	13	30	2·77	19	30	5·74
8	0	.98	14	0	2·97	20	0	6·08
8	30	1·10	14	30	3·18	20	30	6·33

The reduction for 100 feet (from the above table) multiplied by the number of times 100 feet measured, will give the quantity to be subtracted from the measured length of an inclination, to reduce it to a horizontal position.

TABLE,

showing the rate of inclination of inclined planes, for the following angles of elevation.

Angle.		One in	Angle.		One in	Angle.		One in
°	′		°	′		°	′	
0	15	228	3	30	17	7	0	8
0	30	114	3	45	16	7	30	7¼
0	45	76	4	0	15	8	0	7
1	0	56	4	15	14	9	0	6½
1	15	46	4	30	13	10	0	6
1	30	38	4	45	12	11	0	5¾
1	45	32	5	0	11½	12	0	5½
2	0	28	5	15	11	13	0	5
2	15	26	5	30	10½	14	0	4½
2	30	23	5	45	10	15	0	4
2	45	21	6	0	9½	16	0	3¾
3	0	19	6	30	9	17	0	3½
3	15	18	6	45	8½	18	0	3¼



Surveying, and Reconnoitring. *J. W. Lowry, sc.*

Fig. 1. Fig. 2. Fig. 3.
Fig. 4. Fig. 5. Fig. 6.

SURVEYING, AND RECONNOITRING.

HEIGHTS, AND DISTANCES.

The accurate determination of heights, and distances of objects being required in various military operations, especially for the position of batteries, the following methods for their attainment will be found useful when the requisite instruments are at hand; by frequent practice, the eye should, however, be enabled to determine, *nearly*, either the height of, or distance from any object.

HEIGHTS.

1.—BY MEANS OF A "POCKET SEXTANT,"

to ascertain the height of an object.

When the sextant is used for taking the height of objects, it is to be held vertically, and the quicksilvered part of the horizon glass will be on the left hand of the observer, or on the left part of the transparent glass. Altitudes are measured in the same manner as horizontal angles, for if we conceive the horizontal triangle A B C (*vide Plate 2, Fig. 2*), to be raised on its base A C with the angle C next to the observer, then the perpendicular A B becomes the height of the object B; and supposing the object to stand on a horizontal plane, then the ground and the object form the right angle at A; therefore, *if the object is accessible*, the sextant need only be set at any of the angles mentioned for distances (*vide Art.* DISTANCES), and walking backward on the line A C until the top of the object is brought down to the height of the observer's eye from the ground, then the distance from where the observer stands to the object will be in the same proportion to its height as the base was to the distance. Then add the height of the eye from the ground, and the height of the object

will be ascertained. If the object is not accessible, the angle must be taken, and calculated by trigonometry.

2.—BY MEANS OF A PORTABLE BAROMETER, AND THERMOMETER,

to ascertain the height of an object.

Observe the altitude (B) of the mercurial column in inches, tenths, and hundredths, at the bottom of the hill, or other object, the height of which is required.

Observe, also, the altitude (b) of the mercurial column at the top of the object. Observe the temperature on Fahrenheit's thermometer at the times of the two barometrical observations, and take the mean between them. Then 55000 $\times$

$$\frac{B - b}{B \times b}$$

= the height of the hill in feet, for the temperature of 55 degrees on Fahrenheit. Add

$$\frac{1}{440}$$

of this result for every degree which the mean temperature exceeds 55 degrees, and subtract as much for every degree below 55 degrees. This will be a good approximation when the height of the hill is below 2000 feet.

3.—BY MEANS OF THE RECONNOITRING PROTRACTOR,[51]

to measure the height of an inaccessible object.

[*Plate*, SURVEYING, AND RECONNOITRING, *Fig. 1*.]

Place yourself at a convenient distance from the object whose height is required, taking care to have a good base line to the second station. Hold the protractor vertically, with a steady hand, the tube side uppermost, and bring the top of the object in a

line with the centre of the tube. Allow the arm (or index) to vibrate freely, and, when steady, note the angular height of the object (shown by the edge of the index on the marginal scale of degrees). By the aid of points taken through the tube, or by pickets, then pace, or measure a base in a direct line from the object; and, when arrived at the second station, again note the angular height of the object.

Construction—

Set off the angles, and draw the respective lines, which, by their intersection, will determine the height of the perpendicular, to which the height of the protractor above the ground must be added for the altitude of the object. By using the scale of the measured base line, the height required will be ascertained, or it may be calculated by "TRIGONOMETRY, WITHOUT LOGARITHMS."—*Page 303*.

To measure the height of an accessible object.

[*Plate*, SURVEYING, AND RECONNOITRING, *Fig. 2*.]

At an appropriate distance from the object, take its angular height and measure the distance to its base.

Construction—

Draw a line representing this distance, at one end of which draw another line at the angle found, and at the other erect a perpendicular; the intersection of these lines will determine the altitude of the object.

To measure the vertical height of a hill, or mountain.

[*Fig. 3*, *Plate*, SURVEYING, AND RECONNOITRING.]

From a station a short distance from the hill, take,

and note down its angular height; then select a rear position for a base line, using the tube of the protractor to insure a straight direction; proceed to the requisite distance on the base, and again note the altitude of the hill.

Construction—

The intersection of lines drawn from each end of the base line, at the angles found, will determine the altitude; the perpendicular height of which, added to that of the protractor above the ground, will give the altitude required.

To measure the altitude of a tower, &c., on a height.

[*Fig. 4, Plate*, SURVEYING, AND RECONNOITRING.]

From the first station, near the base, take the altitude of the hill, and also that of the tower above it, and note down these angles; proceed to another station in a straight line with the former one, measuring its length, and again observe the angular height of the hill, and also that of the top of the tower.

Similarly to the previously described mode, ascertain, first, the height of the hill; second, the height of the hill, and tower; deduct the first calculation from the second, which will leave the height of the tower.

In all the foregoing cases the heights may be correctly ascertained by trigonometrical calculations (*vide* TRIGONOMETRY, WITHOUT LOGARITHMS, *page 303*).

4.—BY THE SHADOW OF THE OBJECT,

to ascertain the height.

Set up vertically a staff of known length, and measure the length of its shadow upon a horizontal, or other plane; measure also the length of the shadow of the object of which the altitude is required. Then, by the property of similar triangles,

As the length of the shadow of the staff
is to the altitude of the staff,
so is the length of the shadow of the object
to the altitude of the object.

5.—WHEN THERE IS NO SHADOW,

to ascertain the height.

Place a staff (equal in length to the height of the observer's eye) vertically at such a distance from the foot of the required altitude, that the observer, having laid himself upon his back, with his feet against the bottom of the stick, may see the top of the staff, and object in the same line. Then, by similar triangles, the height may be readily ascertained.

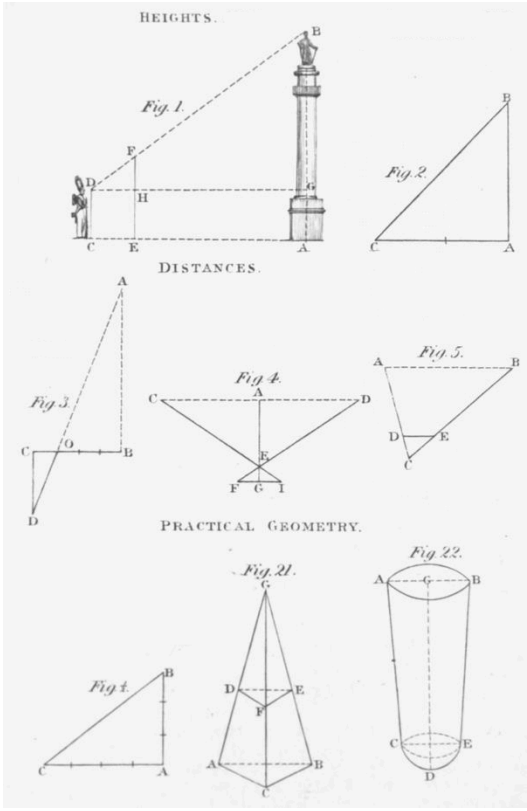
6.—BY MEANS OF THE TANGENT SCALE OF A GUN,

to ascertain the height of an object, the distance being known.

Lay the gun for the top of the object the height of which is required, then raise the tangent scale until the top of it, and the notch on the muzzle are in line with the bottom of the object: then, by similar triangles,

As the length of the gun
is to the length of the raised part of the tangent scale,
so is the distance from the gun to the object,
to the height required.

Plate 2.



HEIGHTS.
Fig. 1. Fig. 2.

DISTANCES.
Fig. 3. Fig. 4. Fig. 5.

PRACTICAL GEOMETRY.
Fig. ½. Fig. 21. Fig. 22.

7.—BY MEANS OF TWO PICKETS,

to ascertain the height of an object.

[*Vide 2nd Plate*, HEIGHTS, AND DISTANCES, *Fig. 1.*]

Let two pickets C D (4 feet), E F (6 feet), be placed with their bases in the line C A passing through A the height required, and move them nearer to, or farther from each other, until the summit B of the object is seen in the same line as D, and F, the tops of the rods. Then, by the principles of similar triangles,

As D H (= C E) : F H :: D G (= C A) : B G.
To which add A G = C D for the whole height A B.

Thus, supposing C E to be 6 feet, F H 2 feet, and C A 150 feet, the proportion will be,

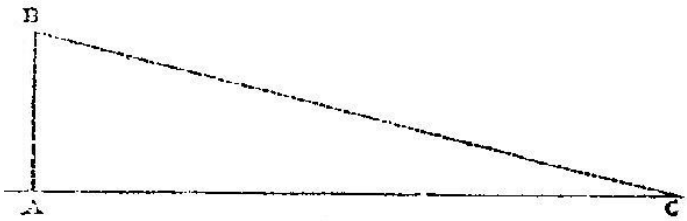
As 6 : 2 :: 150 : 50 feet.
Then 50 + C D will be the altitude required.

DISTANCES.

1.—BY MEANS OF THE SEXTANT,[52]

to find the distance from an object, whose height is known.

Let A B represent the height of the object; C your station; and C B the distance to be found.



Take the angle B C A with the sextant,[52] and note it in minutes; then A B, in feet × 573 ÷ B C A, in minutes = A C in fathoms. Or A B in feet × 573 ÷ B C A, in minutes × 2 = A C in yards.

573 is a constant multiple.

This method requires no table of sines, &c., the number of minutes in the angle being used instead of the sine.

2.—BY MEANS OF A POCKET SEXTANT,

to measure inaccessible distances.

When used for taking the distance of objects, the sextant is to be held horizontally, and the quicksilvered part of the glass will be uppermost, or above the transparent part.

To ascertain the distance A B (*vide Plate 2, Fig. 2*), obtain, by observation, the direction A C perpendicular to A B, which is thus performed:—Set the instrument at 90°, and place yourself at the point A, with your right towards the point B; then look through the sextant, and direct a picket to be placed in the line A C at 100 yards, or feet, from you, so that the point B will appear right above it. Then set the sextant at 45°, and walk along the line towards C until you bring the points A, and B to coincide; the base and perpendicular will then be of equal length, and A C being known, or measured, the distance A B will also be ascertained. But if you cannot walk far enough to find angle C 45°, find it equal to 63° 26′, and then A C = ½ A B; at 71° 34′ = ⅓ A B; at 75° 58′ = ¼ A B; at 78° 41′ = ⅕ A B; at 80° 32′ = ⅙ A B; at 82° 52′ = ⅛ A B; and at 84° 17′ the distance will be ⅒ A B.

Should the object be far distant, it will be necessary to take a long base, and the side A B must be calculated, therefore, by trigonometry.

3.—BY MEANS OF THE PRISMATIC COMPASS,

to measure inaccessible distances.

Having fixed the instrument to the stand, place it over the station-point, spreading the legs so as to give sufficient firmness, and observing that the card is level enough to allow it to play freely; raise the prism by means of the slide, until the divisions of the compass-card are distinctly seen; then look through the slit, and turn the box round until the thread bisects the object whose distance is required; allow the card to settle, and the division on it, which coincides with the thread of the vane, will be the azimuth, or bearing of the object, reckoned from the north, or south point of the needle, when the card is divided into twice 180 degrees. The angular distance between any two objects will, of course, be the difference of their bearings; thus, suppose one to bear 15° N.E., and the other 165° S.E., the angular distance between them will be 150°.

In military sketching, the compass is often supported merely by the hands, using the little spring to check the vibrations of the card. In windy weather, the mean of these vibrations must be taken for the bearing sought.

The directions for surveying, &c., &c., by means of "The Reconnoitring Protractor," apply similarly to the "Prismatic Compass."

4.—BY MEANS OF "THE RECONNOITRING PROTRACTOR,"

to ascertain the distance from inacessible objects.

[*Plate*, SURVEYING, AND RECONNOITRING, *Fig. 6*.]

Select a good position for a base line; fix the protractor on the tripod at the first station, placing the instrument in a direct line between the first station and the point selected for the second station. Direct the index consecutively at the objects, the

relative distances of which are to be ascertained, and note correctly their respective angles. When the object is above the horizontal line, the sliding-sight must be sufficiently raised to take its bearing; and, should the object be below the level of the protractor, its angle may be taken by observation through the upper holes of the near sight; or the feet of the tripod may be adjusted, by raising, or sinking them in the ground, so that the index may be correctly directed to the object. Then proceed to the second station, measuring, or carefully pacing the base line, at the end of which fix the protractor in a straight line between the two stations; direct the index at the objects previously noted at the first station, taking their respective angles as before.

Construction—

Draw the base of the length required, according to the scale; from each end of which set off the angles found, and draw the lines required; the intersection of these will determine the position of the several objects, and their relative distances may be ascertained by measurement on the scale of the base line; or they may be calculated trigonometrically.

5.—BY MEANS OF TWO PICKETS,

to ascertain the distance from an object.

Take two pickets of unequal lengths, drive the shortest into the ground, say close to the edge of a river; measure some paces back from it, and drive in the other, till you find, by looking over the tops of both, that your sight cuts the opposite bank. Pull up the first picket, measure the same distance from the second in any direction the most horizontal, and drive it as deep in the ground as before. Then, if you

look over them again, and observe where the line of sight falls, or terminates, you will have the distance required. This method is only applicable to short distances.

6.—*To ascertain the distance of the object A from B.*

[*Vide Plate 2, Fig. 3.*]

Place a picket at B, and another at C at a few yards' distance, making A B C a right angle, or B C perpendicular to A B.[53] Divide B C into 4, 5, or any number of equal parts, make another similar angle at C in a direction from the object, and walk along the line C D until you bring yourself in a line with the object A, and any of the divisions (say O) of the line B C. Then (having measured C D) as C O : C D :: B O : B A.

Or, as 10 : 53 :: 30 : 159 yards.

7.—*To find the distance between two objects*, C, *and* D.

[*Vide Plate 2, Fig. 4.*]

From any point A, taken in the line C D, erect the perpendicular A E, in which set off from A to E 40 yards, set off from E to G, in the prolongation of A E, 10 yards, at G raise the perpendicular G F, and produce it towards I, plant pickets at E, and G, then move with another picket on G F, till F is in a line with E, and D; and on the prolongation of the perpendicular F G place another picket at I in the line with E, and C: measure F I (54 yards), then—

as G E : A E :: F I : C D;
Or, as 10 : 40 :: 54 : 216 yards.

8.—*To find the inaccessible length*, A, B, *of the front of a fortification*.

[*Plate 2, Fig. 5.*]

Plant a picket at C, from whence both points may be seen; find the lengths C A, C B (by the method in No. 5); make C E one-fourth, or any part of C B, and make C D bear the same proportion to C A: measure D E; then

as C D : D E :: C A : A B.

Nearly in the same manner the distance from B to A may be ascertained, when the point B is accessible; for having measured the line C B, and made the angle C E D equal to C B A, the proportion will be as C E : D E :: C B : B A.

9.—BY MEANS OF THE TANGENT SCALE OF A GUN,

to ascertain the distance, the height of the object at the required distance being known.

Lay the gun by the line of metal for the top of the object; then raise the tangent scale till the top of it and the notch on the muzzle are in line with the foot of the object, and note what length of scale is required.

Then,—by similar triangles—

> As the length of the raised part of the tangent scale
> is to the length of the gun;
> so is the height of the distant object
> to the distance required.

Thus, supposing the height of the object to be 9 feet, the length of that part of the tangent scale which is raised, 3 inches, and of the gun 6 feet, the

proportion will be—

As 3 : 72 :: 108 : 2592 inches, or 216 feet.

10.—BY MEANS OF THE PEAK OF A CAP,

to measure the breadth of a river.

Place yourself at the edge of one bank, and lower the peak of your cap till you find the edge of it cut the other bank, then steady your head by placing your hand under your chin, and turn round gently to some level spot of ground on your side of the river, and observe where your eyes, and the edge of the peak again meet the ground; measure the distance, which will be *nearly* the breadth of the river.

11.—BY THE REPORT OF FIRE-ARMS, TO ASCERTAIN THE DISTANCE OF ANY OBJECT, *vide* SOUND, *page 316*.

To estimate distances, in the field.

Good eyesight recognises masses of troops at 1700 yards; beyond this distance the glitter of arms may be observed. At 1300 yards infantry may be distinguished from cavalry, and the movement of troops may be seen; the horses of cavalry are not, however quite distinct, but that the men are on horseback is clear. A single individual detached from the rest of the corps may be seen at 1000 yards, but his head does not appear as a round ball until he has approached up to 700 yards; at which distance white cross-belts, and white trousers may be seen. At 500 yards the face may be observed as a light coloured spot; the head, body, arms, and their movements, as well as the uniform, and the firelocks (when bright barrels) can be made out. At between 200 and 250 yards all parts of the body are clearly visible, the

details of the uniform are tolerably clear, and the officers may be distinguished from the men.

Vide "UNITED SERVICE MAGAZINE."—No. CCCXXXI.

BY MEANS OF THE RECONNOITRING PROTRACTOR,

to traverse roads.

[*Plate*, SURVEYING, AND RECONNOITRING, *Fig. 5*.]

Fix the protractor on the tripod at the first station, placing it so that the side tube may be in a direct line with the intended second station. From each end of the tube observe the objects in sight (or place pickets) in order to secure a straight line in pacing, or measuring, from the first to the second station. Mark the distance between the stations, and place the protractor, by means of the tube, in a direct line with the first station. Then select the third station, and direct the arm or index correctly to it (using the upper holes of the near sight for a declivity, or raising the sliding-sight for an ascent); note the angle thus found, and notice the objects in front, and rear (if any, if not, place pickets) for points to enable you to pace towards, and work with accuracy at the third station. Select station 4, place the tube in line with the third, and second stations; note the bearing of No. 4, and pace the distance to it. Proceed thus from station to station, entering the angles, and distances in your note-book, as well as the offsets (which must also be carefully measured) from the lines taken, until the survey is completed.

Construction—

The day's work will be easily plotted on paper, by setting off the angles found, and drawing lines for

the measured distances, according to scale.

SOUND.

The movement communicated to the particles of air by the vibrations of a sonorous body is the cause of the sensation of sound; and it is because the particles are driven from the point of vibration in every direction, as from a centre, that the sound is perceived at once, everywhere within the surface of a sphere of a certain extent.

The velocity of sound; or the space through which it is propagated in a given time, has been differently estimated by authors who have written on this subject. Roberval states it to be at the rate of 560 feet in a second; Gassendus at 1473; Mersenne at 1474; Duhamel at 1338; Newton at 960; Derham, in whose measure Flamsteed and Halley acquiesce, at 1142. By accounts in the Memoirs of the Royal Academy of Sciences, at Paris, 1738, where cannon were fired at various distances, under many varieties of weather, wind, and other circumstances, and where the measures of the different places had been settled with the utmost exactness, it was found that sound was propagated, on a medium, at the rate of 1038 French feet in a second of time, which is equivalent to 1107 *English feet*, the French foot being in proportion to the English as 15 to 16.

From various experiments made with great care by Dr. O. Gregory, it has been found that sound flies through the air uniformly at the rate of about 1100 feet per second, when the air is quiescent, and at a medium temperature. At the temperature of freezing, or a little below, the velocity is about 1120. The approximate velocities under different temperatures

may be found by adding to 1100 *half a foot* for every degree on Fahrenheit's thermometer above the freezing point. The mean velocity may be taken at 370 yards per second, or a mile in 4-7/9 second. Hence, multiplying any time employed by sound in moving by 370, will give the corresponding space in yards, or dividing any space in yards by 370 will give the time which sound will occupy in passing uniformly over that space. If the wind blow briskly, as at the rate of 20 to 60 feet per second, in the direction in which the sound moves, the velocity of the sound will be proportionally augmented; if the direction of the wind is opposed to that of the sound, the difference of their velocities must be employed. The velocity of sound is not affected by its intensity, the smallest sound moving as rapidly as the loudest.

To ascertain the distance of any object by the report of fire-arms.

(*Vide 11. Page 314.*)

Multiply the number of seconds which elapse between the time of seeing the flash, and hearing the report by 1100, and the product will be the distance in feet, with sufficient accuracy for ordinary purposes. If greater accuracy be required, this rule must be modified, on account of the velocity, and direction of the wind, and state of the thermometer.

Sound will be louder in proportion to the condensation of the air. Water is one of the greatest conductors of sound; it can be heard on water nearly twice as far as upon land.

GRAVITY.

Gravity is downward pressure, or weight, being the natural tendency of all bodies towards the centre of the earth. (*Vide Gravity*, MOTION, FORCES. *Page 320*.)

Absolute gravity denotes the whole force with which a body tends downwards, as when the body is in empty space.

Specific gravity denotes the relative or comparative gravity of any body, in respect to that of another body of equal bulk, or magnitude.

Centre of gravity is that point in a body, or system of bodies, on which, if rested, or suspended, the whole would remain in a state of equilibrium about that point.

The centre of gravity of a circle, regular polygon, prism, cylinder, or sphere, is in its centre.

The centre of gravity of a triangle is found by bisecting any two of its sides, and drawing lines from the points of bisection to the opposite angles; the intersection of these lines will be the centre of gravity.

Force of gravity, or gravitation, is an accelerated velocity, which bodies acquire in falling freely from a state of rest.

1. The space through which a body will fall in feet, in any given time equals the product of the square of the time multiplied by 16·0833.

Example.—Required the space a falling body will pass through in five seconds?

$$16{\cdot}0833 \times 25 = 412{\cdot}0825 \text{ feet.}$$

2. The velocity in feet, which a body in descending

freely will acquire in a given time, equals the product of the time in seconds multiplied by 32·1666.

Example.—What is the velocity acquired at the end of seven seconds?

$$32{\cdot}1666 \times 7 = 225{\cdot}1662 \text{ feet.}$$

3. The velocity in feet per second that a body will acquire, in falling through a given space, equals the square root of the product of the time multiplied by 64·3333.

Example.—The space through which a body has fallen is 201 feet; required its velocity at the end of the fall?

$$\sqrt{64{\cdot}3333} \times 201 = \sqrt{12931} = 1137 \text{ feet.}$$

SPECIFIC GRAVITIES OF SEVERAL SOLID, AND FLUID BODIES.

Air,[54] in a mean state	1·232	Pitch	1150
Brass, cast	8000	Sand[54]	1520
Brick	2000	Silver, standard	10535
Coal[54]	1250	Steel	7850
Copper	9000	Stone, common	2520
Cork	240	Tin	7320
Clay	2160	Water,[54] rain	1000
		sea	1030
Earth, common	1984		
Flint	2570	Wood—alder	800

Gold, standard	18888	ash, the trunk	845
Gun metal	8784	beech	852
Gunpowder—solid	1745	elm, and larch	540
” loose	868	fir, Riga, & maple	750
Granite	3000	pine, pitch & red	660
Iron, cast	7425	oak	950
Lead	11325	walnut	671

These numbers represent the weight of a cubic foot (or 1728 cubic inches) of each of the bodies in ounces (avoirdupois).

To find the magnitude of any body from its weight.

As the tabular specific gravity of the body
is to its weight in avoirdupois ounces;
so is one cubic foot (or 1728 cubic inches)
to its content in feet, or inches, respectively.

To find the weight of a body, from its magnitude.

As one cubic foot (1728 cubic inches)
is to the content of the body;
so is its tabular specific gravity
to the weight of the body.

To find the specific gravity of a body.

1.—*When the body is heavier than water.*

Weigh it both in water, and out of water, and take the difference:

Then,—As the weight lost in water
is to the whole or absolute weight;
so is the specific gravity of water
to the specific gravity of the body.

2.—*When the body is lighter than water*, so that it will not sink, annex to it another body heavier than water, so that the mass compounded of the two may sink together. Weigh the denser body, and the compound mass separately, both in water, and out of it; then find how much each loses in water, by subtracting its weight in water from its weight in air; and subtract the less of these remainders from the greater.

Then,—As the last remainder
is to the weight of the light body in air;
so is the specific gravity of water
to the specific gravity of the body.

3.—*For a fluid of any sort.*

Take a piece of a body of known specific gravity, weigh it both in, and out of the fluid, finding the loss of weight by taking the difference of the two:

Then,—As the whole or absolute weight
is to the loss of weight;
so is the specific gravity of the solid
to the specific gravity of the fluid.

To find the quantities of two ingredients in a given compound.

Take the three differences of every pair of the three specific gravities, namely, the specific gravities

of the compound, and each ingredient, and multiply each specific gravity by the difference of the other two:

Then,—As the greatest product
is to the whole weight of the compound;
so is each of the other two products
to the weights of the two ingredients.

To find the diameter of any small sphere, or globule, whose specific gravity is given (*or can be found in the Table*) *and weight known.*

Divide its weight in grains by the number expressing its specific gravity; extract the cube root of this quotient, and multiply it by 1·9612 for the diameter.

WEIGHT OF A CUBIC FOOT OF THE FOLLOWING MATERIALS,

in pounds.

Ash	49	Gravel	120
Beech	43	Granite	166
Birch	49	Brick, common	98
Box	60	Chalk	145
Cork	15	Coal, Newcastle	78
Elm	36	Antimony	418
Fir	30	Brass, cast	525
Mahogany, Spanish	50	Copper	538
Pine, red	41	Gold, pure	1203

Teak	41	Iron, cast, variable	444
Walnut	41	Lead	717
Coke	46	Silver, standard	644
Clay	125	Tin	455
Earth, loose	95		

By means of the foregoing table, the weight of any quantity of the materials specified (in cubic feet) may readily be found.

MOTION, FORCES, &c.

Body is the mass or quantity of matter in any material substance, and it is always proportional to its weight, or gravity, whatever its figure may be.

Density is the proportional weight, or quantity of matter in any body.

Velocity, or celerity, is an affection of motion by which a body passes over a certain space in a certain time.

Momentum, or quantity of motion, is the power, or force, in moving bodies.

Force is a power exerted on a body to move it, or to stop it. If the force act constantly, it is a *permanent force*, like pressure, or the force or gravity; but if it act instantaneously, or for an imperceptibly short time, it is called *impulse*, or *percussion*, like the smart blow of a hammer.

A motive, or moving force, is the power of an agent to produce motion.

Accelerative, or retardative force, is that which affects the velocity only, or it is that by which the velocity is accelerated, or retarded.

The change, or alteration of motion by any external force, is always proportional to that force, and in the direction of the right line in which it acts.

If a body be projected in free space, either parallel to the horizon, or in an oblique direction, by the force of gunpowder, or any other impulse: it will, by this motion, in conjunction with the action of gravity, describe the curve line of a parabola.

A parabola is the section formed by cutting a cone, with a plane, parallel to the side of the cone.

Gravity (*vide* *page 316*) is a force of such a nature that all bodies, whether light or heavy, fall perpendicularly through equal spaces in the same time, abstracting the resistance of the air; as lead, and a feather, which, in an exhausted receiver, fall from the top to the bottom in the same time. The velocities acquired by descending, are in the exact proportion of the times of descent, and the spaces descended are proportional to the squares of the times, and, therefore, to the squares of the velocities. Hence, then, it follows that the weights, or gravities of bodies near the surface of the earth are proportional to the quantities of matter contained in them; and that the spaces, times, and velocities generated by gravity, have the relations contained in the three general proportions before laid down.

A body in the latitude of London falls nearly 16-1/12 feet in the first second of time, and consequently, at the end of that time, it has acquired a velocity double, or of 32⅛ feet.

The times being as the velocities, and the spaces as the squares of either; therefore,

if the times be as the Nos.

1, 2, 3, 4, 5, 6, 7, 8, 9, 10;

the velocities will also be as

1, 2, 3, 4, 5, 6, 7, 8, 9, 10;

and the spaces as their squares

1, 4, 9, 16, 25, 36, 49, 64, 81, 100;

and the spaces for each time,

1, 3, 5, 7, 9, 11, 13, 15, 17, 19.

Namely, as the series of the odd numbers, which are the differences of the squares denoting the whole spaces. So that if the first series of natural numbers be seconds of time,

namely: the times in seconds	1	2	3	4	&c.
the velocities in feet will be	32⅙	64⅓	96½	128⅔,	&c.
the spaces in the whole times	16 1/12	64⅓	144¾	257⅓,	&c.
and the space for each second	16 1/12	48¼	80 5/12	112 7/12 ,	&c.

of which spaces the common difference is 32⅙ feet, the natural and obvious measure of the force of gravity.

Thus, a body falling from a state of rest acquires a velocity to pass through 9 spaces in the fifth second of time; 7 in the fourth; 5 in the third; 3 in the second; and 1 in the first. Thus it is 9 + 7 + 5 + 3 + 1 = 25, which shows that the whole spaces passed through in 5 seconds equal the square of 5.

The momentum, or force, of a body falling through the atmosphere is the mass or weight, multiplied by the square root of the height it has fallen through, multiplied by 8·021.

Suppose a weight of 10 tons to be raised 9 feet, and to drop thence suddenly on a bridge; the momentum is 10 × (3 × 8·021) = 240·63 tons. That is, a weight of 10 tons, so falling, would exert as great a strain to break down the bridge, as the pressure of 240·63 tons of dead weight.

Thus, a one-ounce ball falling from a height of 400 feet, would strike the earth with a momentum of

oz. feet.	oz.	lb.
1 × (20 × 8·021)	=	=
	160·42	10·026.

By experiments to ascertain the effect of Carnot's vertical fire, it was found that 4-oz. balls only penetrated

$$\frac{1}{20}$$

of an inch into deal board, and from 2 to 3 inches into meadow ground.

Amplitude signifies the range of a projectile, or the right line upon the ground, subtending the curvilinear path in which it moves.

The time of flight of different shot, and shells is equal to the time a heavy body takes to descend

freely from the highest point described by the curve of the projectile.

To find the time of descent:

Divide the given height, or altitude, by 16 $\frac{1}{12}$, and the square root of the quotient will be the time required. Thus, if the altitude is 1200 feet, and the time of descent is required,

$1200 \div 16\frac{1}{12} = 74{\cdot}61$, the square root of which is 8·637, the time required.

When a body is projected vertically *downwards* with a given velocity, the space described is equal to the time multiplied by the velocity, together with the product of 16-1/12 by the square of the time; but, if the body is projected *upwards*, the latter product must be subtracted from the former.

PRACTICAL GEOMETRY.

DEFINITIONS.[55]

A line is perpendicular to another when it inclines not more on the one side than on the other, the angles on both sides being equal.

Parallel lines are those which have no inclination to each other, being everywhere equi-distant, however far produced, or extended.

An angle is the inclination, or opening of two lines, which meet in a point called the *vertex, or angular point*: and the two lines are called the *legs, or sides* of

the angle.

The measure of an angle is estimated by the number of degrees contained in the arc between its two legs.

A rectilinear angle has its legs or sides, *right*, or straight lines.

A curvilinear angle has its legs *curves*.

A right angle is formed by one line perpendicular to another; the measure of which is an arc of 90°.

An acute angle is less than a right angle, or than 90°.

An obtuse angle is greater than a right angle.

An oblique angle may be either acute, or obtuse.

The circumference, or periphery of a circle is the curved line which bounds it, being everywhere equally distant from the *centre*. The circumference is supposed to be divided into 360 degrees (marked thus °); each degree into 60 minutes, each minute (′) into 60 seconds (″).

An arc is any part of the circumference of a circle.

A chord, or subtense, is a right line joining the extremities of an arc.

The radius of a circle is a right line drawn from the centre to the circumference.

The diameter of a circle is a right line drawn through the centre, and terminated by the circumference.

A semicircle (180°) is that part of a circle which is contained between the diameter, and half the circumference.

A quadrant is the fourth part of a circle, being

contained between two radii, and an arc of 90°.

A segment is that part of a circle which is cut off by a chord.

A sector is that part of a circle contained between two radii, and an arc.

A secant is a line which cuts a circle, lying partly within, and partly without it.

A tangent is a line which touches a circle, or curve, without cutting it.

The point of contact is where a tangent touches an arc.

Triangles are figures having three sides, and three angles.

An equilateral triangle has its three sides equal.

An isosceles triangle has only two equal sides.

A scalene triangle has all its sides unequal.

A rectangular, or right-angled triangle has one of its angles a right one, or 90°; and the square of the side opposite the right angle is equal to the sum of the squares of the sides containing that angle; hence a triangle, having its sides proportional to the numbers 3, 4, 5, will be right-angled.

The hypothenuse is the side opposite the right angle in a rectangular triangle.

An obtuse-angled triangle has one of its angles obtuse.

An acute-angled triangle has all its angles acute.

The three angles of any triangle, taken together, are equal to two right angles, or 180°.

The difference of the squares of two sides of a triangle is equal to the product of their sum and difference.

The sides of a triangle are proportional to the sines of their opposite angles.

Quadrangles, or quadrilaterals, are plane figures bounded by four right lines.

A square is a quadrilateral having all its sides equal, and all its angles right angles. The *diagonal of a square* is equal to the square root of twice the square of its sides: and *the side of the square* is equal to the square root of half the square of its diagonal.

The diagonal is a right line drawn across a quadrilateral figure, from one angle to another. The sum of the squares of the two diagonals of every parallelogram is equal to the sum of the squares of the four sides.

A parallelogram is a quadrilateral, whose opposite sides are parallel.

A rectangle is a parallelogram having four right angles.

A rhomboid is an oblique-angled parallelogram.

A rhombus, or lozenge, is a quadrilateral, whose sides are all equal but its angles oblique.

A trapezium is a quadrilateral, which has none of its sides parallel to each other.

A trapezoid is a quadrilateral, which has only two of its sides parallel.

Polygons are plane figures bounded by more than four sides.

A regular polygon has all its sides, and angles equal.

The perimeter of a figure is the sum of all its sides.

To bisect—is to divide into two equal parts.

To trisect—is to divide into three equal parts.

To inscribe—is to draw one figure within another, so that all the angles of the inner figure touch either the angles, sides, or planes of the external figure.

To circumscribe—is to draw a figure round another, so that either the angles, sides, or planes of the circumscribing figure touch all the angles of the figure within it.

LINES, ANGLES, AND FIGURES.

To divide a given right line into two equal parts.

From the extremities of the line as centres, and with any opening in the compasses, greater than half the given line, as a radius, describe arcs intersecting each other above, and below the given line. A line being drawn through these intersections will divide the given line into two equal parts.

An arc of a circle is bisected in the same manner.

To bisect an angle.

From the angular point, measure equal distances on the two lines (forming the angle), and from these points, with the same distance as radius, describe arcs intersecting each other. A line drawn from their intersections to the angular point will bisect the angle.

To erect a perpendicular.

From the point A set off any length 4 times to C; from A as a centre with 3 of those parts describe an

arc at B, and from C with 5 of them cut the arc at B. Draw A B, which will be the perpendicular required. Any equimultiples of these numbers, 3, 4, 5, may be used for erecting a perpendicular. *Plate 2*, HEIGHTS AND DISTANCES, and PRACTICAL GEOMETRY, *Fig. ½*.

To erect a perpendicular.

Set off on each side of the point A, any two equal distances, A D, A E. From D and E as centres, and with any radius greater than half D E, describe two arcs intersecting each other in F. Through A, and F draw the line A F, and it will be the perpendicular required.

Fig. 1.—*Plate*, PRACTICAL GEOMETRY.

To let fall a perpendicular.

From D as a centre, and with any radius, describe an arc intersecting the given line. From the points of intersection C, and E, with any radius greater than half, describe two arcs, cutting each other at F. Through D, and F draw a line, and D F will be the perpendicular required. *Fig. 2*.

To draw a line parallel to a given line.

From any point D in the given line with the radius D C, describe the arc C E, and from C with the same radius describe the arc D F. Take E C, and set it off from D to F. Through C, and F draw C F for the parallel required. *Fig. 3*.

To divide an angle into two equal parts.

From B as a centre with any radius describe an arc A C. From A, and C with any radius describe arcs intersecting each other in D. Then draw B D, and it will bisect the angle. *Fig. 4.*

PRACTICAL GEOMETRY.

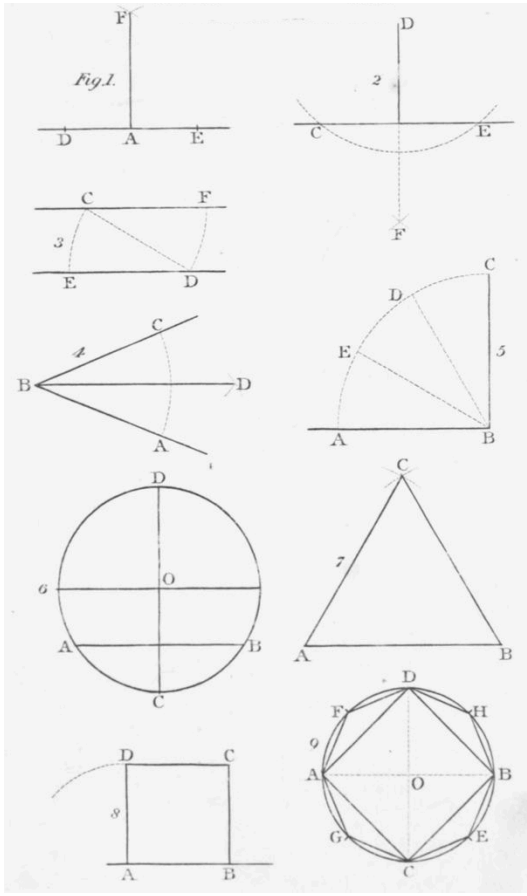


Fig. 1-9.



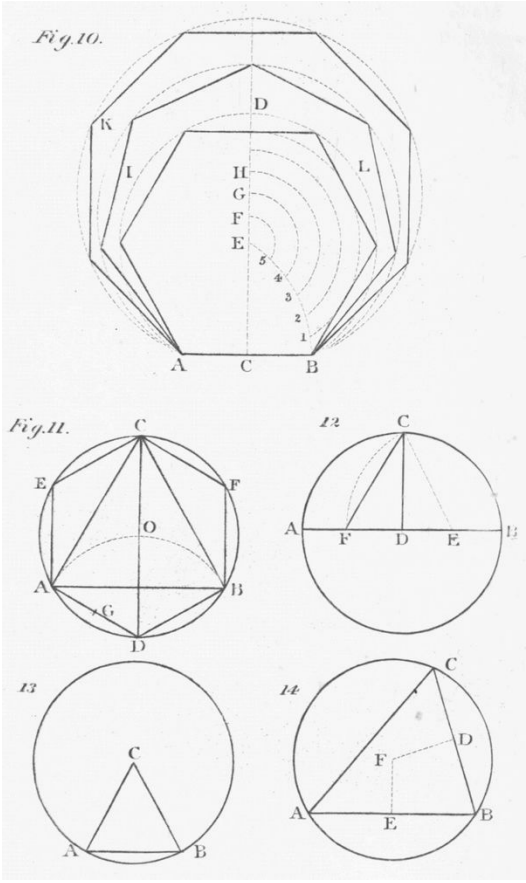


Fig. 10-14.

To divide a right angle into three equal parts.

From B as a centre with any radius describe the arc A C. From A with the radius A B cut the arc A C in D, and with the same radius from C cut it in E. Then through the intersections D, and E draw the lines B D, B E, and they will trisect, or divide the angle into three equal parts. *Fig. 5.*

To find the centre of a circle.

Draw any chord A B, and bisect it by the perpendicular C D. Divide C D into two equal parts, and the point of bisection O will be the centre required. *Fig. 6.*

To describe an equilateral triangle.

From the points A, B, as centres, and with A B as radius, describe arcs intersecting each other in C. Draw C A, C B, and the figure A B C will be the triangle required. *Fig. 7.*

To describe a square.

From the point B, draw B C perpendicular, and equal to A B. On A, and C, with the radius A B, describe arcs cutting each other in D. Draw the lines D A, D C, and the figure A B C D will be the square required. *Fig. 8.*

To inscribe a square in a circle.

Draw the diameters A B, C D perpendicular to each other. Then draw the lines A D, A C, B D, B C; and A B C D will be the square required. *Fig. 9.*

To inscribe an octagon in a circle.

Bisect any two arcs A C, B C of the square A B C D in G, and E. Through the points G, and E, and the centre O draw lines, which produce to F, and H. Join A F, F D, D H, &c. and they will form the octagon required. *Fig. 9.*

On a line to describe all the several polygons, from the hexagon to the dodecagon.

Bisect A B by the perpendicular C D. From A as a

centre, and with A B as a radius, describe the arc B E, which divide into six equal parts; and from E as a centre describe the arcs 5 F, 4 G, 3 H, &c. Then from the intersection E as a centre, and with E A as a radius, describe the circle A I D B, which will contain A B six times. From F in like manner as a centre, and with F A as radius, describe the circle A K L B, which will contain A B seven times; and so on for the other polygons. *Fig. 10.*

To inscribe in a circle an equilateral triangle.

From any point D in the circumference as a centre, and with the radius D O of the given circle, describe an arc A O B cutting the circumference in A, and B. Through D, and O draw D C. Then, join A B, A C, B C; and the figure A B C will be the triangle required. *Fig. 11.*

To inscribe a hexagon in a circle.

Bisect the arcs A C, B C in E, and F, and join A D, D B, B F, &c., which will form the hexagon. Or carry the radius six times round the circumference, and the hexagon will be obtained. *Fig. 11.*

To inscribe a dodecagon in a circle.

Bisect the arc A D of the hexagon in G, and A G being carried twelve times round the circumference, will form the dodecagon. *Fig. 11.*

To inscribe a pentagon, hexagon, or decagon, in a circle.

Draw the diameter A B, and make the radius D C perpendicular to A B. Bisect D B in E. From E as a centre, and with E C as radius, describe an arc cutting A D in F. Join C F, which will be the side of the pentagon, C D that of the hexagon, and D F that

of the decagon. *Fig. 12.*

To find the angles at the centre, and circumference of a regular polygon.

Divide 360 by the number of the sides of the given polygon, and the quotient will be the angle at the centre; and this angle being subtracted from 180, the difference will be the angle, at the circumference, required.

Table, showing the angles at the centre, and circumference.

Names.	No. of sides.	Angles at centre.	Angles at circumference.
Trigon	3	120°	60°
Tetragon	4	90°	90°
Pentagon	5	72°	108°
Hexagon	6	60°	120°
Heptagon	7	51° 25 5′ 7	128° 34 2′ 7
Octagon	8	45°	135°
Nonagon	9	40°	140°
Decagon	10	36°	144°

To inscribe any regular polygon in a circle.

From the centre C draw the radii C A, C B, making an angle equal to that at the centre of the proposed polygon, as contained in the preceding table. Then the distance A B will be one side of the polygon, which, being carried round the circumference the proper number of times, will complete the polygon required. *Fig. 13.*

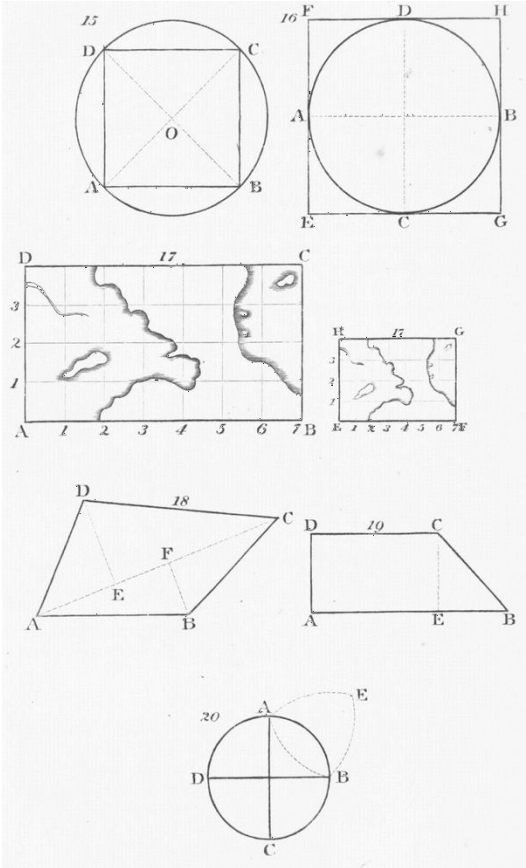


Fig. 15-20.

To circumscribe a circle about a triangle.

Bisect any two of the given sides, A B, B C by the perpendiculars E F, D F. From the intersection F as a centre, and with the distance of any of the angles, as a radius, describe the circle required. *Fig. 14.*

To circumscribe a circle about a square.

Draw the two diagonals A C, B D intersecting each other in O. From O as a centre, and with O A, or O B, as a radius, describe the required circle. *Fig. 15.*

To circumscribe a square about a circle.

Draw the two diameters A B, C D perpendicular to each other, through the points A, C, B, D, draw the tangents E F, E G, G H, F H, and E G H F will be the square required. *Fig. 16.*

To reduce a map, or plan, from one scale to another.

Divide the given figure A C by cross lines, forming as many squares as may be thought necessary. Draw a line E F, on which set off as many parts from the scale M, as A B contains parts of the scale N. Draw E H, and F G perpendicular to E F, and each equal to the proportional parts contained in A D, or B C. Join H G, and divide the figure E G into the same number of squares as the original A C. Describe in every square what is contained in the corresponding square of the given figure; and E F G H will be the reduced plan required. The same operation will serve either to reduce, or enlarge any map, plan, drawing, or painting. *Fig. 17.*

MENSURATION OF PLANES, AND SOLIDS.

Mensuration is of three kinds, viz., lineal, superficial, and solid.

Lineal measure has reference to length only.

Superficial measure (*or the surface*) includes length, and breadth.

Solid measure (*or the content*) comprehends length, breadth, and thickness.

MENSURATION OF PLANES.

The area of any plane figure is the superficial measure contained within its extremes, or bounds. This area is estimated by the number of small squares that may be contained in it, the side of these measuring squares being an inch, a foot, or any other fixed quantity, and hence the area is said to be so many square inches, square feet, &c. *Vide Table, Square measure.* *Page 275*.

To find the area of a parallelogram, whether a square, rectangle, &c.

Multiply the length by the breadth, or perpendicular height, for the area required.

Example.—Required the area of a rectangle, whose length is 9 feet, and breadth 4 feet.

$9 \times 4 = 36$ feet. The required area, or surface.

To find the area of a triangle, its base, and perpendicular height being given.

Multiply the base by the perpendicular height, and half the product will be the area.

Example.—Required the number of square yards contained in a triangle, whose base is 20 yards, and perpendicular height 14 yards.

$$\frac{20 \times 14}{2}$$

$= 140$ square yards. Area required.

To find the area of a triangle, whose three sides are given.

From half the sum of the three sides, subtract each

side severally; multiply the half sum, and the three remainders together, and the square root of the product will be the area required.

Example.—Required the area of a triangle, whose sides are 50, 40, and 30 feet.

$$\frac{50 + 40 + 30}{2}$$

= 60, half the sum of the three sides.
60 - 30 = 30 First difference.
60 - 40 = 20 Second difference.
60 - 50 = 10 Third difference.
30 × 20 × 10 × 60 = 360000.
Square root of 360000 = 600. Area required.

Two sides of a right-angled triangle being given, to find the third side.

1. When the two sides forming the right angle are given, to find the hypothenuse, or side opposite the right angle.

Take the square root of the sum of the two sides squared for the side required.

Example.—Required the length of the interior slope of a rampart, whose perpendicular height is 17 feet, and the base of the slope 20 feet.

17 × 17 = 289
20 × 20 = 400

The square root of 689 = 26·24. The length required.

2. When the hypothenuse, and one of the perpendicular sides are given.

From the square of the hypothenuse, subtract the square of the given side, and the square root of the

remainder will be the side required.

Example.—The hypothenuse being 5 yards, and the base 4 yards, required the other side.

$$5 \times 5 = 25$$
$$4 \times 4 = \underline{16}$$

The square root of 9 = 3 yards. The side required.

To find the area of a trapezium, A B C D.

Draw the diagonal A C, upon which let fall from its opposite angles B, and D, the perpendiculars B F, D E. Find by measurement the diagonal A C, and the perpendiculars B F, D E, then multiply the sum of the perpendiculars by the diagonal, and half the product will be the area of the trapezium. *Fig. 18.*

Example.—Required the area of the trapezium, whose diagonal A C is 100 feet, and perpendiculars B F 30 feet, and D E 40 feet.

$$\frac{(30 + 40) \times 100}{2}$$

= 3500 square feet. Area required.

Or, divide the trapezium into two triangles by a diagonal, then find the areas of these triangles, and add them together.

To find the area of a trapezoid, A B C D.

Multiply the sum of the parallel sides A B, D C by the perpendicular distance E C, and half the product will be the area. *Fig. 19.*

Example.—Required the area of the trapezoid A B C D, of which the parallel sides A B, D C are 120 feet, and 90 feet, and the perpendicular distance E C 40 feet.

$$\frac{(120 + 90) \times 40}{2}$$

= 4200 square feet. Area required.

To find the area of an irregular figure, or polygon.

Draw diagonals dividing the figure into trapeziums, and triangles; then, having found the area of each, add them together, and the sum will be the area required.

To find the area of a figure, having a part bounded by a curve.

Draw a right line joining the extremities of the curve, then find the area of the trapezium. On the right line let fall as many perpendiculars as the several windings of the curve may require. Find their lengths, and divide their sum by the number of perpendiculars, and the quotient will be the mean breadth; which being multiplied by the length of the right line, will give the area of the curved part. This area being added to that of the trapezium will give the area of the required figure.

To measure long irregular figures.

Measure the breadth at both ends, and at several places *at equal distances*. Add together all these intermediate breadths, and half the two extremes, which sum multiply by the length, and divide by the number of parts for the area. If the perpendiculars, or breadths, *be not at equal distances*, compute all the parts separately, as so many trapezoids, and add them all together for the whole area.

Example.—The breadths of an irregular figure at five equi-distant places being 8, 2, 7, 9, 4, and the whole length 40, required the area.

$$8 + 4 = 12 \quad 12 \div 2 = 6$$
$$6 + 2 + 7 + 9 = 24$$
$$\frac{24 \times 40}{4}$$
$$= 240. \quad \text{Area required.}$$

To find the number of square acres in any of the preceding figures.[56]

Divide the superficial content in feet by 43560, and the quotient will be the number required.

To bring square chains to acres.

Of square chains strike off two decimal places to the right, and the rest of the figures will be acres.

To bring square links to acres.

Of square links cut off five of the figures on the right hand, for decimals, and the rest will be acres; then multiply these decimals by 4, for roods, cutting off five figures as before; and the decimals of these again by 40, for perches, when five figures are again to be struck off.

To find the area of a regular polygon.

Multiply the *perimeter* (or sum of the sides) of the polygon by the perpendicular drawn from its centre on one of its sides, and take half the product for the area.

Or, multiply the area of one of the triangles by the number of sides of the polygon, and the product will be the area of it.

Example.—Required, the area of a regular hexagon, whose side is 40 feet, and the perpendicular 34·64 feet.

$40 \times 6 = 240$ the perimeter.

$$\frac{240 \times 34{\cdot}64}{2}$$

$= 4156{\cdot}8$ square feet. Area required.

To find the diameter, and circumference of any circle, the one from the other.

Use either of the following proportions:

as 7 is to 22	}	{ so is the diameter
or as 1 is to 3·1416	}	{ to the circumference.

as 22 is to 7	}	{ so is the circumference
or, as 3·1416 is to 1	}	{ to the diameter.

or, instead of dividing the diameter by 3·1416, multiply it by ·3183, for the circumference.

Example 1.—Required, the circumference of a circle, whose diameter is 20 feet.

As 7 : 22 :: 20 : 62·857 feet. Circumference required.

Example 2.—Required, the diameter of a circle, whose circumference is 36 inches.

As 22 : 7 :: 36 : 11·45 inches. Diameter required.

To find the diameter of a circle, the area being given.

Divide the area by ·7854, and the square root of the quotient will be the diameter required.

Example.—Required, the diameter of a circle, whose area is 176·715 square feet.

176·715 ÷ ·7854 = 225.
Square root of 225 = 15 feet. Diameter

required.

To find the area of a circle.

1. Multiply half the circumference by half the diameter, or multiply the whole circumference by the whole diameter, and take ¼ of the product.

2. Or, square the diameter, and multiply that square by ·7854 for the area.

3. Or, square the circumference, and multiply that square by 0·7958.

Example 1.—Required the area of a circle, whose circumference is 55·548 inches, and its diameter 18 inches.

55·548
2
= 27·774 half circumference.
18
2
= 9 half diameter.
27·774 × 9 = 249·966, square inches. Area required.

Example 2.—Required the area of a circle whose diameter is 12 feet.

12 × 12 = 144, square of the diameter.
·7854 × 144 = 113·0976 square feet. Area required.

Example 3.—Required the area of a circle, whose circumference is 22 feet.

22 × 22 = 484.
484 × ·07958 = 38·51672 square feet. Area required.

To find the area of a circular ring,

or space included between the circumferences of two circles, the one within the other.

1. Subtract the square of the less diameter from the square of the greater, and multiply their difference by ·7854.

2. Or, find the area of each circle separately, and subtract one from the other, for the area required.

3. Or, multiply the sum of the diameters by the difference of the same, and that product by ·7854 for the area.

Example.—Required the area of a ring, the diameters of whose bounding circles are 10, and 20.

By Rule 3.

20 + 10 = 30, sum of diameters.
20 - 10 = 10, difference of diameters.
30 × 10 × ·7854 = 235·62. The area.

To find the length of any arc of a circle.

1. As 360° is to the number of degrees in the arc, so is the circumference to the length of the arc.

2. Or, multiply the degrees in the given arc by the radius of the circle, and the product by ·01745 for the length of the arc.

Example.—Rule 2.—Required the length of an arc of 30°, the radius being 9 feet.

30 × 9 × ·01745 = 4·7115. Length of arc.

To find the area of the sector of a circle.

Multiply the radius by the arc, and half the product will be the area.

Example.—Required the area of the sector, whose radius is 30 inches, and the length of the arc 36·6 inches.

$$\frac{36{\cdot}6 \times 30}{2}$$

= 549 square inches. Area required.

To find the area of the segment of a circle.

Find the area of the sector, by the preceding rule. Then find the area of the triangle formed by the chord of the segments, and the radii of the sector. Then, if the segment be less than a semicircle, subtract the area of the triangle from it; or, if the segment be greater than a semicircle, add the area of the triangle to it; for the area of the segment.

Example.—Required the area of a segment less than a semicircle, the radius being 20 inches, the chord 22·42 inches, the length of the arc 24·43 inches, and the perpendicular 16·56 inches.

$$\frac{24{\cdot}43 \times 20}{2}$$

= 244·3 square inches. Area of the sector.

$$\frac{22{\cdot}42 \times 16{\cdot}56}{2}$$

= 185·6376 square inches. Area of the triangle.

244·3 - 185·6376 = 58·6624 square inches. Area required.

To find the area of a semicircle.

1. Multiply ¼ of the circumference by the radius, and the product will be the area.

2. Or, multiply the square of the diameter by ·7854, and half the product will be the area.

Example.—Rule 2.—Required the area of a

semicircle, the diameter being 50 inches.

$$\frac{50 \times 50 \times \cdot 7854}{2}$$

= 981·75 square inches. Area required.

To find the area of an ellipsis, or oval.

Multiply the longest diameter, or axis, by the shortest, then multiply the product by ·7854 for the area.

Example.—Required the area of the ellipse, whose diameters are 25 inches, and 18 inches.

25 × 18 × ·7854 = 353·43 square inches. Area required.

To find the area of a parabola, or its segment.

Multiply the base by the perpendicular height, and take two-thirds of the product for the area.

Example.—Required the area of a parabola, whose base is 20 feet, and height 12 feet.

20 × 12 = 240
⅔ of 240 = 160 square feet. Area required.

MENSURATION OF SOLIDS.

A solid is a body containing length, breadth, and thickness.

Solids are measured by cubes, whose sides are each an inch, a foot, a yard, &c., and the solidity, capacity, or content of any figure is computed by the number of such cubes as are contained in it.—*Vide Cubic measure, page 276.*

A cube is a solid contained by six equal square

sides.

A pyramid is a solid whose sides are all triangles meeting together in a point, the base being any plane figure whatever. It is called a triangular pyramid when its base is a triangle; a square pyramid when its base is a square, &c.

The segment of a pyramid, cone, or any other solid is a part of D E F G cut off from the top by a plane D E F, parallel to the base A B C.—*Vide Fig. 21, Plate 2*, HEIGHTS, DISTANCES, and PRACTICAL GEOMETRY.

A frustrum, or trunk, is a part A B C D E F, that remains at the bottom after the segment is cut off.

A cone is a round pyramid, of which the base is a circle.

The axis of a solid is a line from the vertex (or point) to the centre of the base, or through the centres of the two ends. When the axis is perpendicular to the base, it is a right prism, pyramid, or cone; otherwise it is oblique.

A sphere is a solid contained under one convex surface, and is described by the revolution of a semicircle about its diameter, which remains fixed.

The centre of the sphere is such a point within the solid as is everywhere equally distant from the convex surface, or circumference of it.

The diameter (*or axis*) *of a sphere* is a straight line, which passes through the centre, and is terminated by the convex surface.

A segment of a sphere is a part cut off by a plane, the section of which is always a circle, called the *base of the segment.*

A sector of a sphere is that which is composed of a

segment (less than an hemisphere) and of a cone.

A prism is a solid, the sides of which are parallelograms, having its ends equal, and similar plane figures.

Prisms are named according to the number of angles in the base.

A cylinder is a solid, the two ends of which are circular; and it is described, or formed, by the revolution of a right-angled parallelogram about one of its sides, which remains fixed.

To find the superficies of a prism, or cylinder.

Multiply the perimeter of one end of the prism by the length, or height of the solid, and the product will be the surface of all its sides. To which add also the area of the two ends of the prism, when required.

Or, compute the areas of all the sides, and ends separately, and add them all together.

Example.—Required the surface of a cube, whose sides are each 5 inches.

$5 + 5 + 5 + 5 = 20$, perimeter of one end.
$20 \times 5 = 100$, surface of sides.
$5 \times 5 = 25$, area of one end.
$100 + 25 + 25 = 150$ square inches. Surface of cube.

To find the surface of a pyramid, or cone.

Multiply the perimeter of the base by the slant height, or length of the side, and half the product will be the surface of the sides; to which add the area of the base when required.

Example.—Required the upright surface of a triangular pyramid, the slant height being 20 feet, and each side of the base 3 feet.

$$3 + 3 + 3 = 9, \text{ perimeter of base.}$$

$$\frac{9 \times 20}{2}$$

$$= 90 \text{ feet. Surface required.}$$

To find the surface of the frustrum of a pyramid, or cone.

Add together the perimeters of the two ends, multiply their sum by the slant height, and take half the product.

Example.—How many square feet are in the surface of the frustrum of a square pyramid, whose slant height is 10 feet, each side of the base 3 feet, and each side of the less end 2 feet.

$$3 + 3 + 3 + 3 = 12, \text{ perimeter of base.}$$
$$2 + 2 + 2 + 2 = 8, \text{ perimeter of less end.}$$

$$\frac{(12 + 8) \times 10}{2}$$

$$= 100 \text{ feet. Surface required.}$$

To find the solid content of a prism or cylinder.

Find the area of the base, or end, and multiply it by the length of the prism, or cylinder. Fora cube, multiply its side twice by itself; and for a parallelopipedon, multiply the length, breadth, and depth together for the content.

Example.—Required the solid content of a cube, whose side is 24 inches.

$$24 \times 24 \times 24 = 13824 \text{ square inches.}$$

Content required.

To find the content of the solid part of a hollow cylinder.

From the content of the whole cylinder considered as a solid, subtract the content of the hollow part, also considered as a solid, and the difference will be the solidity required.

Example.—Required the content of the solid part of the hollow cylinder whose exterior diameter is 12 inches, the interior diameter 8 inches, and height 20 inches.

$12 \times 12 \times \cdot7854 = 113\cdot0976$, area of base of cylinder.
$113\cdot0976 \times 20 = 2261\cdot952$, solidity of whole cylinder.
$8 \times 8 \times \cdot7854 = 50\cdot2656$, area of base of hollow cylinder.
$50\cdot2656 \times 20 = 1005\cdot312$, content of hollow part.
$2261\cdot952 - 1005\cdot312 = 1256\cdot64$ cubic inches. Solidity required.

To find the solidity of the frustrum of a cylinder.

Multiply the area of the base by half the greatest, and the least lengths, and the product will be the solidity.

Example.—Required the solidity of a frustrum, whose diameter is 24 inches, the greatest length 36 inches, and the least length 20 inches.

$24 \times 24 = 576$. Square of the diameter.
$576 \times \cdot7854 = 452\cdot3904$. Area of the base.

$$\frac{452\cdot3904 \times (36 + 20)}{2}$$

$= 12666\cdot9312$ Cubic inches. Solidity required.

To find the content of a pyramid, or cone.

Find the area of the base, and multiply that area by the perpendicular height, and take ⅓ of the product.

Example.—Required the solidity of a square pyramid, each side of its base being 30, and its perpendicular height 25.

$30 \times 30 = 900$, area of base.

$$\frac{900 \times 25}{3}$$

$= 7500$, solidity required.

To find the solidity of the frustrum of a cone, or pyramid.

Add into one sum the areas of the two ends, and the mean proportional between them: take ⅓ of that sum for the mean area, which multiply by the perpendicular height, or length of the frustrum.

Note.—To find a mean proportional.

As one of the sides of the base is to the homologous, or corresponding side of the other end, so is the area of the base to the mean proportional required.

Example.—Required the number of solid feet in a piece of timber, whose bases are squares, each side of the greater end being 15 inches, and each side of the less end 6 inches; also the length of the perpendicular altitude 24 feet.

$15 \times 15 = 225$, area of the base.
$6 \times 6 = 36$, area of the top.
As 15: 6 :: 225: 90, mean proportional.
24 feet = 288 inches.

$$\frac{(225 + 36 + 90) \times 288}{3}$$

= 33696 cubic inches = 19½ cubic feet.

To find the surface of a sphere, or any segment.

Multiply the circumference of the sphere by its diameter, which will give the whole surface.

Or, square the diameter, and multiply by 3·1416.
Or, square the circumference, and multiply by ·3183; or divide by 3·1416.

Note.—For the surface of the segment, or frustrum, multiply the whole circumference of the sphere by the height of the part required.

Example.—Required the superficies of a globe whose diameter is 24 inches.

24 × 24 × 3·1416 = 1809·5616 square inches.

To find the solidity of a sphere, or globe.

1. Multiply the surface by the diameter, and take ⅙ of the product.

Or, multiply the square of the diameter by the circumference, and take ⅙ of the product.

2. Cube the diameter, and multiply by ·5236.

3. Cube the circumference, and multiply by ·01688.

Example.—Required the content of a sphere, whose axis is 12.

12 × 12 × 12 × ·5236 = 904·7808. Content required.

To find the solidity of an hemisphere.

Find the solidity of the sphere, and half the

content will be that of the hemisphere.

Note 1.—Any sphere, or globe *twice* the diameter of another contains *four times* the superficies, or area of the other, and *eight times* the solid content. Hence the superficies of spheres are as the squares, and the solidity as the cubes of their diameters.

Note 2.—The cube of the diameter of a sphere in inches, multiplied by ·00188, will give the number of *imperial gallons it will contain.*

To find the solid content of a spherical segment.

1. From three times the diameter of the sphere, take double the height of the segment; then multiply the remainder by the square of the height, and this product by ·5236.

2. Or, to three times the square of the radius of the segment's base add the square of its height; then multiply the sum by the height, and the product by ·5236.

Example.—Required the content of a spherical segment 2 feet in height, cut from a sphere of 8 feet diameter.

$(3 \times 8) - (2 \times 2) = 20$
$20 \times 2^2 \times \cdot5236 = 41\cdot888$ cubic feet. Content required.

To find the diameter of a sphere, its solidity being given.

Divide the solidity by ·5236, and take the cube root of the quotient.

Example.—The solidity of a sphere being 113·0976 solid inches, what will be its diameter?

113·0976

·5236
= 216, the cube root of which is 6 inches, the diameter required.

To find the weight of an iron shot, its diameter being given.

Take ⅛ of the cube of the diameter, and ⅛ of that eighth, and the sum of these two quotients will be the weight in pounds.

Or, as 64 is to 9 lb. so is the diameter cubed to its weight.

Example.—Required the weight of an iron shot whose diameter is 3·5 inches?

3·5 cubed = 42·875, cube of diameter.

42·875
8
= 5·359

5·359
8
= ·669

5·359 + ·669 = 6·028 pounds. Weight required.

To find the weight of a leaden ball, its diameter being given.

Take ⅓ of the cube of the diameter, and from it subtract ⅓ of this third, and the remainder will be the weight, nearly.

Or, take 3/14 of the cube of the diameter.

Example.—What is the weight of a leaden ball whose diameter is 3·3 inches?

3·3 cubed = 35·937, cube of diameter.

35·937
3

= 11·979

11·979
3

= 3·993

11·979 - 3·993 = 7·986 pounds. Weight required.

To find the diameter of an iron shot, its weight being given.

Multiply the cube root of the shot's weight by 1·923 for the diameter.

Pr.	Cube root.		Diameter.
42	3·4760, &c.	{ }	6·684, &c.
32	3·1748	{ Multiplied }	6·103 ”
24	2·8844	{ by 1·923, }	5·545 ”
18	2·6207	{ diameter }	5·038 ”
12	2·2894	{ of a }	4·401 ”
9	2·0800	{ 1 lb. }	3·999 ”
6	1·8171	{ shot. }	3·494 ”
3	1·4422	{ }	2·772 ”

To find the diameter of a leaden ball, its weight being given.

To 4 times the weight add half the weight, and 3/100 of half the weight; and the cube root of this sum will be the diameter in inches, nearly.

Example.—What is the diameter of a leaden ball, whose weight is 8 pounds?

8 x 4 = 32

$$\frac{8}{2} = 4$$

$$\frac{3}{100}$$

of 4 = ·12.

32 + 4 + ·12 = 36·12, of which the cube root is 3·3 inches, nearly.

Diameter required.

To find the weight of an iron shell, its interior and exterior diameter being given.

Take

$$\frac{9}{64}$$

of the difference of the cubes of the external and internal diameters, for the weight of the shell in pounds.

Example.—What is the weight of a shell whose exterior diameter is 12·85 inches, and interior diameter 8·75 inches?

12·85 cubed = 2121·8241, 8·75 cubed = 669·9218.

2121·8241 - 669·9218 = 1451·9022.

$$\frac{9}{64}$$

of 1451·9022 = 204·1737 pounds. Weight required.

To find the quantity of powder a shell will contain.

Divide the cube of the interior diameter in inches by 57·3, and the quotient will be the weight in pounds.

Or, multiply the cube of the diameter by 11, and divide by 21 for the quantity in half ounces.

Example.—How much powder will fill a shell, whose internal diameter is 7 inches?

7 cubed = 343.

343
57·3

= 6 pounds nearly. Powder required.

To find the side of a cubical box to contain a given quantity of powder.[57]

Multiply the weight in pounds by 30, and the cube root of the product will be the side of the box in inches.

Example.—Required the side of a cubical box to hold 50 pounds of powder?

50 × 30 = 1500, the cube root of which is 11·44, which will be the side of the box in inches.

To find the quantity of powder to fill the chamber of a mortar, or howitzer.

Multiply the content of the chamber in inches by 55, and divide the product by 1728, and the quotient will be the quantity of powder in pounds.

Note.—The chamber of a mortar, or howitzer, is formed of a hollow frustrum of a right cone, and of a hollow hemisphere.

Example.—Required the quantity of powder to fill the chamber of a 13-inch mortar in which the diameter A B is 9·5 inches, the diameter C E 6·5 inches, and the length D G 21·5 inches. *Vide Fig. 22. Plate 2.* HEIGHTS AND DISTANCES, and PRACTICAL GEOMETRY.

The content of the chamber must be found by finding the content of the hollow frustrum of the cone, and that of the hemisphere (*vide preceding rules*): which in this example will be 999·9741875.

Then

$$\frac{999{\cdot}9741875 \times 55}{1728}$$

= 31 pounds, nearly.

To find the quantity of powder to fill a rectangular box.

Divide the content (viz., length × breadth × depth) of the box in inches by 30 for the pounds of powder.

Example.—How much powder will fill a box, the length being 15 inches, the breadth 12, and the depth 10 inches.

$$= \frac{15 \times 12 \times 10}{30} = \frac{1800}{30}$$

= 60 pounds. Number required.

To find the quantity of powder to fill a cylinder.

Multiply the square of the diameter by the length, then divide by 38·2 for the pounds of powder.

Example.—How much powder will the cylinder contain, whose diameter is 10 inches, and length 20 inches?

$$\frac{10 \times 10 \times 20}{38{\cdot}2}$$

= 52⅓ pounds, nearly.

To find the size of a shell, to contain a given weight of powder.

Multiply the pounds of powder by 57·3, and the cube root of the product will be the diameter in inches.

Example.—Required the diameter of a shell to contain 6 lb. of powder?

6 × 57·3 = 343·8, the cube root of which is 7, the diameter required, in inches.

To find what length of a cylinder (or bore of a gun) will be filled by a given weight of powder.

Multiply the weight in pounds by 38·2, and divide the product by the square of the diameter in inches, for the length.

Example.—What length of a cylinder 8 inches in diameter will be filled with 20 lb. of powder?

$$= 11 \frac{20 \times 38{\cdot}2}{8 \times 8} \frac{15}{16}$$

inches.

To find the content, and weight of a piece of ordnance.

Divide the length of the gun into as many sections as may be found necessary. Find the content of each (*by preceding rules*) and from their sum subtract the content of a cylinder, whose length is equal to that of the bore, and its diameter equal to that of the calibre of the piece; multiply the difference (if it be a brass gun) by 5·0833, (if an iron gun) by 4·2968, and the product will be the weight in ounces.

Note.—A cubic inch of gun metal weighs 5·0833 ounces.

Ditto of *cast* iron 4·2968 ounces.

To find the content of a cask.

Multiply half the sum of the areas of the two interior circles, viz. at the head, and bung, by the interior length, for the content.

Or, to the area of the head add twice the area at the bung, multiply that sum by the length, and take one-third of the product.

Example.—Required the content of a cask, its greatest interior diameter being 24 inches, its least interior diameter 20 inches, and the interior length 30 inches.

$24 \times 24 \times \cdot7854 = 452\cdot3904$, area of large circle.
$20 \times 20 \times \cdot7854 = 314\cdot1600$, area of small circle.

$$\frac{452\cdot3904 + 314\cdot1600}{2}$$

$= 383\cdot2752$, half sum.

Then $383\cdot2752 \times 30 = 11498\cdot256$, the content; which being divided by 277¼ (the number of cubic inches in a gallon) will give the number of gallons contained in the cask.

Thus

$$11498\cdot256$$
$$277\cdot25$$

$= 41\cdot4725$, &c. Number of gallons required.

Note.-The content of any vessel in cubic feet, multiplied by 6·232 (or if in inches by ·003607) will give the number of *imperial gallons it will contain*.

EPITOME OF MENSURATION.

OF THE CIRCLE, CYLINDER, SPHERE, ETC.

1. The circle contains a greater area than any other plane figure, bounded by an equal perimeter, or outline.

2. The areas of circles are to each other as the squares of their diameters; any circle twice the diameter of another contains four times the area of the other.

3. The diameter of a circle being 1, its circumference equals 3·1416.

4. The diameter of a circle is equal to ·31831 of its circumference.

5. The square of the diameter of a circle being 1, its area equals ·7854.

6. The square root of the area of a circle, multiplied by 1·12837, equals its diameter.

7. The diameter of a circle, multiplied by ·8862, or the circumference multiplied by ·2821, equals the side of a square of equal area.

8. The sum of the squares of half the chord, and versed sine, divided by the versed sine, the quotient equals the diameter of the corresponding circle.

9. The chord of the whole arc of a circle taken from eight times the chord of half the arc, one-third of the remainder equals the length of the arc.

10. Or, the number of degrees contained in the arc of a circle, multiplied by the diameter of the circle, and by ·008727, the product equals the length of the arc in equal terms of unity.

11. The length of the arc of the sector of a circle multiplied by its radius, half the product is the area.

12. The area of the segment of a circle equals the area of the sector, minus the area of a triangle whose vertex is the centre; and base equals the chord of the segment.

13. The sum of the diameters of two concentric circles multiplied by their difference, and by ·7854, equals the area of the ring, or space contained between them.

14. The sum of the thickness, and internal diameter of a cylindric ring multiplied by the square of its thickness, and by 2·4674, equals its solidity.

15. The circumference of a cylinder multiplied by its length, or height, equals its convex surface.

16. The area of the end of a cylinder multiplied by its length, equals its solid content.

17. The area of the internal diameter of a cylinder multiplied by its depth, equals its cubical capacity.

18. The square of the diameter of a cylinder multiplied by its length, and divided by any other required length, the square root of the quotient equals the diameter of the other cylinder of equal solidity, or capacity.

19. The square of the diameter of a sphere multiplied by 3·1416 equals its convex surface.

20. The cube of the diameter of a sphere multiplied by ·5236, equals its solid content.

21. The height of any spherical segment, or zone, multiplied by the diameter of the sphere, of which it is a part, and by 3·1416, equals the area, or convex surface of the segment;

22. Or, the height of the segment multiplied by the

circumference of the sphere of which it is a part, equals the area.

23. The solidity of any spherical segment is equal to three times the square of the radius of its base, plus the square of its height, and multiplied by its height, and by ·5236.

24. The solidity of a spherical zone equals the sum of the squares of the radii of its two ends, and one-third the square of its height, multiplied by the height, and by 1·5708.

25. The solidity of the middle zone of a sphere equals the sum of the square of either end, and two-thirds the square of the height, multiplied by the height, and by ·7854.

26. The capacity of a cylinder 1 foot in diameter, and 1 foot in length, equals 4·895 imperial gallons.

27. The capacity of a cylinder 1 inch in diameter, and 1 foot in length, equals ·034 of an imperial gallon.

28. The capacity of a cylinder 1 inch in diameter, and 1 inch in length, equals ·002832 of an imperial gallon.

29. The capacity of a sphere 1 foot in diameter, equals 3·263 imperial gallons.

30. The capacity of a sphere 1 inch in diameter, equals ·001888 of an imperial gallon.

31. Hence the capacity of any other cylinder in imperial gallons is obtained by multiplying the square of its diameter by its length; or the capacity of any other sphere by the cube of its diameter, and by the number of imperial gallons contained as above in the unity of its measurement.

OF THE SQUARE, RECTANGLE, CUBE, ETC.

1. The side of a square equals the square root of its area.

2. The area of a square equals the square of one of its sides.

3. The diagonal of a square equals the square root of twice the square of its side.

4. The side of a square is equal to the square root of half the square of its diagonal.

5. The side of a square, equal to the diagonal of a given square, contains double the area of the given square.

6. The area of a rectangle equals its length multiplied by its breadth.

7. The length of a rectangle equals the area divided by the breadth; or the breadth equals the area divided by the length.

8. The side, or end of a rectangle, equals the square root of the sum of the diagonal, and opposite side to that required, multiplied by their difference.

9. The diagonal in a rectangle equals the square root of the sum of the squares of the base, and perpendicular.

10. The solidity of a cube equals the area of one of its sides multiplied by the length of one of its edges.

11. The edge of a cube equals the cube root of its solidity.

12. The capacity of a 12-inch cube equals 6·232 gallons.

Surfaces, and solidities of the regular bodies, when the linear edge is 1.

No. of Sides.	Names.	Surfaces.	Solids.
4	Tetrahedron	1·7320508	0·1178513
6	Hexahedron	6·	1·
8	Octahedron	3·4641016	0·4714045
12	Dodecahedron	20·6457788	7·6631189
20	Icosahedron	8·6602540	2·1816950

The tabular surface multiplied by the square of the linear edge, the product equals the surface required:

Or, the tabular solidity, multiplied by the cube of the linear edge, the product is the solidity required.

OF TRIANGLES, POLYGONS, ETC.

1. The complement of an angle is its defect from a right angle.

2. The supplement of an angle is its defect from two right angles.

3. The sine, tangent, and secant of an angle, are the cosine, cotangent and cosecant of the complement of that angle.

4. The hypothenuse of a right-angled triangle being made radii, its sides become the sines of the opposite angles, or the cosines of the adjacent angles.

5. The three angles of every triangle are equal to two right angles; hence the oblique angles of a right-angled triangle are each other's complements.

6. The sum of the squares of the two given sides of

a right-angled triangle is equal to the square of the hypothenuse.

7. The difference between the square of the hypothenuse, and given side of a right-angled triangle is equal to the square of the required side.

8. The area of a triangle equals half the product of the base multiplied by the perpendicular height;

9. Or, the area of a triangle equals half the product of the two sides, and the natural sine of the contained angle.

10. The side of any regular polygon multiplied by its apothem, or perpendicular, and by the number of its sides, half the product is the area.

Table of the areas of regular polygons whose sides are unity.

Name of polygon.	No. of sides.	Apothem, or perpendicular.	Area, when side is one or unity.	Interior angle.		Central angle.	
				°	′	°	′
Triangle	3	0·2886751	0·4330127	60	0	120	0
Square	4	0·5	1·	90	0	90	0
Pentagon	5	0·6881910	1·7204774	108	0	72	0
Hexagon	6	0·8660254	2·5980762	120	0	60	0
Heptagon	7	1·0382607	3·6339124	128	34 27	51	25 57
Octagon	8	1·2071068	4·8284271	135	0	45	0
Nonagon	9	1·3737387	6·1818242	140	0	40	0

Decagon	10	1·5388418	7·6942088	144	0	36	0
Undecagon	11	1·7028436	9·3656399	147	16 4 11	32	43 7 11
Dodecagon	12	1·8660254	11·1961524	150	0	30	0

The tabular area of the corresponding polygon multiplied by the square of the side of the given polygon, equals the area of the given polygon.

OF ELLIPSES, CONES, FRUSTRUMS, ETC.

1. The square root of half the sum of the squares of the two diameters of an ellipse multiplied by 3·1416 equals its circumference.

2. The product of the two axes of an ellipse multiplied by ·7854 equals its area.

3. The curve surface of a cone is equal to half the product of the circumference of its base multiplied by its slant side, to which, if the area of the base be added, the sum is the whole surface.

4. The solidity of a cone equals one-third of the product of its base multiplied by its altitude, or height.

5. The squares of the diameters of the two ends of the frustrum of a cone added to the product of the two diameters, and that sum multiplied by its height, and by ·2618, equals its solidity.

THE END.

FOOTNOTES:

[1] *Vide page* vi.

[2] The Articles omitted consist chiefly of directions, &c., or are not generally required.

[3] NOTE. *In the "Exercise and Movements."*

Commander's Words are printed in	SMALL CAPITALS.
Executive	Small print.
Directions, &c.	*Italics*.

[4] *Note.*—Vide "Motion," "Forces," &c., Velocity, Gravity, and Amplitude.

[5] Vide "Tables," "Excentric Shot, Experiments."

[6] *When a shot is jammed in a gun, and cannot be rammed home to the cartridge*, destroy the charge by pouring water down the vent, and muzzle until the ingredients are dissolved, and cleared out of the bore; then introduce a small quantity of powder through the vent, and blow out the shot.

[7] The recoil of guns on sleighs varies from four to five feet when on rough ground or in deep snow; to twenty or thirty yards when on glare ice. In the latter case it is of course necessary to send the ammunition sleighs further to the rear; but the recoil may be considerably lessened by placing a small chain round each of the runners.

Ice of eight inches thick will bear with safety a weight of 1115 lb. (or nearly half a ton) on the square foot.

[8] Old pattern.

[9] Further information relative to mixing the composition, and filling combustibles, &c., &c., may be obtained from the "Aide Mémoire," under the head, "Pyrotechny, Military."

[10] This will be discontinued when Shrapnell Diaphragm shells are generally introduced into the Service.

[11] *Vide* Practice Tables for Ranges, Elevations, &c.

[12] The composition for French cannon tubes is two parts of fulminate of mercury and two of mealed powder, mixed together: then formed into a paste with distilled water, slightly impregnated with gum arabic.

[13] Extracted from "Instructions and Regulations for Field Battery Exercise and Movements" for the Royal Regiment of Artillery: the Sections, &c., being similarly numbered.

Commander's Words are printed in	SMALL CAPITALS.
Executive	Common type.
Directions, &c.	*Italics*.

[14] The Sections, of which merely the heads are given, consist chiefly of details too long for the limited size of the Manual, and they are therefore necessarily omitted.

[15] When Guns are in action, and "CEASE FIRING" is given, all Guns then loaded are to be fired off, and on no account is a Gun to be limbered up, or to move whilst loaded.

[16] The Commanding officer's Word of command is always to be repeated by the officers.

[17] From "Field Battery Exercise."

[18] From "Field Battery Exercise," &c.

[19] From "Field Battery Exercise," &c.

[20] In the transport of horses to Turkey (July, 1854,) in the Himalaya and Simla steamers, the distance between the upright posts was 2 feet 1 inch in the clear per horse, and the length 9 feet.

[21] "For the guidance of the Farriers of the Royal Artillery. Suggested by Charles Percival, Veterinary Surgeon; and approved of by the Right Honourable the Master-General, and Honourable Board of Ordnance."

[22] In administering draughts to horses, the greatest possible care and attention are required; should the horse cough, or make an attempt to do so, his head must be instantly lowered, otherwise a portion of the drink will be apt to find its way into the trachea or windpipe, which will produce most distressing symptoms, and often be followed by death. In lowering the head, a can or vessel of any kind should be held under the mouth to catch the drink as it escapes.

[23] From "INSTRUCTIONS FOR THE SERVICE OF HEAVY ORDNANCE."—*Article 15.*

[24] *Words of command*—SMALL CAPITALS.

[25] From "Instructions, and Regulations for the Service, and Management of Heavy Ordnance, for the Royal Regiment of Artillery." Fourth edition. The Parts, and Articles are numbered in conformity thereto.

[26] *Words of command*—SMALL CAPITALS.

[27] Vide PART 12, "ARTILLERIST'S MANUAL," etc., The Mechanical powers. The Lever.

[28] By the ballistic experiment, conducted in May, 1837, it was found that, with a heavy 6-pounder gun, a charge of 1½ lb. gave a velocity of 1740 feet, and a charge of 2 lb. a velocity of 1892 feet per second. The shot employed were of a high gauge, windage only ·078 inch, and the powder was of the strongest quality; the weight of the pendulum fired into was 58 cwt. 3 qrs. 16 lb. A light 6-pounder, two feet shorter than the heavy 6-pounder, with similar charges, gave velocities of about 190 feet less.

[29] Extracted from PART 2, and APPENDIX of General Sir Howard Douglas' highly valued work, entitled "A TREATISE ON NAVAL GUNNERY." 3rd edition.

[30] *On wads for Heavy Ordnance.*

The presence of a compressible body, between the powder and the ball, is necessary for the preservation of the gun. The results of the experiments at Fere, in 1844; at Ruelle in 1844, and 1846; and at Gavres in 1848; with cast iron 30, and 24-pounders, proved that all the pieces, fired without a thin piece of cork interposed between the powder and the ball, burst before 500 discharges were made; whilst those, with which this precaution was taken, sustained 1800 and 2000 discharges without any damage, except an enlargement of the vent. *Vide* United Service Magazine, September, 1855.

[31] *Vide* "TREATISE ON NAVAL GUNNERY." 3rd Edition. By General Sir H. Douglas.

[32] *In Extreme training of a gun to the Right*: Nos. 3, 5, 7, 11, 13, are placed outside; Nos. 8, 6, inside the tackle. No. 13 keeps the end of

the fall coiled up.

In Extreme training to the Left: Nos 4, 6, 8, 2, are placed outside; Nos. 13, 7, 5, inside the tackle. No. 2 keeps the end of the fall coiled up.

[33] *In running out the right guns*, Nos. 3, 5, 5, 7, man the left tackle; Nos. 4, 6, 6, 2, man the right tackle.

In running out the left guns, Nos. 3, 5, 7, 5, man the left tackle; Nos. 4, 6, 6, 2, man the right tackle.

[34] *Note.*—When the direction of the gun is to be altered, the word "Traverse" is to be given, if the gun is in, and "Point," when the gun is out.

[35] *Vide* Sir Howard Douglas's highly-valued publication, entitled "A TREATISE ON NAVAL GUNNERY." Fourth edition.

[36] *Vide*—"United Service Magazine," No. CCCVIII.

[37] *Vide* FIELD FORTIFICATION, pages 246, 247.

[38] *Vide* Preface.

[39] For a square, the length of the perpendicular is ⅛th the exterior side; for a pentagon ⅐th; for the hexagon, and other polygons, ⅙th.

[40] *Vide* *Tables of Weights, and Measures*.

[41] *Vide Tables* of Weights, and Measures.

[42] In reducing fractions to a common denominator, and in multiplication of fractions, the work may be considerably diminished by cancelling any figures, which are in all the multiples; or by dividing a figure in each of them by any figure which can divide

all without any remainder.

[43] See Note, page 268.

[44] *To multiply decimals by 1, with any number of ciphers, as 10, 100*, &c.—This is done by only removing the decimal point so many places farther to the right hand, as there are ciphers in the multiplier, and subjoining ciphers, if need be.

[45] The best way of doubling the root, to form the new divisor, is by adding the last figure always to the last divisor, as appears in the following example.

After the figures belonging to the given number are all exhausted, the operation may be continued into decimals, by adding any number of periods of ciphers, two in each period.

[46] *This rule is only applicable to the very best-made new cordage. The circumference squared should be divided by 6 instead of 5 for the description of rope generally employed.*

[47] When the board is tapering, add the breadths at the two ends together, and take half the sum for the mean breadth. *Or else*, take the mean breadth in the middle.

[48] *To strengthen a beam, &c. which is required to support a great weight over a cavity, or ditch.* —Place a prop, or short skid, under the centre of the beam, and pass a strong rope, or chain, over the beam lengthways, and under the skid, hauling it very tight, and making fast.

[49] In Lieut.-Colonel B. Jackson's scientific "Treatise on Military Surveying, &c., &c., &c.," *Portable trigonometry without logarithms*, is thus introduced—

"The following useful application of

Trigonometry, by means of the natural sines, tangents, &c., is taken from an early number of that valuable periodical, 'The Mechanics' Magazine,' and will be found particularly suited to the purposes of the military surveyor."

[50] For further information on Surveying, and Reconnoitring, reference should be made to the highly-valued publication, entitled "A TREATISE ON MILITARY SURVEYING, INCLUDING SKETCHING IN THE FIELD, PLAN DRAWING, LEVELLING, MILITARY RECONNOISSANCE, &c.," by Lieut.-Colonel Basil Jackson, containing a full account of every surveying instrument, and the right adaptation of them.

[51] 1. The Reconnoitring protractor is not intended to supply the place of the Theodolite, or other expensive instruments, when very great accuracy is required in surveying, or in trigonometrical observations; but, in the hands of officers accustomed to the use of it, bearings may be rapidly taken, heights and distances ascertained, roads traversed, &c., &c., with sufficient accuracy for a military survey, or reconnoissance.

The protractor has a tripod, on which it is to be steadily fixed for taking angles, &c.; but the instrument can nevertheless be used without the tripod; and mounted officers may, after a little practice, make a reconnoissance with the protractor alone, especially if they are able to measure, or calculate the distance of base lines, by the length of the paces of their horses.

2. A survey, &c., may be very rapidly taken in the field, by laying drawing-paper on the face of the protractor, under the marginal scale,

fixing it firmly by means of drawing-pins in the sides, and using, at the first station, the edge of the index as a ruler to set off on the paper, at once, by observation through the sights, the angles of the objects whose distance is required; drawing a base line parallel to the tube side of the instrument, and also lines at the angles found. At the second station, the paper must be moved a few inches, for a base line to be drawn; at the termination of which (the second station) the index is to be directed to the objects, as before, and lines are to be produced until they intersect those drawn at the first station: thus the position of the objects will be obtained; and, by using the scale on the index for the length drawn for the measured base line, as well as for the lines directed to the objects, their respective distances will be ascertained.

3. The reconnoitring protractor, and all other instruments for surveying, &c., &c. can be readily obtained from Messrs. Elliott, 56, Strand, London.

[52] Or Reconnoitring protractor.

[53] To erect a perpendicular, *vide* "Practical Geometry."

[54]

3 inch cube full of air floats 1 lb. in water.
3 inch cube of water weighs 1 lb. in air.
1 cubic foot of water weighs 64 lb. in air.
1 ditto coal ditto 80 - 64 = 16 in water.
1 ditto sand ditto 95 - 64 = 31 in water.

A suit of clothes and a pair of boots, which weigh 7 lb. in air, when well saturated with water, only weigh in water 1 lb.

[55] *Vide also Definitions*—TRIGONOMETRY, page 301.

[56] *Gunter's chain* is in length 4 poles = 22 yards = 66 feet, and is divided into 100 links. Each link is therefore

$$\frac{22}{100}$$

of a yard, or

$$\frac{66}{100}$$

of a foot, or 7·92 inches. *Land is estimated* in acres, roods, and perches. *An acre* contains 10 square chains, or as much as 10 chains in length and 1 chain in breadth; or in yards it is $220 \times 22 = 4840$; or in poles it is $40 \times 4 = 160$ square poles; or in links it is $1000 \times 100 = 100{,}000$ square links. An acre is divided into 4 parts called roods, and a rood into 40 parts called perches, which are square poles, or the square of a pole of 5½ yards long, or the square of a quarter of a chain, or of 25 links, which is 625 links. Thus the divisions of land measure are—

625	square links	=	1 pole, or perch.
40	perches	=	1 rood.
4	roods	=	1 acre.

The length of lines, measured with a chain, should be set down in links as integers, instead of in chains, and decimals. Therefore, after the content is found, it will be in square links.

[57] 57·3 is the number of pounds of powder contained in a cubic foot, when shaken; and 55 pounds when not shaken. According to the first case, one pound of powder will occupy 30 cubic inches; and according to the second case one pound will occupy 31·4182 cubic inches.

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TRANSCRIBER'S NOTE

Footnote [37] is referenced six times from page 237;
footnote [52] is referenced twice from page 311;
footnote [54] is referenced four times from pages 317 and page 318.

Obvious typographical errors and punctuation errors have been corrected after careful comparison with other occurrences within the text and consultation of external sources.

Some hyphens in words have been silently removed, some added, when a predominant preference was found in the original book.

Some { bracketing in some tables has been adjusted or removed for readability.

Except for those changes noted below, all misspellings in the text, and inconsistent or archaic usage, have been retained.

Pg viii: page number '8' replaced by '48'.
Pg xvi: Added new section 'CONGREVE ROCKETS.' to the ToC.
Pg xviii: 'Embrasures' replaced by 'Embrazures'.
Pg xxi: '312, 313, 314' replaced by '312–4'.
Pg 61: 'thirty ronnds of' replaced by 'thirty rounds of'.
Pg 69: in the table header 'Fore | Diameter' replaced by 'Fore | Hind'.
Pg 72: in second column of the table '3¾' replaced by '2¾'.
Pg 80: '4⅗ inch Mortar' replaced by '4⅖ inch Mortar'.
Pg 85: in the table '5½ in c' replaced by '5½ inch'.
Pg 91: in LEVERS section 'lb. oz.' replaced by 'ft. in.'
Pg 171: in the table '1' replaced by '10'.
Pg 171: in the table '1209' replaced by '1200'.
Pg 176: 'to facilite the' replaced by 'to facilitate the'.
Pg 187: 'assist 2 at' replaced by 'assists 2 at'.
Pg 195: 'at an elevavation' replaced by 'at an elevation'.
Pg 222: 'a longe range' replaced by 'a long range'.
Pg 226: 'they ricoched and' replaced by 'they ricocheted and'.
Pg 226: the italic markup on the small table has been

removed.
Pg 227: ‘the same is in’ replaced by ‘the same as in’.
Pg 234: ‘left betweeen the’ replaced by ‘left between the’.
Pg 235: ‘placed at tho top’ replaced by ‘placed at the top’.
Pg 238: ‘embrasures should be’ replaced by ‘embrazures should be’.
Pg 291: ‘(5 × 1)’ replaced by ‘(5 + 1)’.
Pg 318: the footnote in the original book ‘See note, p. 317’ was redundant and has been removed.
Pg 320: ‘is is a’ replaced by ‘it is a’.

Footnote [7]: ‘to five eet’ replaced by ‘to five feet’.

*** END OF THE PROJECT GUTENBERG EBOOK THE ARTILLERIST'S MANUAL AND BRITISH SOLDIER'S COMPENDIUM ***

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