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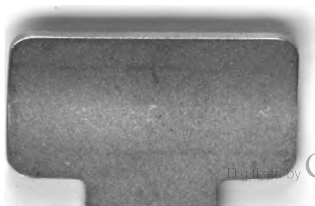
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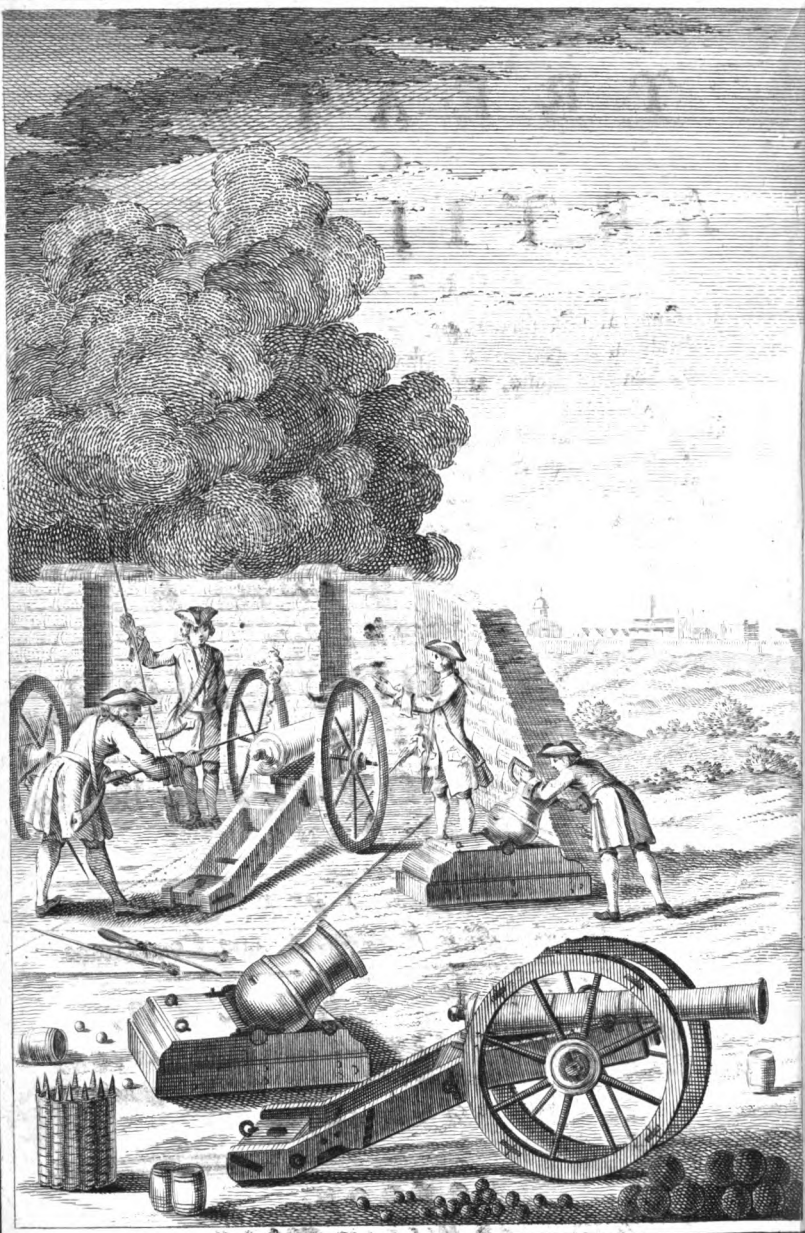




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| <p>I. General Constructions of Brass and Iron GUNS used by Sea and Land, and their CARRIAGES.</p> <p>II. General Constructions of MORTARS and HOWITZES, their BEDS and CARRIAGES,</p> <p>III. DIMENSIONS of all CARRIAGES used in ARTILLERY.</p> | <p>IV. EXERCISE of the REGIMENT at Home, and SERVICE Abroad in a SIEGE or BATTLE.</p> <p>V. Its MARCH and ENCAMPMENT, AMMUNITION, STORES, and HORSES.</p> <p>VI. Lastly, The necessary LABORATORY WORK for FIRE-SHIPS, &amp;c.</p> |
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To which is prefixed,

## An INTRODUCTION, WITH A THEORY of POWDER applied to FIRE-ARMS.

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The SECOND EDITION,  
With large Additions, Alterations, and Corrections.

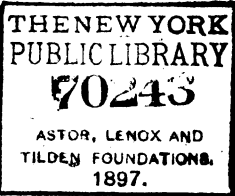
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By J O H N M U L L E R,  
Professor of ARTILLERY and FORTIFICATION,  
And Preceptor of Engineering, &c. to his Royal Highness the  
Duke of GLOUCESTER.

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L O N D O N :

Printed for JOHN MILLAN, Whitehall. 1768.  
Where may be had, MULLER'S Fortification, Artillery, and  
Mathematics, 3 Vols.



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HIS ROYAL HIGHNESS  
The Duke of GLOUCESTER, &c.

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His Royal Highness's

Most devoted,

Most obliged, and

Most obedient Servant,

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## INTRO-

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# INTRODUCTION.

**T**HE origin of fire arms and artillery is owing to the discovery of gunpowder; but when this was, or in what country, we are ignorant of: it is however probable, that it must have been in the eastern part of the world, because saltpetre, which is the principal ingredient, is found in great plenty in some provinces on the surface of the earth, and from thence is brought to *Europe* ever since its use has been known; and saltpetre being mixed with sulphur, or some other combustible substance, either by chance or otherwise, produced a power by its explosion not known before, whereby bodies could be thrown to a great distance.

It is generally supposed that the *Chinese* were the first that made this discovery; for *Ufano Valesco*, a *Spanish* author, mentions, that powder and guns were found in *China* in the year 85, by king *Vitey*; but whether it was known before in any other country is uncertain.

The first discovery of powder in *Europe* was made by *Bartold Schwartz*, a monk, at *Mentz*, in 1320, by accident; being a chymist, he happened to mix some saltpetre with sulphur in a mortar, and covered it with a stone; the composition accidentally taking fire, the explosion blew the stone to a considerable distance. This suggested the notion, that if this composition was properly confined, it might be useful in the attack and defence of places: and from thence the invention of guns may be dated in *Europe*.

*Roger Bacon*, who lived about 50 years before, mentions a composition known in his time, by which thunder and lightning could be imitated: *Schwartz* was the first who applied it to military uses.

It is said that the *Venetians* made the first use of guns at the siege of *Claudia Jessa*, now called *Cbioggia*, in 1366, which were brought there by two *Germans*, with some powder and leaden balls; but father *Daniel* proves from records, that the *French* had guns in 1338. As the invention of guns is so immediately connected with that of powder, it could not well be otherwise than that *Schwartz* was the inventor of both; and that they were from thence carried to *France*, and afterwards to *Italy*.

Some authors say, that the first guns were made of iron bars laid lengthways, and kept together with strong iron hoops; and others, with thin sheets of iron rolled up together and hooped; but which way they were made, it must have been in a rude and imperfect manner, like the first essays of many new inventions.

The first guns were but small, and their shot of lead; but afterwards, when their use became better known, they were cast of gun metal, and of extraordinary size; and their shot were made of stone: for the *Turks* had some at the siege of *Constantinople*, that threw a weight of 500 lb. and *Louis XI.* had one cast of the same size; many others are mentioned in history, who carried shots that weighed from 80, 90, to 100 pounds.

But as these guns were so very heavy, and could not be transported without great difficulty, they have been reduced to smaller calibers, and made their shot of iron. Since that time the largest caliber that were used was a 48 pounder; but at present no larger are made in the land service than 24; and at sea 42 pounders.

It was long imagined, that the more powder a cannon was loaded with, the greater its execution would be; for which reason they were loaded with as much powder as their  
their

their shot weighed, and to resist so great a force, they were made very heavy, and of a great length, in order to give time to the powder to burn all before the shot left the piece.

This great charge was diminished afterwards to two thirds, and then to one half, without lessening the weight of the guns, or their length. The chevalier *Belidor* made some years ago several experiments relating to the charge of battering pieces, whereby he found that one third of the weight of the shot was sufficient, and the *French* used no more during the two last wars: it is very probable that less might do; for some experiments were made at *Woolwich* with light field pieces, and it was found that one fourth and even one fifth was sufficient for the charge of these pieces.

Notwithstanding the great importance it would be to a nation to have its artillery carried to such perfection, as to make use of as little metal and workmanship as possible, and at the same time to bring as many and as large calibers into the field as others, thereby reducing its immense expence to as little as is absolutely necessary; yet it will be found upon examination, that very little improvement has been made in the proportions of guns since *Dilichius*, a *German*, who wrote near 200 years ago.

It is true *St. Remy*, a *French* author, published in 1723 the most compleat and extensive Treatise of Artillery, in two volumes in quarto, that is extant; which has since been much improved in the last *Paris* edition, in three volumes, published in 1745, containing all the improvements made in the artillery since the first edition: but as it is only a collection of memoirs he received from the different artificers employed in these works, and who had no other knowledge than bare imitation, it could therefore not be expected that what they transmitted to him was grounded upon such mechanical principles as depended upon mathematics, without which no real improvements can be made.



All the authors that wrote since have done no more than copied his works in an imperfect manner, even the *German* authors follow him ; though it is plain that the *French* have chiefly copied *Dilichius* : for their field carriages are exactly the same to this day as he has delineated them in his work ; and as to the alterations they have made in the proportions of guns, they are trifling and very little to the purpose.

If we consider the various lengths and weights that have been given to pieces of artillery at different times by all nations, it will appear, that no principle is so uncertain and unsettled as that upon which the artillery artificers have grounded their constructions. For in queen *Elizabeth's* time they made some 18 pounders 24 feet long, calcable included, such as the culverin in *Dover-Castle*, and that at *Nancy* ; and in king *Charles* the second's, Count *Mansfield* made some 6 pounders that weighed but 180 lb. and 25 pounders of 700 lb. as is related in the account of the siege of *Breda* by the *Spaniards* under the command of *Spinola* ; and about the same time the *Spaniards* cast some others not much heavier ; one of them we had at *Woolwich* was 7 feet long, weighed only 21 : 3 : 4, and carried a shot of about 41 pounds of our weight.

Though these light pieces were then highly esteemed for their easy carriage and facility of working, yet much heavier and longer have been made ever since without any manner of reason, till 1744, when Colonel *Weideman*, a *German*, brought light pieces in use again as a new invention of his own. His pieces were made of sheets of copper rolled up and soldered together ; they were so very light, that a 6 pounder weighed no more than two hundred and a half, and yet stood all the proofs that were required.

This gave rise to our light field pieces ; but it was not without great difficulty that they were received, and no less than the express command of his royal highness the late duke of *Cumberland* could have prevailed over the

## INTRODUCTION.

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the servile attachment for an old established custom, though ever so erroneous, which, when once covered by the veil of time, becomes in a manner sacred.

But even lighter field pieces than the present might be used; for on the 12th of *June* 1751, some experiments were made on *Putney-Common* by baron *Stark*, a *German*, with a piece made of a new metal of his invention; which piece was a 6 pounder of 3 feet and a half long, and weighed 3 : 2 : 0, as he said, and it was fired 300 rounds in three hours and 45 minutes, being loaded each time with a pound and a quarter of powder, without receiving the least damage.

This trial being reported to lord *Ligonier*, then master general of the ordnance, he and the rest of the principal officers of the board resolved to try our light 6 pounders, in order to know whether they would stand the same trial or not; and accordingly, on the 15th of *June*, my lord pitched upon one amongst those that had been used at the battle of *Lafeldt*. This piece was four feet and a half long, and weighed 4 : 3 : 0; and after being fired 300 rounds in three hours and 27 minutes, loaded with the same charge as that above, was found not to have received the least damage. The same trial has been repeated afterwards with a gun of the same dimensions as the former, which had been made by another founder, and it succeeded equally as well.

These trials shew, that those light pieces are sufficiently strong for any action ever so obstinate; and that pieces in general may be made lighter than they are at present, appears from several other trials made since with light brass pieces, according to my construction, as will be shewn hereafter.

It is said that such light pieces would not do for battering breaches, nor on board of ships, because of their recoiling too much; but it should be considered, that batteries made upon these occasions are always, or ought to be near the object, and the charges now used are but half the former, because a shot, which has a sufficient

velocity just to enter the wall, shakes it more and destroys it sooner than if the velocity was much greater. This is a matter of fact grounded upon experience.

It is supposed at present, that no less caliber than a 24 pounder will do to make a breach: and it may so happen, that the heavy pieces cannot be carried through bad roads, as in *America*, or over high hills, as in *Scotland*. Upon these occasions it seems to be absolutely necessary to have light pieces: for which reason we have given a new construction of light pieces in page 62, where the weight of a 24 pounder is 18 : 1 : 5; which differs in some things from those used at present: because mine are made the same number of calibers long, and their weights in proportion to that of their shot, as we shall prove hereafter they should be; whereas the large calibers of the present are made shorter and lighter in proportion than the small; and it has been found by experience, that the present light 24 pounders recoil too much, let the hind part of the platform be ever so much raised.

Artillery has hitherto been considered merely as practical, without conceiving that for want of the mechanical principles, deduced from mathematics, no improvements can possibly be made. For all the experience of the artillery officers cannot be of any use in the construction of pieces, as their business is to make the best use of them, and not how they are made, neither are they ever consulted upon that subject.

To put the artillery upon a better footing than it has hitherto been, proper experiments should be made in time of peace, and by such as have sufficient knowledge, so as to be able to draw just inferences, which is seldom the case, as it appears by those hitherto made, and which will be inserted hereafter, where it will be shewn how little the most of them may be relied on.

It is certain, that in most cases common geometry and the principles of mechanics is sufficient; but there are others which cannot be determined without the higher principles

principles of mathematics. For how can the velocities of shots and shells be determined, without being acquainted with the laws of resistance, and which cannot be known without the use of fluxions, nor the finding the curve described by the shot, which is one of the most intricate cases? Again, the proper length and charges of pieces cannot be determined without the laws of motion in a resisting medium: it is true that experiments may be made for that purpose; but how far we may depend on them, without being confirmed by a proper theory, will appear hereafter.

A remarkable custom has prevailed all over *Europe*, which is the making smaller calibers much longer in proportion than those of a higher nature; imagining, I suppose, to increase thereby the velocity of the shot, without knowing that a piece may as well be too long as too short: as long as this pernicious custom prevails, no improvement can be made in artillery; for as a greater number of small calibers are used than large, and the small are thereby as heavy again as they need be, were their length of a just proportion.

Had it been known that every caliber has but one determined length and charge by which it will carry its shot farther than any other greater or less, and that it cannot exceed a determined velocity, let the shot be impelled by any force whatever, and that these velocities are always in proportion to the diameters of the shot, this practice would not have been followed. But as the demonstrations of these principles depend on the method of fluxions, which would not have so well suited in a practical treatise as this, I was obliged to write a treatise, where every thing relating to artillery, not inserted here, will be found.

To settle artillery upon a proper foundation, we shall relate all the most remarkable experiments made here and abroad, beginning with those inserted in *St. Remy's* memoirs, volume i. page 114, which are said to be the oldest upon record.

It is easily perceived, that no dependance can be had on these experiments. For it is a plain contradiction, that the point blank ranges of a 24 and 16 pounders should be longer than that of the 33 pounder; and that the random range of these last guns should be no more than that of the 24 pounder. Again, the 16 pounder random range to be so much greater than the rest.

Ranges in Paces.

Calib.	Point blank.	At random.
33	600	6000
24	800	6000
16	800	8000
12	450	5000
8	300	3000
4	150	1500

As neither the length and weight of pieces, nor the weight of the charges are mentioned, though the experiments were true, no useful inferences can be drawn from them.

Monsieur *du Metz*, lieutenant general, made in his time the following experiments on the ranges of guns, by which he found that the *French* pieces loaded with two thirds the weight of the shot, and those of the new invention loaded with one third, ranged the same distances when elevated at an angle of 45 degrees.

As neither the length or the weight of the pieces are mentioned, nothing can be concluded from these experiments. It is surprizing that *St. Remy* did not mark the dates of these experiments, nor what the *French* pieces were at that time, as well as those of the new invention. If I may venture to guess, their length were 10 feet, all except the 8 and 4 pounders, which were only 8 feet, according to the second table hereafter; and those that are called of the new invention had spherical chambers.

If

Calib.	Ranges.
24	2250 Toises
16	2020
12	1870
8	1660
4	1520

If this be true, all that can be concluded is, that 10 feet is a better length for a 24 pounder than for any other caliber, when loaded with a weight of powder equal to the two thirds of their shot; but as no piece is loaded at present with that charge, these experiments can be of no use.

There are several tables of the lengths and weights of the *French* pieces used at different times not specified, except the last of the present.

That which seems the oldest is the following, pag. 73, volume i.

This table shews how rude and imperfect the first trials of artillery were, and what enormous length the smaller calibers were made in those times.

It is also to be observed, that the 24 pounder, tho' 13 feet long, weighed no more than 4300 lb. whereas the present of 10 feet weigh 5400 lb. If the former were found to be sufficiently strong, what could induce them to load them with so much metal now? All that can be said is, that if experiments are made for a particular fancy only, and are not enquired into by the successors, all the attempts an author can make for improvement are vain and useless to the public.

TABLE I.

Calib	Length.	Weight.
	Feet Inch.	
48	10 : 0	7200lb.
40	16 : 6	7000
32	22 : 0	7200
24	13 : 0	4300
20	16 : 0	7000
16	18 : 0	4200
12	11 : 0	4250
10	13 : 0	3850
8	15 : 0	3500
4	12 : 6	2500

In the table facing page 207, vol. ii. are marked the following dimensions.

This table shews, that the length and weight of pieces were better proportioned in that time than they were before : but that the length of the 24 and 16 pounders should be the same as that of the 33 ; as likewise the 8 and 4 to be of the same length, shews the little reasoning made use of in that time.

The last regulations that were made in 1732, and which are followed at present, may be seen in the next table. It is evident, that the lengths and weights were not deduced from any solid reason, but from the fancy of those who are most at the head of that branch.

That the weight of these guns is greater than they need be, appears from our iron 24 pounders weighing no more than 4800, which is even too much, as will be shewn hereafter ; and according to this proportion, the set of them contains 3250 lb. of metal more than the strongest construction requires.

It must be observed, that the *French* reckon by the neat weight, and not by 112 pounds for a hundred weight, as we do ; but it is shewn in page 11, that 100 *French* pounds weigh something more than 114 of our

TABLE II.

Calib.	Length.	Weight.
33	10 : 0	6200lb.
24	10 : 0	5100
16	10 : 0	4100
12	10 : 0	3400
8	8 : 0	1950
4	8 : 0	1300

TABLE III.

Calib.	Length.	Weight.
24	10 : 1.5	5400lb.
16	9 : 6	4200
12	9 : 0	3200
8	8 : 1	2100
4	6 : 9	1150

our pounds; so that a *French* hundred neat weight is more than our hundred of 112 pounds.

We shall now come to the experiments made at home, or under the direction of *English* officers. The first on record that came to my knowledge are those made by general *Armstrong*, surveyor-general, in 1736, which are:

The length of these pieces are expressed in feet and inches, and the ranges in yards: out of a great many trials, three of the longest ranges of each piece are set down here. All these pieces were brass 24 pounders, and all weighed nearly 5200, and were always loaded with two thirds of the shot's weight, that is, with 16 pounds.

Length.	Range.	Range.	Range.
10 : 6	2486	2614	2406
10 : 0	2570	2532	2436
9 : 6	2633	2560	2500
9 : 0	2796	2494	2563
8 : 6	2586	2490	2466
8 : 0	2438	2470	2453

The intent of these experiments was to find the best length for a battering piece, when loaded with the common charge then given; and that of 9 feet 6 inches was fixed upon as the best, though the first and last of the 9 feet ranges were the longest of those in the same columns: this was owing, I suppose, to this length being more convenient for battering than that of 9 feet long.

If we examine strictly into these experiments, it will be found, that no improvement can be made from them. For no two guns can be equally bored, and the least difference may cause a considerable one in the ranges: nor no two vents can be pierced so as to come out at the same distance from the bottom of the bore, which is of the greatest consequence, as we shall prove from repeated experiments.

Length



Length.	Number.	Elevation.	Ranges in Yards.	Powder.
11 Feet.	1	6 Degrees.	1780	9 Pounds of Powder.
11 Feet.	2		1750	
9 Feet.	3		1725	
9 Feet.	4		1725	
9 Feet.	5	6 Degrees.	2000	
9 Feet.	6		1830	
9 Feet.	7		1965	
9 Feet.	8		2018	
11 Feet.	9	7 1/4 Degrees.	1860	
11 Feet.	10		1935	
11 Feet.	11		1960	
11 Feet.	12		2048	
9 Feet.	13	7 1/4 Degrees.	2060	
9 Feet.	14		2165	
9 Feet.	15		2050	
9 Feet.	16		2272	
11 Feet.	17	10 Degrees.	2490	
11 Feet.	18		2395	
11 Feet.	19		2567	
11 Feet.	20		2670	
9 Feet.	21	10 Degrees.	2910	
9 Feet.	22		2780	
9 Feet.	23		2790	
9 Feet.	24		2577	
11 Feet.	25	12 Degrees.	3016	
11 Feet.	26		2720	
11 Feet.	27		2800	
11 Feet.	28		3000	
9 Feet.	29	12 Degrees.	2712	
9 Feet.	30		2910	
9 Feet.	31		2955	
9 Feet.	32		3070	

11 Feet.	33	15 Degrees.	3185	9 Pounds of Powder.
11 Feet.	34		3095	
11 Feet.	35		3400	
11 Feet.	36		3185	
9 Feet.	37	15 Degrees.	3532	
9 Feet.	38		2940	
9 Feet.	39		3460	
9 Feet.	40		3725	
11 Feet.	41	10 Degrees.	2550	
11 Feet.	42		2377	10lb.
11 Feet.	43		2365	—
11 Feet.	44		2575	—
11 Feet.	45	10 Degrees.	2495	11lb.
11 Feet.	46		2375	—
11 Feet.	47		2520	—
11 Feet.	48		2605	12lb.
11 Feet.	49	10 Degrees.	2645	—
11 Feet.	50		2730	10lb.
11 Feet.	51		2380	—
11 Feet.	52		2445	—
11 Feet.	53	10 Degrees.	2200	11lb.
11 Feet.	54		2780	—
11 Feet.	55		2550	12lb.
9 Feet.	56	45 Degrees.	4160	9 Pounds.
9 Feet.	57		4135	
9 Feet.	58		4100	
9 Feet.	59		3970	
9 Feet.	60	45 Degrees.	4015	
9 Feet.	61		3980	
9 Feet.	62		3700	
9 Feet.	63		3960	10lb.
9 Feet.	64	45 Degrees.	3945	—
9 Feet.	65		3785	11lb.
9 Feet.	66		3930	—
9 Feet.	67		3802	12lb.

But

But supposing all the pieces were exactly bored alike, and the vents placed the same, what other conclusion could be drawn from these experiments, than that the best length of a 24 pounder is 9 feet 6 inches when loaded with 16 pounds of powder? It is not probable, that if a less charge was used, as at present is the case, this length would be the best; neither can we draw any inferences from them in respect to the length of greater or smaller calibers.

It is not sufficient to make experiments without any intention of their being useful towards the improvement of artillery in general, and such as proper conclusions may be drawn from them; otherwise the greatest use they can be of, is to determine some particular cases only, which are by no means sufficient.

The best and most useful experiments that have hitherto been made, are those of general *Williamson's*, assisted by major *Hislope*, and several other officers of artillery, which I shall insert here, as taken from major *Hislope's* account.

EXPERIMENTS made at *Mabon* in *Minorca* in 1745, with two iron 18 pounders, one of 11 feet long, which weighed 51 : 0 : 5; and the other of 9 feet weighed 39 : 1 : 3. They were fixed upon a rocky ground, and so contrived as to be elevated to any number of degrees.

Hence it appears, that when the pieces were loaded with 9 pounds of powder, the range was greater than when loaded with more or less.

Again, that the pieces of 9 feet long carried farther than those of 11, in almost all the same circumstances, though the first is lighter than the second; which shews that the length of the ranges does not so much depend on the weight, as on a proper length, and on a proper charge.

The accuracy of these experiments is confirmed by the theory: for we have proved in our appendix, that the greatest range an 18 pounder can have, when elevated to 45 degrees, cannot be quite equal to 4190 yards,

yards, because we have supposed such a velocity as the shot cannot possibly have, but may continually approach it.

Now as the greatest range in these experiments is 4160 yards, which differing only by 30 yards, the computed ones evidently prove the accuracy of these experiments; and it proves with no less certainty, that 9 pounds of powder communicated the greatest velocity to the shot that it possibly could receive by any force whatever.

When thus experiments agree with a theory founded upon unexceptionable principles, there cannot remain the least doubt of their certainty.

As 9 feet is nearly 21 diameter of an 18 pounder shot, and 9 pounds of powder half the weight of the shot; and it is presumed that pieces, whose lengths and charges are proportional, will have their ranges likewise so; because their greatest velocities are proportional to the diameters of the shot, as we shall prove in the appendix: we may conclude with some degree of certainty, that if the length of a piece of any caliber be 21 diameters of its shot, and loaded with powder equal to half the weight of the shot, it will carry farther than any other of the same caliber, either longer or shorter, loaded with any charge whatever.

Thus we have at last determined that important question in artillery sought for ever since its invention; but to be entirely convinced of the truth of our determination, more experiments of this kind should be made with various calibers; but care should be taken that they may not be liable to any exception.

The most certain way of proceeding, in my opinion, would be, to cast a gun of any caliber of 22 diameters of its shot long; to examine whether it is truly bored, and that the vent comes exactly out at the bottom of the bore; then let it be fired with various charges and elevations, till there is a sufficient proof of its best charge; this being done, a part of the piece must be sawed off the length of its diameter, and the first trials repeated

repeated as before: and when the best charge and its range are ascertained, the length of the piece must be diminished again by the length of the diameter of its shot. These trials being continued till the greatest ranges diminishes, then the best length and charge will be ascertained of that caliber; and those of any other caliber may be found in the same manner. The only care to be taken in these experiments, is to mix well the powder, and to dry it in the sun, that it may have always the same strength as nearly as possible: another caution must be taken, which is, to make these experiments in clear and serene weather, and of the same heat, because the powder will act more violently in a cold frosty morning than in hot weather, as we shall shew.

Though it is proper to know the best length and charge of a piece, yet in real service their length depends mostly on the use they are made of, according to the different circumstances: thus ship guns should be short and light, so as to be easily housed and loaded, because the rammer handle is made of rope; in long pieces it must be bent, which requires great care to ram the powder and shot home; and when this is not done, the priming fires without the powder, which is always in cartridges; the sailors thinking that the shot was discharged, load it again, and miss firing as before. This has been found so for three times running, and when at last the powder in the first cartridge takes fire, often bursts the gun, and destroys the sailors placed near to serve it; whereas when the guns are short, the rammer handles may be made of wood in all small calibers, and the service become more expeditious. Besides, ships now come so near to one another, that the shots are not required to go so far; provided it takes place it is sufficient.

The only objection against light guns is, that if they recoil too much, they will be apt to tear their tackle; but it has been found by experience, that half the usual charge is quite sufficient, and perhaps less. If then the charge is diminished, the weight of the gun may likewise

wise be diminished, without increasing the recoil. This should however be done with discretion, and not without proper trials ; for hazards should be avoided as much as possible.

Field pieces or battalion guns should be short and light, in order to be able to advance or retreat as fast as the army ; such are those we make use of at present, with very little alterations in the calibers above a 6 pounder.

Battering pieces, on the contrary, should be of a proper length to enter into the embrasures, that by their blasts they may not destroy them too soon, because it cannot be prevented entirely ; for which reason the gunners repair them every evening when it is dark.

With regard to garrison pieces, their length should be such as that the shot may go farthest, because in a siege they will oblige the besiegers to open their trenches at a greater distance, which is generally without gun shot ; and in a fort placed near a navigable river, or the sea, they will reach the ships, when the ships cannot reach the fort.

For these reasons we make in our new constructions the length of light field pieces 14 diameters of their shot, the ship guns 15 of those diameters, and the battering as well as the garrison pieces 21 ; whereby the 24 pounder for battering becomes 9 feet 8 inches long, which is 2 inches more than the usual length. We might likewise use a 32 pounder, which, according to our construction, page 52, would weigh but 5400, that is, only 200 more than our present brass 24 pounder.

The intent of the following experiments, which I made in 1753 with two small mortars, was to find the properest place of the vent, and the best figure of the chambers : their bore was three inches, and 7.5 long ; one had a cylindric chamber of one inch diameter, and two long ; the other a concave in the shape of an egg, with a small cylindric entrance of half an inch diameter, and the inside terminated by a sharp edge. Both these chambers held an ounce of powder at first, but widened by

by firing so as to hold an ounce and a quarter afterwards. Each had two vents, one in the middle, and the other at the bottom; I had a screw to stop one when the other was used: the mortars weighed 36 pounds each, and the shells 2 pounds 7 ounces at a medium. We have not marked the angles of elevations, because they were unnecessary, only so far as that they were the same, when the lower and upper vents were compared.

Pdr.	Vent	Cylind.	Concave	
One Ounce.	Middle.	630	750	Loaded with the common shooting powder. Weather cool in the morning, and sultry afterwards.
		630	730	
		600	686	
		550	722	
		560		
	Lower.	806		
		900		
	Middle	800	889	With common ordnance powder. Weather warm and windy.
		756	875	
864		877		
1 1/4 Ounces.	Lower.	1100	1194	With the best ordnance powder. Weather warm and windy.
		1023	1088	
		1003	1121	
		1020	1122	
		1020	1200	
		Ranges in Yards.	Ranges in Yards.	

Colonel *Desaguliers* and myself made several other experiments, together with a mortar of the same size that had several shifting chambers. The substance of what was most remarkable in them are as follows:

A narrow cylindric chamber of about four inches long holding 12 grains of powder, being loaded with 6 grains by means of a thin cartridge: when the powder was placed close to the shell, so as the lower part of the chamber

chamber was empty, and fired by means of a quick match introduced through the vent; and after this, it was loaded again with the same charge placed at the bottom of the chamber, and the empty space between the shell and the powder; the shell went near twice the distance in the first experiment that it did in the second, and when the powder was placed in the middle of the chamber at an equal distance from the bottom and the shell, the distance or range was a mean between the two former. These experiments were frequently repeated, and the ranges in the first case were always nearly double those in the second. From what cause it may proceed that the same quantity of powder, placed in the same space, should produce such various effects, is not in my power to conjecture.

The same mortar being loaded with the same quantity of loose powder, I put a little piece of writing paper upon it, by which the shell went much farther than when loaded with the same quantity of powder without paper.

Three cylindric shifting chambers of different lengths holding the same quantity of powder, produced the same range when full; but when they were not quite filled, the longest produced the greatest range.

Two chambers in the form of a frustum of a cone, the largest base was at the bottom in one, and the smallest of the other; the first carried the shell farther than the second.

The colonel tried two experiments more; the one between grained and mealed powder; and they were both found to be of an equal strength: and the other he put a small phial filled with water into the chamber amongst the powder, and found its strength considerably increased; that is, the shell went farther with the water than without it. The colonel tried likewise a cylindric chamber of about four inches long, with four vents, one at the bottom, one at the upper end, and two in the

the middle, all four at an equal distance from each other, so that when one was used, the others were stopped by screws; and he found that the lowest carried the shell farthest, and the ranges of the others diminished in proportion as they were distant from the bottom.

Many useful observations may be made on these experiments. First, that the vent placed near the bottom of the chamber is more advantageous than any where else; though this has been found so in mortars, we are not certain that it is the same in guns, which should therefore be tried; and if it be found the same, the query is, whether the bottom of the bore should not be flat, instead of roundish, as is the custom, or to pierce the vent from the breech moulding, as colonel *Weideman* did, or else as the *French* do in some of their mortars, with a small cup at the end of the chamber to receive the vent. From hence it appears how inaccurate experiments have hitherto been made, and how necessary it is to make new with all the necessary precautions, in order to improve artillery, and to bring it to perfection.

Before these experiments were made, it was imagined, that when the vent is in the middle of the chamber the range would be the greatest, because if a tube filled with powder was lighted in the middle, the powder would be burnt in half the time it would if lighted at one end, and it was supposed that the greater quantity burnt before the shot was sensibly moved from its place, the greater force it would receive; but notwithstanding this plausible reason, experiments have evinced the contrary.

The next observation to be made is, that the concave chamber is preferable to the cylindric, and this to any other; which has not hitherto been considered: the *Spaniards* make theirs spheric, the *French* in the shape of a pear; and we conical. The various opinions authors and artillerists have concerning the figure of chambers are very extraordinary. The chevalier *Belidor* esteems the conical the best; but his reasoning concerning the pro-



erties of different chambers in page xxiv. of his *Bombardier François*, are so very weak and inconsistent, that it is needless to answer them : how so great a man as he is in all other respects could descend to such vulgar errors is inconceivable.

Mr. *Robins*, in page 41, old edit. pretends, that the figure of a chamber has no effect upon the action of powder, without shewing the least reason for his assertion. Count *Bukeburg* will have a parabolic form, imagining, that if the fire was introduced to the focus, the rays of lighted powder would, by the nature of the figure, reflect into parallel direction in the same manner as the rays of light : supposing this was true, the shell would not receive a greater force by it, because a fluid acts always in a perpendicular direction to the surface it strikes ; thus in a globe the directions of the fluid tend all to the center, as we shall prove in the fifth theorem ; and when all the forces are reduced to the direction of the shell, it is that force reunited into one direction that produces the real effect, and not the partial ones. This not only refutes what his lordship said, but likewise *Belidor* and *Robins*, as having all split upon the same rock. It is not the inward figure of the chamber, but its entrance, which produces the effect ; because the smaller it is, the nearer it reduces the effect into the direction of the shell. This is likewise proved by the practice of making sky-rockets, which being choaked at the end, by which it confines the force of explosion into a narrow stream, and increases its violence so as to make the rockets rise so high as they do ; whereas if the opening was not confined, they would scarcely rise at all. The notion that a concave chamber with a narrow neck shakes the mortar violently without increasing the force of explosion, or the range, is so inconsistent with the laws of motion, that it merits not the least attention.

It is the general opinion of the artillery officers, that a mortar or gun carries farther when it is warm by much firing than when cold, or in the heat of the day than in the

the morning. The constant practice by sea and land is, that when the guns are much heated to diminish their charges, from the notion that they carry them much farther; which is a mistake. For when guns are much heated, they are liable to be spoiled; and it is prudent to lessen their charges in that case. For it appears from my first four experiments made in the cool of the morning, that the ranges were greater than those when the weather grew warm. The chevalier *Belidor* made several experiments for that purpose, which I have seen, and which are mentioned in general only in his *Bombardier*, page xxxviii; but the particulars are as follows: several mortars were fired in the cool of the morning; the same trials were repeated in the middle of the day when it was very hot, and the ranges in the morning were always greater than those in the heat of the day: but as this was not sufficiently satisfactory, the chamber of a mortar was heated with lighted charcoals as hot as could be without endangering the powder from taking fire; the range in this state of heat was much shorter than when the mortar was quite cold. It is true that heat will dry the powder, and gives it a greater force, if it remains a certain time in the chamber, which is not the case in brisk firing; and dried powder is better than when it is damp; yet the elasticity of the air is much increased by cold, and relaxed by heat; I mean from the state of the atmosphere.

Having said every thing necessary in respect to the length of guns, we are now to consider their thickness or strength of their several parts, which should be proportional to the efforts of fired powder; but its absolute force cannot be determined otherwise than by experiments. The weight of the guns depends on the charge of powder, and on their length; and though the charge has been lessened from that given formerly, yet the thickness of metal remains in general the same; nor have the experiments with light guns mentioned before,

prevailed as yet in diminishing the weights of larger calibers.

I had two brafs 12 pounders cast for admiral *Keppel*, according to the construction in page 54; they weighed 13 : 1 : 0, which stood the full ordnance proof; the old weigh 29 : 1 : 0.

I had also several eighteen brafs pounders cast for the *India* company; some of them were lately proved at *Woolwich* with fifteen pounds of powder, though the charge in service should not exceed six pounds: they weigh 2400, and are 9 feet long: a 24 pounder would in the same proportion weigh 3200, and their length 9 feet 8 inches. I look upon this proportion to be sufficiently strong for brafs battering pieces, though much lighter than the present; even a 32 pounder of that length would weigh only 4200, and in my opinion make better battering pieces; because the largest shot makes a breach sooner than a smaller, and the ancients made use of 48 pounders for that purpose; but on account of their unweildiness they were reduced to 24 pounders, not that they were better, but more manageable. That these guns are sufficiently strong appears not only from their proof, nor that they weigh twice as much as those of the light nature, but likewise from some old 32 iron pounders cast in king *Charles* the second's time; some of them remain serviceable to this day, and they weighed 4200 only.

The first cast guns were made of what is called gun metal, and this metal continued for a great while before cast iron was used; but in time, as artillery became more in use, the number of cannon became very great, and to lessen the expence iron guns were invented; but the opinion of their being liable to burst when much heated by firing, was the cause of making them heavier than the brafs; and as some did burst in effect, either through wrong management, or the unskilfulness of some founders, this notion has prevented the more general use that might be made of them to this day. But for what reason

reason we make them much heavier now than in king *Charles's* time cannot be accounted for ; for the present 32 and 42 pounders weigh 54 and 55 or 56 hundreds ; whereas they weighed formerly only 4200 and 5200. This cannot be owing to better ore, or to more skilful founders ; because I have seen iron cast by the *Carron* company that could not be broke by any means, but would flatten and tear like brass. I had two iron three pounders cast by that company for lord *Egmont* that weighed 3 : 3 : 0 each, which stood the full ordnance proof with three pounds of powder ; whereas their charge in service should never be more than one fourth, or at most one third of that quantity. I had since two six and two twelve pounders cast by the same company for the *Portuguese* service ; the first weighing 7 : 3 : 0, and the others 15 : 2 : 0 ; and though they are not yet proved, I will answer for their strength. The old 6 pounders weigh 17 : 1 : 0, and the 12 pounders 32 : 2 : 0.

That iron pieces are preferable to brass evidently appears from the experience we had in the last war ; for at *Belleisle* the brass guns were soon rendered useless, and iron ship guns were used to finish the siege. I have been assured by several artillery officers, that in all the sieges we made in the last war, they were obliged to use iron guns, because the brass did never stand great firing, though they weigh 400 more than the iron.

This is easily accounted for, because gun metal is a composition of copper and tin ; the copper requires a red heat to melt, and tin only a common fire ; so that when the gun is heated by much firing, the tin melts, and the copper alone remains to support the force of explosion ; by which the muzzle droops, and the vent widens sometimes to that degree, as a man's fist may go in it. To make the vent more durable they put in a piece of copper to grain it, as it is called. This grain is fixed into the mould before the melted metal is let in to make them unite together ; but as copper is softer than gun metal, instead of making the vent more

durable, as it is imagined, it rather weakens it in my opinion. If a steel grain was put in, provided it can be united with the metal, there is no doubt but it would be better than any other metal; for it has been found by experience, that a new vent of iron being made, it was scarcely ever spoiled afterwards. The *French* had a gun with an iron vent at *Belleisle*, which was found after the siege to be the only one that stood out the siege without being spoiled. To make a composition of gun metal of a durable substance, the ingredients should be such as require the same degree of heat to melt; but no such metals have as yet been discovered. It is true, that some *Saxons* pretend to have that secret; but as they have not yet made any guns of it, no dependance can be made on it.

As good iron cast from virgin ore has all the quality that can be desired in gun metal, and not one burst all this war that I heard of, what occasion is there for any other? and there is such a plenty of it every where, especially in *England*, and the founders are so expert in their business at present, that they can make it more or less malleable, as they please; besides, the expence is so much less, as 9 or 10 to one; which one would think should be a sufficient motive to use no other. Although the artillery officers agree, that iron battering pieces are preferable to brass, yet to make field pieces of iron they by no means approve of, because they say it would be too dangerous to stand by them in time of action; but what should prevent a proper trial to be made? And if it does not succeed, the expence would be inconsiderable; and if it does, as I do not doubt it will, what a prodigious expence would be saved.

I would advise to have two six pounders cast of the same weight as the brass, and proved in the same manner; then fire them three hundred rounds as quick as they can, with a pound and a quarter of powder, in the same manner as the brass were tried; and if they stand such a trial, let the officers then judge whether there can
   
 be

be any danger in using them. We are not to judge rashly in a matter of so great importance as this, without a full and sufficient proof. It is not the opinion of a few persons we are to judge by, but by matter of fact. I may possibly be mistaken, though I think to have sufficient proofs of what I assert; and therefore recommend proper trials to be absolutely certain.

As we propose chambers to be made in all calibers from an 18 pounder upwards, it will not be improper to shew here their advantage, first from experiments, and afterwards from theory. General *Williamson* and the rest of the artillery officers made likewise several experiments with shells from a bomb vessel in the harbour of *Mahon* in 1746. Of which I shall only insert the range of the fifth, which was 4570 yards; the mortar was loaded with 35 lb and 10 ounces, the shell weighed two hundred or 224 pounds, and the angle of elevation 45 degrees; and the range of the seventeenth experiment with a ten inch mortar was 3787 yards; the shell weighed 97 lb. and the mortar loaded with 12 pounds of powder. Now the charge of the first mortar being about 5.6 parts of the weight of the shell, produced a greater range than the 18 pounder gun loaded with half the weight of the shot; the second mortar was loaded with no more than an eighth part of the shell's weight, and yet its range differed but 373 yards from that of the gun. This great difference between the forces of powder, when it was confined in a chamber, and in a gun without a chamber, can arise from no other cause, than that the direction of its force is nearer to that of the shell than it is to that of the shot. It is true, that the resistance of the air is less on the shell than on the shot; but, on the other hand, the bore of the mortar is so short, and so wide in comparison to the width of the chamber, that the explosion of the powder can only act upon the shell before it is sensibly moved from its place; instead of which it acts upon the shot till it leaves the gun. All this being considered, the advantage

tage of chambers in guns, as well as in mortars, will be found to be very considerable.

We shall prove this likewise by theory hereafter in theorem the vth.

Though we have shewn that the theory of powder is as yet defective in many respects for want of a sufficient number of good experiments, those which have hitherto been made were with too small quantities, as can by no means be depended upon; since the smallest error in a few grains becomes very considerable in the charges of artillery pieces; neither do we know the time of the degrees of inflammation. All that can be done, is to suppose that it fires all at the first instant, and proceed upon this supposition, though erroneous, till such time that the law of inflammation has been discovered.

## THEORY OF POWDER.

### THEOREM I.

*The explosion of fired powder produces a permanent elastic fluid, and forms a sphere, if not prevented by any external obstacle.*

**A**UTHORS agree, and experience shews, that fired powder produces an elastic fluid; and if it be fired under an exhausted receiver, the mercurial gage descends; and though it rises again when the heat is abated, yet it remains always below its common standard; which plainly shews, that the fluid produced by fired powder is elastic and permanent.

Again, if a small quantity of powder be fired on a table, its flame rises in the form of a semi-sphere; and in whatever vessel powder is confined, the explosion will always burst it in the weakest part, if the elastic force be

be sufficient. Consequently fired powder acts on every side alike ; which could not happen, unless the explosion was spherical.

### REMARK.

Though authors agree, that powder produces an elastic fluid when fired, yet they differ in the manner of it. Most of them are of opinion, that powder is only condensed air, which being heated by the explosion, as well as the natural air contained between the interstices of the grains, produces this elastic fluid. Others affirm, that the air contained in powder exists in its natural state ; which being heated expands itself, and produces the explosion. But this is contradicted by the above-cited experiment : for when the heat in the receiver is abated, the mercurial gage should, according to this supposition, rise again to the same height as it was before ; which is contrary to experience.

Sir *Isaac Newton* says, in his *Optics*, Query 10, that if salt of tartar be mixed with powder, and that mixture be heated till it takes fire, the explosion will be more violent and quick than that of powder alone ; which can proceed from no other cause, than the action of the vapour of the powder upon the salt of tartar, whereby that salt is rarefied ; and therefore the explosion of powder arises from the violent action, whereby all the mixture being quickly and vehemently heated, is rarefied and converted into fume and vapour ; which vapour, by the violence of that action becoming so hot as to shine, appears in the form of flame. Thus far Sir *Isaac Newton*.

But whether the elastic force of powder be owing to the expansion of air, or to some other fluid produced by the ingredients of which it is made, is not material in respect to what follows ; it being sufficient for our purpose, that the force produced thereby acts chiefly according to the same law as all other elastic fluids ; which it will be proved to do by experiments hereafter.

THEOREM



## THEOREM II.

*The densities of the same quantity of an elastic fluid, contained in different capacities, are as these capacities inversely.*

For the same quantity of matter being reduced to half the bulk, will have its parts twice nearer each other; if it be reduced to one third or one fourth of the bulk, the parts will be three or four times closer to each other; and whatever the bulk is reduced to, the parts will always be closer to each other in the same proportion. And since the density of matter consists in the closeness of the parts, it is evident that the density increases as the bulks diminish; consequently, the densities of the same quantity of an elastic fluid, contained in different capacities, are as these capacities inversely.

## COR. I.

Hence it follows, that the densities of different quantities of the same elastic fluid, contained in the same or equal capacities, are as these quantities. For if twice the quantity be contained in the same capacity, the density will be double; if three or four times the quantity be contained in the same capacity, the density will be triple or quadruple; and therefore, in general, whatever the ratio is between the quantities contained in the same or equal capacities, that of the densities will always be the same.

## COR. II.

Hence the densities of different quantities of the same elastic fluid, contained in different capacities, are as the quantities directly, and the capacities inversely. For because the densities of the same quantity of an elastic fluid,

fluid, contained in different capacities, are as these capacities inversely, by Theorem II. and the densities of different quantities of the same fluid, contained in the same or equal capacities, are as these quantities directly by Cor. I. it is evident, that if the quantities are different, as well as the capacities, the densities will be as the quantities directly, and the capacities inversely.

THEOREM III.

*The intensity of heat produced by the explosion of fired powder, will be as the density of the fluid.*

For the heats of the same quantity of powder, fired in different capacities, will be as these capacities inversely; and the heats of different quantities, fired in the same or equal capacities, are as these quantities directly. Therefore the intensity of heat produced by different quantities of fired powder in different capacities, is as the quantities directly, and the capacities inversely; or as the densities by the last Corollary.

THEOREM IV.

*The elastic force produced by an explosion of fired powder, is in the compound ratio of the density of the fluid, and the intensity of heat.*

For the elastic force of condensed air is as the force of compression, and the force of compression is as the density; and since the elastic force is also increased by heat, it is manifest, that the elastic force is in the compound ratio of the density of the fluid, and the intensity of heat.

This may likewise be proved as follows: since every particle of the fluid has the same degree of heat, and the total force of the explosion is equal to the sum of the forces of all the parts; the elastic force of the explosion

plosion is therefore in the compound ratio of the heat of one particle, and the sum of all the particles, or, which is the same, the density of the fluid. Consequently the elastic force, produced by the explosion of fired powder, is in the compound ratio of the density of the fluid, and the intensity of heat.

### REMARK.

Mr. *Robins* supposes the elastic force, produced by the explosion of fired powder, to be as the density of the fluid, which is the case of condensed air void of heat; and therefore he supposes the increase of force, produced by heat, to be constant, in his proposition; but finding afterwards that the force increased by heat, he says, we have hitherto supposed powder, when fired, to be equally hot with iron, at the beginning of its white heat; but we have observed, that it varies according to the quantity of powder fired together. The flame therefore may have all the different degrees, from that of a languid red heat, to the heat sufficient for the vitrification of metals; which agrees exactly with what has been said in the last Theorem. That heat increases greatly the elasticity of air, is known by heating an empty bottle, well corked, in boiling water; for it will either drive the cork out, or else burst the bottle. It is likewise well known, that the steam of boiling water produces a great elastic force, and perhaps more than fired powder; although cold water seems to be intirely void of elasticity, since it cannot be compressed by any force we know of. Hence it seems as if cold water was in its densest state; and it appears very probable, that the density of air has its limit, beyond which it never can be reduced.

### COR. I.

Since the intensity of heat is as the density of the fluid, By Theor. III. and the elastic force of fired powder

der is in the compound ratio of the density of the fluid, and the intensity of heat, the elastic force of fired powder is therefore in a duplicate ratio of the density ; and, consequently, by Cor. II. of Theor. II. the elastic force of fired powder is in the duplicate ratio of the quantity of powder directly, and the duplicate ratio of the capacities inversely.

COR. II.

Hence, if the quantities of powder are in the same ratio as the capacities in which they are contained, the forces of explosion will be equal.

For since these forces are in the duplicate ratios of the quantities of powder directly, and the duplicate ratio of the capacities inversely ; the single ratios being equal by supposition, the duplicate will likewise be equal.

COR. III.

By a known property of fluids in general, the pressure against any surface is in the compound ratio of the impressing force, and the surface pressed ; and since, of all equal solids, the sphere has the least surface, it is evident, that of all capacities which contain the same quantity of powder, the spheric is the strongest, or, which is the same, is the least pressed.

COR. IV.

Hence, the forces against spheric shells, filled with quantities of powder proportional to their capacities, are to each other as the squares of their radii ; for the forces of explosion being equal by Cor. II. the forces against these shells will be as the surfaces pressed ; and they being as the squares of the radii, the forces impressed will be in the same ratio of the squares of the radii. Consequently, if the thickness of shells are proportional

portional, to their radii, they will be equally strong, since their thickness will be to each other as the squares of the radii, and consequently as the impressing forces.

## COR. V.

It is also manifest, that the forces against the concave part of the cylindric surfaces, filled with proportionable quantities of powder, are as these surfaces : for the forces of explosion are equal in this case, by Cor. II. and therefore the impressing forces are as the surfaces pressed. Now because cylindric surfaces are in the compound ratio of their radii and their axes ; if the axes are equal, the forces are as their radii ; if the radii are equal, as their axes ; and if they are similar, as the squares of the radii or axes.

## REMARK.

When pieces of artillery are loaded with charges proportional to the weights of their shots, the axes of the charges are proportional to their radii ; and as they are equally pressed by the elastic force of powder, as far as the charge reaches, their outward surface should be so far parallel to their inner one, and the thickness of the metal made proportional to the radii of their bases ; or because the diameters of the bores are proportional to the diameters of the shots, and from thence to the mouth, the outward figure should be that described by the rotation of a cubic hyperbola about one of its asymptotes, which is placed in the axis of the bore : this appears from what has been said in Cor. I. after Theor. IV. But because of the action of the shot against the inside of the piece, the thickness of metal must be somewhat more towards the muzzle than what this figure makes it.

Before the foregoing Theory can be applied to any particular example, it is necessary to find the ratio between

tween the pressure of the atmosphere and the elastic force of powder, which is very difficult, because authors disagree very much in their experiments on that head.

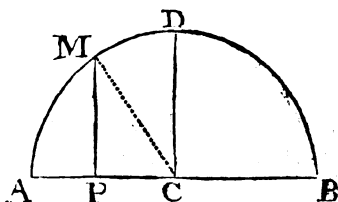
For Mr. *Robins* says, that the air contained in powder is but 244 times denser than that we breathe; and that its elasticity cannot be increased above five times by the heat of the explosion; and from thence he concludes, that the elastic force of fired powder is about 1000 times greater than the pressure of the atmosphere. The late Mr. *Hauksbee* assured me, that he found, by several experiments, the flame of powder to occupy about 5000 times the space of the powder unfired. Mr. *Belidor* says, that, by some experiments he made, he found that space to be about 4000 times increased, and that the same thing had been found by Mr. *Amonton*. Mr. *Bigot de Morogues* says, in page 65, that he found that space to be from 4 to 4500 times; and lastly, *Daniel Bernoullie* found it to be from 4 to 6000 \*.

It is certain that these experiments are attended with great difficulties, on account of the quickness with which the powder fires, and the flame disappears. Another difficulty arises from the inequality of the pressure of the atmosphere, as well as from the different strength of powder; and therefore it is impossible to arrive at any tolerable degree of exactness, notwithstanding all the precautions that can possibly be taken in making the experiments: so all that can be expected will be to take such a number as agrees nearest with the experiments made on the velocities of shots, which is that of Mr. *Belidor's*, as being a mean between the greatest and least of these several experiments.

\* Mr. *Boyle* says, that the greatest density of air is to the greatest rarefaction, as unity to 520,000.

## THEOREM V.

*The force of an elastic fluid against any part of a spheric surface described by the arc DM about the radius CD as an axis, perpendicular to the diameter AB, is to the abso-*



*- lute force, as the solid described by the segment PMDC terminated by the sine PM of that arc, is to the cylinder of the same base and altitude; and the force against the semi-sphere is to the total force, as the semi-sphere to the circumscribed cylinder.*

Draw the radius CM; then, by the nature of fluids, the surface is pressed in a direction perpendicular to every point; whence the absolute force in the direction CM is to the force impressed at the point M, in the direction PM, as CM is to CP; and as this happens in respect to every point in the arc MD, the force impressed on the arc MD, will be to the absolute force as the area PMDC is to the rectangle made by CP and CD: consequently the force against the surface described by the arc MD about the axis CD, is to the absolute force as the solid described by the segment PMDC in that rotation to the cylinder, described by the rectangle PC and CD; and the force against the semi-sphere is to the absolute force, as the semi-sphere is to its circumscribed cylinder.

Mr. *Robins* and Mr. *Morogues* have supposed, that the force against the semi-sphere was equal to that against the circle AB of the base: but they did not consider, that the directions of the forces against the different parts of the sphere were oblique to the direction CD, in which the sphere is supposed to move; and therefore the total force must be less than the absolute force.

This

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~XXXV

This Theorem agrees exactly with Sir *Isaac Newton's* prop. 35, book ii.

### C O R. I.

Since the sphere is the two thirds of its circumscribed cylinder, it follows that the ball is acted upon by the two thirds of the absolute force of the powder.

### E X A M P L E I.

If we suppose  $CP$  to be a third part of the radius  $CA$ , it will be found by geometry that the cylinder, whose radius of the base is  $CP$ , and altitude  $CD$ , is to the solid described by the space  $CPMD$  about the axis  $CD$ ; or the total force of the powder is to that part which acts upon the surface described by the arc  $MD$ , as 900 to 875: and since the semi-sphere is acted upon by the two thirds of the total force of the powder, and if the quantity be the same in both causes, the force of explosion upon the sphere will be to the part which acts upon the surface described by  $MD$ , as 600 to 875; which shews that the force against the surface is only 25 parts less than the absolute force 900: whereas the force against the semi-sphere is but 600, the two thirds of the absolute force 900.

### E X A M P L E II.

If  $CP$  be one half of the radius  $CA$ , then it will be found in the same manner as before, that the circumscribed cylinder is to the solid described by the space  $CPMD$ ; or the total force of the powder is to the part acting upon the surface described by the arc  $MD$ , as 900 to 841; and the force acting upon the sphere acting upon this solid, as 600 to 841.



that

# INTRODUCTION.

C O R. II.

Hence it is manifest that chambers, whose diameters are but one third of the diameter of the bore, are more advantageous than those whose diameters are one half; as they are made at present in our mortars; and if they were still less, they would be better; which however may have its limits. This agrees exactly with several experiments made for that purpose: for Mr. *Hawksbee* tried several times a little mortar, which had three shifting chambers of the same capacity, and always found that the chambers which were narrowest carried the shell farthest.

As the first part of artillery was printed before the 18 brass pounders have been proved, and the general construction of these pieces appears to be properly adapted to brass guns for the land service, I shall insert it here, in order to shew how much the metal might be diminished.

*General construction of brass cannon for the land service:*

Let the length *AB*, see plate I, be 21 diameters of its shot, the thickness of the metal at the breech and vent 18.5 parts, and at the mouth 9; the rest of the construction may be the same as that given in page 46.

0 : 2 : 4	1 : 4	3	12 1/2
0 : 8 : 0	2 : 4	2	10 1/2
0 : 0 : 0	1 : 2	1	2 1/2
0 : 2 : 0	0		

*Weight.*

# INTRODUCTION

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## *Weight and dimensions of brass guns for land service.*

It must be observed; that we made the lengths of the 24, 32, and 42 pounders the same, being sufficient for battering pieces, and reduces the weight of the two last considerably; that these pieces are sufficiently strong appears from the old iron 32 and 42 pounders cast in king Charles the second's time, which weighed no more. But it must be remembered, that the charges of these pieces

Calib.	Length.	Weight.
6	6 : 1	8 : 0 : 4
9	7 : 0	12 : 0 : 6
12	7 : 8	16 : 0 : 8
18	9 : 0	24 : 0 : 12
24	9 : 8	32 : 0 : 16
32	9 : 8	42 : 0 : 20
42	9 : 8	52 : 0 : 24

should never exceed one third of their shot's weight, because that charge has been found sufficient by experiments in all battering pieces.

We have inserted this table of the dimensions of iron field pieces, in order to shew how they may be constructed, in case it should be thought proper to make trial of their strength. Their length is 14 diameters of the shot, the thickness of metal at the breech and vent 18 parts, and 9 at the mouth; the rest of the construction is the same as that of the light brass field pieces.

### Iron Field Pieces.

Calib.	Length.	Weight.
3	3 : 3	2 : 1 : 0
6	4 : 1	4 : 2 : 0
9	4 : 8	6 : 3 : 0
12	5 : 1	9 : 0 : 0
18	5 : 10	13 : 2 : 0
24	6 : 5	18 : 2 : 0

The proof of these pieces should be made with one half of the shot's weight of powder,

powder, and their charge in service one fourth, which is the same as those of brass.

If these pieces are cast from good virgin ore by a skilful founder, such as the *Carron* company, and some others, without mixing any pig iron, there cannot be the least doubt but they will be as useful, and last longer than the light brass; because their vents scarcely ever spoil, and the pieces never bend at the neck.

The reader may perhaps be glad to know the greatest velocities that shot can have, and their greatest ranges, which often have been sought for by most artilleryists, but they could never agree; for which reason we shall insert them in the following table.

The first column contains the weight of the shot, the second the number of feet moved over uniformly, in a second by the greatest velocity; and the third the greatest random ranges which these shots can possibly have, let the charges be ever so great.

This shews that small calibers can never go so far as greater, and contradicts the common practice of making small calibers longer in proportion, in order to go farther.

A ten inch shell may go to 5384 yards at an elevation of 45 degrees, and a thirteen to 7041 yards at the same degree of elevation; which is upwards of four miles. Again, the greatest velocity a leaden bullet of three quarters of an inch diameter can possibly have, is at the rate of 395 feet a second, when uniformly continued.

Shot	Velocities.	Ranges.
3	615.7	2326
6	691.3	2932
9	739.0	3352
12	775.3	3688
18	826.5	4191
24	866.8	4610
32	912.9	5113
42	955.5	5602
48	976.4	5849

The

# INTRODUCTION.

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The demonstration of these velocities and ranges is given in the appendix. Mr. *Robins* thinks to prove, in his seventh problem, that the velocity of the foregoing leaden bullet is 1668 feet in a second, which is more than four times greater than that above; and what is more extraordinary, he pretends to have found the same velocity by experiments. As he seems to build his theory upon Sir *Isaac Newton's* principles, had he read the 40th proposition, book ii. he must have been convinced of his mistake; and from over-rating the velocities, the resistance of bodies moving in the air is, according to his computation, above twenty-four times too great in a 24 pounder.

Height. Distance.

Height. Distance.

Yds.	Yards	Miles
1	3735	2. 12
2	5278	3. 00
3	6470	3. 67
4	7470	4. 24
5	8353	4. 74
6	9150	5. 20
7	9863	5. 60
8	10566	6. 00
9	11206	6. 36
10	11800	6. 70
11	12390	7. 04
12	12940	7. 35
13	13468	7. 65
14	13977	7. 94
15	14468	8. 22
16	14942	8. 49
17	15402	8. 75
18	15850	9. 00
19	16283	9. 25
20	16706	9. 49
21	17118	9. 72
22	17521	9. 95
23	17915	10. 18
24	18300	10. 40
25	18678	10. 61

Yds.	Yards	Miles
26	19048	10. 82
27	19410	11. 03
28	19767	11. 23
29	20107	11. 42
30	20460	11. 62
31	20800	11. 82
32	21133	12. 00
33	21459	12. 20
34	21780	12. 38
35	22100	12. 55
36	22413	12. 73
37	22720	12. 91
38	22895	12. 97
39	23329	13. 20
40	23631	13. 40
41	23919	13. 59
42	24209	13. 75
43	24500	13. 92
44	24780	14. 08
45	25059	14. 24
46	25336	14. 40
47	25610	14. 55
48	25880	14. 70
49	26148	14. 85
50	26414	15. 00

As

As the distance a ship may be seen at sea is esteemed useful, we have given them from one yard high to 50, from the surface of the sea, and the respective distances in yards and miles: they are deduced from the roundness of the seas surface, according to the prob. in art. 411, of our treatise of mathematics: the mean diameter of the earth being 6548856 *French* toises, according to our determination; which being reduced into *English* yards, gives 7.1447018 for its logarithm; to which adding continually the logarithm of the height, gives the logarithm of the square of the distances in yards; and the distances in yards being divided by 1760, the number of yards in a mile, gives the number of miles which these distances contain.

The navigator may always know the height he is from the surface of the sea, when he observes the hull of another ship, at the water edge, then he has the distance marked in the table against the height from which he observes; but if any part of the ship he observes is hid by the surface of the water, he must give a guess how high the part hid is; then if he adds the distance against that height expressed in yards, to that against the height he sees, the same will be the true distance to the ship.

**EXAMPLE.** Suppose he observes a ship from a height of 15 yards, and the part of the ship hid is 5 yards; then the distance 6470 against 5 yards, added to the distance 14468 against 15 yards, gives 20938 yards or 12 miles nearly for the distance required.

We have not considered the refraction of the air, by which the ship may be seen a little farther than what is marked in the table. But if the ship is within the horizon, and the height of the part seen between the surface of the water and the horizontal line, then the distance answering to this height, subtracted from the first, gives that between the two ships.

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# ARTILLERY.

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## PART I.

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### WEIGHTS and MEASURES.

**T**O proceed with order in the ensuing work, it is proper to mention the necessary weights and measures used in Artillery, for the better understanding the use and construction of the tables.

An inch is the least common measure; 12 inches make a foot, 3 feet a yard, a pole is 16.5 feet, a furlong 40 yards, and a mile 1760 yards. These measures are also sub-divided into 10, 100, and 1000 parts.

Avoirdupois weight is used in Artillery, and in all heavy commodities; a drachm is the least weight, 16 of which make an ounce, 16 ounces a pound, 14 pounds a stone, 112 pounds a hundred weight, 20 hundreds a ton.

As *French* weights and measures are proper to be understood in Artillery, we shall give the proportion between ours and theirs. The gentlemen of the Royal Society in *London*, in conjunction with those of the Royal Academy of Sciences at *Paris*, are said to have, with

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great

great accuracy, compared our weights and measures with those of *France*; the result of which is,

The *English* foot to the *French* royal, as 107 to 114. The *English* pound avoirdupois to the *French* pound marc, as 63 to 68. Whence 100 *French* pounds make very near 108; and therefore their hundred-weight is to ours, as 108 to 112; that is, as 27 to 28, according to this proportion.

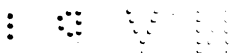
The proportion of the *French* and *English* foot is nearly exact; for I tried two *French* sectors, the one made by *le Maire* seemed to be exactly divided, and I found that three *French* inches make 3.2 of ours; so that the *French* foot is to ours as 32 to 30, which is near 114 to 107; since if 114 be multiplied by 15, the product will be 1710; and 107 multiplied by 16, gives 1712; which exceeds the former by 2 only.

But the proportion of the *French* and our weights is by no means right, as will appear hereafter, when we give tables of shots. It is hard to judge how such a mistake could happen, unless the weights they compared were not those used in the Artillery there and here.

Before we proceed any farther, it will be necessary to premise some geometrical propositions, which ought to be known, in order to understand several parts of this work.

- I. The diameter of the circle is to its circumference, as 113 is to 355 nearly.
- II. The square of the diameter is to the area of the circle, as 452 to 355.
- III. The cube of the diameter is to the solid content of a sphere, as 678 to 355.
- IV. The cubes of the axes are to the solid contents of equalititude cylinders, as 452 to 355.
- V. The solid content of a sphere is to the circumscribed cylinder, as 2 to 3. These propositions are demonstrated in the Ninth Section of my Elements of Mathematics.

The



The following table contains the weight of a cubic foot, expressed in ounces, of the several substances specified, which I have for the most part taken from Mr. Cotes's hydrostatic lectures. Those of gun metal have been computed from their mixture, and the cast iron from the 9 pound ball, whose diameter is four inches, exceedingly near, according to Sir *Jonas Moor*.

## *Specific gravities of bodies.*

Copper	—	9000	Steel	—	—	7645
Tin	—	7320	Marble	—	—	2700
Gun metal	—	8784	Dry oak	—	—	925
Cast brass	—	8000	Dry ash	—	—	800
Lead	—	11325	Dry maple	—	—	755
Iron	—	7645	Dry elm	—	—	600
Cast iron	—	7425	Dry fir	—	—	550
Shells	—	4892	Powder	—	—	880

For his father weighing several iron balls with a curious scale, found one nearly round, whose diameter was 6.63 inches, and weighed 41 pounds; from thence the diameter of a 9 pound ball is found to be 3.9995 inches, which being so very near 4 inches, by taking it as such, no sensible error can happen in computation.

Having the weight of a cubic foot of these bodies, that of any parts may be found by proportion; and on the contrary, the weight of any part of a body being given, its specific gravity, or the weight of a cubic foot, may be found. Thus a cubic foot, or 1728 cubic inches of gun metal, weigh 8784 ounces, or 549 pounds: then dividing 1728 by 9, we get 192 cubic inches; and dividing 549 by 9, we get 61 pounds. Hence 192 cubic inches of gun metal weigh 61 pounds.

Again: 1728 cubic inches of cast iron weighing 7425 ounces, or 464 pounds and an ounce, which we shall neglect; then 1728 divided by 16, gives 108; and 464 divided by 116, gives 29. Hence 108 cubic inches of



cast iron weigh 29 pounds. These two examples will be useful hereafter in finding the weight of guns.

A shell, whose diameter is  $12\frac{1}{2}$ , weighs 192 pounds when loaded, as will be shewn; and 355 is to 678, as the content or weight 192, is to the content or weight of the cube 366.69 made by its diameter: but the cube 2072.67 of  $12\frac{1}{2}$ , is to the cube 1728 of 12, as the weight 366.69 is to the weight 4892 of a cubic foot, or the specific gravity of shells.

Again: a cylinder of powder, whose axis and diameter are each 3.42 inches, contains one pound, or 16 ounces, as will be shewn hereafter; and 355 is to 452, as the weight 16 ounces of the cylinder is to the weight 20.372 ounces of the cube made by its axis: but the cube 40 of 3.42 is to the cube 1728 of 12, as the weight 20.372 is to the weight 880 ounces of a cubic foot, or the specific gravity of ordnance powder.

### EXAMPLE I.

To find the diameter of an iron ball, whose weight is given, supposing that of a 9 pound is 4 inches. Say, the cube root, 2.08, of 9 pounds is to 4 inches, as the cube root of the given weight is to the diameter sought; or if 4 be divided by 2.08, the cube root of 9, the quotient 1.923 will be the diameter of a one pound ball; which being continually multiplied by the cube root of the given weight, gives the diameter required.

This may be done in a shorter manner by making use of logarithms; for if the logarithm .2839793 of 1.923 be constantly added to the third part of the logarithm of the weight, the sum will be the logarithm of the diameter. Suppose a ball to weigh 24 pounds, add the given logarithm .2839793, to the third part .4600704 of the logarithm 1.3802112 of 24, the sum .7440494 will be the logarithm of the diameter of a ball weighing 24 pounds, which therefore is 5.5468 inches.

If

If the weight be expressed by a fraction, the rule is still the same; for instance, the diameter of a pound and a half ball, or of  $\frac{3}{2}$ , is found, by adding the logarithm .2839793, found above, to .0586971, one third of the logarithm of  $\frac{1}{2}$ ; the sum .3426764, will be the logarithm of the diameter required, which therefore is 2.2013 inches.

The diameter of an ounce ball is found, by subtracting .4013733, one third of the logarithm of 16, from the logarithm .2839793, of one pound; as this logarithm is less than the other, an unit must be added to it; then the difference .882606, will be the logarithm of the ball's diameter, which weighs an ounce. This logarithm being continually added to the third part of the logarithm of the weight, expressed in ounces, and an unit being taken from the sum, the remainder will be the logarithm of the diameter: thus, let the ball weigh eight ounces, add .3010300, the third part of the logarithm of 8, to the logarithm .882606 of one ounce; the sum .18363, after having subtracted unity, will be that of the diameter, which is 1.526 inches.

As the diameter of the bore, or the caliber of the piece, is made one twentieth part larger than that of the shot, according to the present practice, we have computed the following

*Diameters of the shots and calibers of English guns.*

lb.	0	1	2	3	4	5	6	7	8	9	
0	0	1. 923	2. 422	3. 775	3. 052	3. 288	3. 498	3. 679	3. 846	4. 000	Diam.
	0	2. 019	2. 544	2. 913	3. 204	3. 668	3. 658	3. 861	4. 038	4. 200	Calib.
1	4. 143	4. 277	4. 403	4. 522	4. 635	4. 743	4. 846	4. 945	5. 040	5. 131	Diam.
	4. 349	4. 490	4. 623	4. 748	4. 866	4. 981	5. 088	5. 192	5. 292	5. 386	Calib.
2	5. 220	5. 305	5. 388	5. 4. 9	5. 547	5. 623	5. 697	5. 769	5. 839	5. 908	Diam.
	5. 480	5. 570	5. 661	5. 742	5. 824	5. 893	5. 982	6. 057	6. 129	6. 203	Calib.
3	5. 975	6. 041	6. 105	6. 168	6. 230	6. 290	6. 350	6. 408	6. 465	6. 521	Diam.
	6. 273	6. 343	6. 410	6. 475	6. 541	6. 604	6. 665	6. 707	6. 788	6. 846	Calib.
4	6. 576	6. 631	6. 684	6. 737	6. 789	6. 840	6. 890	6. 940	6. 989	7. 037	Diam.
	6. 904	6. 962	7. 018	7. 076	7. 128	7. 182	7. 234	7. 287	7. 338	7. 383	Calib.

The

## ARTILLERY.

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The numbers in the first horizontal line are units, and those in the first vertical column the tens : the other numbers under the one, and opposite to the others, are the respective diameters of shot and calibers. Thus to find the diameter of the shot, and the caliber of a 24 pounder, look for the number 2 at the side, and for 4 at top ; then the number 5.547 under 4, and opposite to 2, will be the diameter of the shot in inches and decimals, and the number 5.824, under the first, the caliber of the 24 pounder. Again, to find the diameter of the shot, and the caliber of a 36 pounder ; look for 3 at the side, and 6 at the top, then the number 6.350, under 6, and opposite to 3, will be the diameter of the shot, and the number 6.666 under it, the caliber of the 36 pounder. In the same manner may be found the diameter of the shot and the caliber of any gun, under a 60 pounder : those above 48 are not used.

**B 4**

*Diameters*

*Diameters of the shots and bores of French guns by inches and decimals of their measure.*

	0	1	2	3	4	5	6	7	8	9	
0	0	1. 889	2. 381	2. 726	3. 000	3. 253	3. 434	3. 615	3. 790	3. 931	Diameter.
	0	1. 950	2. 469	2. 827	3. 111	3. 351	3. 561	3. 749	3. 920	4. 076	Caliber.
1	4. 072	4. 203	4. 327	4. 444	4. 555	4. 661	4. 762	4. 859	4. 953	5. 043	Diameter.
	4. 222	4. 390	4. 487	4. 608	4. 723	4. 833	4. 938	5. 039	5. 134	5. 229	Caliber.
2	5. 130	5. 214	5. 295	5. 375	5. 451	5. 526	5. 599	5. 670	5. 739	5. 847	Diameter.
	5. 320	5. 407	5. 491	5. 584	5. 653	5. 730	5. 806	5. 880	5. 951	6. 061	Caliber.
3	5. 872	5. 937	6. 000	6. 062	6. 122	6. 182	6. 237	6. 297	6. 354	6. 409	Diameter.
	6. 089	6. 157	6. 222	6. 288	6. 349	6. 411	6. 468	6. 530	6. 589	6. 646	Caliber.
4	6. 463	6. 517	6. 569	6. 621	6. 672	6. 722	6. 771	6. 820	6. 868	6. 916	Diameter.
	6. 702	6. 758	6. 812	6. 866	6. 918	6. 971	7. 022	7. 072	7. 122	7. 172	Caliber.

This

This table is constructed upon the supposition that the diameter of a four pound ball is three *French* inches, according to their authors ; and from thence, the difference between the logarithm of three inches, and one third of the logarithm of four pounds, gives the logarithm .2764347 of the diameter of a one pound ball, which being continually added to one third of the number of pounds of the ball, the sum will be the logarithm of the diameter of that ball in inches and decimals. The windage of the *French* guns is but one twenty-seventh part of the ball's diameter ; which, therefore, being added to the diameter, gives that of the caliber. Mr. *Saint Remy* gives a table of these diameters in page 136, vol. i. new edit. in inches and duodecimals, without mentioning how it was constructed. In page 82, he says, that *Butterfield* has computed it, and that it is very exact. *Butterfield* was an *English* mathematical-instrument-maker established at *Paris*.

This table agrees nearly with that given by *Saint Remy*, p. 136, as appears from the following numbers, where lines and points are reduced into decimals of an inch.

<p>The first column contains the weights of the shot, the second their diameters in inches and decimals according to <i>Saint Remy</i>, and in the third the same diameters according to our tables. Hence, our diameters are greater as far as a thirty-six pound shot, and less above it. Therefore the <i>French</i> table has not been constructed from the rule that the weights of shots are as the cubes of their diameters, unless some errors have been committed in their computations.</p>	<p><i>lb.</i>  24—5.444—5.451  36—6.229—6.237  39—6.417—6.409  41—6.518—6.517  46—6.776—6.771</p>
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The following table has been computed upon the supposition, that the *French* foot is to the *English* as 114 is to 107, as we have shewn in page 2 ; and from thence, the logarithm of the diameter of a *French* pound is .3039558, expressed in *English* inches and decimals.

As to the rest of the diameters they are found in the same manner as before.

*Diameters of the shots and bores of French guns in English inches.*

	0	1	2	3	4	5	6	7	8	9	
0	0	2. 013	2. 537	2. 904	3. 196	3. 443	3. 659	3. 852	4. 027	4. 186	Diameter.
0	0	2. 088	2. 631	3. 011	3. 315	3. 570	3. 794	3. 994	4. 180	4. 343	Caliber.
1	4. 338	4. 478	4. 610	4. 734	4. 853	4. 966	5. 074	5. 177	5. 277	5. 373	Diameter.
1	4. 499	4. 554	4. 781	4. 910	5. 032	5. 150	5. 262	5. 365	5. 472	5. 571	Caliber.
2	5. 466	5. 555	5. 642	5. 726	5. 808	5. 887	5. 965	6. 041	6. 114	6. 186	Diameter.
2	5. 668	5. 761	5. 851	5. 938	6. 023	6. 105	6. 186	6. 264	6. 341	6. 415	Caliber.
3	6. 256	6. 325	6. 393	6. 458	6. 523	6. 586	6. 648	6. 709	6. 769	6. 828	Diameter.
3	6. 488	6. 559	6. 629	6. 698	6. 765	6. 830	6. 895	6. 958	7. 020	7. 086	Caliber.
4	6. 886	6. 943	6. 999	7. 054	7. 108	7. 162	7. 215	7. 266	7. 318	7. 368	Diameter.
4	7. 141	7. 202	7. 258	7. 315	7. 372	7. 427	7. 481	7. 536	7. 589	7. 641	Caliber.

This

This table serves to compare the *French* calibers to ours : for example, the diameter 5.808 of a 24 pound ball is something more than 5.769, that of our 27. That 6.393, of their 32, nearly equal to 6.408, that of our 37. That 6.648 of their 36, nearly equal to 6.634 of our 42.

The diameter of a *French* 9 pound shot is 4.188 inches of our measure, and its cube 73.453 ; and as the diameter of our 9 pounder is 4 inches, and its cube 64 ; therefore the *French* weight is to ours as 73.453 is to 64, or as 70 to 61 nearly : which differs greatly from the ratio mentioned before. Therefore 100 *French* pounds make 114 $\frac{1}{2}$  pounds, and not 108, as the former proportion gives.

The proof that this ratio is the nearest that can be given by two figures, we shall suppose, with Sir *Jonas Moor*, that the diameter of a 9 pound iron shot is 3.9995 inches ; then as 114 is to 107, as 3.9995 is to 3.7593 *French* inches, whose cube is 52.899, and 70 is to 61 as 9 to 7.8428 pounds *French* weight. Therefore the cube 52.899 is to the cube 27 of 3, as the weight 7.8428 is to the weight 4.0004 pounds of the shot, whose diameter is 3 *French* inches, which agrees nearly with the supposition of the *French* : but if the ratio 63 to 61 be supposed, a 9 pounder *English* weighs 9.3382 ; then by proportion the weight of a shot, whose diameter is 3 *French* inches, will be 4.2558 pounds, or above a quarter more than 4 pounds ; which is certainly more than it is possible not to perceive.

*Iron*



## ARTILLERY.

*Iron grape shot from 1 to 39 ounces.*

3	0	1	2	3	4	5	6	7	8	9
—	—	—	—	—	—	—	—	—	—	—
0	0	. 763	. 9615	1. 103	1. 209	1. 305	1. 387	1. 450	1. 526	1. 587
—	—	—	—	—	—	—	—	—	—	—
1	1. 644	1. 697	1. 747	1. 794	1. 839	1. 882	1. 923	1. 962	2. 000	2. 036
—	—	—	—	—	—	—	—	—	—	—
2	2. 072	2. 106	2. 138	2. 170	2. 201	2. 231	2. 261	2. 286	2. 318	2. 345
—	—	—	—	—	—	—	—	—	—	—
3	2. 371	2. 397	2. 423	2. 448	2. 472	2. 496	2. 501	2. 543	2. 566	2. 588

Whence

Whence the diameter of any bullet is found, by dividing 1.6706 inches by the cube root of the number, which shews how many of them make a pound; or this may be done in a shorter manner. From the logarithm .2228756 of 1.6706 subtract continually the third part of the logarithm of the number of bullets in the pound, and the difference will be the logarithm of the diameter required.

Thus the diameter of a bullet, whereof 12 weigh a pound, will be found by subtracting .3597270, a third part of the logarithm of 12, from the given logarithm .2228756, or, when this logarithm is less than the former, an unit must be added, so as to have 1.2228756, and the difference .8631486 will be the logarithm of the diameter sought; which is .7297 inches; observing that the number found will always be a decimal, when the logarithm which is to be subtracted is greater than that of one pound; because the divisor is greater than the dividend in this case.

From the specific gravity of lead, the diameter of any bullet may be found from its given weight. For since a cubic foot weighs 11325 ounces by our table, and 678 is to 355 as the cube 1728 of a foot, or 12 inches, is the content of the sphere, which therefore is 5929.7 ounces; and since spheres are as the cubes of their diameters, the weight 5929.7 is to 16 ounces, or one pound, as the cube 1728 is to the cube of the diameter of a sphere which weighs a pound; which cube therefore is 4.66263, and its root 1.6706 inches, the diameter sought.

Sir *Jonas Moor* makes this diameter 1.69 inches: though he was very curious in his experiments, yet as the specific gravities have likewise been determined by *Cotes* and several eminent men, it would be a presumption in me to determine which of the two diameters is the most accurate; for which reason we shall give two tables, one of each of these suppositions, leaving the choice to the impartial reader.

*Diameters*

*Diameters of leaden bullets from 1 to 39 in the pound, according to the author.*

	0	1	2	3	4	5	6	7	8	9
0	0	1.671	1.325	1.158	1.05	.977	.919	.873	.835	.803
1	.715	.751	.730	.711	.693	.677	.663	.650	.637	.626
2	.615	.605	.596	.587	.579	.571	.564	.557	.550	.544
3	.538	.532	.526	.521	.517	.511	.506	.501	.497	.493

*Diameters of leaden bullets from 1 to 39 in the pound, according Sir Jonas Moor.*

	0	1	2	3	4	5	6	7	8	9
0	0	1.690	1.341	1.172	1.064	0.988	0.930	0.883	0.845	0.812
1	0.784	0.760	0.738	0.719	0.701	0.685	0.671	0.657	0.645	0.633
2	0.623	0.612	0.603	0.594	0.586	0.578	0.570	0.563	0.556	0.550
3	0.544	0.537	0.532	0.527	0.521	0.517	0.512	0.507	0.503	0.498

The diameter of the musket bores differ not above one fiftieth part from that of the bullet ; for if the shot but just rolls into the barrel it is sufficient. The government allows 11 bullets in the pound, for the proof of muskets, and 14 in the pound, or 29 in two pounds, for service : 17 for the proof of carabins, and 20 for service ; and 28 in the pound for the proof of pistols, and 34 for service.

As powder measures are useful in artillery, being more handy than weights, saving time, and are necessary in ricochet firing, we shall insert here some experiments I made upon that subject in 1753, at the royal academy of artillery.

I. A cy-

I. A cylinder, whose axis and diameter were two inches each, contained 3 ounces and 3 grains, or 51 grains; and as similar cylinders are as the cubes of their axis, if we say 51 grains are to 256 grains, or one pound, as the cube 8 of 2 inches is to the cube 40.166 of the diameter of a like cylinder holding one pound.

II. A cylinder, whose axis and diameter were 4 inches each, held 25 ounces and 10.5 grains, or 410.5 grains; whence 410.5 grains are to 256 grains, as the cube 64 of 4 inches is to 39.912, the cube of the axis of a cylinder holding one pound.

III. A cylinder, whose diameter and axis were 6 inches each, held 5 pounds 6 ounces and 6 grains, or 1382 grains. Hence  $1382 : 256 :: 216 : 40.01$  for the cube required.

IV. A two-inch cube held 4 ounces and 1 grain, or 65 grains; and as 452 is to 355, so is the cube 8 of the axis to the content of the cylinder, which therefore is 51.05. Hence  $65 : 256 :: 8 : 40 : 117$ , the cube of the axis.

V. A six-inch cube held 6 pounds 13 ounces and 13 grains, or 1757 grains; so then  $452 : 355 :: 1757 : 1379.944$ , or 1380, the content of the cylinder; and if  $1380 : 256 :: 216 : 40.07$ , this fourth term will be the cube of the axis required. Hence a medium of these five experiments gives 40.053 cubic inches, whose cube root 3.42 will be the diameter of a cylinder holding a pound of powder.

From hence we may deduce the specific gravity of powder, which is no more than the content of a cubic foot expressed in ounces. Now since 355 is to 452, as the content 16 ounces of the cylinder is to 20.372, the content of the cube of its axis, and the cube 40 of the axis is to the cube 1728 of 12 inches, or a foot, as 20.372 ounces to 880 ounces contained in a cubic foot of powder.

Sir *Jonas Moor* found by several experiments the diameter of a cylinder holding a pound of powder to be 3.165 inches.

*Dia-*

*Diameters and heights of cylindric powder measures from 1 to 39 ounces, according to the author.*

3	0	1	2	3	4	5	6	7	8	9
0	0	1.357	1.710	1.957	2.154	2.321	2.467	2.596	2.714	2.830
1	2.924	2.963	3.107	3.191	3.271	3.347	3.420	3.490	3.557	3.622
2	3.684	3.744	3.803	3.859	3.915	3.968	4.021	4.072	4.121	4.170
3	4.217	4.263	4.309	4.353	4.397	4.439	4.481	4.523	4.563	4.603

The logarithm of an ounce is .1326467; the other numbers are found, by adding one third of the logarithm of the number of ounces. Thus the number of 8 ounces is found by adding .3010300, one third of the logarithm of 8 to that of one ounce, which gives .4336767 for the logarithm of the number sought; which therefore is 2.714.

*Diameters and heights of cylindric powder measures from 1 to 39 pounds, according to the author.*

lb	0	1	2	3	4	5	6	7	8	9
0	0	3.420	4.309	4.932	5.429	5.848	6.214	6.541	6.824	7.114
1	7.368	7.606	7.830	8.041	8.243	8.434	8.618	8.794	8.963	9.126
2	9.283	9.435	9.583	9.726	9.865	10.00	10.13	10.26	10.38	10.51
3	10.63	10.74	10.86	10.97	11.08	11.16	11.29	11.45	11.50	11.60

*Diameters*

*Diameters of cylindric powder measures, when the diameter is to the axis as 2 to 3, according to the author.*

3	0	1	2	3	4	5	6	7	8	9
0	0	1.181	1.491	1.710	1.880	2.027	2.155	2.268	2.371	2.472
1	2.554	2.588	2.714	2.788	2.857	2.924	2.988	3.049	3.164	3.164
2	3.218	3.271	3.322	3.371	3.420	3.466	3.513	3.557	3.600	3.643
3	3.684	3.724	3.764	3.802	3.841	3.878	3.915	3.951	3.986	4.021

lb.	0	1	2	3	4	5	6	7	8	9
0	0	2.988	3.764	4.308	4.743	5.109	5.428	5.714	5.961	6.215
1	6.436	6.644	6.840	7.024	7.201	7.368	7.529	7.682	7.830	7.972
2	8.109	8.242	8.372	8.496	8.618	8.736	8.849	8.963	9.069	9.181
3	9.286	9.382	9.496	9.583	9.679	9.769	9.863	10.00	10.05	10.13

These diameters are found, if those of the former tables be divided by 1.1447, the cube root of  $\frac{3}{2}$ .

As I look upon these experiments to have been made with great accuracy, this difference can proceed from no other cause, than that the grain of the powder was something finer in his time than at present. The changing the size of the grains, is attended with many inconveniencies without the least advantage; for the powder measures made at one time are either larger or less than what they should be at another, whereby great mistakes are made in loading of pieces. Sometimes more, and other times less powder is used than intended; and to change them continually, is attended with expences,

pences, and cannot always be done abroad, where they have no conveniency to do it : such mistakes were made at *Minorca* some years ago, where the powder measure held 35 pounds instead of 30 ; and at the end of the season, the officer could not account for the spending so much more powder than he intended, till he found the mistake by examining the measure.

When the grains are made as large as we do at present, it happens that some of them are much smaller than others, and the small take fire sooner than the rest, by which the force of some is partly expended before the rest is fired, and consequently the total force is not so great as it would be, if the grains were nearly of the same size.

It has been imagined by some, that the large grained powder is stronger than the small : but Captain *Desaguliers* made some experiments with grained and mealed powder ; both which carried the shot the same distance. It may be presumed, that powder was not grained at its first discovery, but in course of time experience shewed, that it kept longer in grains than otherwise ; for which reason this custom is followed by all nations, and is undoubtedly the best.

*Diameters and heights of cylindric powder measures, holding from 1 ounce to 19, according to Sir Jonas Moor.*

3	0	1	2	3	4	5	6	7	8	9
0	0	1.257	1.583	1.811	1.994	2.148	2.282	2.403	2.512	2.613
1	2.706	2.793	2.876	2.953	3.027	3.098	3.165	3.230	3.292	3.352

These diameters are in inches and decimals.

*Diameters*

*Diameters and heights of cylindric powder measures, holding from 1 to 19 pounds.*

lb.	0	1	2	3	4	5	6	7	8	9
0	0	3.16	3.988	4.565	5.024	5.412	5.751	6.05	6.330	6.583
1	6.890	7.039	7.245	7.442	7.628	7.805	7.975	8.138	8.295	8.391

This last table is constructed in this manner; multiply continually the cube 31.705, of 3.165, by the number expressing the weight of powder, and the product will be the cube of the diameter and axis of the cylinder sought. Or thus, add continually .5003737, the logarithm of 3.165, to the third part of the logarithm of the number shewing the weight, then the sum will be the logarithm of the diameter required.

Thus one third .2006866, of the logarithm of 4, being added to the logarithm .5003737, gives .7010603, for the logarithm of the diameter of a cylinder, holding 4 pounds of powder, which is 5.024 inches.

The diameter of a cylinder, holding an ounce of powder, is found by subtracting one third of .4013733, the logarithm of 16, from the logarithm .5003737, then the difference .0990004, will be the logarithm of the diameter required; which being continually added to one third of the logarithm of the given number of ounces, gives the logarithm of the diameter sought.

As powder measures are more convenient, when their axis is longer than their diameters, we shall give the



*Diameters of cylindric powder measures, when the diameter is to the height, as 2 to 3, according to Sir Jonas Moor.*

3	0	1	2	3	4	5	6	7	8	9
0	0	1.097	1.382	1.582	1.742	1.876	1.994	2.099	2.194	2.282
1	2.364	2.440	2.512	2.580	2.644	2.706	2.765	2.820	2.874	2.926

lb.	0	1	2	3	4	5	6	7	8	9
0	0	2.765	3.483	3.988	4.389	4.728	5.024	5.289	5.530	5.751
1	5.957	6.149	6.330	6.501	6.664	6.819	6.967	7.104	7.241	7.325
2	7.505	7.628	7.749	7.863	7.975	8.085	8.191	8.204	8.396	8.495

These two last tables are constructed, by multiplying continually the diameter in the two former tables, by the cube root .873 of  $\frac{2}{3}$ , then the product will give the diameters of cylinders, holding the same quantity of powder, or else by adding —.0586971, the logarithm of .873, or the third part of that of  $\frac{2}{3}$ , to the logarithm .5003737, found above; then the sum .4416766, being continually added to one third of the logarithm of the number expressing the weight, the sum will be the logarithm of the diameter sought.

For example, to find the measure that shall hold 28 pounds: the logarithm of 28 is 1.4471580, one third of which being added to the given logarithm .4416766, gives .9240626, for the logarithm of the diameter required, which therefore is 8.396 inches.

This rule is proved from the known property in geometry, that equal solids have their bases and altitudes reciprocally proportional. Hence, if  $a$  expresses the diameter of the base or altitude, and  $x$  the diameter of the

the base of the cylinder required ; then because the diameter  $x$  of the base is to its altitude as 2 to 3 by supposition, the altitude will be  $\frac{3}{2}x$  ; and hence,  $a^3 = \frac{3}{2}x^3$ , by the condition of the problem, or  $\frac{2}{3}a^3 = x^3$  ; the cube root of which is  $a^3\sqrt{\frac{2}{3}} = x$ .

In the same manner may be found the diameter of a cylinder, which is to its altitude in any other given ratio, such as 1 to 2, or as 3 to 5.

As it is necessary that an artillery officer should know how to compute the number of shot contained in a square or oblong pile, finished or unfinished, we shall give here a method for finding the number of shot more general than that in our Elements of Mathematics, page 98, deduced from a most compendious principle.

*INVESTIGATION of a general rule for finding the sums of series's.*

If  $z$  expresses the number of terms of a series, whose sum can be expressed by the product of factors that are in an arithmetical progression ; to find the  $z$  or general term of that series.

*N. B.* The general term of a series is such an expression composed of a variable  $z$  and constant quantities, that when  $z$  is made equal to 0, 1, 2, 3, or 1, 2, 3, 4, it gives the first, second, third, fourth term of that series.

It is evident, that by diminishing the value of  $z$  by the common difference  $n$  of the factors, the sum will be diminished by the last term, and the difference between these two sums will be the  $z$  or general term required.

Thus if  $z, z + n, z + 2n, z + 3n$ , be the sum of any series, by writing  $z - n$  for  $z$ , we get  $z - n, z + n, z + 2n$  : which subtracted from the first, gives  $4n, z, z + n, z + 2n$ , for the general term required.

*N. B.* The points between the factors signify multiplication.

## General RULE.

From the sum of a series, to find its general term ; multiply the sum by the number of factors and the common difference, and strike out the last factor.

*N. B.* Whether the sum is multiplied by a constant number, or the factors decrease or increase, the rule is the same.

Thus the sum  $az$  gives  $a$  for a general term ;  $z. z + 1$  gives  $2z$  ; the sum  $z. z - 1. z - 2$  gives  $3z. z - 1$ , and  $z. z + n. z + 2n. z + 3n$ , gives  $4n. z. z + n. z + 2n$ .

## General RULE.

From the general term of a series to find the sum of any number  $z$  of terms.

Increase the factors by one more factor, and divide by the number of factors thus increased, and by the common difference.

Thus the general term  $a$  gives  $az$  for the sum,  $az$  gives  $\frac{1}{2}az. z + 1$  ;  $z. z + 1$  gives  $\frac{1}{3}z. z + 1. z + 2$ , and  $z. z - n. z - 2n$ , gives  $\frac{1}{4n}z. z - n. - z - 2n. z - 3n$ .

Observe, when the first value of  $z$  is 0, the factors must be of a decreasing progression ; but if it is any number of an increasing progression, as examples will shew,

## EXAMPLE I.

Let the series be any arithmetical progression as  $a, a + n, a + 2n, a + 3n$ , &c. whose general term is  $a + zn$ , when the values of  $z$  are 0, 1, 2, 3, and the sum  $az + \frac{1}{2}n. z - z - 1$ . of  $z$  terms. If 1, 2, 3, 4 ; then  $a = n = 1$ , and  $\frac{1}{2}z. z + 1$ , the sum of  $z$  terms. If 5, 7, 9, 11, then  $a = 5, n = 2$ , and  $5z + z. z - 1$  or  $z. z + 4$ , the sum of  $z$  terms.

## EXAMPLE

## EXAMPLE II.

Let the series be the squares of an arithmetical progression, as  $a a$ ,  $a + n$ ,  $a + 2n$ , &c. whose general term is  $a + zn$  or  $a a + 2nz + nnzz$ , and 0, 1, 2, 3, the values of  $z$ : hence the sum of the two first terms is  $a a z + nz. z - 1$ , and since  $z z = z + z. z - 1$ , whose sum is  $\frac{1}{2} z. z - 1 + \frac{1}{2} z. z - 1. z - 2$ , or  $\frac{1}{6} z. z - 1. 2z - 1$ , when reduced under the same denomination.

Therefore  $aaz + nz. z - 1 + \frac{1}{6} nnz. z - 1. 2z - 1$ , is the Sum of  $z$  terms of that series.

Thus if the series is the squares of the natural numbers 1, 2, 3, 4, then  $a = n = 1$ , and  $z + z. z - 1 + \frac{1}{6} z. z - 1. 2z - 1$ , or  $\frac{1}{6} z. z + 1. 2z + 1$ , when reduced under the same denomination.

If the series is 1, 9, 25, 49, that is the squares of the numbers 1, 3, 5, 7, 9, then is  $a = 1$ ,  $n = 2$ , and  $z + 2z. z - 1 + \frac{1}{3} z. z - 1. 2z - 1$ , or  $\frac{1}{3} z. 2z + 1. 2z - 1$ , the sum when reduced. If  $z = 10$ , then will 1330 be the sum of the 10 first terms.

## EXAMPLE III.

If  $ab$ ,  $a + 1.b + 1$ ,  $a + 2.b + 2$ , be the series, which is that of the horizontal range of a rectangular pile of shot, whose general term is  $a + z.b + 2$ , or  $ab + a + b.zxxx$ , and 0, 1, 2, 3, 4, the values of  $z$ ; the sum is therefore  $abz + a + b. \frac{1}{2} z. z - 1 + \frac{1}{6} z. z - 1. 2z - 1$ , by examp. II.

This series may be reduced to  $A. 2a + z - 1 \times 2b + z - 1 + \frac{1}{3} z + 1. z - 1. z$  by  $\frac{1}{2} z$ . For  $2a + z - 1$ , multiplied by  $2b + z - 1$ , gives  $4ab + 2a + 2b. z - 1 + z - 1. z - 1$ , and  $z - 1. z - 1$  added to  $\frac{1}{3} z + 1. z - 1$ , and the whole divided by 4 gives the first sum.

*General RULE for an incomplete pile.*

*To twice the length and breadth of the upper surface, add the corner row less one.*

*To the product of these two numbers add one third of the product, the corner row less one by the corner row more one, and multiply the sum by one fourth of the corner row.*

Thus, if the sides of the upper-surface are 20 by 4, and the corner row 6;

Then the sum of 40 and 5, multiplied by the sum of 8 and 5, gives — — — 585

One third of 7 multiplied by 5, gives — — — 11 $\frac{2}{3}$

Then the sum 596 $\frac{2}{3}$  of these two products, multiplied by 6 and divided by 4, gives 895 for the number of shot contained in that pile.

## CASE I.

When the pile is complete then  $b=1$ , and the sum A, becomes  $3a+2z-1x$  by  $\frac{1}{6}z.z+1$ . Which gives this

*General RULE for a complete pile.*

*To three times the upper row add twice the corner row less one.*

*Multiply the sum by the product of the corner row, by the corner row more one, and divide the product by 6.*

If the upper row be 20, and the corner one 12; then 3 times 20, added to 23, gives — — — 83

Multiply 83 by 12, this product by 13, and divide by 6, which gives 2158 for the number of shot required.

## CASE II.

When both  $a$  and  $b$  become unity, the sum A becomes  $\frac{1}{6}z.z+1, 2z+1$ , which gives this

General

*General RULE for a complete square pile.*

*Multiply the corner row by that row more one, multiply this product by twice the corner row more one, and divide by 6.*

If the corner row be 50, then  $\frac{1}{6} 50 \cdot 51 \cdot 101$ , or  $25 \cdot 17 \cdot 101$ , gives 42925 for the number of shot required.

*N. B.* By dividing before the multiplication is performed, as we have done, and which is always possible, the operation becomes shorter.

## C A S E III.

When  $b = a + 1$ , the series becomes  $a \cdot a + 1, a + 1 \cdot a + 2$ , and if each of these terms be divided by 2, it will be that of a triangular pile, and because  $b = a + 1$ , the sum  $A$  divided by 2, gives  $2a + z - 1 + 2a + z + 1 + \frac{1}{2}z + 1 \cdot z - 1 \times$  by  $\frac{1}{8}$ .

*General RULE for triangular incomplete piles.*

*To twice the side of the upper row, add the corner row less one, and the corner row more one.*

*To the product of these two numbers, add one third of the product, the corner row less one by the corner row more one, and multiply the sum by one eighth of the corner row.*

If the side of the upper row be 26, and the corner 20; then twice 26 added to 19, gives 71; twice 26 added to 21, gives ———— 73

And 71 multiplied by 73, gives ———— 5183

One third of 21 multiplied by 19 ———— 133

The sum 5316, multiplied by 20, and divided by 8, gives 13290, for the number of shot contained in the pile.

## CASE IV.

When  $a$  is unity, the sum in the last case becomes  $\frac{1}{2}z.z + 1.z + 2$ , which gives this

*General RULE for a complete triangular pile.*

*Multiply the base by the base one more, this product by the base more two, and divide by 6.*

If the base be 40, then 40 by 41, by 42, and the product divided by 6, gives 11480 for the number of shot contained in this pile.

These are all the different rules that can be given upon that subject, and to save the reader the trouble of computation, we shall insert here four large tables containing the number of shot in 2912 complete piles. The first column of these tables contains the number of the corner rows, and the upper horizontal line the number of the upper ranges. The number of shot in a pile is against the number of the corner row, and under that of its upper range. The last column contains the number of shot in a triangular pile, opposite to the number of its corner row in the first column.

## PART II.

*Construction of GUNS.*

**W**HAT has been said in the Introduction, with regard to the proper length of pieces, and the properties of different chambers in mortars, will enable us to form some general constructions of pieces, deduced from experiments and theory, and therefore less liable to exceptions, than those hitherto given by others, which

which seem to have no other foundation, than the particular fancy of the contriver, and generally a bare imitation of others. Before we proceed any farther, it is necessary to give the names of the several parts of which pieces are composed, in order that what is said may be clearly understood.

*Names of the several parts of a gun.*

Plate I. Fig. I.

- A B. The length of the gun.
- A E. The first reinforce.
- E F. The second reinforce.
- F B. The chace.
- H B. The muzzle.
- A h. The cascable.
- A C. The breech.
- C D. The vent field.
- F I. The chace girdle.
- r s. The base ring and ogee.
- t. The vent astragal and fillets.
- p q. The first reinforce ring and ogee.
- v w. The second reinforce ring and ogee.
- x. The chace astragal and fillet.
- z. The muzzle astragal and fillets.
- n. The muzzle mouldings.
- m. The swelling of the muzzle.
- A i. The breech mouldings.

The vacant cylinder, wherein the powder and ball are lodged, is called the Bore, and the entrance of the bore, the Mouth of the Gun. The cylindric parts T, by which the gun is fixed upon its carriage, are called Trunnions; and the handles on brass pieces, are called Dolphins, from the fish whose form they represent. The diameter of the bore is called the Caliber of the Piece. Lastly, the difference between the diameters of the shot and the bore, is called the Windage of the Gun.

REMARKS



## REMARKS.

The length of a gun is always reckoned from the hind part of the base ring, or beginning of the cascable, to the extremity of the muzzle. The second reinforce begins at the same circle where the first ends; and the chace at the same circle where the second reinforce ends.

The first reinforce includes the base ring, ogee next to it, the vent field, vent astragal, and first reinforce ring; the second reinforce, the ogee next to the first reinforce ring, and the second reinforce ring; and the chace, the ogee, next to the second reinforce ring, the chace girdle and astragal, the muzzle and astragal. The trunnions and dolphins are always placed on the second reinforce; the first, so as the breech part may weigh something more than the muzzle part, to prevent the piece from kicking up behind when it is fired; which it will always do so long as the center line is placed below that of the piece, as has been the custom ever since their invention. On the contrary, the dolphins are so placed, that when the gun is suspended thereby, the breech and muzzle parts may equally poise.

The artillerists here differ in the names of several parts; not one of them can tell precisely how far the muzzle reaches, nor the cascable; for some call the swelling the muzzle, others the breech mouldings, the cascable, and say, that the button is a separate part by itself, and not included in the cascable.

As no one has hitherto attempted to write upon Artillery in *English*, and to fix the names, it is no wonder that the practitioners differ, since they have no guide to go by. The only thing we could do, was to fix the names of the parts in the most convenient manner to their construction, and to prevent confusion. We have called the part from the beginning of the muzzle astragal to the mouth, the Muzzle; because that astragal deriving its name from the muzzle, it seems therefore that

These Tables are to be inserted immediately after Page 26, Signature [C].

I	16	17	18	19	20	D
10	1210	1265	1320	1375	1430	55
11	1496	1562	1628	1694	1760	66
12	1820	1898	1976	2054	2132	78
13	2184	2275	2366	2457	2548	91
14	2590	2695	2800	2905	3010	105
15	3040	3160	3280	3400	3520	120
16	3536	3672	3804	3944	4080	136
17	4080	4233	4386	4539	4692	153
18	4674	4845	5016	5187	5358	171
19	5320	5510	5700	5890	6080	190
20	6020	6230	6440	6650	6860	210
21	6776	7007	7238	7469	7700	231
22	7590	7843	8096	8349	8602	253
23	8464	8740	9016	9292	9568	276
24	9400	9700	10000	10300	10600	300
25	10400	10725	11050	11375	11700	325
26	11466	11817	12168	12519	12870	351
27	12600	12978	13356	13734	14112	378
28	13804	14210	14616	15022	15428	406
29	15080	15515	15950	16385	16820	435
30	16430	16895	17360	17825	18290	465
31	17856	18352	18848	19344	19840	496
32	19360	19888	20416	20944	21472	528
33	20944	21505	22066	22627	23188	561
34	22610	23205	23800	24395	24990	595
35	24360	24990	25620	26250	26880	630
36	26106	26862	27528	28194	28860	666

## EXPLANATION. Shot.

The foregoing rules are for regular occasions, and to satisfy the curious the foregoing tables may be performed in an easier row from 10 to 36, and is an arithmetic number of shot in the upper ranges equal numbers from 1 to 60.

The second column, that of the natural numbers; thus to unity yes 14 for the next pile; to this add the continued at pleasure, or any one may be

The last column under have the same corner row, and are always 1; thus the difference 55 against the end by adding continually the next corner non difference of the next line; and 12

Having the second of last of the differences, the other column the horizontal line. Thus the first pyramid 55, their sum 440 is the content of the whose upper row is 3. Again, the difference 210; the sum 6230 of 210 and

The column of differences by adding the common difference to the find the true number: thus the content add the difference 300 to 15400, of that number.

Mr. St. Remy gives a from 1 to 20, and upper ones from 1 to 20, excepting three numbers, being the corner rows at 10, because any like nearly the largest. The upper row together contain the number of 1620 differences

that the muzzle should reach so far. As to the cascable, it cannot properly be determined otherwise than we have done; since it is commonly said, that a piece is of such a length, exclusive of the cascable; it agrees likewise with what general *Armstrong* says in his Construction, as well as the distinction made by the founders and practitioners.

Formerly pieces were distinguished by the names of Sakers, Culverins, Cannon, and Demi-cannon; but at present their names are taken from the weight of their shot; as for example, a 12 or 24 pounder, carries a ball of 12 or 24 pounds weight.

As most constructions of authors agree in general, and differ only in some particulars, we shall give that of general *Armstrong's*, formerly surveyor-general of the ordnance, which appears to me less deficient than any that have hitherto been given, which are

*General RULE for brass and iron guns.*

The length of the gun being divided into 7 equal parts; the length of the first reinforce A E, is two of these parts; the second E F, one, and a diameter of the bore; so that the chace F B is four of these parts, wanting a diameter of the bore.

The distance from the hind part of the base ring, to the beginning of the bore, that is, the breech A C, is always equal to the thickness of the metal at the vent. The trunnions T, are always a caliber in length, and as much in diameter, clear of the second reinforce ring, and placed in such a manner, that a right line drawn through their centers touches the lower part of the bore, as in the fourth figure, where that line is marked a. b, and passing through the third division; that is to be three sevenths from the hind part of the base ring. The length of the cascable A b, is always two calibers and a quarter.

These

These divisions are in general made by all nations, only the trunnions are placed half a caliber more backward by the *French* \*.

### *General dimensions of brass guns.*

The caliber of the gun is divided into 16 equal parts.

The thickness of metal at the base ring from the bore, is ———— 16.

At the end of the first reinforce ring, ———— 14.5

At the same place, for the beginning of the second reinforce, ———— 13.5

At the end of the second reinforce, ———— 12.5

At the same place for the beginning of the chace, ———— 11.5

At the end of the chace or muzzle, the mouldings excluded, ———— 8.

### MOULDINGS.

Breadth of the { base ring, — — — 1.5 inches,  
ogee, next to the base  
ring, — — — 2.

From the ogee to the fore part of the astragal, a caliber.

The fillets of the astragal, are each — .28

The astragal, or half-round — — .56

Total of the astragal and fillets, — — 1.12

At the first and second reinforce ring, the fillets are — — — .25

Breadth of the first and second reinforce rings — — — 1.25

The ogees next to these rings, — — 1.5

The fillets at the muzzle, — — .25

\* This figure does not answer to the following constructions, but it is sufficient to shew the reader how to proceed, according to the given dimensions.

The

The muzzle ogee, in a 12 pounder and upwards, is 1.25 inches; but in a 9 pounder and under, it is an inch only. The chace girdle and astragal is one caliber. The space from the mouth of the gun to the muzzle astragal, in an 18 pounder and upwards, is equal to a diameter of the second reinforce ring; but in a 12 pounder and under, it is equal to the diameter of the first reinforce ring.

The rising of the mouldings at the first and second reinforces, is an eighth of an inch; and the rising of the base ring is determined by laying a ruler to the extremities of the first and second reinforce mouldings. The swelling of the metal at the muzzle is always equal to the diameter of the second reinforce ring.

#### C A S C A B L E.

From the hind part of the base ring, to the fore part of the fillet next to the bottom,  $\frac{1}{3}$  of a caliber.

From the fore part of the fillet next to the button, to the centre of the button, one caliber.

From the hind part of the base ring, to the hind part of the fillet, between the two \* ogees,  $\frac{1}{6}$  of a caliber.

Diameter of the fillet next to the button, 1.5 caliber.

Diameter of the neck,  $\frac{1}{4}$  of a caliber.

Diameter of the button, something more than a caliber, it is six inches in a 24 pounder.

It must be observed, that the shell at the vent is 3 inches broad, and reaches from the base ring, to within a quarter of an inch of the vent astragal, leaving that space for the ease of turning, and the vent is a fifth part of an inch.

\* The reader must observe, that general Armstrong made two ogees, though there is but one marked here.

*General*

*General dimensions for iron guns.*

The caliber of the gun is here divided into 14 equal parts.

The thickness of metal at the vent from the bore, is ——— 16 parts.

At the end of the first reinforce — 14.5

At the beginning of the second reinforce, 13.5

At the end of the second reinforce, — 12.5

At the beginning of the chace, — 11.5

At the end of the chace or muzzle, — 8.

As to the mouldings, and the rest of the dimensions, they are much the same as before, only the diameter of the vent is here one fourth of an inch, without any reason given for it.

The lengths of the guns, according to this gentleman, were as follows; the 32 pounder brass, 10 feet; the 24 and 18 pounders, 9.5 feet; the 12 pounder, 9; the six, 8; the three, 7; and the 1.5 pounder, 6 feet.

The iron 32 pounder, 9.5 feet; the 24 and 18 pounders, 9; the 12, eight; the 9, seven; the 6, six and half; and the 3, four and half feet.

Some of these dimensions have been altered since for others, grounded upon no better reason than the former.

The reader may easily perceive the perplexity of these constructions, arising from the different scales that are used without the least necessity. That the greatest part of the mouldings should have the same dimensions, from a 3 pounder to one of 32, appears contrary to reason, and especially contrary to the rules of architecture; from whence they have been taken. To make as many mouldings in iron guns, which are rough and not turned, as in brass ones, is another blunder; but these are trifles in regard to the absurdities in general committed in these constructions; which cannot better be discovered, than by examining all the parts separately, each in their order.

*Length*

*Length of guns.*

If the continual changing the length of pieces be considered, it will appear evident, that practice alone is insufficient to determine that which is the best ; and if the experiments hitherto published on that account are examined with some attention, it will be found, that for want of proceeding from proper principles, the result of them is erroneous and inconclusive.

For the greatest part of them were made to discover such a length as should carry the shot farthest, without mentioning what the charge should be ; believing that the greater the velocity of the shot is, the more its execution would be : but it has been found on the contrary by experience, that a velocity which is sufficient to carry the shot just through a wall, does more execution than one that is greater. Others, such as Mr. *Dumetz*, and the late general *Armstrong*, endeavoured to find the best length of a piece, when loaded with two thirds of the shot's weight ; and to attain which, Mr. *Dumetz* made use of different calibers, which had all the same length, viz. 10 feet, and he found that the 24 pounder carried its shot farthest.

Now, what can be concluded from these experiments ? Nothing more, as I conceive, than that 10 feet is a better length for a 24 pounder, loaded with that charge, than for any smaller caliber : but it does not determine, that this length is such, as to carry the shot farthest of any other ; for we are not certain, whether one of 8 or 9 feet long would not be better than this, since no trial has been made to shew that it would not. Besides, we are as much at a loss as ever, to know what are the best lengths for smaller or greater calibers.

From the experiments made by general *Armstrong* it was concluded, that 9.5 feet was the best length for a 24 pounder, though that of 9 feet produced the greatest range.

D

As



As these pieces were all of the same weight, it is plain that some of them were too strong in proportion to their length ; and if they had been reduced to a proper size, their ranges might probably have changed : but suppose this is in reality the best length for a 24 pounder, we are nevertheless in the dark with respect to the other calibers. So that the most that can be made of these experiments, is, that the length of the 24 pounder has been determined nearly, with regard to the charge made use of.

But it has been found since by experiments, that 8 pounds of powder are sufficient for a 24 pounder, when it is to make a breach ; for the *French* used no more all the two last wars in all their sieges. This being the case, all former experiments are exploded, and consequently others ought to be made, in order to determine the best length for that charge.

But are we certain that this charge is the best that can be used ? I think by no means ; for we have found, that one fourth of the weight of the shot is sufficient for field-pieces, and even a less one. And we are not certain, that the same charge might not do in battering pieces, or on board of ships ; so that new trials should be made first, to know the best charge before the lengths of the pieces can be determined.

The making small calibers longer in proportion than great ones, is attended with many inconveniences and of no advantage, so far as I can judge, since there is no necessity for their carrying as far as the heavy ones, which I suppose was the reason the artists went upon ; but this supposition is erroneous ; because there is but one certain length that is better than any other, greater or less, as we shall shew ; and therefore they may as well be too long as too short.

Another inconveniency attends this practice, which is, that some of these pieces weigh above twice more than they ought to do, according to the most heavy construction, whereby their carriage from place to place becomes

becomes more troublesome, and the expence at least one third more.

Lastly, when the lengths of pieces are not proportioned to the diameters of their shot, the experiments made with one caliber will not be of any use to any other, nor the dimensions used; and therefore as many experiments must be made as there are different calibers, as well as so many different constructions, in order to make them equally good and strong; and I may add, that this practice is the principal reason that so little improvement has been made in the construction of pieces, and that so much confusion is met with in them; whereas, if they are all the same number of diameters long, one general construction will be sufficient for all those made of the same metal; and when the dimensions of any one piece have been determined by experiments, it will serve for them all; the pieces will be similar, and their weights in the same proportion to that of their shot. Finally, the construction of all kind of pieces will be so short and easy, as that they may be comprehended in a few leaves, as will be seen hereafter.

Since then neither practice, nor any theory hitherto published, no more than the experiments made in *England* or *France*, have as yet furnished us with any satisfactory rule to proceed by, and yet Artillery cannot be improved without it; we shall endeavour to shew here, both from theory and some unexceptionable experiments, that there is a certain length of a gun better than any other longer or shorter, whereby it will carry its shot the farthest possible. For general *Williamson* of the Artillery made many experiments at *Minorca*, which are related in the introduction; whereby it appears that an eighteen pounder, which weighed 3900, and length 9 feet, carried farther than another eighteen pounder that weighed 5100, and was 11 feet long, when equally loaded, and with the same angle of elevation; it was found likewise, that nine pounds of powder was the best charge, and carried the shot farther than any other. From

whence it appears, that the greatest length of this caliber ought not to exceed 9 feet; but whether it might not be less has not yet been tried.

Now as 9 feet is 21 diameter of the shot nearly, and it is very probable that all calibers, proportionably long and charged, will produce similar effects, we may draw this conclusion, *that the length of pieces which carry their shot farthest does not exceed 21 diameter of its shot; and that their best charges are equal to half the weight of their shot.*

This will receive no small degree of certainty from what we have proved in the appendix to this work, page 122, where we have shewn, that the greatest velocities which cannon shot of different calibers can have, are always proportional to their diameters; and as their lengths ought to be in proportion to their charges, and they are proportional to the diameters of their shot, the length must therefore likewise be proportional to the diameters of their shot.

We have likewise proved in the same page, that the greatest velocities of projected bodies have certain limits which they cannot exceed, let the force that acts upon them be what it will; which confirms that part of the experiments with respect to the best charge.

Now since the greatest velocities of projected bodies are proportional to their diameters, the largest caliber will therefore carry their shot farthest. Consequently, the question of finding the length of a piece, so as to produce the greatest range, depends on its caliber, its length, and on its charge, which we have here determined.

As these experiments are the best and only ones that ever were made on Artillery, as far as I have seen or know, and agree exactly with the theory we have given in the appendix, so we may affirm this theory to be the best and only one grounded upon true and unexceptional principles, and that all others hitherto published are  
without

without foundation ; and therefore all the conclusions drawn from them erroneous.

Though it may be convenient on some particular occasion to have guns which carry their shot as far as possible, yet in common practice this rule is not to be followed ; for on board of ships these long and heavy guns would not answer so well as shorter and lighter, because short guns are easier loaded, require less room for the recoil, and are more expeditious in action ; and since ships come so near together in action as they do at present, the long ranges are intirely usefess : besides, the charge of half the weight of the shot is too much, and ought never to be used, one third at most is quite sufficient, and perhaps less, does more execution, and heat the guns less : all these advantages ought not to be neglected.

The length of battering pieces ought to be such, as to enter into the embrasures so far, as that the blast of explosion does not destroy them in a day's firing ; in that case they may be repaired again at night, because it is impossible to prevent the effect of the blast intirely : for which reason all calibers, not exceeding a 24 pounder, may be 21 diameters long, but those above cannot be so long without inconveniencies ; but the charges should never exceed one third of the shot's weight, because it has been found by experience that this charge is sufficient, and perhaps less would be better.

It must be observed, that guns should never be loaded with more powder than is just sufficient to produce the desired effect, which a skilful commander can or may always discover in practice ; by which the guns will not be heated more than is necessary, and they may be fired longer without receiving much damage.

What has been said in respect to battering pieces may be applied to garrison ones ; only the best charges may be given them on particular occasions, as at the beginning of an attack to oblige the enemy to begin his approaches as far as possible, or in a place situated near

the sea or a navigable river, to prevent ships from coming too near.

The field pieces should have the best length and charges, in order to annoy the enemy at the greatest distance, excepting the battalion guns, which should be short and light, that they may advance as well as retire as quick as the army. From whence follows this

### General RULE,

*That the length of guns ought to be determined from their particular uses.*

### *Thickness of METAL.*

It is an universal custom in *Europe* to make the guns with reinforces; that is, they are, as it were, made of three frustrums of cones joined together, so as the least base of the former is always greater than the greatest of the succeeding one, whereby the metal breaks off in two places on a sudden, as the reader has seen in the construction of pieces given here before. But since powder acts uniformly and not by starts, it is hard to judge from whence this ridiculous custom has arisen, which seems to be as old as the invention of guns; and nothing but the ignorance of the effects of powder has been the cause of its being handed down to our time. Our veneration for old customs is so great, that whoever attempts to make any change is looked upon with contempt, let his reasons be ever so plain and good; this I know too well by experience.

Yet I shall freely communicate whatever I think to be an improvement and useful to the public; let the consequence be what it will, I shall do my duty. Since then powder acts gradually and not by starts, there should be no breakings off in the metal; and we have shewn in the remark after Theor. IV. that the piece should be cylindric, from the base ring to the end of the

the charge, and from thence, by the nature of the explosion, a curve line bending inwards quite to the mouth of the piece: but as the construction of the curve is not very easy, and differs in the main but very little from a right line, by making the part between the end of the charge and the mouth conical, it will be sufficiently exact for practice.

When pieces were loaded with two thirds of their shots weight, the thickness of metal was then at the vent equal to the diameter of the shot; but since there is no occasion to load pieces with more than half that weight, the thickness of metal ought to be less; for which reason the present light 6 pounders are only the two thirds of the diameter of the shot thick, and their length 15 diameters; the same thickness is given to the 24 pounders, and their length is but 12 diameters; and as this thickness has been found sufficient by many trials, when the charge and length remain the same, there is no reason to make them stronger.

The strength given to iron guns is certainly more than required, supposing the charge no more than one third of the shot's weight; this has been found true by some, whose thickness at the vent was equal to the diameter of the shot, and half that thickness at the mouth.

#### V E N T.

The common method of placing the vent is within about a quarter of an inch from the bottom of the chamber or bore: yet it is imagined, that if the vent was to come out at the middle of the charge, the powder would be inflamed in less time than in any other case. But notwithstanding that this appears so visible, and seems to be demonstrable, yet I have found the contrary, to the great surprize of the spectators. I had two mortars, the chamber of one cylindric, the diameter of the base one inch, and the axis two; the chamber of the other

D 4 concave;

concave; each of these chambers had two vents, one at the bottom, and the other in the middle, and contrived in such a manner, that one could be screwed up, whilst the other served to fire; and I found always the range of the shell greater, when the lower vent was used, than when the powder was fired by the middle one. The same thing was tried by colonel *Desaguliers* and me, with different cylindric chambers, some of which were three or four times the diameter of the base in length.

This being fact, it remains now to know, whether the same would do in mortars of a larger size, or in guns; for I must own, that after these trials, and some others of a still more extraordinary nature, which have been mentioned in the introduction, I can scarcely believe any thing relating to the effect of gunpowder, but what has been found true by a sufficient number of experiments.

#### B O R E.

The windage, or difference between the diameters of the shot and the bore, is not the same in *England* as abroad. Suppose the diameter of a shot divided into 20 equal parts, then the diameter of the bore is 21 of these parts; the *French* suppose the diameter of the shot divided into 26 parts, and the diameter of the bore to be 27; what the proportion is in *Holland* and other parts of *Germany* I do not know; but it is evident, that the less windage there is, the truer the shot will go; and having less room to bounce from one side to another, the gun will not be spoiled so soon; for which reason I suppose, in the following constructions, the diameter of the shot to be divided into 24 equal parts, and make the bore 25, which is a medium between the *English* and *French* method. This we do not so much in order to differ from others, as on account of the convenient scale it affords, to construct not only guns thereby, but also their carriages, as will be seen hereafter.

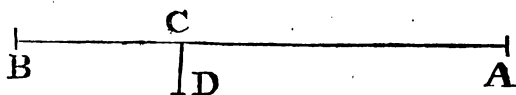
The

The *French* make little chambers in their 16 and 24 pounders, of one third of a caliber long, and as much in diameter; by this means they say the metal becomes thicker at the vent, and prevents its spoiling so soon. But as chambers are much more advantageous in other respects, we shall construct some hereafter, so as to have all the advantages that can be had.

Some are for making the bottoms of the bore conical, others spherical; and lastly, some quite flat; but I can find no reason to prefer one way before another, excepting the conveniency there may be in adapting the cartridges in a more easy manner to their form.

## TRUNNIONS.

The method of placing the trunnions so that their axis touches the lower surface of the bore, as is practised all over *Europe*, is so absurd, that it is amazing no author or artist has thought proper to change it; the only reason I ever heard given for this practice, was, that by this means they were stronger fixed to the gun, and of consequence would not break off so soon as in any other place. As insignificant as this reason is, it serves however to defend that old established custom.



But to shew the absurdity of it; suppose A B to represent the center line of the bore, and C D the distance of the center line of the trunnions from that of the bore. Now because when the piece is fired, the explosion acts against the breech B, and makes the piece recoil, but being fixed to the carriage by the trunnions, endeavours to turn about the point D, whereby it presses also upon the coils under the breech B, where they by their elasticity



city repel it upwards, and its weight brings it down again. The piece therefore acquires a pendulous motion about the center D, which causes the coins to fly off, changes its direction, and shakes the carriage with great violence, and often breaks it to pieces.

In long pieces this effect is not so sensible as in short ones; and though carriages generally break in their centers, yet the cause has never been attributed to the wrong situation of the trunnions; not even after the many accidents of that kind which have happened lately: for a short and light 24 pounder was tried at *Woolwich*, to know whether they might not be as useful in action as the light 6 pounders; but every time it was fired, it broke its carriage to pieces. From these accidents, and its recoiling more than the heavy pieces, they were rejected as useless, without thinking in the least that both inconveniencies might easily be remedied.

The piece stood upon a platform of stone quite level, which is not, nor ever has been, practised on any occasion whatever; for in the field they are placed upon the rough ground without any platform; and as the recoil is never so great in such a situation, as upon a level stone platform, this objection is to no purpose: and that this is fact beyond dispute, appears from the trials made at the same time with light 6 pounders, which recoiled likewise in an extraordinary manner, notwithstanding they are found in real service not to do so.

In a siege, when batteries are erected, the platforms are made of wooden planks, raised behind, more or less, according as it is necessary, to prevent the pieces from recoiling farther than is convenient to reload them. And since this may be done at pleasure, without the least inconvenience, the rejecting them on that account is frivolous and absurd.

To prevent these pieces from breaking their carriages is easy, if we dare break through old customs, by making the axis of the trunnions to pass through the center line of the bore, as may be seen in our constructions

tions hereafter. The pretence of their breaking off from the piece is taken away, by making shoulders to them; besides, this objection is only imaginary, since it has never been tried.

What we have said upon this head is likewise confirmed by practice in howitzes, which, being fixed to their carriages in the same manner as guns, are properly nothing else than short guns with chambers; for their trunnions are placed in the manner we propose, and, when fired, acquire no other motion than a backward one, without shaking in the least the carriage, nor did their trunnions ever suffer.

## MOULDINGS.

As they are made by way of ornament only, they depend chiefly on the maker's fancy; it must however be observed, that they should be plain and simple, and such as are used in architecture, from whence they have been borrowed; the metal should be projected as little as can be, that the piece may lie close on the carriage: the mouldings of our mortars are oddly jumbled together, without any order or judgment; and those of our iron guns are more numerous than is consistent with reason, for they have fillets on both sides the first and second reinforce rings, which are not used in brass pieces; and as these mouldings are not turned in iron, they appear ridiculous, and more so in swivel guns, which have as many as those of the largest caliber.

## MUZZLE.

The swelling of the metal at the muzzle seems to have been made merely to make the pieces look graceful, or perhaps to appear of a larger caliber to an enemy at a distance than they really are. When they are too heavy, the piece is liable to bend at the neck when heated with much firing, which makes it either break  
or

or bend, and so become useless. Some are of opinion, that the metal should be as high at the muzzle as at the base ring, that the visual ray over the metal may be parallel to the center line of the bore, which they imagine to be necessary for laying or pointing the piece in a proper manner; but those who are for this practice are very little acquainted with real service: for as the shot descends in its flight by the force of gravity, the piece must be laid higher than the object to be hit; so that when the metal is equally high before and behind, the object is hid intirely by the thickness of the metal, and consequently the piece can never be laid true; whereas if the height of the metal be less at the muzzle than at the breech, the elevation of the piece, when pointed at the object, will answer the descent of the shot at a certain distance, and the skill of the gunner will be sufficient to make a proper allowance when the object is either farther or nearer.

#### CASCABLE.

They are made of various figures; sometimes like a bunch of grapes, or as the heads of different kinds of animals: the *French* distinguish their calibers by the different forms of the cascables; but as this is expensive when they are well carved, and looks paltry when not well done, the manner of making them quite plain, with a button and a few breech mouldings, as we do here, seems in my opinion much neater, and is less expensive. It is true, that the distinguishing the different calibers is very proper; but this may be done in another manner, more agreeable to the sight, and cheaper.

#### *Line of Direction.*

Formerly pieces were made with a cavity upon the base ring, and a button upon the highest part of the muzzle, whereby they were directed in the same manner

as

as fowling-pieces are ; but how this line came to be left off in latter times I cannot tell ; for to find the center line of a piece every time it is to be fired with a plummet or an instrument, as is the custom, is very tedious, uncertain, and unmasterly : for as it is impossible to turn the outside of a piece true to the bore, considering the bluntness of the tools and the heaviness of the engine, the center line can never be found to any tolerable degree of exactness, by an instrument applied on the outside of a piece ; and when the shot does not hit the mark, the gunner is at a loss to know, whether it is owing to his want of skill, or to this line not being rightly marked ; whereby it is impossible he should be able to form a right judgment how to direct the piece.

But when the line of direction is marked on the piece in the aforefaid manner, and the shot does not hit the mark, he knows how to rectify the mistake, because the line remains always the same, whether it be marked right or not, which I have seen many times. It is said, that the platforms are never rightly level, and if one wheel of the carriage stands higher than the other, the line of direction becomes useless ; but I can find no reason for not laying the planks level when the platform is made, since I always have seen a level used ; and this may even be done sufficiently exact by the eye without a level, since a small trifle, either on one side or other, cannot cause any great error in the laying of the piece ; and in a field engagement, where no batteries are made, it is of no signification, whether the piece points a little to the right or left, provided it is not too high or too low.

## CALIBERS.

The choice of calibers depends on two considerations, *viz.* they should never be less than those of other nations ; because in an engagement by land or sea, the larger shot have always the advantage ; and their diameters

meters should have a sensible difference to distinguish their shot with ease; otherwise it may happen in an engagement, when men are generally in some confusion, that the one will be taken for the other, as has happened to my knowledge, whereby the piece becomes unserviceable, till the shot sticking in it, has been blown out again; which sometimes cannot be done without rendering the piece unserviceable.

As the construction of pieces, as well as that of their carriages, ought to depend on the diameter of their shot, methinks they should be expressed by whole numbers as much as can be, or at least by some easy fractions. Thus they should be expressed by 3; 3.5; 4; 4.5; 5; 5.5; 6 inches; which answer nearly to a 4, 6, 9, 13, 18, 24, and 31 pounders. And as the diameter of a 9 pound ball is 4 inches, and may serve in a manner as a standard to make the rest by, I am sorry to see that this caliber has been rejected lately in brass cannon.

This is what we thought necessary to premise before we enter upon the construction of pieces, to satisfy the reader, that they are the result of a well asserted theory, and of such reasons as ought to be well considered beforehand; but whether they will satisfy artists prejudiced in favour of the most absurd, old established customs, is what time will shew: the subject is of so great an importance to the nation, that it deserves to be well examined beforehand, and proper experiments made before any change is introduced; for which reason I submit these my endeavours to serve the public to the judgment of my superiors.

*General CONSTRUCTION for brass battering pieces.*

Plate I. Fig. 1.

Let the length AB, of the piece, be 18 diameters of the shot; divide that diameter in 24 equal parts for a  
5 scale,

scale, whereby all the rest of the dimensions are determined. Make the diameter of the bore equal to 25 of these parts; from the hind part A of the base ring, to the fore part D of the vent astragal set off 40 parts; make the thickness of metal taken from the bore at A and D, equal to 18 parts, that is, three quarters of the shot's diameter, and 9 parts, or half that thickness at the mouth; then the lines drawn through these points will determine the figure of the gun, which therefore is cylindric from A to D, and conical from thence to the mouth.

The center line of the trunnions crosses the center line of the bore at right angles, and at a distance of three sevenths of the total length A B of the gun, from the hind part A of the breech; their diameter is 18 parts, as well as their length, free from the projection of the second reinforce ring; the second reinforce E F, is always two thirds of the first A E; the breech A C is 16 parts, the chace girdle F I, 14; the muzzle H B, the tenth part of the total length of the gun, which is here 43 parts, and the diameter of the swelling, m, of the muzzle is 6 parts distant from the mouth.

The breadth of the base ring and ogée next to it are each 6 parts; the first and second reinforce rings, and the ogées next to them, 5, the astragals and fillets 4; the cavetto at the mouth 2.5, and the fillets one each.

The base ring projects the metal by two parts, the first and second reinforce rings by one, or rather less; the fillets of the astragals by one half, and the round part is described from a center placed in the outline of the piece. There is a circular shoulder about the trunnions, whose diameter exceeds that of the trunnions by 6 parts, and projects even with the second reinforce ring.

## C A S C A B L E. Fig. 2.

The distance from the hind part A, of the base ring, to the center C, of the button, is 27 parts, the radius of the button 9, the breadth of the quarter round 2, the ogee 5, and the fillets one each. From the center C of the button, draw lines to the extremity of the base ring E, F, in which find the center O, so as the arc described meets the arc of the button in the line C F, and touches the second fillet: these arcs will determine the neck; the line O p, drawn through the center O, parallel to C A, will determine the second fillet, and C F, the first.

To describe the ogee, join the extremities n, q, of the fillets; through the point q, draw the line r p, parallel to O n, produced; in these two lines find the centers p, so as the arcs described through the points n q, meet in the middle of the line n q: the arc which determines the quarter round, is described from a center r, in p, q, produced so as to meet the extremity F, of the base ring within one part. The shell is 6 parts broad, and the diameter of the vent a fifth part of an inch.

## M U Z Z L E. Fig. 3.

Take the line B K, equal to twenty parts, and erect the perpendicular I K, after having made L P, equal to 6 parts, the center I, is to be found so as the arc described, through the point K, shall meet the point L; and if through the point a, at 4 parts distant from H B, the line a r, be drawn perpendicular to L P, the center r, is to be found so as the arc described through the point L, may meet the extremity of the fillet a. The cavetto is no more than a concave quarter round.

It has been found by experiments, that when pieces have chambers, they require a less charge than they would do otherwise; for which reason I would make a chamber in all Pieces of 24 pound ball and upwards, whose diameter should be two thirds the diameter of the bore,

bore, and length equal to that diameter; such, as is represented in the first figure. Although this chamber contains but one ninth part of the shot's weight of powder, yet the effect it produces is nearly equal to that of a fourth part; which is sufficient in large pieces.

Whatever faults there may be found with the particulars of this and the following constructions, it cannot, however, be denied but this is the true method whereby artillery pieces should be made; for since architecture has its certain rules whereby to construct the several parts of a column from its diameter, there is no reason why the parts of a piece should not be determined in the same manner.

*To find the weight of metal.*

The square of 43, the diameter of the muzzle without mouldings,      _____	1849
The square of 61, the diameter at the vent astragal,      _____	3731
The rectangle, or main plan of these diameters, 43 and 61,      _____	2623
<hr/>	
The sum of these three products added, —	8193
Which multiplied by one third of 392, the length DB,      _____	1070552
The square of the diameter 61, multiplied by 40, the length AD,      _____	148840
Four times the cube of 18, for the trunions, cascable, and mould,      _____	23328
<hr/>	
The sum of these last three products added,	1242720
The square of the bore 25, multiplied by its length 416,      _____	260000
<hr/>	
The difference between these two last sums,	982720
The square of the diameter is to the area of the circle, as 452 to 355,      _____	771826
E	These



These are cubic parts of the shot's diameter, divided into 24 equal parts : and as a cubic foot of gun metal weighs 459 pounds, according to our tables, or 192 cubic inches 61 pounds ; the last sum reduced in this proportion gives 245215.

But the cube of 24, the diameter of the shot, is to the cube of 4, the diameter of a 9 pound ball, as 216 to unity, so is 245215 to 1135 pounds, the weight of a 9 pounder ; and if this number be divided by 9, we shall have 126 pounds of metal for every pound of the shot's weight. Consequently the weight of the shot of any gun, according to this construction, multiplied by 126, and the product divided by 112, gives the weight of the gun.

*Length and weight of battering pieces.*

*Old Pieces.*

Calib.	Length.	Weight.
6	8 : 0	19 : 0 : 0
9	9 : 0	25 : 0 : 0
12	9 : 0	29 : 0 : 0
18	9 : 6	48 : 0 : 0
24	9 : 6	51 : 0 : 0
32	10 : 0	55 : 2 : 7
42	9 : 6	61 : 2 : 10

*New Pieces.*

Calib.	Length.	Weight.
12	6 : 7	13 : 2 : 0
18	7 : 6	20 : 1 : 0
24	8 : 4	27 : 0 : 0
32	9 : 2	36 : 0 : 0
36	9 : 6	40 : 2 : 0
42	10 : 0	47 : 1 : 0
48	10 : 6	54 : 0 : 0

The lengths of pieces are in feet and inches ; old guns of the same caliber are not always of the same length, nor of the same weight ; these given here are those most commonly used at present ; but for what reason the 32 pounder is longer than the 42 is only known to the maker.

*Remarks*

*Remarks on this construction.*

We have shewn in the Introduction, that the guns should be cylindric as far as the charge reaches, and from thence conical to the mouth ; and therefore the construction is conformable to the theory : we have likewise shewn, that the center line of the trunions ought to pass through the center line of the bore ; for when it is lower, as has hitherto been the custom, the carriages are destroyed in a short time ; the distance of the trunions from the breech is the same in both, and we found it likewise to be right by computation : the length of the 36 and 42 pounders is agreeable to that commonly given to battering pieces ; and since both these calibers weigh less than the old 24 pounders, they may be used instead thereof, as well as the 48 pounder, which weighs very little more than some 24 pounders, especially as a breach is much sooner made by large calibers than by small ones ; and that they are strong enough we are certain, since our present field-pieces, whose strength is to that of these in the proportion of 8 to 9, have been found by repeated experiments, to bear any firing whatever ; and they need not be loaded but with one fourth of the shot's weight, when they are made without chambers, since the force of a 32 pounder, loaded with 8 pounds of powder, is greater than that of a 24 pounder loaded with 8 pounds, in the proportion of the weights of their shot ; that is, in proportion of 4 to 3 ; and the force of a higher caliber is still greater.

It is true that these new pieces would recoil more than the old, if they were loaded with the same charges, which is not the case ; besides, it may be easily prevented, by allowing a greater slope to the platform. Consequently the pieces, according to this construction, have greatly the advantage over the old ones.

*Construction of iron battering and garrison pieces.*

Let the length  $AB$  be 21 diameters of the shot, divide that diameter into 24 equal parts as before, make the diameter of the bore 25; from the hind part  $A$  of the base ring, to the fore part  $D$  of the vent astragal, set off 48 parts; make the thickness of the metal, taken from the bore at  $A$  and  $D$ , equal to 25 parts, and 12 at the mouth  $B$ .

The center line of the trunions crosses the center line of the bore at right angles, at the distance of three sevenths of the total length of the gun, that is nine diameters from the hind part  $A$  of the breech: their diameter is 24 parts, as well as their length, free from the progression of the second reinforce ring; the first reinforce 9 diameters and 3 parts; the second 5 diameters and 9 parts; the breech  $AC$ , 24 parts; the muzzle  $HB$ , 50; the chace girdle  $FI$ , 16; the diameter of the swelling at the muzzle is 6 parts distant from the mouth; and the rest as before.

By the same manner of computation as before, I find two hundred weight of metal for every pound of the shot's weight. Hence we have the following,

*Iron battering and garrison pieces.*

Caliber.	Length.	Weight.
3	4 : 10	6 : 0 : 0
4	5 : 4	8 : 0 : 0
6	6 : 1	12 : 0 : 0
9	7 : 0	18 : 0 : 0
12	7 : 8	24 : 0 : 0
18	9 : 0	36 : 0 : 0
24	9 : 8	48 : 0 : 0
32	9 : 8	56 : 0 : 0

Observe,

Observe, that the 32 pounder is but 19 diameters long; the thickness of metal at the breech 24, and 11 at the muzzle. Experience has sufficiently shewn in this last war, that iron guns stand much better, in making a breach, than the brass; for the latter have failed in all the sieges they were used.

I can affirm, that a hundred and a half of metal is sufficient for one pound of the shot's weight, provided the guns are made of good virgin ore: and one should think it would be the interest of the nation, to make use of the best that is to be found in the country for that purpose.

Besides, a set of 6, 7, 12, 18, 24, 32 of brass pieces, weigh 22700 weight, which, at 130 *l. per ton*, cost 1475 *l. 10 s.* and the same set of iron weighs 19400, a ton costs 16 *l.* and the whole set 155 *l. 4 s.* So that 9 sets of iron cost no more than one of brass.

## *Construction of brass pieces for ships.*

As long guns are very inconvenient on board of ships on account of the difficulty in loading them, we shall suppose the length *AB* to be 15 diameters of the shot, which diameter being divided into 24 equal parts, as before, and the diameter of the bore being likewise 25 parts; the distance *AD* is 40 parts; the breech *AC* 18; the thickness of the metal at *A* and *D* is 20, and 10 at the mouth *B*; the rest of the construction is the same as before; only the diameter and length of the trunions are 20 parts each.

By the same manner of computing the weight of metal as before, we shall have 124 pounds of metal for every pound of the shot's weight; which gives the following table.

*Brass ship-guns.*

Caliber.	Length.	Weight.
3	3 : 6	3 : 1 : 17
6	4 : 4	6 : 2 : 14
9	5 : 0	10 : 0 : 0
12	5 : 6	13 : 1 : 3
18	6 : 4	20 : 0 : 0
24	7 : 0	26 : 2 : 7
32	7 : 6	35 : 1 : 17
36	7 : 10	40 : 0 : 0
42	8 : 4	46 : 2 : 0
48	8 : 6	53 : 0 : 14

*Remarks on this construction.*

In this construction we have not considered the strength so much as the weight, on account of the recoil; for should that be too great it might be attended with great inconveniency, such as tearing the tackle. But when these guns are loaded with one fourth of the shot's weight, if there are no chambers made, the recoil will be but little greater, or perhaps no more than that of old guns loaded with half of the shot's weight: this being the case, there is not the least reason to make pieces so heavy as at present, nor so long: for if it be considered that ships may carry 12, 18, 24, 36, 42, 48 pounders of this new construction, instead of 6, 9, 12, 18, 24, and 32 pounders of the present, and at the same time carry less burthen; it must appear to every rational person, what advantage such a ship must have above an enemy's.

enemy's of the same rate. To illustrate this by an example, we shall give here a list of the guns, length and weight, which are on board the *Royal George*.

P <sup>r</sup> .	Num.	Length.	Weight.	Total.
42	28	9 : 6	61 ; 2 : 10	1820
24	28	9 : 6	51 : 0 : 0	1428
12	28	9 : 0	29 : 0 : 0	812
6	16	8 : 0	19 : 0 : 0	304

Total 4366 or 218.3 tons,

*A new set of guns.*

P <sup>r</sup> .	Num.	Length.	Weight.	Total.
42	28	8 : 4	46 : 2 : 0	1302 : 0 : 0
32	28	7 : 6	35 : 1 : 17	991 : 3 : 1
24	28	7 : 0	26 : 2 : 7	743 : 3 : 21
18	16	6 : 4	20 : 0 : 0	320 : 0 : 0

Total ——— 3357 : 2 : 22

Total in tons — 167.8

Difference ——— 50.5

It must be observed, that instead of 28 pieces of 42 pounders (formerly taken from the *French*) which are at present on board, the same number of ours are to be put in their place.

Hence it appears, notwithstanding, that there are 28 pieces of 32 pounders in the new list, instead of 28 twelve pounders, and 16 eighteen pounders instead of the same number of sixes ; yet the difference between the total weights is 50.5 tons, an object too considerable not to be observed. Besides, the new guns being shorter than the old, they may be fired much faster.

That the strength of these guns is sufficient appears from the trial of 2 twelve pounders made for admiral Keppel ; they were loaded with 12 pounds of powder each

E 4

time.

time, and stood the proof, without receiving any damage; and I may venture to say, that they would stand any number of firings with the common charge.

*General construction for iron ship guns.*

Let the length of the piece be 15 diameters of the shot; the diameter of the bore 25 parts of the shot's diameter divided into 24, as before; the distance A D, 40 parts; the breech A C, 24; the thickness of metal at the vent 24, and half that thickness at the mouth; the diameter and length of the trunions 24 each, and the rest of the construction the same as before.

By the same way of computing as before, we shall find 140 pounds of iron, or a hundred and a quarter, for every pound weight of the shot: supposing that 108 cubic inches of cast iron weigh 29 pounds, according to our table of specific gravities.

*Iron ship guns.*

*Old pieces.*

Calib.	Length.	Weight.
3	4 : 6	7 : 1 : 7
4	6 : 0	12 : 2 : 13
6	7 : 0	17 : 1 : 14
9	7 : 0	23 : 2 : 2
12	9 : 0	32 : 3 : 3
18	9 : 0	41 : 1 : 8
24	9 : 0	48 : 0 : 0
32	9 : 6	53 : 3 : 23
42	10 : 0	55 : 1 : 12

*New pieces.*

Calib.	Length.	Weight.
3	3 : 6	3 : 3 : 0
6	4 : 4	7 : 2 : 0
9	5 : 0	11 : 1 : 0
12	5 : 6	15 : 0 : 0
18	6 : 4	22 : 2 : 0
24	7 : 0	30 : 0 : 0
32	7 : 6	40 : 0 : 0
42	8 : 4	52 : 2 : 0
48	8 : 6	60 : 0 : 0

*Remarks*

*Remarks on this construction.*

The making iron pieces in such a manner as not to be heavier than is necessary, nor yet too weak, so as to be in any danger to break when fired briskly for some time, is of the greatest importance, insomuch as all our ships, one or two excepted, are provided therewith; for by making them too heavy the ships cannot carry so many large large calibers as they otherwise might, which is agreed by the best judges to be a great disadvantage; if, on the other hand, they should be so weak as not to bear a brisk firing, the bursting of a piece in an action might create such a confusion as to cause the loss of the ship. But to prove beyond doubt that no danger can be apprehended from guns made according to this construction, provided the iron is good (such as that of the *Carron* company) appears from the trial of 2 three pounders made for lord *Egmont*; for they both stood the ordnance proof loaded with three pounds of powder, and I am certain they would have stood if they had been loaded with double that charge. There was also made 2 six and 2 twelve pounders for *Monf. De Malo*, the *Portuguese* envoy; and they stood their proof, and would have done it, if they had been loaded with much greater charges than the weight of their shot. Now since all the calibers are proportionally strong; according to their charges, the one being found strong enough by practice, all the rest must be so too. Secondly, we have a great many 6 and 9 pounders that were cast formerly, and which have been used a great while, and are less thick at the muzzle astragal than the new ones: this being an undeniable fact, proves again, that the new are of a proper strength. The reason that the present guns are so much heavier than the new, is owing to their greater length; besides the charges of powder have hitherto been greater than was necessary, and the strength of the pieces has, or ought to have been



been made in proportion. With regard to the length of these new pieces, they are such as are conceived by some of the best sea officers to be much more convenient than if they were longer, on account of the rope rammer they are obliged to use ; for in long pieces, if the rope is hard and stiff, it is bent with great difficulty, and if not, will scarcely suffice to ram the shot home.

*Guns of a new construction used in the several men of war.*

Num. of guns.	Weight of old.	Weight of new.	Num. of ships.	Weight of old number.	Weight of the new number.
100	4367. 3	2556. 0	5	21838. 3	12780
90	3537. 3	2001. 0	9	31839. 3	18009
80	3108. 3	1827. 0	7	21761. 1	12789
74	3091. 0	1840. 2	32	98912. 0	58896
70	2997. 0	1796. 2	10	29970. 0	17965
64	2543. 3	1305. 0	23	58506. 1	30015
60	2177. 3	1185. 0	30	65332. 2	35550
50	1881. 1	1035. 0	19	35743. 3	19665
44	1365. 2	705. 0	8	10924. 0	5640
40	1234. 2	312. 2	9	11110. 2	2812
36	963. 3	450. 0	7	6746. 1	3150
32	956. 2	435. 0	28	26782. 0	12180
28	593. 2	285. 0	23	13650. 1	6555
24	531. 3	255. 0	12	6381. 0	3060
20	421. 2	191. 1	15	6322. 2	2869

Total of the Weights — — — 445820 : 241935

Difference — — — — — 20388500 or 10194 $\frac{1}{2}$  tons.

Difference of the expences—1631081.

If to this we add the difference 26321 l. between the brass guns of the *Royal George* and the same set of iron, we get 189429 l. for the difference between the expences of the old and new set. And if the number of guns on board of the sloops and those in the garrisons, as well as those which serve in the field, it may perhaps amount to as much more.

Hence

Hence every ship may carry very nearly double calibers of these new guns to those of the old ones, and that with safety, and be less burthened at the same time, as has been fully proved: the great advantage of such a change must be plain to all such as are concerned in naval affairs. I must observe one thing more, that the small charge we propose may appear insufficient in calibers under a 24 pounder; but when it is considered, that when ships come to a proper distance, the small shots have as much chance to penetrate the ship as the large, though their effect is less in proportion; but at a great distance the resistance of the air is greater in proportion as the diameter diminishes, as Mr. *Robins* has rightly observed.

But as all commanders make, or ought to make a point of it, to come close to an enemy before they begin to fire, there is no reason to fear but that these small calibers are as useful as any others.

*Number*

*Number and caliber of guns on board the several men of war.*

Old Establishment.

No	42	32	24	18	12	9	6	4
100	28		28		28		16	
90		26		26	26		12	
80		26		26		24	4	
74		28		28		18		
70		28		28		14		
64			26		26	12		
60			24		26		10	
50			22		22		6	
44				20		20	4	
40				20		20		
36					26		10	
32					26		6	
28						24		4
24						22		2
20						10		10

New Establishment proposed.

No	48	42	32	24	18	12	9	6
100	28		28	28		16		
90		26	26	26		12		
80		26	26		24	4		
74		28	28		18			
70		28	28		4			
64			26	26	12			
60			24	26		10		
50			22	22		6		
44			20		20	4		
40			20		20	4		
36				26		10		
32				26		10		
28				24		4		
24				22			2	
20				10		10		

The first column contains the number of guns which the ships carry, according to the present establishment; the numbers in the first horizontal line express the calibers used on board the men of war; and the number of each fort are under them opposite the number the ships carry.

*Construction*

*Construction for light field pieces.*

Let the length  $AB$  of the piece be 14 diameters, the diameter of the shot divided into 24, and the bore 25 as before; the thickness  $AC$  of the breech 14, the distance  $AD$  39; the thickness of metal at the vent  $AD$  16, and 8 at the mouth; the diameter and length of the trunions each 16 parts, and the rest of the construction as in the first.

A ring of metal is cast under the cascable in these light pieces, as is seen in figure the second, which serves to fasten the head of a screw, that is used instead of coins to raise the piece by: this ring is described from the same center, and with the same radius as the neck; the diameter of the hole to receive the bolt is 5 parts, and the thickness of the ring is 4 parts.

By the same way of computing the weight of metal as after the first construction, we find about 85 pounds of metal for every pound of the shot's weight, which gives the following dimensions.

## FIELD PIECES.

Present.

Calib.	Length.	Weight.
3	3 : 6	2 : 3 : 10
6	4 : 6	4 : 3 : 10
12	5 : 0	8 : 3 : 8
24	5 : 6	16 : 3 : 13

New.

Calib.	Length.	Weight.
3	3 : 3	2 : 1 : 2
6	4 : 1	4 : 2 : 5
9	4 : 8	6 : 3 : 8
12	5 : 1	9 : 0 : 10
18	5 : 10	13 : 2 : 16
24	6 : 5	18 : 1 : 5

From

From whence it appears, that the weights of the new constructed pieces nearly agree with those used at present: the lengths of the 3 and 6 pounders new are less, and those of 12 and 24 something more than the lengths of the present. We have hitherto used but the four calibers marked above, and even the 12 and 24 very little, because it has been found that these pieces, placed on a level platform, and loaded with one-fourth of the shot's weight of powder, recoil too much: yet as platforms are never made upon any occasion without a slope, and in an engagement are placed upon turf, and the advantage of the ground is or may be taken, the firing these pieces upon a level platform made of stone is not an experiment to be depended upon.

These light 18 and 24 pounders may serve in private expeditions for battering pieces, especially where the road is very bad, and no heavy pieces can pass, and yet battering pieces are required; which is the case where a fort or any other post is to be taken; for no less calibers are esteemed sufficient to make a breach, or induce the commander to surrender. There have been much lighter pieces made not many years ago, as a 6 pounder weighing but three hundred and a half, and which carried its shot very well with a pound and a quarter of powder; but it is imagined that they are attended with inconveniencies in real use, for which reason they have been rejected.

#### *Construction of iron garrison pieces.*

Let the length of these pieces be 18 diameters of the shot, and the rest of the construction be the same as that of iron ship guns: then by a like computation as before, we find  $172\frac{2}{3}$  pounds of iron for every pound of the shot, and from thence we get the following dimensions.

IRON

## IRON GARRISON PIECES.

Calib.	Length.	Weight.
3	4 : 2	4 : 2 : 12
6	5 : 3	9 : 1 : 0
9	6 : 0	13 : 3 : 12
12	6 : 7	18 : 2 : 0
18	7 : 6	27 : 3 : 0
24	8 : 4	37 : 0 : 0
32	9 : 2	49 : 2 : 16
42	10 : 0	64 : 0 : 0

As the 32 pounder weighs about the same, and is nearly the same length as the old 24 pounder, it may well serve upon the same occasion. As to the lengths and weights of the other calibers, I imagine them such as are proper for the uses they are commonly applied to. The 42 pounder may also serve near the sea, or in harbours, to prevent enemy's ships from passing by, with more advantage than 24 and 32 pounders, which are chiefly used at present upon those occasions.

But if some of the smaller calibers should be thought too short, according to the present practice, they may be lengthened so much as necessary, without changing any of the other dimensions, which do not depend on the length.

Having given general constructions for the several sorts of brass and iron cannon, which are necessary upon different occasions by land or sea, in the most plain and easy

easy manner we could think of (which none have yet done) and as these constructions are grounded on the most plausible reasons, supported by theory and practice, it is hoped our endeavours will be of use to the public, as expences are considerably lessened. For if the great quantity of metal required in all the guns necessary to the nation, and the vast number of horses now used in the field be considered, and that according to our construction above one-third will be saved, as likewise a proportional number of horses, one would imagine these advantages sufficient to induce the directors of these affairs to examine well our scheme, and to make proper trials, in order to be convinced whether what is here proposed is of any real advantage or not; at the same time guarding against the crafty insinuations of ignorant artists, who find fault with improvements merely out of a selfish vanity, without judgment or knowledge.

As we propose to make chambers in all guns above an 18 pounder, it may be objected, that the difficulty of loading them will prevent their use; but as a rammer may be contrived so, as to load these pieces as easy as others, the only difference being to put the powder in cartridges, which is more than recompensed by saving almost half of it; besides, the pieces will not be heated so soon, and consequently they may be fired much oftener without any danger of being damaged. When all these advantages are well considered, it will be found that chambers in large cannon is an improvement not to be neglected.

We must observe one thing more before we leave this subject, which is, that as we make the diameter of the bore but one 24th part larger than that of the shot (whereas the common practice is to make it one 20th part more) if the bores of the new constructed guns are made as usual, they will be something lighter than what we have marked them in the preceding tables. But as a shot goes much truer when it just fits the bore, and does less damage to the gun, by not bouncing from one side

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FIG: 3

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sides to the other, it is to be hoped that they will be made in the manner we propose.

It is true that some artillery officers say, that the windage of a gun should be equal to the thickness of the ladle; because when it has been loaded for a while, the shot will not come out without being loosened thereby, in order to unload it; and when this cannot be done, it must be fired away, and so lost; but as the windage of a 9 pounder, according to our construction, is .166 of an inch, this is conceived a sufficient thickness for a ladle, and those of a higher caliber become still thicker in proportion. But suppose this thickness is not sufficient, the loss of a shot is a mere trifle in respect to the advantage got thereby; besides, as there is always a wad before the shot, I do not see that any dust or dirt can get into the piece; and therefore when the muzzle is lowered, the shot will roll out of course.

There is another advantage in these general constructions, which is, that the diameters of the shots being marked on brass rulers at full length, and divided into 24 equal parts, they will serve as scales to draw the draughts in full lengths for the use of the founders and the carriage-makers, whereby the patterns may be made with great ease and exactness.

### PART III.

#### *Constructions of MORTARS and HOWITZES.*

**M**ORTARS are a kind of short cannon of a large bore, with chambers. Their use is to throw hollow balls filled with powder, called *shells*; which falling upon any building, or into the works of a fortification, burst, and their fragments destroy every thing within reach. *Carcasses* are also thrown out of them, which are a sort of shells with five holes, filled with  
F pitch

pitch and other combustible matters, in order to set buildings on fire ; and sometimes baskets full of stones, the size of a man's fist, are thrown from them upon an enemy, placed in the covert way in the time of a siege.

Mortars are distinguished here chiefly by the diameter of the bore. For example, a ten inch mortar is that the diameter of whose bore is ten inches ; there are however some small sorts, as coehorns and royals ; the name of the first is derived from that of the inventor.

Sea mortars, or those placed on board of ships, are longer and much heavier than the land. There is besides another sort, called howitzes, of a *German* invention, which differ from the former, in having their trunnions placed nearly in the middle, and being mounted upon carriages like travelling gun-carriages.

#### PLATE II. Fig. 5.

The principal parts of a mortar are on the outside the chase A, the reinforce B, the breech C, and the trunnions D. In the inside, the part where the shell is lodged, is the bore ; and the part where the powder is lodged, called the chamber. The parts *n n*.

The figure of the chamber is made variously by different nations ; the *Spaniards* use chiefly the spheric ; the *French* the conic, cylindric, and the bottled or concave ; the *English* make them in the form of a frustum of a cone. Each nation has its reasons, good or bad, to prefer their make before that of others ; but whoever considers these different forms in an impartial manner, and the reasons given by authors for adhering to one preferable to others, will find, that nothing is less determined upon true principles or experiments, than the proportions of the several parts of a mortar ; we shall therefore begin to give some tables of their dimensions, and afterwards examine the different parts separately, as we have done in guns, in order that the reader may distinguish their perfections and imperfections.

*Dimensions*

## ARTILLERY.

*Dimensions of the brass land mortars now in use. Fig. 5.*

Diameter of the bore	—	13	10	8	5.8	4.6
Total length of the mortar	—	44	33	25.5	16.5	13.5
From the mouth to the reinforce	—	15.25	10	8.5	4.75	4.2
Length of the reinforce	—	8.75	8.1	5	5	3.9
Length of the trunnions from end to end	—	32.5	26	20	12	9.2
Diameter of the trunnions	—	7.15	6.3	5	2.75	2.15
Length of the bore	—	24	18.	13	8.5	7
Length of the chamber	—	12	7.8	7.75	4.5	3.7
Greatest diameter of the chamber	—	6.6	4.5	4	3	2.7
Least diameter of the chamber	—	6	3.6	3.4	2.4	1.4
Diameter of the muzzle ring	—	21	15.15	11.2	8	6.4
Breadth of the muzzle ring	—	1.1	.8	.6	.7	.5
Breadth of the atragals and fillets	—	1.25	1.0	.75	0	0
Distance from the muzzle ring	—	1.5	1.0	1.0	0	0
Diameter near the muzzle atragal	—	18.1	13.2	10	6.9	5.6
Diameter near the reinforce	—	18.1	13.2	10.0	6.9	5.6
Diameter of the reinforce	—	21	15.15	15.1	8	6.4
Breadth of the ogees	—	1.5	1.0	1.0	0	0
Diameter behind the breech atragal	—	18.1	13.2	9.8	6.9	5.9
Chamber contains powder	—	lb. 9:1:8	4:0:0	2:0:10	1:0:10	0:8:0
Weight of the mortar	—	C. 25:0:0	10:2:18	4:0:20	1:1:0	0:3:0
Weight of the shell when filled	—	C. 1:2:25	0:3:2	0:1:17	0:0:13	0:0:7
Shell contains powder	—	lb. 9:4:8	4:14:12	2:3:8	1:1:8	0:8:0

F 2

N. B.

*N. B.* The extremity of the bore is made round, and formed by an arc, whose radius is equal to that of the bore, and terminated by the lines which form the chamber: the bottom of the chamber is semi-circular, the outside of the metal is determined by a circular arc, described from the same center as the bottom of the chamber, and touching the lines drawn parallel to its sides.

As all the necessary dimensions are set down here accurately, the reader may easily construct these mortars by the help of the plate, which shews their form; for which reason we shall insist no farther upon them.

*Dimensions of sea mortars in inches. Fig. 6, 7.*

Diameter of the bore	—	—	13	10
Length of the mortar	—	—	63	56
From the muzzle to the reinforce			21	20
Length of the	{ reinforce	—	18	12
	{ bore	—	24	30
	{ chamber	—	21	15
Its greatest diameter	—	—	8.5	6.6
Its least diameter	—	—	7	6
Breadth of the muzzle ring	—	—	3	2.4
Of the muzzle, ogee, and fillet			1.9	0
From the muzzle to the astragal			0	.4
Of the astragals	—	—	0	1.6
Of the	{ reinforce rings	—	1.9	0
	{ ogees next to them	—	4.5	2.2
	{ chace ring	—	1.5	0
	{ chace ogee	—	2.2	0
	{ chamber astragal	—	0	1.6
Thickness of metal at the muzzle			4.7	2.8
At the muzzle ring	—	—	5.3	6
Near the reinforce	—	—	4.7	3.3
At the reinforce	—	—	8	6
Behind the reinforce	—	—	9.5	6
Trunions length from end to end			45.4	36

Its

Its greatest diameter	—	—	12		0
Its least diameter	—	—	10		8
Length of the part diminished	—		6		0
Chamber contains powder	lb		32		12 : 8
Weight of the mortar	—	C.	81 : 1 : 18		32 : 3 : 7

*N. B.* The thickness of metal at the muzzle, and near the reinforce, is taken from the lines produced, which determine the bore of the mortar; and behind the reinforce it is taken from the lines, which terminate the chamber. The round part or the breech of the mortar is circular, and described from the same centre as the bottom of the chamber in the 10 inch, and so as to come within 3.5 inches of the end of the mortar in the 13 inch; and in both so as to touch the outlines, which are drawn parallel to the sides of the chamber.

The reader may easily perceive, that wherever stands an o in the two last tables, there is no such dimension in that mortar; for there are mouldings in one which are not in the other.

*Dimensions of HOWITZES by inches. Fig. 8.*

Diameter of the bore	—	—	10		8
From the muzzle to the reinforce			19.4		16
Length of the reinforce	—		11.9		10.7
Total length of the howitz	—		50.4		37.4
Length of the { bore	—	—	29.2		25.9
{ chamber	—		16.8		9.9
Its greatest diameter	—	—	6.5		4.6
Its least diameter	—	—	5.6		4
Breadth of the muzzle ring	—		1.7		1.25
From the muzzle ring to the astragal			4.3		4.6
Breadth of the astragal	—		1.3		.7
Of the ogee before the reinforce			2.		1.4
Of the ogee behind the reinforce			1.7		0
			F 3		Of

Of the astragal	—	—	1.4	.7	
Of the base ring	—	—	1.8	1.25	
From the base ring to the astragal			2.2	0	
Breadth of the astragal	—	—	1.3	0	
Thickness of metal at the muzzle			2.75	2.25	
At the muzzle ring	—	—	5	3.4	
Near the reinforce	—	—	3.4	2.6	
At the reinforce	—	—	5.0	3.4	
Behind the reinforce	—	—	4.4	2.5	
Diameter of the base ring	—	—	20	14.7	
Diameter at the vent astragal	—	—	17.5	12.5	
Diameter of the	{	casable	—	8.25	7.6
		button	—	7	3
		neck	—	5	3.5
Breadth of the ogee and fillets			1	.9	
Of the second ogee and fillets			1.6	.9	
Diameter of the	{	first fillet	—	11.13	9.5
		second	—	7.64	4.5
Length and diameter of the trunion			6.	4.4	
From the fore reinforce to the trunion			2.	1.2	
Chamber contains powder	lb	18		4	
Weight of the howitz	—	C. 31 : 2 : 26		12 : 1 : 11	

*Remarks on the construction of MORTARS.*

Of all the parts of Artillery, the construction of mortars is the most variable and uncertain; almost every artilleryist has some favourite notion or other concerning their figure. Mr. *Belidor* mentions, in his *Bombardier François*, four different chambers; namely, the cylindric, the spheric, the conic, and the bottled; of these he says the cylindric is the worst, and the conic the best; for, says he, the vent being at the end of the cylindric chamber, prevents the powder from taking fire so quick as in the conical one; he alledges likewise another reason against the use of these chambers, which is, that they are seldom cast so as their axis corresponds with

with that of the bore, whereby the direction of the shell becomes variable and uncertain.

But since there is no necessity for placing the vent at the end of the chamber, as he supposes, all his arguments on that account can only be against the present practice, and by no means proves their badness; and had he considered the explosion of powder as an elastic fluid, as he ought, he would have easily perceived that the direction of the chamber, with regard to that of the shells, is of no consequence, since the action of fired powder is every-where perpendicular to the surface it acts upon. Besides, according to the experiments I made, which are mentioned in the preface, the force of powder, when fired at the end, is greater than when fired in the middle. I dare not however inter, that the same thing will happen in larger mortars, because I have found by experience, that we ought to depend upon nothing but what has been found to answer in pieces of the same caliber; and therefore all the different sizes of mortars should be tried and examined, to determine where the vent is to be placed in the most advantageous manner.

We have proved in the fifth Theorem, and the examples that follow, that the action of fired powder diminishes in proportion as the surface pressed enlarges; the same thing we have likewise found by experiments, and therefore the conic chambers are the very worst of all.

The late General *Borgard* made his chambers likewise conical, terminating in a circular form at the bottom, as has been shewn in the foregoing tables of the dimensions; and so as the sides of the chamber produced meet the extremities of the diameter at the mouth; imagining, I suppose, that the powder acts in right lines parallel to the sides of the chamber. Though he was one of the bravest officers of his time, and served about seventy years, yet his qualifications as an inventor were but very moderate.



As to the advantage of concave chambers of any kind, it consists in this, that their entrance may be made narrower than those of any other form, and that this is a real advantage, we have proved both by theory and practice: yet when the entrance is so small as not to admit of a man's hand, they are not easily cleaned; and if any sparks of fire should remain, cannot be so well extinguished; for which reason I would make them of this form only in sea mortars, because they are loaded with large quantities of powder, and in the land ones cylindrical: since these latter need be charged with but little powder.

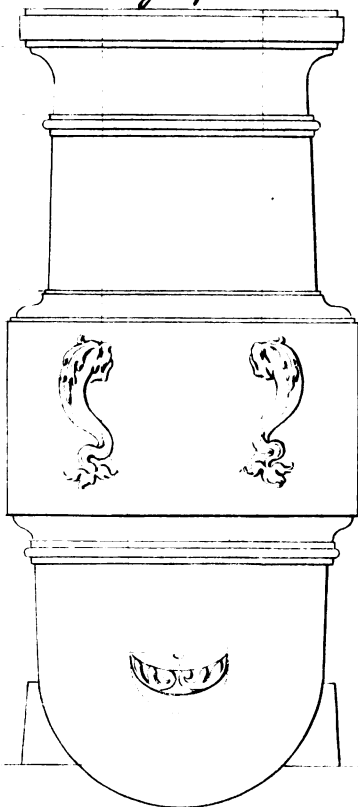
As to the vulgar notion, that mortars with concave chambers, when fired, shake their beds with great violence, and make the direction of the shell very uncertain, it is grounded upon ignorance, and deserves no notice.

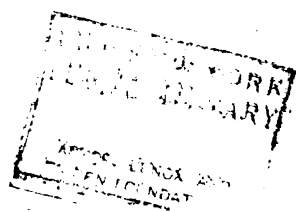
The length of mortars is no more ascertained than the rest of the dimensions: the *French* make the length of the bore a diameter and an half of the shell; on the contrary, we make that of our land mortars two of these diameters, and three in the ten inch sea mortar, which causes a great difference in the weights; for our thirteen inch land mortars weigh C. 25 : 0 : 0, whereas the *French* weigh only C. 13 : 0 : 0.

It is a query, whether this difference produces any material advantage in the ranges; if not, it would be unnecessary to make them so long as we do, since this increase makes them so much the heavier. For the same thing (*viz.* that those guns which carry farthest are not the best) is also true in mortars; since if they carry their shells about 12 or 1500 yards with a moderate charge, it is in my opinion sufficient in respect to land mortars; because when they carry farther, the hitting an object becomes so extremely uncertain, as to render that advantage useless; therefore all means should be tried to make them as light as conveniently can be.

The

*Fig 7*





The thickness of metal in the different parts of a mortar, is as undetermined as the rest; for not any two sorts are equally strong; some are as much too weak as others the reverse, and those who have the direction of these things are so slightly acquainted with the common principles of geometry, that when a mortar of any size is made with proper dimensions, and has been found in practice to answer perfectly well, they cannot make another either less or larger, that shall still retain the properties of the former.

The reason is, that commonly none but workmen are employed on them, whose knowledge consists only in imitation and guess. For though a workman may be very capable to execute the work, or to see it done, yet it can hardly be supposed that he is able to determine the proper dimensions of the several parts.

The parts of mortars are formed in imitation of those of guns; for which reason they make them with a reinforce. This only overloads the mortar with a heap of useless metal, and that in a place where the least strength is required; yet, as if this unnecessary metal was not sufficient, they add a great projection at the mouth, which serves to no other purpose than to make the mortar top-heavy. The mouldings are likewise jumbled together, without any taste or method, though they are taken from architecture.

As there has not the least hint hitherto been given, with regard to a general rule to construct all sizes of mortars by, without which, the artillerist cannot possibly understand what he is about, nor can he judge whether he is right or wrong, whenever he attempts to construct others of a different size from those in use at present, he must remain in ignorance, let him take ever so much pains, we shall give the following rules.

*General*

*General dimensions for land mortars.*

Plate III. Fig. 9.

Diameter of the	{ bore	—	30	30	30
	{ chamber	—	10	10	10
Length of the	{ bore	—	54	45	40
	{ chamber	—	22	21	20
From the end of the chamber to the	{	end of the mortar	16	15	14
Total length of the mortar		—	92	81	74
From the mouth <i>a</i> to the reinforce <i>b</i>			30	26	22
Length of the reinforce <i>b c</i>			18	14	14
Breadth of the	{ muzzle ring and fillets	3.5	3	3	3
	{ ogee next to it	—	3	2	2
From the ogee to the muzzle astragal			5	4	3
Breadth of the	{ astragal and fillets	2.5	2	2	2
	{ ogee before the re-	{	3	2	2
	{ inforce				
	{ two ogees and fillets	{	6	5	4
	{ behind the rein-				
	{ force	—			
Thickness of metal	{ at the muzzle	5	4.5	4	
	{ near the reinforce	6	5	4.5	
Thickness of metal at the	{ reinforce	7	5.5	5	
	{ chamber	12	12	12	
	{ muzzlering	6.5	5.5	5	
Diameter of the trunions		14	13	12	
Length of the trunions from the mortar		15	14	13	
		<i>d</i>	<i>d</i>	<i>d</i>	
Chamber contains powder		—	—	—	—
		421	442	466	
Weight of the mortar		—	—	—	—
		5 <i>d</i>	2 <i>d</i>	3 <i>d</i>	
		6	3	5	

N. B.

*N. B.* The chamber is cylindric, and the bottom a semi-sphere; the round part of the mortar is described from the same center as the bottom of the chamber. The letter  $d$  in the content of the chamber and that of the weight of metal, expresses the cube of the diameter of the bore in inches; that is,  $d = 2197$  in a thirteen inch mortar, and  $d = 1000$  in a ten inch.

The reader may see that the diameter of the bore is to be divided into 30 equal parts, for a scale to set off all the rest of the dimensions. The same scale serves to construct their beds, which renders the whole easy and uniform, a necessary consequence of well settled principles.

*Remarks on these dimensions.*

We have endeavoured to dispose the metal in such a manner, as to make the strength of the parts nearly in proportion to the forces which act upon them: at the chamber it is sufficient, though less than in most mortars now in use; for the thickness of metal there is greater than its diameter, which is more than ever has been allowed in any brass gun whatever; it is true that the effort also is greater, but then an allowance has been made accordingly: we made a reinforce, merely to comply in some manner with the common practice, though the mortar should be conical from the chamber to the mouth, according to the action of powder, as proved before; however, the difference between the reinforce and chace is no more than just sufficient to admit of an ogree, whereby the mortar looks more graceful to the eye; at the mouth the projection is no greater than is necessary for the mouldings, more would be superfluous, and make the mortar top-heavy; besides, as we suppose it capable of being either raised or depressed, and not fixed to its bed, as hitherto the custom, that operation would thereby become more difficult. As  
to

to the vent, we do not pretend to determine its true place, though we have always found the nearer it was to the bottom the farther the shell went; but as these experiments were made with a three inch mortar only, no just conclusion can be drawn from thence with regard to larger.

The cylindric figure of the chamber, is, in my opinion, the best for these kind of mortars; for though we have shewn that the concave figure, or those whose entrance was the least, will throw the shell farthest of any with the same charge; yet in this case, where but little powder is required, their entrance would become too narrow and inconvenient to clean; whereas when they are cylindric, the difference between the advantage of the one and the other will be but little, and not attended with any inconveniencies.

Colonel *Desaguliers* and myself made several experiments with different chambers, which contained the same quantity of powder, and we found that the cylindric threw the shell always farther than any other whose entrance was larger, and more especially when they were not quite filled. We made likewise some other experiments, which were, by putting as much powder as would fill half the chamber into a cartridge made of common writing paper, and when it was put into the chamber, so as to be close to the shell, leaving a vacancy at the bottom, it threw the shell near twice as far as when the cartridge touched the bottom, and the vacancy was left between the shell and the powder; we repeated this experiment several times, and found always the same effect. Another remarkable thing happened; I put a piece of common writing paper upon the powder, the chamber being but partly filled, and the shell went much farther than with the same charge when there was no paper. Lastly, we compared two chambers of the same content, the one cylindrical, and the other conical; they had both the same height, and the diameter of the bottom of the conical one was but half the diameter of the

the entrance, and when these chambers were not quite full, the cylindric one threw the shell much farther than the other, and this happened as often as the experiment was repeated. Whoever considers these experiments with some attention will find, that we know very little of the effects of gunpowder as yet, and that we ought to depend upon nothing but what has been tried.

That our chambers hold a sufficient quantity of powder, for any occasion whatever, has been proved by experiments; for I fired a three inch mortar, with an ounce and a quarter of powder, at an angle of elevation of 45 degrees, and the shell went 1200 yards; and since our mortars are similar to that tried, the powder will give the shell the same velocity; but because the resistance of the air is in this case inversely as the shells diameters, the three inch shell will meet above four times the resistance of a thirteen inch shell; from whence, and some other experiments made upon *Woolwich Common*, with the present thirteen inch mortar, I conclude, that the shells in our mortar will range about a mile, which is more than is wanted; for when the ranges are greater, they are so uncertain, and it is so difficult to judge how far the shell falls short, or exceeds the distance of the object, that it serves to no other purpose than to throw away the powder and shell, without being able to do any execution.

The first of these mortars is of the same length with our land mortars; the second with the *French*; but the third is shorter than either. The reader may easily see, that these dimensions are general for any size of mortars whatever, as all constructions ought to be, whereby they become all alike; and consequently one of them being found strong enough by practice or experience, all the rest will be so too; which can never be the case in particular constructions, as hitherto has been the case in all countries so far as I know.



*To find the weight of metal.*

The square of the mean diameter 41 of the muzzle part, multiplied by 30, gives	—	}	50430
The square of the diameter 44 of the reinforcement, multiplied by 18, gives	—		
The square of 34, the chamber part, multiplied by $34\frac{1}{3}$ , gives	—	}	39689
Four times the trunion 2940, for the trunions and mouldings	—		

Sum total in cubic parts of the diameter of the bore	—	}	136727
The content of the bore in like parts is	—		
The content of the chamber is	—		2033

The two last sums subtracted from the content of the mortar, leaves

This reduced in the ratio of 452, to 355, of the square of the diameter to the circle, gives

Then as 192 cubic inches weigh 61 pounds of metal, we get

But as the diameter  $d$  is divided into 30 equal parts; if we say, as the cube of 30 is to the cube  $d$ , so is 22605 to the weight of the mortar of the first fort, it will be

found to be  $\frac{5}{6} d$  nearly. In the same manner are found the weights of metal of the other two mortars.

*To find the contents of the chambers.*

The square of 10 multiplied by the length, reduced  $20\frac{1}{3}$ , gives 2033 in the first mortar; but as the diameter is divided into 30 equal parts, if we say as the

cube of 30 is to the cube  $d$ , so is 2033 to  $\frac{2033}{27000} d$ , we

get

get the cubic parts of the diameter. Now, because the diameter of a cylinder, which holds one pound of powder, is 3.165, according to Sir *Jonas Moor*, if we divide the last number by 31.7, the cube of that diameter, we

shall have  $\frac{2033}{855900} d$ , for the content of the chamber;

which being reduced, gives  $\frac{d}{421}$  or  $\frac{d}{531}$  nearly. In the same manner are found the contents of the chambers of the other mortars.

In order to compare these mortars with those used at present, we shall insert their weights and charges in the following tables.

*Weight of the new mortars.*

Diam.	13	10	8	6
First	16 : 1 : 10	7 : 1 : 21	3 : 3 : 6	1 : 2 : 11
Second	13 : 0 : 0	5 : 3 : 22	3 : 0 : 0	1 : 1 : 0
Third	11 : 3 : 0	5 : 1 : 12	2 : 2 : 27	1 : 0 : 15

*Weight of the powder.*

Diam.	13	10	8	6
First	5 : 3	2 : 6	1 : 3	0 : 8.2
Second	4 : 15	2 : 4	1 : 2	0 : 7.8
Third	4 : 11	2 : 2	1 : 1	0 : 7.4

*Weight*

*Weight of the present mortars.*

Diam.	13	10	8	5.8	4.6
Wt.	25:0:0	10:2:18	4:0:10	1:1:0	0:3:0
Cham.	9:1:8	4:0:0	2:0:10	1:0:0	0:8:0

Hence if we compare the weights of our mortars with those of the present ones, we shall find the difference between the 13 inch to be, 8 : 2 : 18; between the 10 inch, 3 : 0 : 15, and between the 8 inch, 0 : 1 : 4. Now as the difference between the weights of the 13 inch mortars, is much greater than between any others, it is evident they are much heavier in proportion than they ought to be, in respect of the small ones; it appears therefore, that no true proportion has been observed in their construction.

Though our mortars are so much lighter than the present ones, yet I may affirm, they are equally strong, because they are as thick at the chamber as they need be; and at the muzzle, or where the least thickness is, ours are stronger; for the 8 inch mortar is but an inch in that place, whereas ours is 1 inch and a third; the 10 inch, is 1.6 inches thick, ours  $1\frac{2}{3}$ ; and as to the reinforcement, it is loaded with more metal than it need be, since the force of powder is very little more there than at the muzzle. But the difference between the weights arises chiefly from the chambers, which are both wider and longer in the present mortars than in ours, and therefore they require more metal.

*General Dimensions of howitzes. Fig. 11.*

Diameter of the bore, ———	30	30	30
Length of the bore, ———	90	90	97.5
Diameter of the chamber, ———	15	15	15

Length

Length of the chamber, — — —	33	33	33
From the muzzle a, to the reinforce b, — — —	50	50	54.5
Length of the reinforce b c, — — —	34	34	37
From the reinforce c, to the end of the howitz, — — —	50	50	50
Total length of the howitz, — — —	134	134	141.5
Thickness of the metal at the muzzle, — — —	8	7	8
Thickness near the reinforce, — — —	9	8	9
Thickness at the reinforce, — — —	10	9	10
Thickness at the chamber, — — —	16	15	16
Breadth of the muzzle and base ring, fillets included, — — —	5	5	5
Breadth of the ogees, that behind the reinforce excepted, — — —	3.5	3.5	3.5
Distance between the muzzle and breech, ogees and astragals, — — —	6	6	7
Breadth of the astragals and fillets, — — —	3	3	3
Breadth of the ogee behind the reinforce, — — —	6	6	6
The muzzle and base ring project the metal by — — —	1.5	1.5	1.5
Length of the trunions — — —	18	18	18
Diameter of the trunions — — —	15	15	15
Distance of the trunions from the fore end of the reinforce, — — —	5 <i>d</i>	5 <i>d</i>	5 <i>d</i>
<hr/>			
The chamber contains powder, — — —	116	116	116
Weight of the howitz, — — —	2.25 <i>d</i>	1.97 <i>d</i>	2.4 <i>d</i>

The cascable is 24 parts long, the radius of the button 8, the ogee and fillet included 4.

The reader may observe, that for want of room in the plate, the button could not be marked, which he may easily supply from the given dimension in the same manner as in guns.

The dimensions of the first howitz are nearly the same as those of the present, the chamber part excepted; the reinforce is not so strong as it is commonly made, without any ground or reason, because the force of explosion acts but very little more there than at the muzzle. The dimensions of the second are less, and yet I am persuaded sufficient; for a 6 inch howitz is an inch and .4 thick near the muzzle, whereas the present 8 inch mortar is barely an inch in that place; for which reason I would prefer the second fort before the first, because there can be no reason assigned to load them with more metal than is necessary.

The third fort is a quarter of the bore's diameter longer than the other two, and the rest of the dimensions the same as the first; hence the artillerist is left to his choice to use which he likes best.

*Weight of the howitzes and powder.*

Bore, —	13	10	8	6
Weight $\left\{ \begin{array}{l} 1\text{ft}, \\ 2\text{d}, \\ 3\text{d}, \end{array} \right.$	44: 0: 13	20: 0: 9	10: 1: 0	4: 1: 5
	38: 2: 8	17: 2: 3	9: 0: 0	3: 2: 24
	47: 0: 7	21: 1: 14	10: 3: 13	4: 2: 6
Powder,	18: 15: 0	8: 9: 14	4: 6: 9	1: 13: 12

*Weight of the present howitzes and powder.*

Bore, —	10	8	5.8
Weight,	31: 3: 26	12: 1: 6	4: 0: 18
Powder,	18: 0: 0	4: 0: 0	1: 0: 0

From

From these tables of the weights of howitzes, we see that the present 10 inch weighs about one third more than it should do in respect to the 8 inch, for the weights should be in proportion to the cubes of the diameters. Now the cube 512, of 8, is to the cube 1000, of 10, as the weight 12 : 1 : 6, of the 8 inch, is to the weight 24 : 0 : 3, which should be the weight of the 10 inch. Whence it evidently appears, that no better proportions have been followed in constructing howitzes than mortars.

This superfluous weight of the 10 inch howitz has occasioned its disuse, at least these 25 years; whereas by observing a due proportion, and such as our second sort, not only a 10 inch but even a 13 inch might have been used, if it had been thought proper. It may be observed again, that though ours are so much lighter than the others, they are full as strong, because the metal is better disposed over all the parts, and there is not that useless lump at the muzzle, reinforce, and trunions, as in those made at present.

It is to be wondered that no greater use has hitherto been made of howitzes, since the shells may do execution likewise as shots, and besides grapes of shots, or shells, might be fired out of them to more advantage than out of guns, especially in a siege where the distance is but small; and in the field, if they were placed in the flanks, or between the battalions; the terror they would cause, especially amongst the horse, by rolling amongst the ranks with the fuse burning, and the expectation of their bursting every moment, would disorder the bravest men, by means whereof they might easily be broke, and the day thereby won.

In a siege where the works are not lined with walls, or when the walls are once battered down by cannon, there can be no speedier way to complete the breach than by firing shells into them; for they will lodge in the earth, and when they burst will produce the same effect as mines. This practice has been recommended by

*St. Remy*, and the *French* followed it in the siege of *Bergen-op-zoom*, where they chiefly used mortars, mounted upon field carriages for that purpose; besides, when you are pretty near the enemy's works, grapes made of shells will do wonderful execution, as I have been assured by some artillery officers, who have tried it, and found that all the fuses took fire.

As howitzes are easier carried from one place to another than mortars, which require also a good deal of time to prepare the ground, to lay the beds, and mount them, the use of the former would be more convenient than the latter in all cases, except in throwing shells upon powder magazines. It may be observed, that the wheels and axletree of the present 10 and 8 inch howitz carriages, are of the same strength as those of a 24 and 18 pounder's carriages, without any judgment or reason. For since the wheels of an 18 pounder's carriage support a weight of 48 : 0 : 0, which is just four times the weight of the 8 inch howitz, there is not the least proportion observed between the weight and the strength to support it; it is true, that an 8 inch shell is heavier than an 18 pound ball, but when it is considered that the force of the shell affects the carriage in its recoil only, and not at all the wheels; this can be no reason for making them so strong as has hitherto been the custom.

#### *Of sea mortars.*

As these mortars are generally fired at a much greater distance than ever is required by land, they are made something longer and much heavier than the land. Their proper dimensions can only be determined from their charges of powder. The chamber of the present 13 inch holds 32 pounds of powder, though the late General *Borgard* told me, he never made use of more than 12 pounds, and as he had more experience in that service than perhaps any other, we may depend on what he

he said; besides, some very expert officers employed in the late war assured me, they never exceeded the charge of 15 pounds. Now, as this chamber is never half filled, the powder won't act so forcibly as if there was no vacant space between the charge and the shell; it is therefore plain, that a charge of 12 or 15 pounds of powder at most will be sufficient; besides, this chamber being conical, and its greatest base two thirds of the diameter of the bore, lessens the force of powder considerably, and more so when not filled, as Colonel *Desaguliers* and myself found by several experiments made with such a chamber, and compared with a cylindric one of the same content. This being an undoubted fact, the following dimensions will, I may venture to affirm, be sufficient in all respects.

*General dimensions of sea mortars.* Fig. 10.

Diameter of the bore divided into	—	—	30	30	
Length of the bore,	—	—	75	75	
Diameter of the chamber,	—	—	15	15	
Length of the chamber,	—	—	33	33	
From the end of the chamber to the end of the mortar,	—	—	20	20	
Total length of the mortar,	—	—	128	128	
From the muzzle a, to the the reinforce b,	—	—	43	43	
Length of the reinforce b c,	—	—	28	28	
Thickness of the metal at the muzzle, mouldings excepted,	—	—	8	7	
Thickness of metal	{	near the reinforce,	—	9	8
		at the reinforce,	—	10	9
		at the chamber,	—	16	16
Breadth of the	{	muzzle ring and fillets,	—	4	4
		ogee next to it, and of that before the reinforce,	—	3	3
Distance from the ogee to the muzzle astragal,	—	—	—	6	6



Breadth of the	{ astragal and fillets,	— 3	3
	{ ogee behind the reinforce,	4	4
The muzzle ring projects the metal, by	—	1. 5	1. 5
Diameter of the trunions,	—	18	18
Length of the trunions from the mortar,	—	20	20
		<i>d</i>	<i>d</i>
<hr/>			
The content of the chamber,	—	126	126
Weight of the metal,	—	2. 1 <i>d</i>	1. 8 <i>d</i>

The arcs which determine the round part of the mortar are described from the same center which determines the bottom of the chamber: the weight of metal, and that of the powder which the chamber contains, have been found in the same manner as in the guns, allowing four times the value of one trunion for the trunions and mouldings.

*Weight of sea mortars and powder.*

Diameter of the bore,	13	10
<hr/>		
Weight of { present sea mortars,	81 : 1 : 18	32 : 3 : 7
the first new mortar,	41 : 0 : 19	18 : 2 : 19
the second, —	35 : 1 : 2	16 : 0 : 7
Powd. cont. in { present mortars,	32 : 0 : 0	12 : 8 : 0
new mortars, —	17 : 7 : 0	8 : 0 : 0

The enormous weight of the present 13 inch mortar proceeds from the antient notion, that those pieces which throw a shell farthest are the best; for which reason the artist imagined, that the heavier they were, the farther they would carry. But by the account of all those artillery officers whom I have conversed with, and who have been employed in that service, the ship or bomb-ketch is not able to bear the shock of those mortars, when loaded with their chambers full of powder; and consequently it is ridiculous to make them so heavy.

The





The first of the new mortars is as strong at the muzzle as the 10 inch present one, and consequently strong enough upon all occasions; and I may venture to affirm, that the second sort is so too; since it is above twice as strong as the land. With regard to the size of our chambers, we have shewn before, that they never use above 15 pounds of powder in bombarding; we have likewise proved in the theory of powder, as well as by several experiments, the great advantage a cylindric chamber has over the conic when the greatest base is uppermost, so that there cannot remain the least doubt but that our chambers are full as large as they need be on any occasion.

It may appear strange to some of my readers, that mortars so much lighter than the present should be near equally strong. I account for it in this manner, their chambers are near twice as long as ours, and as the thickness is very great in that place, there must needs be a great deal more metal there than is necessary; the same thing may be said with respect to the reinforce part, which without any reason is made about twice as strong as the muzzle part; though the force of explosion is nearly the same in both places. This was never considered in the constructions of old mortars.

In the bombarding of *Havre de Grace*, the mortars were fired quick and with a full charge, by which they were spoiled and rendered useless in a short time; for the vents grew so large, and the metal melted in the chambers, that it would have been dangerous to fire them any more, and so were rendered entirely useless.

It has been observed both in guns and mortars, that the great thickness of metal, instead of being an advantage, renders them sooner useless. For at the battle at *Lasfeldt* several 6 pounders, that weighed 1900, were spoiled, and the light, which weighed but 4:3:0, received no damage; and our sea mortars generally fail when much fired with great charges; whereas the land, which do not weigh one third of the others, scarcely

scarcely ever fail: the reason of this is imagined to be, that thin metal heats not imperceptibly sooner than thicker, and cools much sooner; and when thick metal is once much heated requires a longer time in loading, and consequently accumulates the heat to such a degree as to make it incapable to resist the shock of the fire. This is confirmed by experience,

Plate IV. Fig. 12.

The following mortar with a concave chamber is, I think, preferable to the two former; the base *a b*, or *c d*, is ten parts; the distance between the lines *a b*, and *c d*, is 26 parts; and its greatest transverse diameter 20; the thickness of metal at the chamber is 16 parts, as before; the outside form is similar to that of the chamber, and all the other dimensions are the same as those of the first of the two preceding mortars. This mortar will weigh nearly as much, and its chamber contain the same quantity of powder as the first; but as the entrance of it is to that of the former, as 4 to 9, the powder will act with a greater force; for which reason it is preferable.

As the entrance is wide enough to introduce the hand, and clean it without any inconveniency, it may be loaded with as much ease as any other; whereby we avoid the objection made by some against these kinds of chambers.

As to the placing the vent both in guns and mortars in the best manner, I must confess it is beyond my knowledge; and it appears to me, that nothing but experiments can determine it; for those I made with two small mortars appear so contradictory to theory, and the notion we have in respect to the explosion of powder, that I am more uncertain than ever; and it is very probable they will vary more in those of larger calibers, for which reason we leave it undetermined. I suppose it, in all the preceding draughts, pretty near the end of the chamber;

chamber; because the few experiments I made shewed that to be the best place in small mortars.

### SHELLS. Plate IV. Fig. 14.

As the dimensions of shells are undetermined, and no proportion observed therein, nor is it known how much the thickness of the bottom ought to exceed that at the fuse hole, so as they may burst in the greatest number of pieces, we have in the following dimensions observed the proportions of the present 13 inch ones; so that if they are right, we are certain that ours will be so too; but if it should so happen, that the shell of any other caliber is found to have a better proportion than that we have made use of, the general dimensions may easily be made in the same proportion, by saying, the diameter of the shell is to 30, as any part expressed in inches, is to the same part, expressed in parts of the diameter divided into 30 equal parts.

Diameter	{	of the bore, _____	30
		c d of the shell, _____	29.5
		of the hollow sphere, _____	21
Thickness	{	of metal at the fuse hole, _____	3.5
		at the bottom or opposite part _____	5
Diameter a b of the fuse hole, _____			4
			<hr/>
The weight of the shell unloaded, _____			11.7
			<hr/>
Weight of the powder the shell contains—			236.5

The fuse hole is conical, and when produced, terminates at the extremity d of the diameter c d, which passes through the center.

There are two handles of hammered iron fixed in the mould when they are cast, which fasten to the shell, and serve to lay hold on when the mortar is to be loaded thereby, as likewise to carry them from one place to another.

other. In *France* these handles are cast iron; but this renders them clumsier, and liable to break sooner than the others. The letter *d* stands here for the cube of the diameter of the bore, as well as in the construction of mortars.

Two reasons are given for making shells thicker at the bottom than at the fuse hole; one is, that they are thereby better enabled to resist the shock or impression of the powder that discharges them; the second, that the shell always falling with the heaviest part undermost, the fuse will of course be uppermost, and therefore will not be extinguished by its fall. Both these reasons are, in my opinion, of no consequence; for if the shells were every-where equally thick, and of the same weight as those above-mentioned, the blast of powder lodged in the chamber would hardly be able to break them; and as to the fuse falling uppermost or not, that is of no detriment, since the composition of fuses is such, that nothing but an absolute stoppage from the air is able to choke them; for they burn in water as well as any other element; for which reason I would make them every-where equally thick, because they would then burst into a greater number of pieces. But to be certain, it would be easy to make the experiment.

The quantity of powder they ought to be filled with, so as to burst into most pieces, is not known; but most artilleryists agree, that they should not be quite full; and Colonel *Desaguliers*, after having made several experiments, imagines, that two thirds of the weight which would fill them is the quantity they should be loaded with.

*Weights of the present shells and powder.*

Bore,	13	10	8	5.8	4.6
Wt.	1 : 2 : 15	0 : 2 : 25	0 : 1 : 15	0 : 0 : 12	0 : 0 : 7
Powd.	9 : 4 : 8	4 : 14 : 12	2 : 3 : 8	1 : 1 : 8	0 : 8 : 0

*Weight*

## *Weights of the new shells and powder.*

Bore,	13	10	8	5.8	4.6
Wt.	1 : 2 : 15	0 : 2 : 27	0 : 1 : 14	0 : 0 : 16	0 : 0 : 8
Powd.	9 : 4 : 8	4 : 3 : 10	2 : 2 : 10	0 : 13 : 3	0 : 6 : 9

It is to be observed, that the windage of the present shells is a quarter of an inch, let them be great or small, which is contrary to all reason ; whereas we allow  $\frac{1}{80}$  part of the bore's diameter, which is something less in a 13 inch one, and decreases in proportion to the shell's diameter ; whereby our small shells become something heavier than the present.

There is another kind of mortar which serves to fling stones into an enemy's works, when near at hand ; such as from the town into the trenches in the covert way, or upon the glacis, and from these trenches into the town, or ravelins. As we have none of that sort here, I shall give such dimensions as agree nearly with those mentioned in *St. Remy*, whose diameter is 15 inches.

## *Dimensions of stone mortars. Fig. 13.*

Diameter of the bore,	_____	_____	30
Length of the { bore,	_____	_____	37
{ chamber,	_____	_____	16
Its greatest diameter	_____	_____	8
Its least diameter,	_____	_____	6
Diameter of the cylindric part to hold a wooden tapon,	_____	_____	14
Depth or axis of that cylinder,	_____	_____	3
From the muzzle to the reinforce	_____	_____	20.5
Length of the reinforce	_____	_____	8
			Thickness



Thickness of the metal at the	{ muzzle, — —	3. 5
	{ reinforce, — —	4. 5
	{ chamber belt, —	9
	{ entrance of the chamber, —	6
The chamber enters into the trunions, by	—	2
Diameter of the trunions,	— — —	40
Length from end to end of the trunions,	— — —	40
Breadth of the	{ muzzle ring and fillets, — —	3
	{ chamber belt, — — —	2
	{ ogre next to this belt, —	3
		d
Content of the chamber,		1102
Weight of the metal contained in this mortar,		3. 1

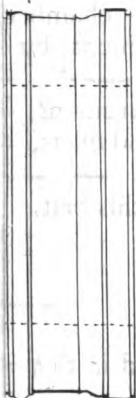
The bore is terminated by two quadrants of a circle, terminated by the reinforce and lines drawn from the ends of the cylinder made to lodge the tapeon parallel to the axis of the mortar; and the round part on the outside are arcs described from centers, taken in the line which terminates the reinforce, and so as to meet the extremities of the belt. The bottom of the conic chamber is terminated by an arc of 60 degrees, and the round part of the outside is a semicircle.

Thus a 15 inch stone mortar weighs 10 : 3 : 4, and the chamber contains 3 pounds of powder; this agrees very nearly with the *French* mortar of the same size, which weigh 1000 pounds. When it is considered that we made the chamber part stronger than theirs, we conceive that this mortar may likewise serve to throw baskets full of hand-grenades, which will be much more dangerous to an enemy than stones.

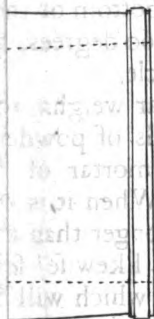
The reader may easily perceive, that the conic chamber is very proper here in this case, as a great force is not so much required as the extent of that force against the tapeon, for fear it might break it in the middle.

The

#### IV Sea Mortar With a Concave Chamber.



#### Stone Mortar



Pl 156  
926



The form of the bore at the bottom being different from that in other mortars, is likewise adapted here to the bodies to be thrown out of it; baskets are made to fit the bottom of the bore, which, when filled, are let into the mortar by means of two handles, in order to load it quicker. The stones generally made use of upon this occasion are pebbles the bigness of a man's fist, and as round as can be found. But as we said before, hand-grenades or small shells made for that purpose, of about two or two and a half inches diameter, will answer the purpose much better than stones. This has been practised at *Bergen-op-zoom* with a common mortar, and succeeded to the satisfaction of the artillery officers who tried the experiment.

Having thus given general constructions for mortars used on all different occasions either by sea or land, it remains to shew in what the use of howitzes differs from that of common mortars; as they are carried upon gun travelling carriages, they are easily transported in the field from one place to another, and are more readily fired than the others; they have likewise another advantage, which is, that they may be laid to any elevation, whereas the common mortars are fixed upon their beds at an angle of 45 degrees, whereby they are not so useful in a siege: for the shells thrown into the works, either from the trenches into the fortification, or from the fortification into the trenches, should always be directed in a less elevation than 45; and when they are to be thrown upon powder magazines, or any other building, with an intention to destroy it, the elevation should be greater, in order that they may fall with more force.

All these considerations are seeming advantages in favour of the howitzes; but if we consider that a 10 inch howitz weighs considerably more than a 13 inch mortar, and an 8 inch one, more than a 10 inch mortar, it is easily perceived that the use of howitzes is not so superior to that of the common mortars as is imagined by most artilleryists. As to the different degrees of elevations in which

which they may be directed, it is a property that mortars ought to have as well as they. For there is not the least occasion to fix them on their beds so as not to be moved, since no nation but this does it; nor to lash them on their beds with so much cordage, as if their weight was not sufficient to keep them in their situation. The reason given for this practice is, that if they were not lashed to their beds they would kick up before, and fall backwards, which is trifling, and inconsistent with the rules of mechanics; besides the *French* mortars, which are much lighter than ours, and are not tied, never overset; and as no nation makes more use of them than they do, it is very improbable they should neglect a thing of that kind if there was any necessity for it.

As to the advantage of carrying howitzes upon travelling carriages, it is as insignificant as the rest, since no reason can be given why mortars may not be carried in the same manner. That this may be done, appears from the practice of the *French* during the last war. But what will not people do to support an old custom let it be ever so absurd?

## PART IV.

### *Construction of ship and travelling carriages.*

**T**HERE are three different sorts of gun carriages; namely, those used in garrisons, at sea aboard ships, and in the field. The two first differ only in some iron rings, and also that the trucks or wheels of garrison carriages are made of cast iron; whereas ship carriages are of wood; but the rest of the construction is the same.

*Construction*

*Construction of ship and garrison carriages.*

Plate V. Fig. 15.

In a line A B, take two points C, D, so as their interval be equal to the distance from the center of the trunions to the extremity of the breech, that is, equal to three sevenths of the gun's length ; through these points draw two lines at right angles to A B ; in the first take C E, C F, each equal to half the diameter of the second reinforce ring ; and in the second D G, D H, each equal to half the diameter of the base ring ; then the lines drawn through the points E, G, and F, H, will determine the width within of the carriage.

If to these lines there be drawn two parallels at a caliber's distance, they will determine the breadth of the side pieces ; and by setting off from D to B, the length of the cascable, and from C to A, half the diameter of the trunions and half the diameter of the fore trucks ; then will A B be the length of the carriage.

The line E F passes through the center of the trunion holes, which are a caliber, and whose center is a quarter of an inch below the upper surface of the side pieces. On each side of G H set off 6 inches for the breadth of the axletree, which is always 12 inches broad ; and the fore part of the trunion holes is the center line of the fore axletree, whose dimensions, as well as those of the trucks, are given in the following table.

Fig. 16.

The height of the side pieces is  $4\frac{1}{2}$  diameters of the shot before, and half that height behind ; and if half the length of the side pieces be divided into four equal parts, beginning at the hind end, you will have the steps ; the quarter-round is taken from the fore part. The lower part of these pieces is hollowed in the form

of a circular arc, in order to make them something lighter without diminishing their strength. Both axletrees are sunk into the side pieces in the manner represented in the 17th figure; and as to the transom, we chuse to place it directly over the fore axletree, it is a diameter of the shot broad and two high, and placed exactly in the middle of the height of the side pieces; though it is customary to place the fore part in a line, passing through the center of the trunion holes, and so as to project the axletree by an inch, and the lower edge to touch the axletree.

*Dimensions of ship and garrison carriages.*

Nature of the gun, —	42	32	24	18	12	9	6	3
Width inclosed { before	18	18	16.5	15.5	14	13	11.5	9
{ behind	23.5	23.5	22.5	21.5	19.5	18.5	16.8	12.5
Fore axletree length —	57	57	54.5	51.5	45.5	42.5	38.8	32.5
Body { length, —	35.4	36.6	34.9	33.1	29.5	27.5	24.8	19.5
{ height, —	10.8	10.8	10	10	10	9.5	9	8.5
{ breadth, —	6.8	6.8	6.8	6	5.5	5.2	5	4
Arms { length, —	10.8	10.2	9.8	9.2	8	7.5	7	6.5
{ diameter, —	6.2	6.2	6.2	5.8	5.2	5	4.5	3.5
Hind axletree length, —	57	57	54	51.5	45.5	42.5	38.8	32.5
Body { length, —	35.4	36.6	34.9	33.1	29.5	27.5	24.8	19.5
{ height, —	6.8	6.8	6.8	6	5.5	5.2	5	4
{ breadth, —	12	12	12	12	12	12	12	12
Fore trucks, { diameter, —	19	19	18	18	16	16	14	14
{ breadth, —	6.5	6	5.5	5	4.5	4	3.5	3
Hind trucks, { diameter, —	16	16	16	15	14	14	12	10
{ breadth, —	6.5	6	5.5	5	4.5	4	3.5	3
Side pieces { height before, —	26.8	26.2	26	23.6	20	18.8	16	13.6
{ length, —	78	78	72	69	66	63	60	37.5
{ breadth, —	6.5	6	5.5	5	4.5	4	3.5	3
Trunions from the head, —	8	8	8	8	6.8	6.6	6.6	6

These

These dimensions are expressed in inches and decimals ; and as the arms of the hind axle-tree have the same dimensions as those of the fore ones, they have been omitted, as well as the height behind the side pieces.

It may be observed, that these dimensions were used in 1748 ; but if the guns are made different from those at that time, the length and width of the carriages will likewise differ. The height of the side pieces and the diameter of the trucks depend on the height of the port-holes in ships from the deck. Those of the lower tiers ought to be such, that when the breech of a gun lies upon the hind axle-tree, the muzzle of the gun should touch above the port-hole, in order that it may not push the shutter open when the ship rolls in stormy weather.

*General construction of carriages for new guns.*

We suppose the diameter of the shot to be divided into 24 equal parts, as in the construction of the gun, so that the guns and their carriages may be constructed by the same scale ; which is both more methodical and easier for the reader and the artillereft.

This being supposed ; take C D equal to 6 diameters of the shot and 10 parts ; and C E, C F, each equal to 34 parts, as likewise D G, D H, each equal to 39.5 ; the breadth of the side pieces is a diameter or 24 parts ; D B to a diameter and 12 parts ; A C to 2.5 diameters. The breadth of the fore axle-tree is 30 parts, its length  $6\frac{1}{2}$  diameters ; the length of the arms 44 parts, and their diameter 24. In the elevation, the height before of the side pieces is  $4\frac{1}{2}$  diameters, and behind half that height ; the height of the fore axle-tree is 42 parts, that of the hind one 30 ; the bed bolt passes under the middle of the fourth step, and even with the last or hind step.

The breadth of the wooden trucks is always equal to that of the side pieces, which is here one diameter or 24 parts ; the diameter of the fore ones 4 diameters,

H

and



and that of the hind 3 diameters and a half : but we have observed before, that if the port-holes in ships are made higher or lower, these diameters must be increased or diminished.

The *French* make use of a carriage on board of ships with two trucks before only, and are preferred by many officers to those of 4 : I had some of them made, which seem to answer very well ; they are nearly of the same height before as the common ; but to lessen the great height of the side pieces, the trucks are made of a larger diameter ; they have no steps, and behind have a transom for the stool-bed to rest upon instead of the body of the hind axle-tree. These carriages do not recoil so much, and are more readily pointed, because the trucks are not tight to their axle-tree. When they are traversed but a little, the carriage will move without the truck, and then fall back again so soon as the hand-spike is taken away.

The *French* garrison carriages are made much in the same manner ; but the trucks are made larger and of several pieces, and have a trail like travelling carriages, but much shorter.

Fig. 17.

This elevation shews the inside of the side pieces, with some of the irons, not else to be seen, and the manner we would have the side pieces let into the axle-trees, which is more simple, and yet equally as secure as the common manner, as likewise how the transom is to be placed, and not obliquely as the custom is. The rest of the figures in this plate shew the plans and elevations of the axle-trees and the stool-bed, as well as the transom.

*Iron*

*Irons for ship carriages.*

a. Cape squares,	_____	_____	2
b. Eye bolts,	_____	_____	2
c. Joint bolts,	_____	_____	2
d. Transom bolt,	_____	_____	1
e. Bed bolt,	_____	_____	1
f. Bracket bolts,	_____	_____	2
g. Hind axle-tree bolts,	_____	_____	4
h. Breeching bolts with rings,	_____	_____	2
k. Burrs,	_____	_____	2
l. Loops,	_____	_____	6
m. Dowel pins,	_____	_____	4
n. Square rivetting plates,	_____	_____	8
p. Rings with keys,	_____	_____	10
q. Traversing plates,	_____	_____	2
r. Linch pins,	_____	_____	4
s. Axle-tree hoops,	_____	_____	2
t. Axle-tree stays,	_____	_____	2
w. Keys, chains, and staples,	_____	_____	2
x. Stool bed bolts with rivetting plates,	_____	_____	2

The garrison carriages have the same irons, excepting the breech rings, and their trucks are of cast iron; for which reason their axle-trees have copper clouts underneath, to diminish the friction of the iron against the wood.

*Of travelling carriages. Plate VI. Fig. 19.*

Previous to their constructions, it is necessary to mention the names of the several parts they are composed of, which are as follows. The long side pieces QP, RS, are called the Cheeks; the fore part QR of the carriage, the Brest; and the hind part PS, the Trail; T, the Trail Transom; V, the Center Transom; X, the Bed Transom; and Y, Brest Transom; GH, the

Body of the Axletree; m, n, the Trunion Holes; and w, the Pintle Hole.

*Dimensions of the present cheeks.*

Nature of the gun, — — — — —	24	12	6	3
Length of the cheeks, — — — — —	13	12	11	10
Thickness, — — — — —	5.8	4.6	3.6	3
Height of the plank, — — — — —	22	19	16	13
Height of the cheek {	20	17	14	11.5
	17	15	12	9.5
	12	11	10	7.5
Head from the center, — — — — —	74	69	60	51.5
Length of the trail, — — — — —	18	15	12	10

*Axle-trees.*

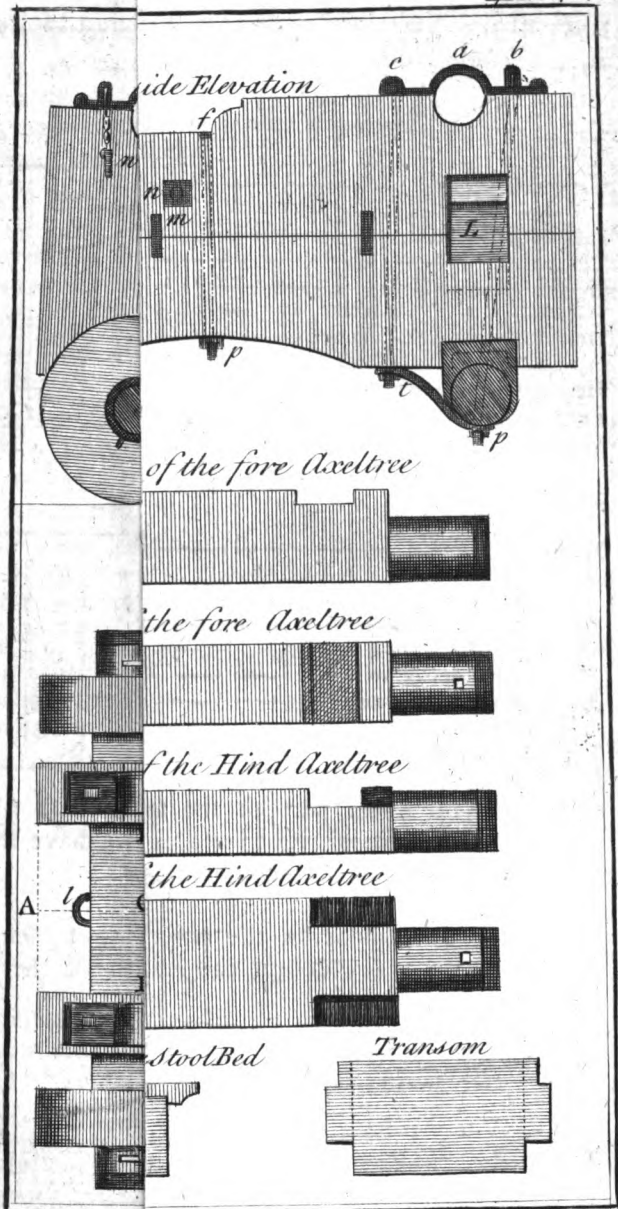
Nature of the gun, — — — — —	24.	12.	6	3
Body, {	38.5	39	40	40.5
	7	6.5	6	5.5
	9	8.5	8	7.5
Arms, {	21	20.5	19	17.5
	7	6.5	6	5.5
	5	4.5	4	3.5
Total length — — — — —	81	80	78	76

*N. B.* The under part of the axletree should be in one continued right line, as we have shewn in our *Elements of Mathematics*.

All the dimensions in the preceding tables are in inches and decimals, except the length of the cheeks, which are in feet.

*Construction of travelling Carriages.* Plate VI. Fig. 18.

Let A b c d be the plank, and A B the height before of the cheeks; set off from B to C the sum of the head A B, and the distance from the hind part of the





trunions to the extremity of the cascade; then from the point A as center, describe an arc CD through the point C, on which as a chord set off the height at the center, and draw the lines AD, BC. On BC take BE, equal to the head AB, and towards the head Er, rS, each equal to half the diameter of the trunions, so that ES will be the width of the trunion hole, whose center is about a quarter of an inch below the line BC. From the point r draw rF, perpendicular to AD; in AD take FH, equal to the breadth of the axle-tree, which is sunk about an inch into the cheeks. On the side FH make a square, and from the intersection I of diagonals, as center, describe an arc, with a radius of 29 inches, or equal to the radius of the wheel; this arc will represent a part of the wheel. Then if a ruler be laid so as to touch this arc, and cut the plank in two points M, L, such that the distance ML be equal to the length of the trail, and you erect at these points two perpendiculars MN, LO, to KM, each equal to the height of the trail; by drawing the lines CN, NO, and DM, you will have the figure ABCNOLD A of the cheek required.

The part MP is made round, that the carriage may slide with more ease on the ground, which is done by dividing LO into four equal parts, so that LP be one of them, by drawing MP; and at the points M and P, erecting two perpendiculars on DM, and on MP, which meeting in Q, then the point R, which bisects MQ, will be the center of the arc MP required.

The mortise V of the center transom is determined by drawing a line through the point C, perpendicular to the horizon KM, in which Cp is taken equal to a fourth part of the shot's diameter, and pq equal to two of these diameters for the height, and in pz, parallel to KM, the breadth px equal to one diameter. The distance between the center and bed transom X is two diameters; this last is a diameter each way. The breast transom Y is a diameter broad and two high; the sides

are parallel to the head  $AB$ , and terminate above even with the bottom of the trunion hole one way, and when produced the inside meets the point  $S$ . Lastly, the mortise  $T$  of the trail transom is equal in length to the trail, a diameter high, and is parallel to the upper side  $NO$ , so as when the lower is produced to meet the point  $P$ .

All these mortises are divided into four equal parts by horizontal lines; the upper part is sunk half an inch into the cheeks; the two middle parts are sunk to the depth of two thirds of the thickness of the cheeks, but the lower part is not sunk in at all. They are made in this manner to prevent the wet from getting into the joint and rotting the tenons.

*Construction of the plan. Fig. 19.*

Draw the indefinite line  $AB$ , in which take the points  $C, D$ , so as their interval be equal to the distance from the center of the trunions to the extremity of the base ring; through these points draw  $EF, KL$ , at right angles, to  $AB$ ; make  $DK, DL$ , each equal to the radius of the base ring, and  $CE, CF$ , each equal to the radius of the second reinforce ring; then the lines drawn through the points  $F, L$ , and  $E, K$ , will determine the width within of the carriage; if to these lines two others are drawn parallel, and at a distance equal to the length of the trunions, you will have the thickness of the cheeks  $QP$  and  $RS$ .

On both sides of the points  $E$  and  $F$ , set off half the diameter of the trunions, in order to have the trunion holes  $m, n$ ; draw the breast transom  $Y$  of a diameter broad, so as the inside be in a line with the fore part of the trunion holes; and if  $CA$  be taken equal to  $AB$  in the last figure, the line  $RQ$  at right angles to  $AB$  will determine the breast of the carriage, and the total length  $AB$  of the carriage is determined by the last figure.

If

If you set off from the line K L two diameters for the length of the cable, you will have the hind part of the center transom V, whose width is a diameter as well as the bed transom X, and their interval is two of these diameters, as has been said before; the trail transom T is determined as before by the length of the trail. In the middle of this transom is the pintle hole of an oval figure, wider above than below, that the pintle may have room to play on uneven ground.

The bed w is a board of an inch and a half thick, a foot broad, and sunk into the bed and center transoms; the width of the axle-tree has been determined before, and its fore part passes through the centers of the trunion holes: there is a board fixed upon the axle-tree with one end, and the other upon the bed transom, which serves to lay hay or straw upon for wadding.

Between the trail and center the breadth of the cheeks is diminished on the inside by a sixth part, beginning at about a diameter from the trail, and ends within a diameter and a half from the center transom.

This is the common construction of field carriages; but as it relates only to the four calibers, whose dimensions have been given, the reader will still be at a loss how to construct any other; and as the length of the cheeks depends not only on the caliber of the gun, but likewise on the height of the wheels, as well as on the length of the pieces, which varies very often: therefore, in the following construction, we suppose the wheels of the common size, and the guns to be 20 or 21 diameters long, which is the common length at present of the 24 pounders.

*General dimensions of travelling carriages. Fig. 18.*

The length A d of the plank is 12 diameters of the shot and 7.5 feet besides; its height A b three diameters and three quarters; the height A B of the cheeks three diameters and a quarter; so that B b is half a diameter, the

H 4

height



height DC at the center 70 parts of that diameter, divided into 24 equal parts, as in the construction of guns; the length of the trail is three diameters, and its height MN two; the breadth FH of the axle-tree is two diameters, and the rest of the dimensions depend on the size of the gun.

*General construction of travelling carriages for the new guns.*

Plate VI. Fig. 18.

The length Ad of the plank is 10 diameters of the shot and 7.5 feet; its height Ab, three diameters and three quarters; the height Ab of the cheeks, three diameters and a quarter. Set off from B to C eight diameters, and twenty parts of that diameter divided into 24, as in the construction of guns; then from the point A, as center, describe an arc through the point C, on which, as a chord, set off 70 parts from C to D, and draw the lines AD, BC. On BC take BE, equal to the head AB, and towards the point B, the parts Er, rS, each equal to 9 parts, so that ES will be the width of the trunion holes, whose center is sunk about a quarter of an inch into the cheek. From the point r draw rF, perpendicular to AD, and in AD take FH, equal to 30 parts for the breadth of the axle-tree, which is sunk into the cheek about an inch. On the side FH make a square, and from the intersection I of the diagonals, as center, describe an arc with a radius of 29 inches, which arc will represent a part of the wheel. Now if a ruler be laid so as to touch this arc, and cut the plank in two points M, L, so that the distance ML be equal to three diameters, and there be erected at these points the perpendiculars MN, LO, to KM, each equal to two diameters, then, by drawing the lines CN, NO, and DM, you will have the outline ABCLDA of the cheeks. The under part of the trail is made round,

round, and the mortises of the trunnions are made as before.

*Construction of the plan. Fig. 19.*

Draw the indefinite line  $AB$ , in which take the points  $C, D$ , so as their interval be 7 diameters and 17 parts; through these points draw  $EF, KL$  at right angles to  $AB$ ; make  $DK, DL$ , each equal to 32.5 parts, and  $CE, CF$ , each equal to 27.5 parts; then the lines drawn through the points  $F, L$ , and  $E, K$ , will determine the width within of the carriage. If to these lines two others are drawn parallel, and at 18 parts distant, you will have the thickness of the cheeks,  $QP$  and  $RS$ .

On both sides of the points  $E, F$ , set off 9 parts for the radius of the trunnions, in order to have the trunion holes  $m, n$ . If  $CA$  be taken equal to  $AB$  in the last figure; the line  $RQ$ , drawn at right angles to  $AB$ , will determine the breast of the carriage, and the total length  $AB$  is determined by the last figure. The rest of the construction is the same as before.

*Remarks on this construction.*

Regard must be had in the construction of these carriages to their strength, and that the piece may lay close and steady in it; as likewise that the gun may be properly elevated, in case ricochet firing should be required.

The thickness of the cheeks are here supposed eighteen parts instead of a caliber, as is usual; this we esteem sufficient, because pieces are now loaded with no more than one third of their shot's weight, or ought not at least; which charge has been found sufficient for battering pieces.

The length of these carriages is such, that a 24 pounder may be elevated to about an angle of 9 degrees, and

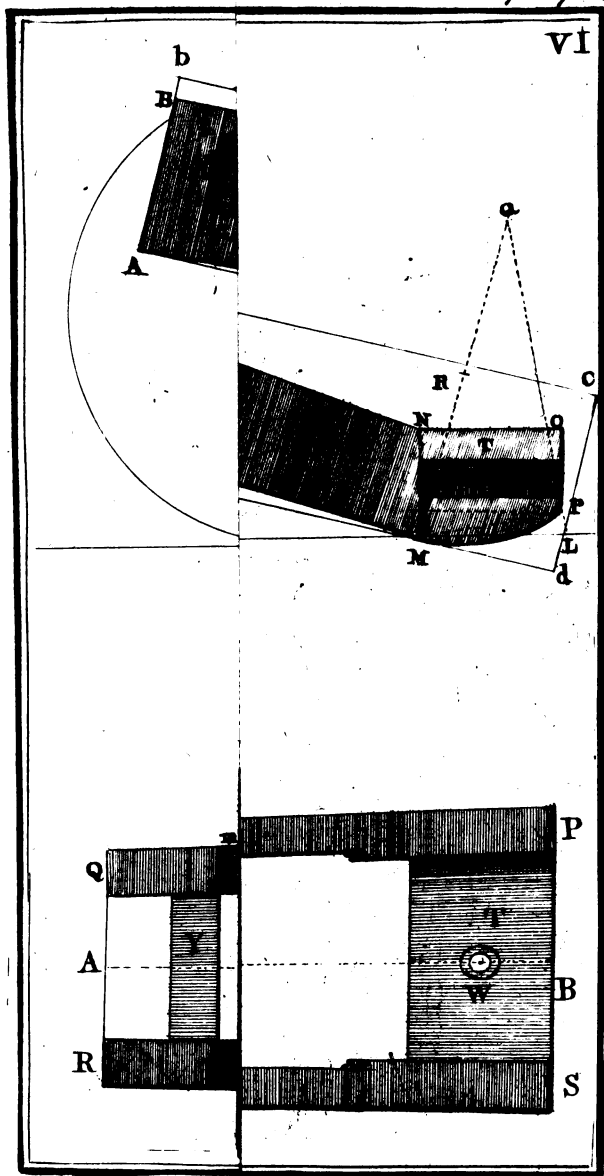
and the smaller ones to 10, or 11 and 12, which is more than sufficient upon all occasions. The cheeks are not bent too much at the center, because, if they are, they become very weak in that part. We make the trunion holes so as one half of them is over the axle-tree, whereas the common practice is to make them just without, which, in my opinion, occasions the weight of metal to hang too much beyond the center of the wheels.

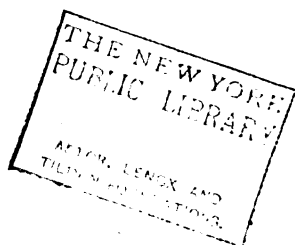
## Plate VII. VIII.

In these plates are the plan and elevation of a 6 pounder travelling carriage, with all the irons marked on them, such as are now made.

*Iron-work of travelling carriages.*

Transom bolts with burrs	{	breast	—	—	1
		center	—	—	2
		trail	—	—	2
Transom plates with hooks	{	breast	—	—	2
		center	—	—	2
		trail	—	—	2
Trunion plates		—	—	—	2
Cap squares with joint bolts		—	—	—	2
Spring keys with chains and staples		—	—	—	4
Eye bolts	{	fore	—	—	2
		hind	—	—	2
Breast plates		—	—	—	2
Plates with roses	{	garnish	—	—	2
		trail	—	—	2
Garnish	{	bolts	—	—	2
		nails	—	—	6
Axle-tree bands		—	—	—	2
Side straps		—	—	—	4
Draught rings with bolts and burrs		—	—	—	2
Locking plates		—	—	—	2
Lashing rings with loops		—	—	—	8





# A, R T I L L E R Y.

107

Single forelock keys	_____	_____	8
Bed piece chain with staple	_____	_____	1
Locker { hinges	_____	_____	2
{ hasp with staples	_____	_____	1
Wood screws			
Rivets			
Nails { rosebuds			
{ diamond headed			
{ countersunk			
{ trail			
Pintle plates upper and under	_____	_____	1

## *Names of the parts of a wheel.* Plate IX.

A. Nave	_____	_____	_____	1
B. Spokes	_____	_____	_____	12
C. Fellies	_____	_____	_____	6
n. Dowel pins	_____	_____	_____	6
a. Streaks	_____	_____	_____	6
b. Streak nails	_____	_____	_____	48
c. Nave hoops	_____	_____	_____	3
d. Nave boxes	_____	_____	_____	2
f. Dowledges	_____	_____	_____	6
g. Rivets for ditto	_____	_____	_____	24
h. Nave hoop stubs	_____	_____	_____	9
k. Box pins	_____	_____	_____	6

The dowel pins are wooden pegs, of about three inches long, and three quarters of an inch in diameter; they serve to fasten the fellows together; and the dowledges are iron plates, fastened and sunk into the fellies on the outside, so are not seen here; they serve to bind the joints of the fellies strongly together, each with four pins.

The nave is always made of elm, cut six months before it is used, and left in the bark all the while till it is used; the spokes are made of elm or young oak, and used as dry and well seasoned as possible; the fellies are likewise

likewise made of dry elm, or in default of which young beech split in two only will do as well, if not better; and the axle-tree is made of dry elm, young oak, or young beech.

The cheeks and transoms are always made of dry elm, on account that this wood is very pliable, receives the nails better than any other, and does not split; yet I have seen some made of young oak, and am of opinion it is much stronger than elm, and I think may answer better.

*Dimensions of wheels for travelling carriages.*

Caliber	—	—	—	24	22	6	3	Parts
Wheel, diam. inches	—	—	—	58	58	58	58	
Nave, length	—	—	—	17.5	17	15.5	15	76
Diameter	{	body	—	15	15	13	12.5	62
		middle	—	16	16	14	13	74
		linch	—	13.5	13.5	10	10	60
Fellies	{	thickness	—	5	4.5	4	3	22
		breadth	—	6.5	6	5.5	4.5	28
Spokes	{	thickness	—	2.3	2.2	2.1	2	10
		breadth	—	4.5	4	3.5	3	20

The mortises of the spokes should be placed in the middle of the nave, but the workmen make them an inch nearer to the linch. The spokes are somewhat less near the fellows than at the nave; they are likewise inclined towards the linch three inches in a wheel five feet high, and so in proportion in one of any other diameter; which the workmen call *disbing*. How they found out that this inclination renders the wheels more perfect is not easily known; those that I have conversed with knew no more than that it was an old custom, which made me inquire farther into it, and I have found that it is grounded on true mechanical principles, as may be seen in my *Elements of Mathematics*, page 245.

The

The last column in the preceding table contains the general dimensions of the respective parts for wheels of any such carriages, expressed by the parts of the diameter of the shot divided into 24, as in the construction of guns, and proportional to the dimensions of a wheel for a 24 pounder's carriage. These general dimensions are very useful in several respects: suppose it were required to make wheels for any other calibers than those above, then you must either refer thereto, or else perform the work by guess. Again, these dimensions being expressed by the same parts as the guns, they may both be constructed upon the same scale; which cannot be done in the common manner without a great deal of labour and difficulty: in short, artillery would be incomplete without them; because it is not sufficient to know how to execute what has been done before, but any other work of the same kind that may be necessary.

The *Span*, or interval between the wheels, varies in different countries; even every county in *England* observes a different width, which is very inconvenient for those who travel in carriages. The artillery carriages are made like those in *Flanders*, which is four feet eight inches; but as the fellies are not of the same breadth in all wheels, we shall make the distance between the middle of the fellies five feet in all the carriages used by land, which are hereafter mentioned, the truck one excepted.

## Iron-work of an axle-tree. Plate IX.

a. Axle-tree bar	_____	_____	1.
b. Clouts { body	_____	_____	2
linch	_____	_____	2
c. Axle-tree hoops { linch	_____	_____	2
arms	_____	_____	2
body	_____	_____	2
d. Hurters with straps	_____	_____	2
f. Washers	_____	_____	2
		g. Linch	



g. Linch pins	_____	_____	2
h. Axle-tree bolt	_____	_____	1
k. Single forelock	_____	_____	2
Clout nails	_____	_____	12
Dog nails	_____	_____	8

*Tools necessary to prove and load guns.*

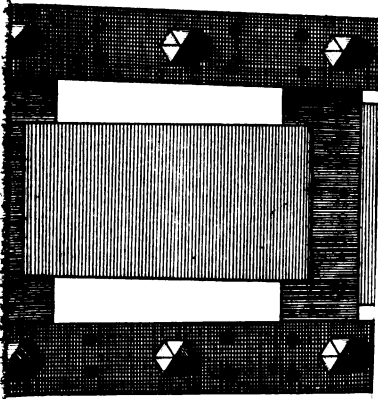
The searcher is an iron socket with branches, from four to eight in number, a little bent outwards, with small points at their ends : to this socket is fixed a wooden handle, from 8 to 12 feet long, of about an inch and a quarter diameter. This searcher is introduced into the gun after it has been fired, and turned round, to discover the cavities within ; and after their distances are marked on the outside with chalk, they make use of another searcher, that has only one point, about which a mixture of wax and tallow is put to take the impression of the holes ; and if there are any of a quarter of an inch deep, or of any considerable length, the gun is rejected as unserviceable to the government ; though the iron is sold to merchants. The gun is thus proved and searched twice.

The reliever is an iron ring fixed to a handle by means of a socket, so as to be at right angles : it serves to disengage the first searcher, when any of its points are retained in a hole, and cannot otherwise be got out.

The worm is a double-wired screw, fixed to a handle by means of a socket ; it serves to draw out the wadding or bottoms of cartridges which remain in the gun after frequent firing, and which would otherwise accumulate so much, that other cartridges could not be rammed home enough to reach the priming, whereby the gun would miss fire.

The ladle is made of copper, about three diameters of the shot long, and the thickness equal to the windage of the gun : it is of a cylindric form, having an opening above of about a sixth part of the circle, and made like

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like a scoop at the end. The use of the ladle is to introduce the charge of powder into the gun, when it is not made up into a cartridge, or to loosen the shot, and draw it, in case it is retained by dust got into the gun after much travelling.

The rammer is a cylinder of wood, whose diameter and length are each equal to the diameter of the shot, with a handle fixed to it; it serves to ram home the shot and powder when the gun is loaded.

The sponge is likewise a cylinder of wood, from 10 to 12 inches long, of the same diameter with the rammer, and covered with lambskin, so as to fit the gun exactly; it is commonly fixed to the other end of the rammer's handle in small guns, but has a separate one in those of larger calibers. The use of the sponge is to clean the piece before and after it is fired. The IXth plate represents the forms of these tools, whereby the reader may have a clear conception of them.

Guns are proved various ways, to find whether they are sufficiently strong; the most common in *England* is with a charge of powder, which weighs as much as the shot in all pieces under a 24 pounder; which, if brass, is loaded with 21 pounds, the 32 pounder with 26 and 12 ounces, the 42 pounders with 31 pounds 8 ounces\*; but in *France* they are charged with two thirds of the shot's weight only. Sometimes water is forced into them, but this proof is insufficient; it has been found, that though the water penetrated through the piece in several places, yet they were very good and serviceable. The best and surest way of proving pieces made after a new pattern, or of some new metal, is to charge them with no more powder than they are loaded with in action, and to fire them 2 or 300 rounds as quick as possible; and if they stand this trial, there is no danger of their

\* The charge of the iron 24 pounder is 18 pounds; that of the 32 is 21 pounds 8 ounces; and the 42 is 25 pounds. As to the light brass field pieces, they are proved with half the weight of the shot; except the 24 pounder only, with 10 pounds.

bursting afterwards. This has been done by our light 6 pounders, when they were first introduced into our service. Mr. *De Valliers*, lieutenant-general of the artillery in *France*, has proposed another method for proving pieces, which is, instead of loading them with shot, to ram clay in as hard as possible two feet deep. But I doubt whether an iron cannon could stand such a proof, nor would I advise the trial.

*To construct field carriages. Plate X.*

As field pieces are shorter and much lighter than those above, their carriages likewise observe the same proportion. They have the same form, but their wheels are only four feet two inches high; which, in my opinion, is too low; for the draught of low wheel carriages is known to be greater than the higher: and, though the guns are light, yet that is no reason to make the draught greater. I think, if they were 4.5 feet high, it would be much better; but it being no easy matter to change any thing established by custom, we shall insert the dimensions used at present, that the reader may see what has hitherto been the practice, leaving my observations to his judgment, either to approve or not, as he pleases.

*Dimensions of field carriages.*

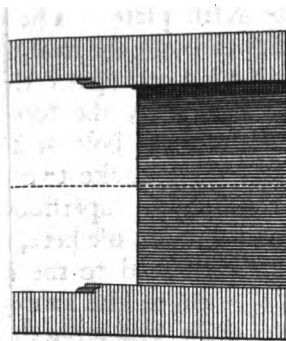
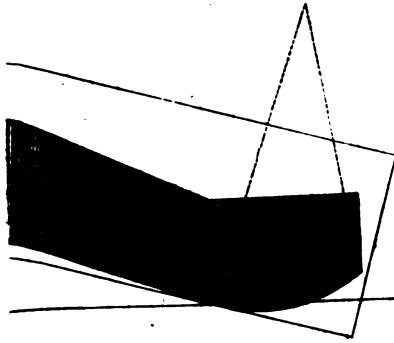
Calibers	—	--	24	12	6	Parts
Length	} of the plank	{	108	106	94	13 : 4
Height			15.6	14	12.4	3 : 6
Thickn.			4.5	3.7	3	0 : 18
Cheeks, height before	—	—	14.5	12.7	11	2 : 18
Height at the	{ center	—	12	10.9	9.8	2 : 16
	{ trail	—	10	9.2	8.4	1 : 16
Length of the trail	—	—	11	10.5	10	1 : 22
From head to center	—	—	10	45	40	11 : 6
Width within	{ before	—	11.5	10.7	10	2 : 1
	{ behind	—	17	15	13	2 : 15

*Dimensions*



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Pl. X.



There is one gun carriage more, which is called Galloper; it serves for a pound and an half gun. This carriage has shafts so as to be drawn without a limber, and is thought by some artillerists to be more convenient and preferable to other field carriages: and as it may likewise serve for our light three and six pounders, we shall give the following

*Dimensions of a galloper carriage.* Plate XII.

		Feet.
Total length of the shafts,	— — —	11 : 0
From the { fore end to the fore cross bar,	— — —	6 : 4
{ hind end to the round part, —	— — —	5 : 0
Height at the { hind end,	— — —	0 : 6
{ fore end,	— — —	0 : 3
Breadth { behind and before,	— — —	0 : 3.5
{ in the middle,	— — —	0 : 4.5
Width within behind,	— — —	2 : 6.5
At the fore { cross bar,	— — —	2 : 4
{ end,	— — —	2 : 1
From the hind end to the axle-tree,	— — —	0 : 11
Cross bar from the hind end,	— — —	0 : 3
Length {	— — —	4 : 2
Breadth { of the cheeks, {	— — —	0 : 2.5
Height {	— — —	0 : 6.5
Width within { before,	— — —	0 : 8
{ behind,	— — —	0 : 11.5
Total length of the axle-tree,	— — —	6 : 4
Length of the { body,	— — —	3 : 6.5
{ arms,	— — —	1 : 4.6
Breadth { of the body, {	— — —	0 : 5
Height {	— — —	0 : 6
Greatest { diameter of the arms, {	— — —	0 : 5
Least {	— — —	0 : 3.3
Diameter of the wheel,	— — —	4 : 3
Nave, length,	— — —	1 : 1



Diameters,	{ body,	— — — —	0 : 11
	{ middle,	— — — —	1 : 0
	{ linc,	— — — —	0 : 10
Spokes,	{ breadth,	— — — —	0 : 1.5
	{ thickness,	— — — —	0 : 3
Fellows	{ breadth,	— — — —	0 : 3
	{ height,	— — — —	0 : 4.5

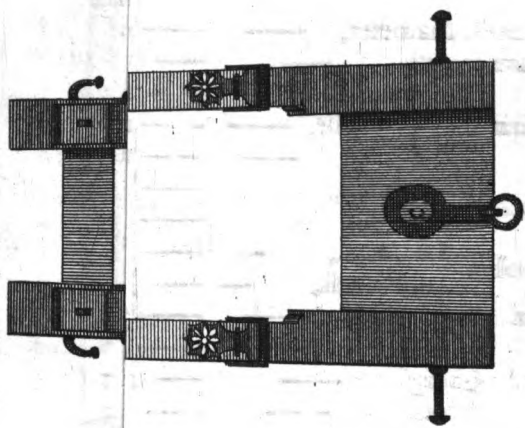
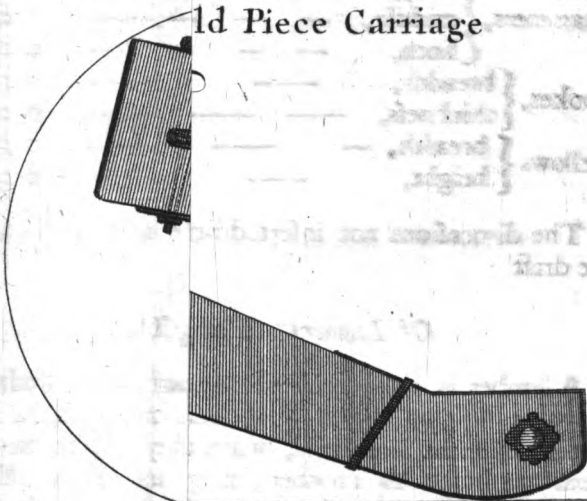
The dimensions not inserted here may be taken from the draft.

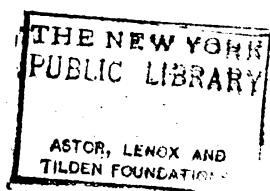
### Of Limbers. Plate XIII.

A limber is a two wheel carriage with shafts, and serves to support the trail of field carriages, by means of the pintle or iron bolt, when they are to be drawn from one place to another; they are taken off again when the pieces are to be fired. Their dimensions are,

Caliber,		24	12	6	3
		Inches			
Wheels diameter,	— — — —	48	48	48	45
Nave length,	— — — —	16	15	14	10
Diameters	{ body,	13.5	13.5	12	12
	{ middle,	14	14	13	12.5
	{ linc,	12	12	11	10
Fellows	{ breadth,	4.5	4	3.5	3
	{ height,	5	4.5	4	3.5
Spokes	{ breadth,	1.8	1.6	1.4	1.2
	{ thickness,	4	3.5	3	2.5
Axle-tree length,	— — — —	78	76	74	69
Body	{ length,	40	40	40	45
	{ height,	7.6	7	6	5.5
	{ breadth,	6	5.5	5	5
Arms length,	— — — —	19	18	17	13
Diameters	{ body,	5	4	4	4
	{ linc,	4	3	3	3
Shafts length,	— — — —	94	94	94	94

# 1d Piece Carriage





# ARTILLERY.

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Breadth	{ hind end, ———	6	5.5	5	4
	{ fore end, ———	3	3	2.5	2.5
Height	{ hind end, ———	3.3	3	3	3
	{ fore end, ———	3	3	2.5	2.5
Bolster height, ———		12.5	10	8	7
Length, ———		40	40	40	43
Breadth, ———		6	5.5	5	5
Fore cross bar	{ breadth, ———	4.5	4	3.5	3
	{ height, ———	1.5	1.5	1.5	1.5
Hind cross bar	{ breadth, ———	3.5	3.5	3.5	3
	{ height, ———	1.5	1.5	1.5	1.5
Axle-tree from the fore cross bar,		11.5	11.5	11.5	11.5

All shafts are about two feet open before, two feet ten inches in the middle, and something less near the axle-tree, according as the wood happens to be more or less crooked; for it is never cut across the grain, because that would weaken it too much. The bolster diminishes towards both ends, as in the drafts; so that the height given here is to be measured in the middle.

## Iron work of the shafts.

a. Limber bolt, ———	1
b. Shaft rings, ———	2
c. Shaft pins with chains, ———	2
d. Breech hooks, ———	2
e. Ridge chain with hook and loop, ———	1
f. Limber chain with hook and rings, ———	1
g. Single forelock keys, ———	4
h. Nails, diamond headed, ———	8
k. Dog nails, ———	6
l. Bolster hoops, ———	2
m. Pintle, ———	1
n. Pintle washer, ———	2
Stubs for bolster hoops, ———	8

The iron work of the wheels and axle-tree being the same as before, only lighter in proportion to the wooden work, we think a repetition needless.

### REMARKS.

The wheels of the limbers being but four feet high, and the extremities of the shafts five, the draught of the shaft horse becomes so oblique, that the greatest part of his force is lost in supporting the fore ends of the shafts, which the other horses draw down again, so as to bring the whole draught in a right line from the axle-tree to the breast of the fore horse; whereby the shaft horse is so shook (the difference between the height of the fore end of the shafts and the center of the axle-tree being at least two feet) that he is spoiled in a short time, and rendered unfit for service: on the other hand, the bolster of a 24 pounder limber is 14 inches high from the center line of the axletree; when the carriage is moving, it endeavours to turn the limber about its axis, and the trail would slip out of the pintle, were it not for the limber chain that retains it. All these oblique motions being considered, it will be found by those conversant in mechanic principles, that worse cannot be contrived. It is very difficult to contrive better: for the trails of field carriages cannot be altered; and if the wheels were made higher and the bolster lower, the carriage cannot turn so well in a narrow road, nor can the trail be fixed under the axle-tree for the same reason: the only remedy that can be found, in my opinion, would be to fix a pole or shafts in some way or other to the head of the carriage, so as to draw it forwards, and the trail to slide on the ground like a sledge; but how this may be done must be left to some ingenious workman.

PART

## PART V.

*Of mortar beds and howitz carriages.*

**T**HE land mortar beds are here made of solid timber, consisting generally of four pieces; those of the royal and coehorns excepted, which are but one single block. As to sea mortars, their beds are made quite different from these, as will be shewn each in their order.

*Dimensions of land mortar beds.* Plate XIV.

Bore,	13	10	8	5.8	4.6	
	Inches					
Lower bed {	length, —	84	66	50	0	0
	breadth, —	33	20	0	0	0
	height, —	13	10	9	0	0
Upper bed {	length, —	83	65	49	31.5	28.6
	breadth, —	32	25	19	16	14
	height, —	13	12	11	10	9
Breadth quarter round, —	3	2.5	2.5	0	0	
Of the ogee and fillet, —	4	3.5	3	0	0	
Length of the cavity, —	20	16	12	8	5.7	
Trun. hole from fore end,	31	20	15.5	13.3	11.7	
Diam. } of trun. holes, {	7.2	6.4	5.4	3.4	2.4	
Depth }	7	6	5	3.2	2.2	

The distance of the trunion holes is measured from the quarter round, and not from the end of the bed. The joint of the two pieces of the upper bed, in the 13, 10, and 8 inch beds, are so contrived as not to be directly over the joint of the pieces in the under bed.

*Names and number of irons in a 13, 10, and 8 inch bed.*

a. Cap squares,	_____	_____	_____	2
b. Eye bolts,	_____	_____	_____	2
c. Joint bolts,	_____	_____	_____	2
d. Under and upper bed bolts,	_____	_____	_____	9
f. Dowel bars,	_____	_____	_____	4
g. Rings with bolts,	_____	_____	_____	4
h. Reverse bar,	_____	_____	_____	2
k. End rivetting plates,	_____	_____	_____	2
l. Middle plate,	_____	_____	_____	1
m. Rivetting bolts,	_____	_____	_____	6
n. Square rivetting plates,	_____	_____	_____	12
p. Traversing bolts,	_____	_____	_____	6
q. Keys, chains, and staples,	_____	_____	_____	2

*Names and number of irons in a royal and coeborn bed.*

a. Cap squares,	_____	_____	_____	2
b. Eye bolts,	_____	_____	_____	2
c. Joint bolts,	_____	_____	_____	2
d. Rivetting bolt with ring,	_____	_____	_____	1
f. Handles with starts,	_____	_____	_____	2
g. Square rivetting plates,	_____	_____	_____	5
h. Keys, chains with staples,	_____	_____	_____	2

*Dimensions*

*Dimensions of beds for the three new mortars.*

Diameter of the bore, —		30	30	30
Lower bed	{ length, —	6 : 0	5 : 10	4 : 25
	{ breadth, —	2 : 10	2 : 2	1 : 26
	{ thickness, —	0 : 28	0 : 25	0 : 22.5
Upper bed	{ length, —	5 : 28	5 : 8	4 : 23
	{ breadth, —	2 : 8	2 : 0	1 : 24
	{ thickness, —	0 : 28	0 : 25	0 : 22.5
Breadth of the ogee, —		0 : 6	0 : 5	0 : 4.5
Of quar. round and fillet, —		0 : 6	0 : 5	0 : 4.5
Diam. }	of trun. holes {	0 : 14	0 : 13	0 : 12
Depth }		0 : 10	0 : 9.5	0 : 9
Interval between them, —		1 : 5	1 : 5	1 : 4
Their length, —		0 : 15	0 : 14	0 : 13

The first numbers in each column express the diameters of the bore, and the second the parts of that diameter divided into 30, as in the construction of mortars. The center line of the trunion hole passes through the middle of the upper bed.

The dimensions of the first of these beds will hold nearly true in regard to the present mortars. As to those used at present, there is no proportion between them; some are larger and others smaller than they should be; for it has been observed, that when the royal and cohorn are fired, their beds kick about very much, which is a certain sign that they are too small. We have observed before, that the mortars both here and in *France* are not constructed by any rule; the same is true in regard to their beds; and it is no wonder, since *St. Remy*, the only author who has wrote a complete treatise upon artillery, did no more than copy such memoirs as he received from the workmen, without pretending to reason upon the subject, and in all appearance was not qualified for it.

*General*



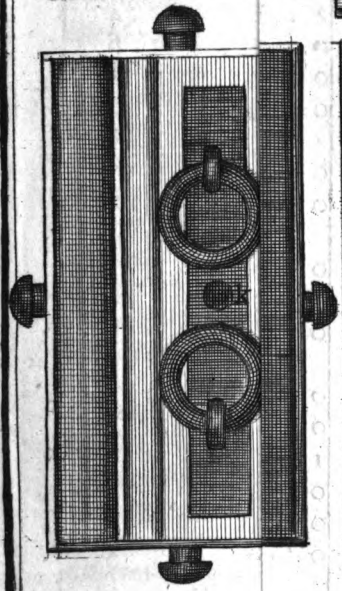
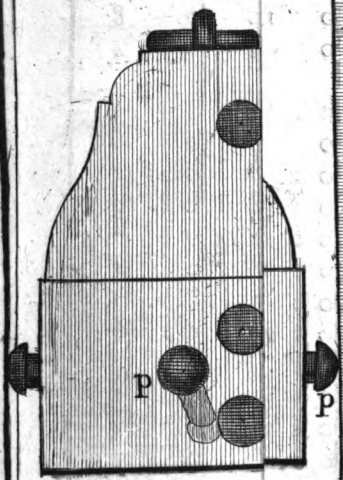
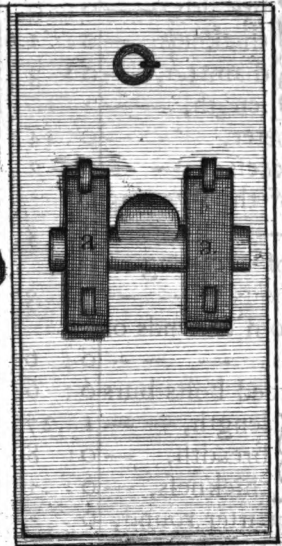
*General dimensions of the iron work.*

Cap square	{ length, —	1 : 18	1 : 14	1 : 9
	{ breadth, —	0 : 12	0 : 10	0 : 8
	{ thickness, —	0 : 3	0 : 2.5	0 : 2
Fore end from the trunion hole,	—	0 : 16	0 : 14	0 : 13
Eye bolt head	{ height, —	0 : 8	0 : 7	0 : 6
	{ breadth, —	0 : 7	0 : 6	0 : 5
	{ thickness, —	0 : 3.5	0 : 3.5	0 : 3
Joint bolt head	{ diameter, —	0 : 11	0 : 8.5	0 : 7.5
	{ thickness, —	0 : 3.5	0 : 3.5	0 : 3
Dist. from the trun. hole,	—	0 : 10.5	0 : 9.5	0 : 7.5
Traversing bolt length,	—	0 : 23	0 : 20	0 : 16
Diameter of	{ head, —	0 : 4.5	0 : 3.5	0 : 3
	{ bolt, —	0 : 3	0 : 2	0 : 2
Their distance from	{ below, —	0 : 12	0 : 11	0 : 10
	{ end, —	1 : 2	0 : 29	0 : 24
Mid. plate	{ length, —	2 : 8	2 : 0	1 : 24
	{ breadth, —	0 : 9	0 : 7	0 : 6
	{ thickness, —	0 : 1.6	0 : 1.5	0 : 1.5
Bed bolt	{ diameter, —	0 : 3	0 : 2.5	0 : 2
	{ length, —	2 : 10	2 : 2	1 : 26
Ring	{ diameter, —	0 : 14	0 : 12	0 : 10
	{ thickness, —	0 : 3	0 : 2.5	0 : 2
Diameter of the rivetting bolts,	—	0 : 3	0 : 2.5	0 : 2
Diameter of the ring rivetting bolts,	—	0 : 3	0 : 2.5	0 : 2
Distance from the ends of the plates,	—	0 : 6	0 : 5	0 : 4
Dia. of the bed bolts burs	—	0 : 6	0 : 5	0 : 4
Rivetting plates	{ length, —	1 : 27	1 : 19	1 : 14
	{ breadth, —	0 : 8	0 : 6	0 : 5
	{ thickness, —	0 : 1	0 : 1	0 : 1
From the quarter round,	—	0 : 8	0 : 6	0 : 5
Diameter of the traversing bolt plates,	—	0 : 11	0 : 10	0 : 10

We

XIV

A Coehorn Bed





We suppose these mortars so fixed in their beds as to be moveable, quite contrary to the present practice, and that they may be raised from an angle of 10 degrees to any under 90 ; for which reason the depth of the trunion hole is not equal to its diameter, and the cavity in the bed is to be made in such a manner as to receive the wedges by which the mortar is raised.

## *Dimensions of sea mortar beds. Plate XV, XVI.*

Diameter of the bore,	—	—	13	10
Length	} of the bed, {	—	94	84
Breadth		—	54	47
Height		—	27	23
Pintle hole from the fore end,	—	—	39	32
Diameter of the pintle hole,	—	—	6.5	6.5
Trunions from the fore end,	—	—	46	42.5
Diameter	} of the trunion holes, {	—	10	8
Depth		—	8	5
Diameter	} of the circular bed, {	—	59	59
Height		—	8	6
Distance to the bed bolster,	—	—	15	16
Depth of the cavity,	—	—	15	12
Its opening above,	—	—	30	21
Bed bolster length,	—	—	53	44
Length below,	—	—	29	2.1
Its height,	—	—	16	17
Its breadth,	—	—	14	12

These beds are placed upon very strong timber frames, fixed into the bomb ketch, to which the pintle is fixed so as the bed may turn about it. The fore part of these beds is an arc of a circle described from the same center as the pintle hole. The plans, elevations, and different sections shew in a distinct manner the several parts of these beds.

*Iron*

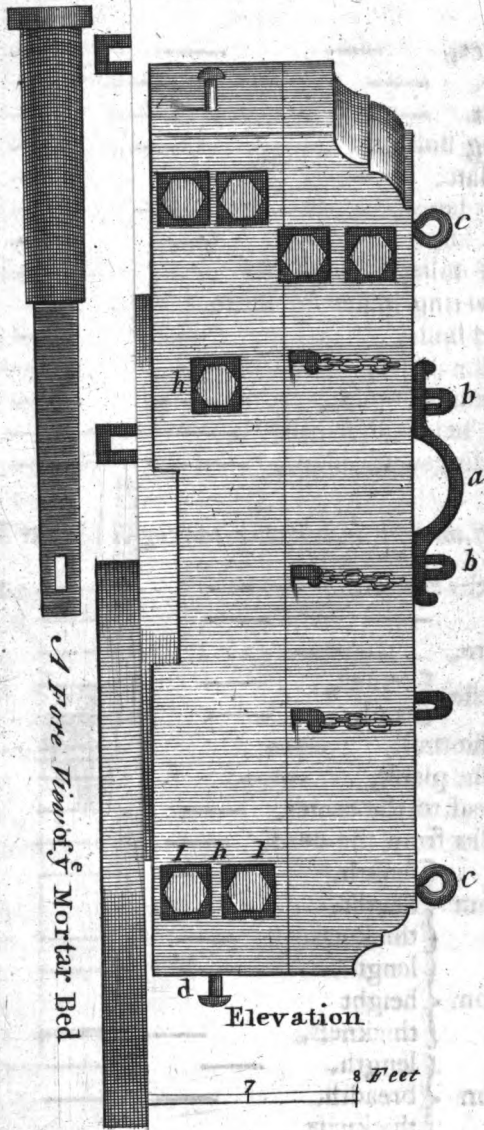
*Iron work of these beds.*

a. Cap squares,	_____	_____	_____	2
b. Eye bolts,	_____	_____	_____	6
c. Loop bolts,	_____	_____	_____	4
d. Traversing bolts,	_____	_____	_____	4
e. Middle plate,	_____	_____	_____	1
f. Riveting plates,	_____	_____	_____	1
g. Riveting bolts,	_____	_____	_____	6
h. Cross bed bolts,	_____	_____	_____	7
i. Square riveting plates for ditto,	_____	_____	_____	7
k. Down bed bolts,	_____	_____	_____	15
m. Bed bolster plates,	_____	_____	_____	2
Keys, chains and staples,	_____	_____	_____	6
Nails to the bed bolster bed,	_____	_____	_____	4
Bed bolster rings with loops,	_____	_____	_____	2

*Dimensions of an eight inch howitz carriage. Plate XVII.*

Length of the cheeks,	_____	_____	101
Thickness,	_____	_____	4.5
Height before,	_____	_____	18
Height at the { center,	_____	_____	16
{ trail,	_____	_____	14
Length of the trail,	_____	_____	15
Height of the plank,	_____	_____	18
From the head to the center,	_____	_____	43
Trunion holes from the head,	_____	_____	9
Breast transom { length,	_____	_____	14.5
{ height,	_____	_____	
{ thickness,	_____	_____	4.5
Center transom { length,	_____	_____	16.5
{ height,	_____	_____	
{ thickness,	_____	_____	4.5
Trail transom { length,	_____	_____	19
{ breadth,	_____	_____	16
{ thickness,	_____	_____	

The



A Fore View of Mortar Bed

Elevation

7 8 Feet



The iron work of these carriages is the same as in field carriages ; but there are only four garnish nails, two of a side, because they are so short as not to admit of more. As to the wheels and axle-tree they are the same as in an 18 and 12 pounder's carriage.

## PART VI.

*Of different sorts of carriages used in the artillery.*

*Dimensions of a Tumbrel. Plate XVIII.*

			Inches.
<b>D</b> iameter of the wheel,	—	—	60
Nave length,	—	—	15
Diameters {	body,	—	12
	middle,	—	13
	linch,	—	10
Spokes {	breadth,	—	2.2
	thickness,	—	3.3
Fellows {	breadth,	—	4.5
	thickness,	—	3.5
Axletree length,	—	—	76
Body {	length,	—	42
	breadth,	—	5.
	height,	—	6.7
Arms length,	—	—	17
Diameters {	body,	—	4.5
	linch,	—	3
Shafts total length,	—	—	147
From the hind {	end to the cross bar,	—	7
	cross bar to the fore cut,	—	62
From the fore cut to the fore end,	—	—	78
			Breadth,



			Inches.
Breadth	{ behind	_____	4
	{ at the fore cut	_____	4.5
	{ in the middle	_____	3.5
	{ at the fore end	_____	2.3
Height from the hind end to the fore cut			3.5
Height at the fore end			2.3
Width within	{ behind, and at the fore cut	_____	34
	{ in the middle	_____	35
	{ at the fore end	_____	25
Cross bars	{ breadth	_____	3.5
	{ thickness	_____	2
	{ length	_____	31
Fore cut	{ length	_____	51
	{ breadth	_____	4
	{ thickness	_____	2
Raves	{ length	_____	62
	{ breadth	_____	2
	{ thickness	_____	3
Standards	{ length	_____	24
	{ breadth	_____	2.8
	{ thickness	_____	1.3
Head bars	{ length	_____	36
	{ breadth	_____	1.2
	{ thickness	_____	1.8
Uprights	{ length	_____	22
	{ breadth	_____	1.3
	{ thickness	_____	3

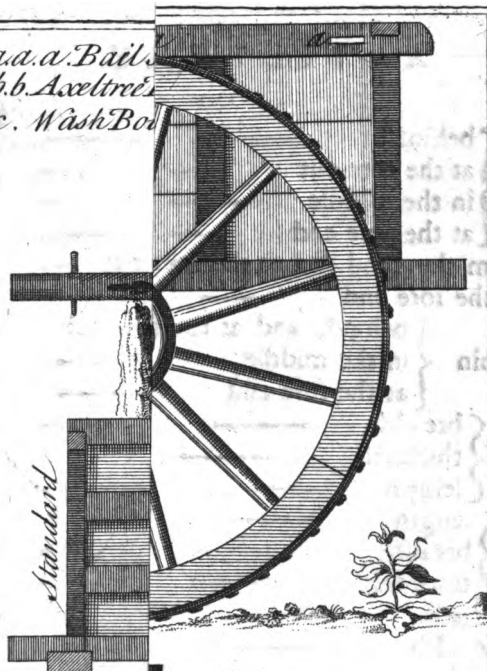
*Iron work of a tumbrel.*

A pair of wheels and axle-tree complete.

Axle-tree pins with rings and keys	_____	2
Fore cut pins	_____	2
Breech hooks	_____	2
Shaft rings	_____	2
Shaft pins with chains and staples	_____	2
Ridge chain with hook and loop	_____	1
Bail staples	_____	6

The

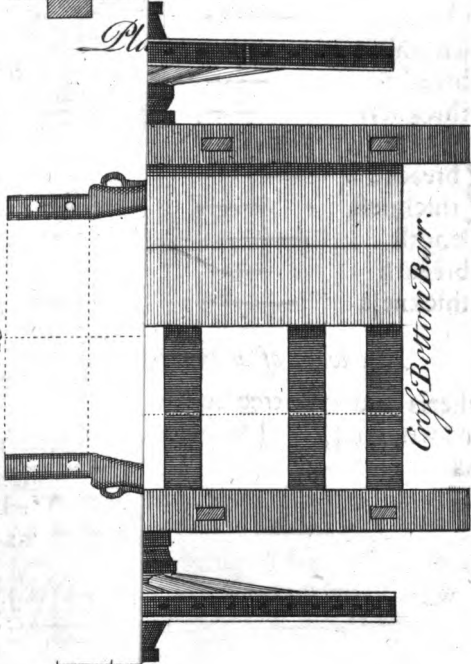
a.a.a. Bails  
 b.b. Axeltree  
 c. Wash Box



Standard

Pl

25



Cross Bottom Barr



The common use of tumbrels is to carry the pioneers and miners tools; but they serve likewise to carry the money of the army.

## *Dimensions of a powder cart. Plate XIX.*

The wheels and axle-tree are the same as in the tumbrel, except the height of the wheels is here 5.5 feet.

		Inches.
Sides with shafts, total length	_____	180
From the hind	{ end to the cross bar _____	5.5
	{ cross bar to the fore cross bar _____	88.5
From the fore cross bar to the fore end	_____	77.5
Breadth	{ behind _____	3.3
	{ fore cross bar _____	4.4
	{ middle _____	3.7
	{ before _____	2.8
Height	{ behind _____	3
	{ fore cross bar _____	4
	{ before _____	2.8
Opening behind, and at the fore cross bar	_____	34
At	{ middle _____	35
	{ before _____	25
Two shaft cross bars	{ length _____	34
	{ breadth _____	2
	{ height _____	3
Under cross bars	{ length _____	40
	{ breadth _____	3
	{ height _____	2
Side pieces	{ length _____	100
	{ breadth _____	13
	{ height _____	3
The axle-tree passes through the side pieces	{	
from the bottom _____		3
From the shafts to the beginning of the roof		6
Height of the roof	_____	12
Lids	{ length _____	88
	{ breadth _____	10
	{ thickness _____	1

Roof

			Inches.
Roof lids	length	— — — — —	88
	breadth	— — — — —	11
	thickness	— — — — —	1

The roof is covered with oil cloth to prevent dampness from coming to the powder, and each shot locker is divided into four parts by boards of an inch thick, which enter about an inch into the shafts. Each of these carts can stow four barrels of powder only.

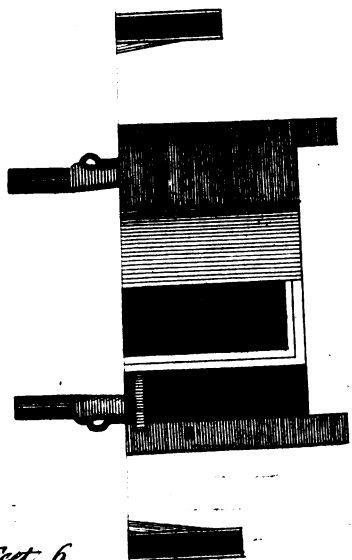
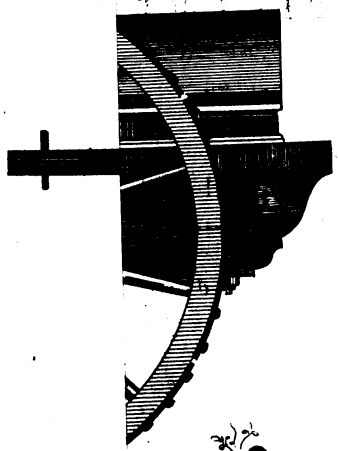
*Iron work of a powder cart.*

a. Side bolts with screws	— — — — —	8
b. Cross bolts with single keys	— — — — —	2
c. Double hinges for the shot lids	— — — — —	6
d. Staples and keys with chains	— — — — —	4
e. Hinges for roof lids	— — — — —	2
f. Hasps, staples, and keys for ditto	— — — — —	3
g. Axle-tree pins with keys	— — — — —	2
Compleat irons for shafts, wheels, and axle-tree.		

*Dimensions of an ammunition waggon. Plate XX.*

			Inches.
Fore wheels, height	— — — — —	— — — — —	48
Nave, length	— — — — —	— — — — —	13
Diameter	body	— — — — —	12
	middle	— — — — —	14
	linch	— — — — —	10
Fellows	breadth	— — — — —	3
	height	— — — — —	4
Spokes	breadth	— — — — —	1. 5
	thickness	— — — — —	3
Hind wheels, height	— — — — —	— — — — —	60
Nave, length	— — — — —	— — — — —	13
Diameters	body	— — — — —	12
	middle	— — — — —	14
	linch	— — — — —	10
			Fellows

XIX























































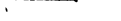
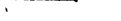













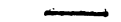
Feet 6



# ARTILLERY.

129

Inches. .

Inches.					
Fellows	{	breadth			3
		height			4
Spokes	{	breadth			1.8
		thickness			3.5
Fore axle-tree, total length					 72
Body	{	length			40
		breadth			5
		height			6
Arms, length					 16
Diameters	{	body			5
		linch			3
Hind axle-tree, total length					 70
Body	{	length			38
		breadth			5
		height			6
Arms, length					 16
Diameters	{	body			5
		linch			3
Fore bolster	{	length			49
		breadth			5
		height			6
Hind bolster	{	length			46
		breadth			5
		height			6
Rider	{	length			49
		breadth			5
		height			4.7
Sommers and sides	{	length			144
		breadth			3
		height			3
Pole	{	length			120
		square before			4
		square behind			3
Middle bar	{	length			40
		breadth			3.5
		height			6.5

K.

Hind



			Inches.
Hind guide	{ length to the axle-tree	_____	28
	{ breadth at the head	_____	5
	{ square at the axle-tree	_____	3
	{ opening at the axle-tree	_____	24
Fore guide	{ length to the axle-tree	_____	32.5
	{ breadth before	_____	5
	{ breadth behind	_____	4
	{ thickness	_____	3
Length of the straight part			20
Length from the axle-tree to the hind end			28
Opening	{ to receive the tong	_____	4
	{ near the axle-tree	_____	19
	{ behind	_____	40
Sweep bar	{ length	_____	50
	{ breadth	_____	3.5
	{ height	_____	2.5
Raves	{ length	_____	144
	{ breadth	_____	2.2
	{ height	_____	2.2
Flate staves	{ length	_____	15.5
	{ breadth	_____	2.5
	{ thickness	_____	1
Shafts length			67
Length of the straight part			10
Breadth	{ behind	_____	3.2
	{ at the fore shaft bar	_____	5
	{ before	_____	3
Thickness before			3
Opening	{ at the shaft bolt	_____	15
	{ at the fore shaft bar	_____	21
	{ in the middle	_____	30.5
	{ before	_____	24
Shaft bars	{ breadth	_____	3
	{ thickness	_____	2
Tong	{ length	_____	17
	{ breadth	_____	3.6
	{ thickness	_____	3
			Length

# ARTILLERY.

131

		Inches.
Length of the guide bar	— — — — —	50
Breadth { in the middle	— — — — —	3
{ at the end	— — — — —	1.5
Thickness	— — — — —	1.5
Distance from the center of one axle-tree to the other	— — — — —	89

The sommers go 10 inches beyond the fore axle-tree, and 38 beyond the hind.

## *Iron work of an ammunition waggon.*

Pintle	— — — — —	1
Pole pin	— — — — —	1
Booster pins with keys	— — — — —	4
Locking plates	— — — — —	2
Bail staples	— — — — —	16
Sweep bar pins	— — — — —	2
Shaft bolt with key	— — — — —	1
Swing tree pins	— — — — —	2
Hooks for ditto	— — — — —	2
Bars to fix the swing-tree to the axle-tree	— — — — —	2
Plate for the cross bar of the fore guide	— — — — —	1
Washing plates for the shafts	— — — — —	2
Booster bands	— — — — —	4
Pole plate	— — — — —	1

Irons complete for shafts, axle-trees, wheels, dowldges excepted.

This waggon serves likewise to carry bread, it being lined round in the inside with basket work.

## *Dimensions of a block carriage. Plate XXI.*

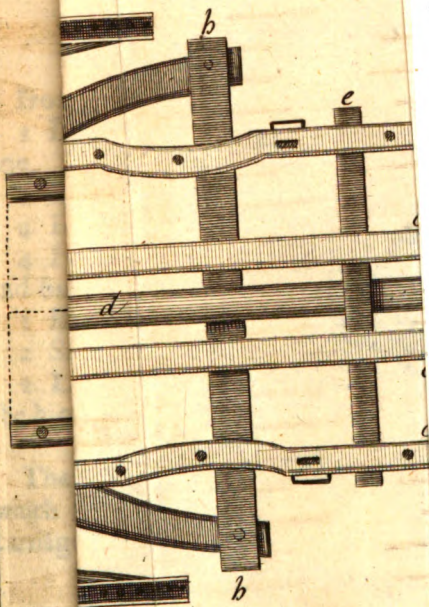
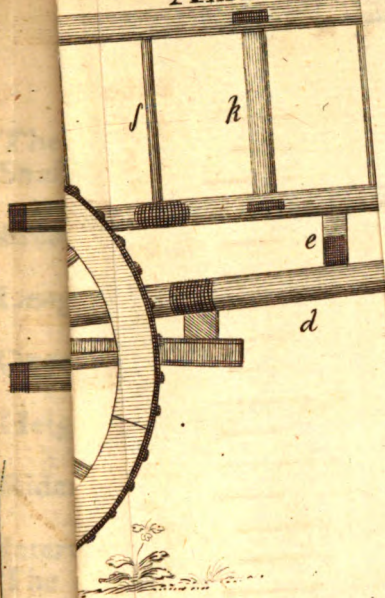
		Inches.
Fore wheels, height	— — — — —	48
Nave, length	— — — — —	15
Diameters { body	— — — — —	14
{ middle	— — — — —	15
{ linc	— — — — —	13

K 2

Fellows

				Inches.
Fellows	{ height	_____	_____	5. 5
	{ breadth	_____	_____	3. 5
Spokes	{ breadth	_____	_____	2
	{ thickness	_____	_____	3
Hind wheels, height		_____	_____	60
Nave, length		_____	_____	17
Diameters	{ body	_____	_____	14
	{ middle	_____	_____	15
	{ lynch	_____	_____	13
Fellows	{ height	_____	_____	6. 5
	{ breadth	_____	_____	4
Spokes	{ breadth	_____	_____	2. 3
	{ thickness	_____	_____	4
Fore axle-tree, total length		_____	_____	77
Poly	{ length	_____	_____	39
	{ breadth	_____	_____	6. 5
	{ height	_____	_____	8
Arms, length		_____	_____	19
Diameters	{ body	_____	_____	6
	{ lynch	_____	_____	4
Bolster	{ length	_____	_____	49
	{ breadth	_____	_____	6. 5
	{ height	_____	_____	7
Hind axle-tree, total length		_____	_____	77
Body	{ length	_____	_____	37
	{ breadth	_____	_____	7
	{ height	_____	_____	8. 7
Arms, length		_____	_____	20
Diameter	{ body	_____	_____	6
	{ lynch	_____	_____	4. 8
Bolster	{ length	_____	_____	47
	{ breadth	_____	_____	7
	{ height	_____	_____	8
Side pieces	{ length	_____	_____	132
	{ breadth	_____	_____	6. 5
	{ height	_____	_____	6. 5
Distance between the axle-trees		_____	_____	72
				The

# Amunition



Feet



			Inches.
The side pieces project equally by	_____	_____	24
Shafts, length	_____	_____	96
Breadth {			
behind	_____	_____	5. 3
in the middle	_____	_____	6
before	_____	_____	3
Length of the straight bar	_____	_____	19
Opening {			
behind	_____	_____	28. 5
middle	_____	_____	32. 5
before	_____	_____	24
Height of the shafts	_____	_____	3
Rider {			
length	_____	_____	46
breadth	_____	_____	6. 5
height	_____	_____	8
Interval between the side pieces	_____	_____	12
The side pieces are let into the rider and hind bolster	_____	_____	} 2

*Iron work of a block carriage.*

Irons compleat for wheels, axle-tree, and shafts.

1 Iron bar to fasten the hind axle-tree to the fore one.

2 Bolts to fix this bar to the axle-trees.

4 Bolster bolts.

4 Hooks fastened to the side pieces with two bolts and burs.

1 Bar to fasten the side pieces in the middle.

2 Staples for shafts, and two iron bands with loops.

2 Loops, one fastened to the rider, and the other to the hind bolster.

The use of this carriage is to carry guns in the field, which are too heavy to be transported upon their own carriages, as likewise mortars and their beds.

*Dimensions of a sling waggon, Plate XXII.*

				Inches.
Side pieces	{	length	_____	152
		breadth	_____	6
		height	_____	7. 8
		opening	_____	32
		exceed, axle-tree	_____	10
Interval between the centers of the axle-trees				123
Fore wheel, height		_____	_____	48
Nave, length		_____	_____	14
Diameters	{	body	_____	13
		middle	_____	14
		linch	_____	11
Fellows	{	breadth	_____	3. 8
		height	_____	55
Spokes	{	breadth	_____	2. 2
		thickness	_____	3. 5
Hind wheel height		_____	_____	68
Nave, length		_____	_____	17
Diameter	{	body	_____	16
		middle	_____	17
		linch	_____	13
Fellows	{	breadth	_____	4. 4
		height	_____	6
Spokes	{	breadth	_____	2. 2
		thickness	_____	4
Fore axle-tree, length		_____	_____	75. 5
Body	{	length	_____	41. 5
		breadth	_____	5
		height	_____	8
Arms, length		_____	_____	17
Diameter	{	body	_____	5
		linch	_____	3
Hind axle-tree, length		_____	_____	81
Body	{	length	_____	41
		breadth	_____	5
		height	_____	7
				Arms.





.....

1

1

1

1

1

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1

B

			Inches.
Arms, length	—	—	20
Diameter	{ body	—	5
	{ linc	—	4
Fore bolster	{ length	—	41. 5
	{ breadth	—	5
	{ height	—	12
Hind bolster	{ length	—	51
	{ breadth	—	5
	{ height	—	11
Rider	{ length	—	54
	{ breadth	—	5
	{ height	—	7. 2
Checks to support the rack work	{ length below	—	60
	{ length above	—	22
	{ height	—	20
	{ breadth	—	6
Shafts, length	—	—	94
Breadth	{ behind	—	5. 5
	{ middle	—	4
	{ before	—	3
Opening	{ behind	—	23
	{ middle	—	34
	{ before	—	25
Thickness of the shafts	—	—	3

## *Iron work of a sling waggon.*

- 2 Cap squares.
- 4 Eye bolts.
- 2 Trunion plates.
- 2 Beam hooks.
- 1 Iron to fasten the tooth wheel.
- Rack work with pland and handle.
- An iron bar to stop the jack.
- 8 Bolts with screws to fasten the checks to the side pieces.
- 2 Hind axle-tree stays with bolts.

K 4

A 4

A cross bar to fasten the side pieces together.

4 Hooks fastened to the side pieces with bolts and burs.

4 Bolster bolts with rings and keys.

Pintle with band and washer.

4 Bolster hoops.

Wheels and shafts compleat.

The use of this carriage is to carry mortars or heavy guns from one part of a place to another at a small distance.

*Dimensions of a sling cart. Plate XXIII.*

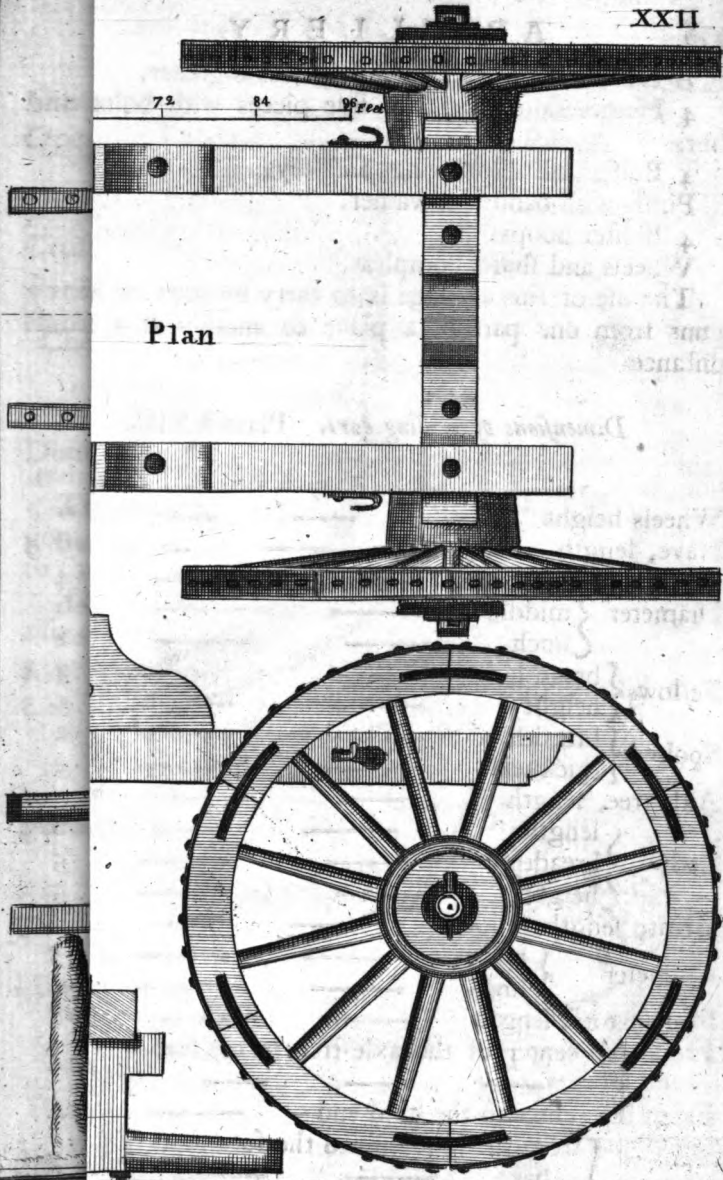
			Inches.
Wheels height	_____	_____	60
Nave, length	_____	_____	15. 5
Diameter	{ body	_____	14
	{ middle	_____	16
	{ linc	_____	12
Fellows	{ breadth	_____	3. 4
	{ height	_____	5. 5
Spokes	{ breadth	_____	2
	{ thickness	_____	3
Axle-tree, length	_____	_____	77. 5
Body	{ length	_____	40. 5
	{ breadth	_____	5
	{ height	_____	5. 5
Arms, length	_____	_____	18. 5
Diameter	{ body	_____	5
	{ linc	_____	4
Shafts, total length	_____	_____	168
From the center of the axle-tree to the fore end	_____	_____	144
From the center to the hind end	_____	_____	
Breadth	{ from the hind end to the fore cross	_____	24
	{ bar	_____	7
	{ middle	_____	5
	{ fore end	_____	3. 4
			Opening

Fig. 22.

XXII

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Plan


























			Inches.
Opening	{ axle-tree and fore cross bar	—	23
	{ middle	— — — —	30
	{ before	— — — —	24
Height of the shafts		— — — —	3.6
Cross bars	{ breadth	— — — —	4
	{ thickness	— — — —	2
Cheeks to support the roller	{ length below	— — — —	28
	{ above	— — — —	7
	{ height	— — — —	9
	{ thickness	— — — —	4
	{ interval	— — — —	32
Diameter of the roller.		— — — —	7

This cart serves for the same uses as the former waggon, but chiefly to carry the guns from the water side to the proof place, and from thence back again.

The iron work of this cart is the same as before, as also of the wheels, axle-tree, and shafts.

*Dimensions of a truck carriage.* Plate XXIV.

			Inches.
Fore axle-tree	{ body length	— — — —	32
	{ breadth	— — — —	5
	{ height	— — — —	11
	{ arms length	— — — —	6.5
	{ diameter	— — — —	3
Hind axle-tree	{ body length	— — — —	32
	{ breadth	— — — —	6
	{ height	— — — —	7.8
	{ arms length	— — — —	6.5
	{ diameter	— — — —	3
Side pieces	{ length	— — — —	100
	{ breadth	— — — —	10
	{ height	— — — —	2.5
	{ interval	— — — —	10
	{ to the fore axle-tree	— — — —	15
	{ to the hind axle-tree	— — — —	15
			Fore





				Inches.
Fore bolster	{	length		32
		breadth		5
		height		6
Hind bolster	{	length		32
		breadth		6
		height		8
Shafts	{	length		96
		height		3. 3
Opening	{	near the bolt		23
		middle		35
		before		24
Breadth	{	before		3
		middle		4
		at the bolt		3. 5
From the end to the straight cross bar				12
Fore guide	{	length		30
		breadth		21
		height		4
		interval		10
Trucks	{	diameter		25
		thickness		4

The cross piece fixed upon the fore ends of the side pieces is 5 inches broad, 3 high before, and 1.5 behind.

The cross piece behind the fore bolster under the side pieces is ten inches broad, and 1.5 thick. The bolsters are let into the side pieces about half an inch. The iron work is so distinctly seen in the plan and elevation of this carriage, that it would be needless to mention it.

The use of this carriage is to carry timber and other burthens from one place to another.

*Dimensions of a travelling forge.* Plate XXV.

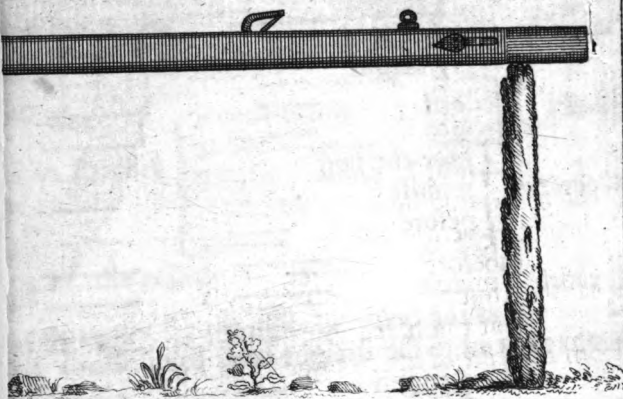
			Inches.
Wheels, diameter			56
Nave, length			14
			Diameter

4-214 1301

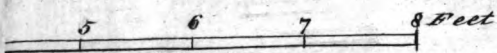
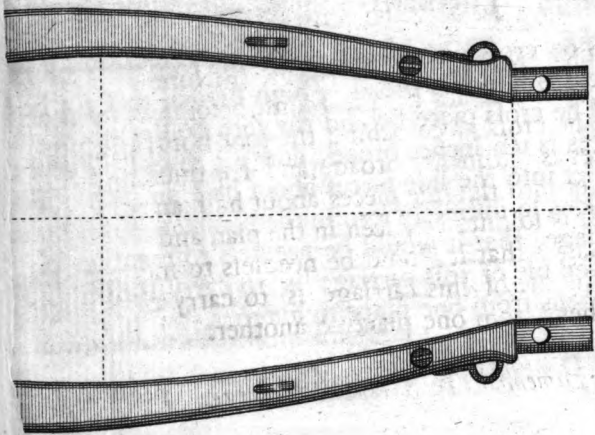
138

Pl. XXIII.

Part



t













































































# ARTILLERY.

139

Inches.

Diameters	{ body			12
	{ middle			13
	{ linch			9
Fellows	{ breadth			3
	{ height			4
Spokes	{ breadth			1.7
	{ thickness			3
Axle-tree, length				76
Body	{ length			42
	{ breadth			5
	{ height			6
Arms, length				17
Diameters	{ body			5
	{ linch			3
Shafts with fides, total length				167
Length of the shafts				72
Breadth	{ behind			4
	{ middle			4.5
	{ before			2.8
Height	{ behind			3
	{ middle			4
	{ before			2.8
Opening	{ before			25
	{ middle			33
	{ axle-tree			30
Raves	{ length			61
	{ breadth			3
	{ height			2.2
Uprights	{ length			27
	{ breadth			3
	{ thickness			2.2
Fore cross bar	{ breadth			3
	{ thickness			2.2
From the hind upright to the end				40
From the hind end to the axle-tree				55

EXPLANATION.

## EXPLANATION.

- a. The bellows.
- b. Place boarded up to put the tools in.
- c. Iron plate for the fire place.
- d. Wooden trough for water.
- f. Iron plate to receive the cinders, and to lay the hammers and tongs upon.
- g. Iron plate to prevent the flame setting fire to the carriage.

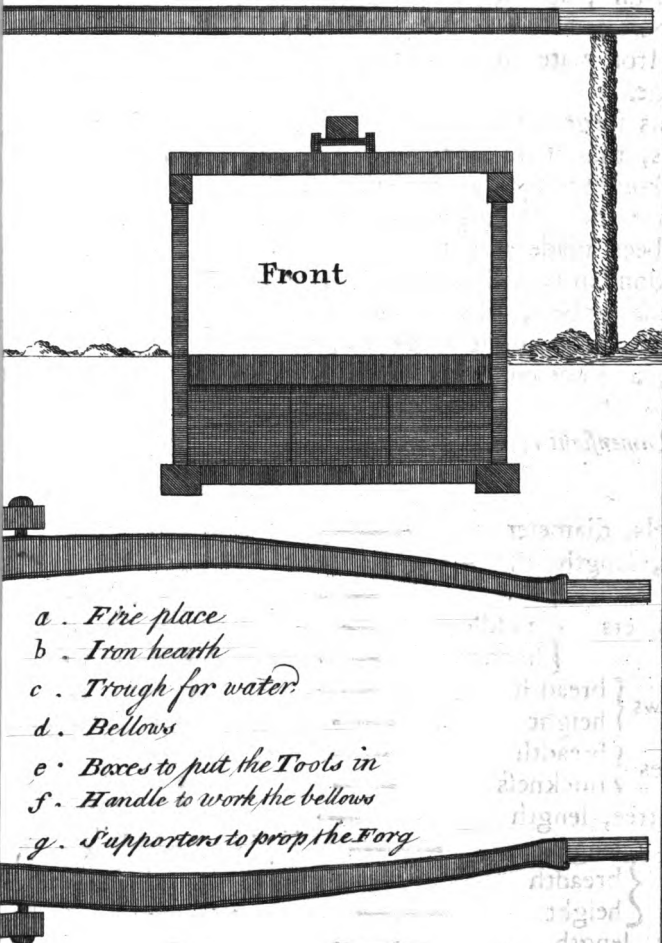
This forge is very ill contrived; it should have four wheels, that it might stand firm, and be easier carried; the *French* use such as this last described.

Since the first impression of this work these forges have been made with four wheels: the same has since been done in regard to the pontoon carriage, where they now use limbers, which mend it in part, but not compleatly; for it ought to be a compleat four-wheel carriage, and not one with limbers.

*Dimensions of a pontoon carriage.* Plate XXVI.

			Inches.
Wheels, diameter	_____	_____	68
Nave, length	_____	_____	15
Diameters	{	body	14
		middle	15
		linch	12
Fellows	{	breadth	4
		height	5.5
Spokes	{	breadth	2
		thickness	3.5
Axle-tree, length	_____	_____	82
Body	{	length	46
		breadth	6
		height	8.5
Arms, length	_____	_____	18
			Diameter

# Travelling Forge





# ARTILLERY.

141

			Inches.
Diameter	{ body	_____	6
	{ lynch	_____	3.5
Bolster	{ length	_____	54
	{ breadth	_____	6
	{ height	_____	18
Side pieces with shafts length		_____	228
Breadth	{ axle-tree	_____	5
	{ middle	_____	4
	{ before	_____	3.2
Height	{ behind the axle-tree	_____	4.8
	{ before the axle-tree	_____	6
	{ at 21.5 from it	_____	5.2
	{ at the end	_____	3.2
Opening	{ near the axle-tree	_____	29
	{ at the fore cross bar	_____	28
	{ before	_____	28
Fore cross bar	{ breadth	_____	4
	{ height	_____	3.5
	{ length	_____	60
Distance from the shafts end		_____	108
Next cross bar	{ breadth	_____	4
	{ height	_____	2.5
Distant from the first		_____	24

The cross bar next to the axle-tree is of the same dimensions as the last, and 24 inches distant from the axle-tree.

The shafts slip through the axle-tree, and are pinned behind, so that they may be taken out when the carriage is to be put into the storehouse; for which reason they are made higher before, so as to afford a shoulder against the axle-tree.

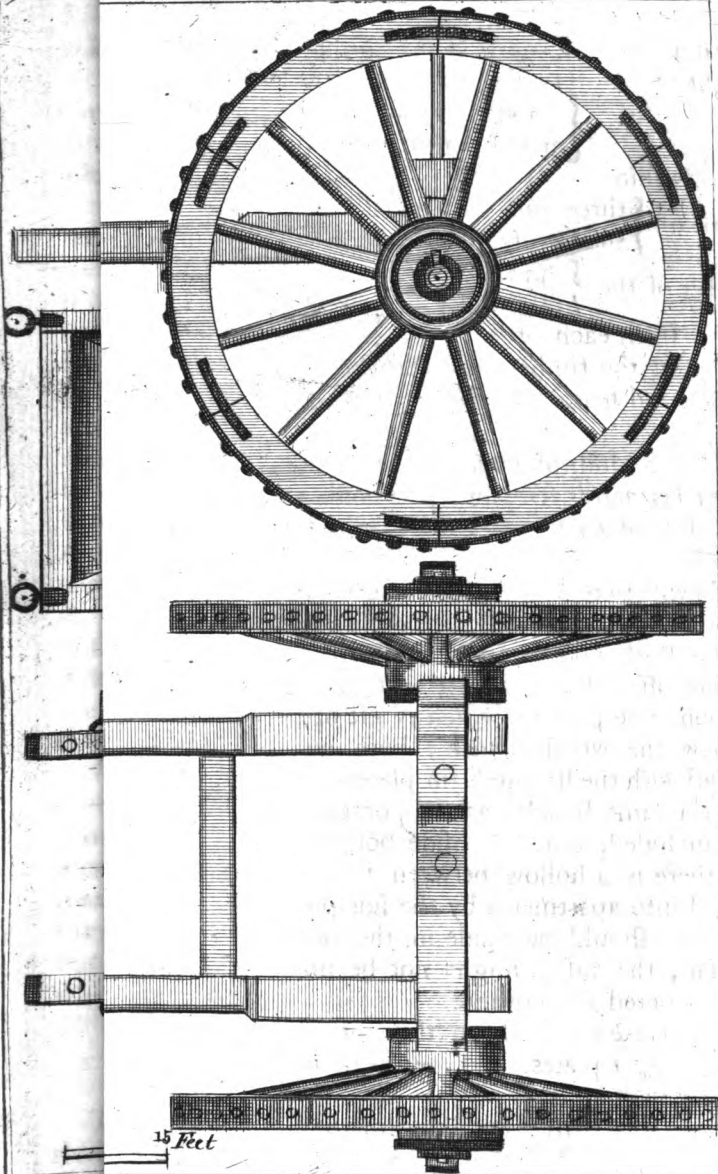
## Dimensions of a pontoon.

		Feet. Inch.
Total length of the pontoon	_____	21 : 0
Length of the bottom	_____	16 : 8
		Width

	Feet.	Inch.
Width above and below at the outside	4	10
Height of the sides	2	5
Width within { above	3	11
{ at the bottom	3	5
Depth within	2	1.5
Width of { three long bars underneath	0	3
{ the two side ones underneath	0	3.8
Breadth of the { upper ones	0	5.5
{ cross bars	0	1.7
Distant from each other	0	9
Length of the timbers laid across	22	8
Breadth and height of ditto	0	4

There are four of these timbers for each pontoon, and as they lay across over two pontoons, there are 5 placed at the side of each other, the planks laid over them are an inch and a quarter thick, and 11.5 feet long. There are likewise two long narrow boards laid on each side of the bridge over the ends of the cross ones, and fastened to them with wooden bolts, to keep the carriages from running off. The XXVIth plate shews the plan of the pontoon, one part of which is left open at the bottom, to shew the wooden work; both out and insides are covered with the strongest tin plates; the outside bottom is of the same breadth as the pontoon is at the top, the sides included, but the inside bottom is less broad, so that there is a hollow between the inside and outside, divided into apartments by the side pieces, in order that if a hole should be made in the outside by a shot or accident, the inside might not be filled, and the pontoon rendered less boyante.

The *French* cover the outside of their pontoons with strong copper plates, and use no lining within, which, in my opinion, is preferable to our method, because copper is much stronger than tin, and is not damaged by rust; and a stump of a tree or any thing that will make a hole in ours will not be able to hurt theirs; and since







since we have copper of our own, I cannot conceive the reason why we do not follow their method.

The pontoon carriage is as ill contrived as possible, for its length is greater than that of any waggon, and yet it is supported by two wheels only; they have since added a limber to it. The great stress that lies on the shaft horse, would, one would think, be more than he can support, especially in going down hill; and I have been informed, that twenty men are scarcely sufficient to assist him; and in going up hill the men are obliged to support the carriage behind, for fear the weight should overbalance that of the horse. This being sufficiently experienced in the last war, it is surprising that no artillery officer or artist have not contrived a more convenient carriage. The most obvious would be to have a limber to it, such as the field carriages have; this the *French* have to theirs, but instead of making it with a high bolster as usual, I would make the wheels higher, and no bolster at all, or only as high as the naves, so that the pontoon might lie as low as possible: by this means the carriage would go with more ease, and the shaft horse draw as free as any of the others. To make use of two wheel carriages in travelling a great way, and through bad roads, is contrary to sense and reason; because the whole weight laying upon two wheels must needs make them sink more in the ground than those of a four wheel carriage, where but half the weight is supported by two: it is true that carts may be useful in a town at home, where they go upon pavement, and they are besides cheaper; but that is no reason they should be used abroad, for which, I dare say, they were not intended.

*Of the gin.* Plate XXVII.

The use of this machine is to mount cannons upon their carriages, or to dismount them; also to heave mortars on or from their beds. It consists of three round

round poles of about 12 or 13 feet long, whose diameters at the lower end are about four inches, five just below the roller, besides the cheeks that are added to them in that place, and about 3 or 3.5 inches above.

The roller is  $7\frac{1}{4}$  inches in diameter, and six feet long; 20 inches are left square at each end for the holes made in them to receive the hand-spikes, by which the roller is turned; the middle part is made round to wind the cable upon; the two poles, which support the roller, are fastened together by two iron bars, the one about 28 inches below the roller, and the other as much above it. These bars are fixed with one end to one of the poles by means of a bolt, and with the other end to the other pole with a bolt and key, so as to be taken out, in order that when the gin is to be carried abroad, the poles may lay close together upon the waggon; sometimes wooden bars are used instead of these iron ones, which cost less, and answer the purpose as well. There are two iron bands and two iron bolts to fasten each cheek to the poles, and likewise iron plates round the poles where the iron or wooden bars are fixed. The poles are hooped at each end, and those above have straps, through which the iron bolt passes. This bolt keeps the upper ends together, as likewise serves to support the iron to which the windless is hooked: this windless contains two brass pullies, about which the cable goes, which is fixed to the dolphins of the gun or mortar with another windless, containing two brass pullies likewise.

The first figure shews the form of the gin, as likewise the dimensions of the different parts, with all the iron work; therefore it would be needless to say any more of its construction. It must be observed, that when it is to be used, it is laid flat on the ground, the lower end of the single pole extends the contrary way, in order to fasten the upper windless after the cable has been turned round them; after this the upper end is raised

raised gradually till the three poles stand nearly at equal distances.

The *French* gins differ from ours; *viz.* the two legs, which support the roller, are fastened together by three wooden bars, nearly at equal distances; the third leg is not fixed to the others, but enters into a notch or mortise above, so as not to slip when it is used; the upper windless is fixed to the two legs by means of an iron bolt, so that when they want to use the gin, a man gets up by means of the bars, and passes the end of the cable round the pullies. This I heard objected against, saying, that if the gun is mounted near an enemy, it would be dangerous; but as that gin is as easily raised as ours, they need not climb up, but when they can do it with safety.

## Of Petards. Plate XXVII.

The *French* petards are made in the form of a frustum of a cone, with the vent in the lesser base; in *England* they are made nearly in the same manner, only some are round towards the smallest base. The second figure shews the section of one as they are made here; it is 8.5 inches within at the bottom; the diameter at the beginning of the round part is 6, and distant from the lower base 9 inches; the circular part is described from the point where the perpendicular to the sides meets the middle line or axis; the thickness of metal is 1.6 inches; there is a brim at the bottom that projects the metal by two inches, and is one thick, in which are six holes of half an inch diameter, which serve for screws to fasten the petard on a board in a firm manner; there is a cavity within at the bottom half an inch deep, and as much in height, to fix a board, to keep the charge in the petard before it is fixed to the board or plank. There are likewise two handles of about three inches from the flat ring, five inches long, seven tenths thick, and 1.8 from the outside to the metal. Lastly, a hole of an inch dia-

L

meter

meter is made either at the top or on the side, to screw in an iron fuse to fire the powder by, which fuse is filled with a slow composition, in order that when it is lighted, the petardier may have time to retire out of danger.

Petards are made of various dimensions, some larger, and others smaller than this; but it may be observed that they should not be too heavy, otherwise it would be troublesome to carry them to the gate or sally port where they are to be fixed; and if they are too little, the effect would not be sufficient, and therefore would be useless. In short, the largest should not weigh above 70 pounds when loaded and fixed to its plank, and the least not less than 45 or 50.

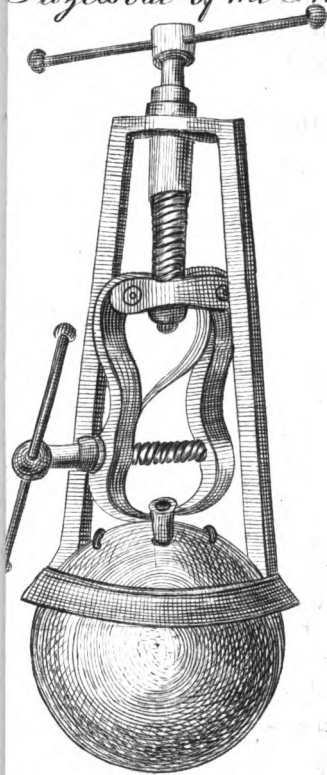
It will be easy to make any other petard larger or less, in proportion to this, whose diameter of the base is given, by making all the other parts in the same proportion; thus, suppose the given diameter is 10 inches; to find the height between the two bases, say, the diameter 8.5 is to the height 9, as the diameter 10 is to the height required, which will be 10.59 inches; and to find the thickness of metal, say, the diameter 8.5 is to the thickness of metal 1.6, as the diameter 10 is to the thickness required, which is 1.9 inches. In the same manner the dimensions of any other part may be found.

The common way of loading the petard, and the best in my opinion, is, to fill it gradually with powder, and every two or three inches thick, to put a wooden mould into the petard, which being beat upon with a mallet, so as to press the powder as close as possible, without bruising the grains, and when it is quite full, the board is put upon the powder, and over this a cloth with rosin, and bound round the brim with packthread to keep the charge and board together, till the petard is screwed on the plank or board; then the part that exceeds the brim is cut off, and the other being pressed by the brim, prevents any air coming to the powder.

The board to which the petard is fixed, is about two feet long, 18 or 20 inches broad, and 2.5 inches thick; it

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Engine for drawing  
Twines out of the Shells



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it has two iron bands on the back, placed cross-ways, and a hook to hang it up against the gate or door, by means of a screw, when it is to be used.

Some moisten the powder with spirits of wine, and dry it in the sun to make it stronger, and then sprinkle every layer of powder of two inches thick with mercury, upon which they lay powder again, and press it down, then sprinkle it again with mercury, and continue so till the petard is filled; but in my opinion good powder alone, well pressed down, is sufficient to produce the desired effect.

Petards have been much out of use since King *William's* wars, when Mr. *Feuquier* forced open many small towns in *Germany* by their means; but the danger that attends it, has deterred officers and partisans from undertaking such enterprizes. Nor do I find any other nation but the *French* have used them, and even they did not use them in the late wars.

## P A R T VII.

*The practice of artillery at home in time of peace, and its service in time of war.*

**H**AVING given in the former part of this work the constructions of the several pieces of artillery now in use, as likewise those of their carriages, in the most concise and easy manner we could, we intend to give here a description of what is practised at home in time of peace, in order to instruct the gentlemen cadets and private men in what they have to do upon the different occasions that may happen in time of war; and then we shall describe the different operations in the field and in a siege, taking the liberty of making observations wherever we think the present practice may be improved;



not with any view of prescribing rules of my own making, but only to set before the judicious reader such things as may possibly be of service to those young gentlemen, who have not had an opportunity of learning them in real service; for we do not presume to offer these sentiments to those experienced officers of artillery, whose conduct and courage in the late war, so well known to every military gentleman, exempts them from all suspicion of being deficient in any part of their duty.

*The practice at home.*

In the spring, so soon as the weather permits, the exercise of the great guns begins, with an intention to shew the gentlemen cadets and private men the manner of laying, loading, and firing the guns, at various distances from the but or mark; and as the line of direction is not marked upon the guns, they have a small instrument called a *perpendicular*, to find the center line or two points, one at the breech, and the other at the muzzle, which are marked with chalk, and whereby the piece is directed to the target; this being done, a quadrant is introduced into the mouth, in order to give it a proper elevation, which at first is guessed at, according to the distance the target is from the piece. When the piece has been fired, it is sponged, to clear it from any dust or sparks of fire that might remain in it, and loaded: then the center line is found, as before; and if the shot went too high or too low, the elevation is altered accordingly. This way of firing continues morning and evening for a month or six weeks, more or less, according as there are a greater or less number of recruits. In the mean time, others are shewn the motion of quick firing with field pieces.

REMARKS.

## REMARKS.

No gun is ever turned so true, that the outside corresponds exactly with the inside; because, if the bluntness of the tools and the heaviness of the work is rightly considered, it will be found morally impossible that it should; and the manner of laying pieces, or finding the line of direction, by an instrument applied on the outside, can be but very dubious and uncertain; it also misguides the gunner; for when the *perpendicular* is not always placed exactly in the same manner, it will give different lines of directions, whereby he is not able to judge when the shot does not hit the mark, whether it is owing to his want of skill, or to the false direction; and consequently is never certain whether he understands his business or not. I should imagine, that if the line of direction was marked, as was formerly the custom, with a slit or cavity at the breech, and a button at the muzzle, it would be much better; for though this line should not exactly answer the direction of the bore, yet when the gunner has once found out its defect, he will easily know how to rectify it: this I have seen in a piece formerly in *France*, which, when directed at the mark, went a great deal to the left; but the gunners, after the first shot, hit the mark with it as well as with any other. It is true, that an objection is made against this fixed line; for it is said that the platforms are never laid so exactly level, but that one wheel will always be higher than the other; and in that case the line of direction must be false. But as I never have seen a platform made without a mason's level, and this is, as far as I know, an universal custom, I cannot see any foundation for this objection; but let us suppose that one wheel was a trifle higher than the other, this would cause very little error in the direction, which however the gunner would rectify the very next shot: but though the platform should be level, it is said the wheels do not always

stand exactly in the same place, whereby the line of direction is changed every time; this the gunners always take care of, by marking the situation of the wheels, and the hind part of the carriage with chalk on the platform. Therefore, since the laying a piece with the line of direction upon it, is more expeditious, and at the same time more certain, it appears to be preferable to the common practice.

As the quadrant is introduced into the mouth of the piece, merely to know its elevation, and when the shot goes either higher or lower than the mark, it is lowered or raised by guess only, without having any rule to go by, the use of that instrument can be of no advantage in practice; on the contrary, it prevents the gunner from learning to judge by the eye, what elevation the piece should have according to its distance from the object, which he should be able to do when he comes to real action; for which reason it ought to be rejected, as well as the *perpendicular*, whether a line of direction is marked on the piece or not.

As the intention of the exercise in time of peace, is to render the young artillerist skilful in all the different branches of his business, I think, that if fascine batteries were frequently raised, and platforms laid, that they may know how to do it in time of war, and at the same time accustom the men to fire through embrasures, it would conduce very much to their perfection: for the manner the exercise is carried on at present upon a stone platform, without any declivity, and without breastwork, can give no true idea of the firing in a siege; the most it can do is to represent a faint notion of firing in a battle, where no battery or platform is made, except in some cases where a post is to be defended. I know an excuse is made, that it is the duty of the engineers and not that of the artillery officers to make the batteries, and they have hitherto made them accordingly, as far as I know: yet as this custom is grounded upon very erroneous principles, as we shall prove, it ought to be abolished.

abolished. For how seldom does it happen that an engineer in this country has an opportunity to make a battery? and when he has, how shall he know whether the embrasures are rightly made, or what declivity the platform should have, except he is well acquainted with the artillery; or is instructed by the officers of artillery? It may be said, he ought to be acquainted with what has been done by former engineers; but as the length and weight of pieces is changed almost every day, and of course the making the embrasures and platforms must change likewise, it is impossible he should know how to make a battery in a proper manner, unless he was ordered to make experiments every time that pieces are changed, which is never done. Whereas, on the contrary, the officers of artillery are on the spot, and, by firing these guns, have all the opportunity they can wish to determine these things; and to shew the necessity of it, we shall give an instance which makes it evident: formerly, when a 24 pounder weighed from 51 to 52 hundreds, and its length was 10 feet, the platforms were then made 18 feet long, and 9 inches higher behind than before; and now we make 24 pounders, that weigh but 17 hundreds, and whose lengths are 5.5 feet; and as it may happen that these pieces are used upon a battery, how should an engineer be able to raise one properly? and if he makes it as customary, the guns will run off their platforms every time, by which the service will be retarded, and who is to be blamed? not the engineer, as I conceive, since he had no opportunity to try these pieces before-hand. Again, the diameter of the wheels for heavy gun carriages is 58 inches, and that of the light pieces 50 only; so that the height of the embrasures must be made less for the latter than for the former. The distance of the battery from the object depends on the range of the pieces; and as the light carry not so far as the heavy, by reason that their charges are less, a battery for the light pieces must be nearer the object, than that for the heavy. And since

no one can be a better judge than the artillery officers, who daily practise them, they are therefore the properest to direct the making of batteries.

As the word *point blank* is often misunderstood, we shall endeavour to define it here according to the general and proper acceptation; which is, suppose a piece stood upon a level plain, and laid level, then the distance between the piece and the point where the shot touches the ground first, is called the *point blank range* of that piece; but as the same piece ranges more or less, according to a greater or less charge, the *point blank range* is to be understood to be that, when the piece is loaded with that charge, which is used commonly in action. It is therefore necessary that the ranges of all pieces should be known, since the gunner judges from thence what elevation he is to give to his pieces, when he is either farther from or nearer to the object to be fired at, and which he can do pretty nearly by sight, especially if he has practised it often.

Ricochet firing is likewise necessary to be practised, that is, the pieces are elevated from three to six degrees, and loaded with a small charge, in order that the ball may be bound and roll along the inside of the parapet; for which reason a front of a polygon should be made, to shew the gunners clearly the object of these batteries, and to try and find the charges for various distances; but as no work of this kind has hitherto been made (though according to the instructions of the academy there should) piquets or stakes might be placed at proper distances, to represent the traverses or the angles of the front of the polygon, which will answer the purpose nearly as well as if there were real works. As this method of firing saves a great deal of powder, and is more dangerous than the usual way, as will be shewn hereafter, it ought by all means to be practised in time of peace.

*Mortar.*

*Mortar practice.*

After the gun exercise is over, that of mortar begins, and sometimes they are carried on both together; the usual manner is thus: a line of 12 or 1500 yards is traced in an open spot of ground, from the place where the mortars stand, and a flag fixed on the end; this being done, the ground where the mortars are to be placed is prepared and levelled with some sand, so as they may stand at an elevation of 45 degrees; then they are loaded with a small quantity of powder at first, but increased afterwards, by an ounce every time, till it is loaded with a full charge: the times of the flights of the shells are observed, to determine the length of the fuses.

The intention of this practice is, when a mortar battery is raised in a siege, to know what quantity of powder is required to throw the shells into the works at a given distance, and to cut the fuses of a just length, that the shell may burst as soon as it touches the ground. This is certainly a very good method, with regard to its intention; but in a siege shells are not or never should be thrown with an angle of 45 degrees, but in one single case only, which scarcely ever happens, that is, when the battery is so far off that they cannot otherwise reach the works. For when shells are thrown from the trenches into the works of a fortification, or from the town into the trenches, they should have as little elevation as possible, in order to roll along, and not bury themselves, whereby the damage they do, and the terror they cause to the troops, is much greater than if they sink into the ground. On the contrary, when shells are thrown upon magazines, or any other buildings, with an intention to destroy them, the mortars should be elevated as high as possible, that the shells may acquire a greater force in their fall.

It is said that howitzes are made to throw shells with a small angle of elevation, and therefore it is not necessary to use mortars for that purpose, and that an angle of 45 degrees is sufficient in a bombardment; which may likewise be done with less powder than at any other elevation.

Granting this, I should be glad to know the use of mortars, at least of the small; since no less than 13 inch are or ought to be used in throwing shells upon magazines, and even those are not always sufficient to break through the arches of powder magazines; therefore it would be needless to carry any smaller to the field. But the true reason is, our mortars are immoveably fixed to their beds, and the custom has prevailed for some years, to lash them strongly with ropes to their beds, which could not be done if they were moveable, and the belief that without this lashing they would kick up before, and fall backwards when fired. But to convince the reader of the insufficiency of this reason, he must know that the *French* never lash their mortars, though they are much shorter and lighter than ours, and often fire them with an angle of 75 degrees, without their ever falling back, as we absurdly imagine. This is demonstrable without having recourse to any experiments; for we have shewn that confined powder acts every where alike when fired, but being resisted in pieces of artillery on the sides by the strength of the metal, the shot is driven forwards, and acts likewise on the opposite part so as to make the piece recoil. Now as action and re-action are always equal and opposite, whilst the action on the upper part of the chamber endeavours to raise the mortar, that on the under side opposite to the other acts with the same force downwards; and therefore these two forces being equal, and in opposite directions, they destroy each other. Hence, there is not the least occasion to lash the mortars to their beds, nor fix them immoveable, as hitherto has been the custom.

*N. B.* What we have said here relates to land mortars only; for those on board bomb-vessels are so heavy, and the motion of the ship so variable, that it would be needless to attempt any other method than what is used.

In firing mortars no wadding is used here upon the powder, in order that the blast of the powder in the chamber may light the fuse of the shell by means of a quick match; on the contrary, the *French* put a wad upon the powder, and fill the rest of the chamber with earth; and when the mortar is fired, one gunner fires the fuse, while another fires the powder in the chamber. But as the fuse might by chance take fire before the powder, the shell might burst in the mortar, spoil it, and endanger the lives of the men, and as the earth can make but very little resistance, the powder acts nearly with the same force as if there was none; therefore this method is very defective, and much inferior to ours.

Instead of loading mortars with loose powder, as is the custom, I would chuse to use cartridges as well as in guns, for the following reasons; because when the powder lies loose, its surface spreads near horizontally, so that the lower part lies nearer the shell than the upper, which makes its effect much less than it would be were it confined; neither can the chamber be filled with as much powder as it can hold, for which reason they are always made larger than they should be, whereby the effect is never so great as it would be otherwise: thus in our thirteen inch mortars the chamber holds nine pounds of powder, whereas it is well known that six pounds is the most that is wanted; and since loose powder never acts with that force it does when confined, it is evident, that the firing mortars with loose powder is not so advantageous as when they are fired with cartridges. Another advantage this manner has over the other is, that when the chamber is not filled, the cartridge may be left close to the shell, and the empty space

at



at the bottom of the chamber, whereby the powder acts with more violence than if the powder was at the bottom of the chamber, and the empty space near the shell; this colonel *Desaguliers* and myself tried many times with half the charge, and the range was always nearly double in the first case than in the second. When the powder is loose in the chamber, if a piece of writing paper be put over it to keep it up, it will make a greater range than otherwise: all this confirms, that with less powder a greater effect may be produced, than with a greater quantity, which ought not to be neglected.

We have shewn the inconveniency of fixing mortars to their beds so as not to be moved, because they never will produce the effect that might be expected; we shall add another reason, which is, that when the charge is the same, and the elevation varies, the rules of projectiles may be used, which, though deduced from the theory of bodies moving in a non-resisting medium, and the resistance of air is considerable in swift motion, yet they will give the ranges very near under 1200 yards; for which reason we shall set them down here, leaving it to practitioners to try them, or let them alone, as they think proper.

*Practical rules for horizontal ranges.*

I. *The range of a body projected with an angle of 15 degrees, is half the range of that body, if projected with the same force with an angle of 45 degrees.*

II. *The range of a body projected with an angle of 45 degrees, is equal to the square of the time of its flight, expressed in seconds multiplied by 16.1 feet,*

III. *If a body be projected with the same force, but with different angles of elevations, the horizontal ranges are as the sines of angles double those of the elevations respectively.*

IV. *The*

IV. *The times of the flights of the same body, projected with the same force, with different degrees of elevations, are to each other as the sines of the angles of elevations.*

*These rules are demonstrated in my Elements of Mathematics, Book the fourth, Section the third.*

## EXAMPLE I.

*Let a body projected with an angle of 45 degrees of elevation be 12 seconds in its flight, what is the horizontal range?*

The square of 12 is 144, which multiplied by 16.1, gives 2318.4 feet, or 772.8 yards, by rule the second, for the range required.

## EXAMPLE II.

*If the range of a body projected with an angle of 25 degrees be 200 yards, what will be the range if the body is projected with the same force under an angle of 30 degrees?*

The sine of 50 degrees, double of 25, is 76604, and the sine of 60, double of 30, is 86602; therefore  $76604 : 86602 :: 200 : 226$ , equal to the range required by the third rule.

## EXAMPLE III.

*If the range of a body projected with an angle of 20 degrees be 200 yards, what must the angle of elevation be to project the body with the same force at a distance of 300 yards?*

The sine of 40 degrees, double of 20, is 64278; whence  $200 : 300 :: 64278 : 96417$ , equal to the sine of the angle double the required one: this sine answers

to

to an angle of 74 degrees 37 minutes, half of which is 37 degrees 18.5 minutes, for the angle sought.

#### EXAMPLE IV.

*The horizontal range of a body projected with an angle of 45 degrees being 1000 yards, to find the time of its flight?*

Then say, as 16.1 feet is to the given distance 3000 in feet, so is unity to the square of the time required, which is 186, whose square root 13.6 seconds will be the time required.

#### EXAMPLE V.

*If the time of flight of a body projected with an angle of 45 degrees is 20 seconds, what will be the time of the same body projected with the same force with an angle of 35 degrees?*

As the sine of 45 degrees is 70710, that of 35 degrees 57357; whence  $70710 : 57357 :: 20 : 16$ , equal to the time required.

This last example shews how to compute the time of the flight of a shell when the range can be measured, and from thence the length of the fuses; as likewise at sea, where the distance is known from the mortar to the object, the time being computed when a shell is thrown, it may be known whether it fell short, or goes beyond the object, according as the time observed of the flight is less or greater than the time computed.

These are nearly all the different exercises of the artillery in time of peace, except that the men are shewn sometimes how to take the guns off their carriages, and to put them on; whence the reader may see, that the artillery art is chiefly reduced to fire guns and mortars; but as these exercises are soon over, and a great deal of time

time is spent in doing very little, which generally makes the private men get idling about, spend their money, and do mischief for want of other employment, I propose the following scheme to employ them for the good of the public, without any hardship to them.

When all the field exercises and that of small arms are over, and nothing to be done, a detachment of private men, commanded by young officers, consisting of about a sixth part of the garrison, should be ordered to attend the laboratory, to make and prepare all kind of military stores that are necessary, during three hours in the morning, and three in the afternoon; at other times they should be employed to make fireworks for the use of artillery, and for rejoicings; this would be no hardship upon the soldiers to be employed once a week for six hours, the officers would have less trouble to keep them clean and sober; they would likewise know how to prepare those stores when they are wanted to be sent abroad, where there is no laboratory, and yet necessary to be had. Lastly, great expences would be saved to the public, without any hardship or detriment to any body.

This would also be a means to instruct the young officers in that branch of their business, of which they should not be ignorant: for how often does it happen, when a detachment is sent to the *East* or *West-Indies*, where having powder, shells, and shot, it is necessary to make grape shot, fill the shells, and drive the fuses; or after having gained a victory, to make fireworks for rejoicing; now if an officer does not know to order how these things are to be done, what a figure must he make before a commander in chief, who requires it of him, and expects he should be able to do it!

I think it also necessary that an artillery officer should know the names of every thing necessary for a field equipage, especially of all the parts of a gun, a mortar, and their carriages; for if any accidents happen in a siege, how can he send word to the workmen, who are generally

generally in or near the park of artillery, of what is wanting? for they, not knowing what is broke, must come perhaps a mile to see it, and go back again to fetch it; in the mean time the piece cannot be fired, whereby the service is retarded.

It appears also to be necessary upon many occasions, that the officers should be acquainted with the principal constructions of gun and mortar carriages; for it may happen, that when they are sent upon an expedition to the *East or West-Indies*, where either new carriages may be wanted, or old repaired, they may always find wood and iron; as likewise smiths and carpenters in the country; but who not being acquainted with this kind of work, if he knows how to direct them, it will be both an advantage to him as well as to the service: it may be said, that there are always workmen sent with those detachments by the board of ordnance, whose duty it is to do those things; but if those artificers should die, which may happen, what must be done then? if the officer does not know how to direct others, the consequence will be, that the service must be retarded, and who will be blamed?

It is likewise very material, that an officer should know the quantities of stores and their kinds that are required upon any expedition. It is true that this detail is commonly made out at the Tower; but if by mistake any material article should be omitted, when he comes to an action and wants it, the commanding officer would blame him, and not those that sent them.

### *The service of ARTILLERY in a land engagement:*

The pieces are generally placed upon some rising ground before, and at the sides of, the first line, where the enemy is supposed to make the greatest effort, or in some village, garden, or near some hollow way through which he can march; and as they are to advance or retreat, according as the army moves and the enemy approaches,

approaches, there is no time for raising batteries, except a spot of ground is taken possession of the night before, which is advantageous for covering either a wing or the center, and necessarily to be kept and defended; the heaviest pieces should be placed there, and the others in the most advantageous manner the ground will admit of: every time they are fired the men advance them to the same place again; so that when the guns are once pointed right, they continue so all the time they remain in the same place. Our present light pieces are wonderfully well adapted for this service, the men being able to move them as they please with very little trouble, and the screws used to keep them at the same elevation are much more convenient than the coins which were used before, because they fly off every time the pieces are fired.

At first the guns are fired with balls, but when the enemy comes near, they are then loaded with grape shot. In this case the charge should not be so much as before, because it has been found by experience, that when the charge is great, the shots spread too much, by striking against each other, whereby many of them do no execution, which should be avoided if possible. In my opinion a sixth part of the weight of the shot will be sufficient upon this occasion. But when pieces are loaded with balls, one fourth, or perhaps one fifth will be the proper charge, since no more was used in our light pieces during the last war.

It has been observed by several artillery officers, that howitzes might be used in an engagement to very great advantage, if they were placed in the flanks, so as to fire obliquely upon the enemy's line, or amongst their horse, when loaded with small charges, that the shells may roll and bound along, whereby a great disorder would ensue among them; which being perceived, if they are briskly charged, might be the means of gaining the day. For it must be observed, that cannon shot pass so swift through the ranks, that men are killed

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without;

without seeing the danger, which the rest look upon as an accident attending their business; but when they perceive the shells rolling along with their fuses burning, and expecting them to burst every moment, the bravest amongst them will hardly have the courage to wait for their coming near him.

When pieces are fired with cartridges, the bottoms will remain in them whatever care can be taken; they must therefore be drawn from time to time, or else they will accumulate so that the tube cannot reach the powder. The shortest way of doing this, is to fix a worm at the head of the sponge with a good spring, so as when it is pressed upon, it may sponge the bottom of the piece, and draw out the remaining bottom at the same time; for all other methods proposed by some artists are insufficient. Another method I think might likewise do, is to pierce the vent from behind the breech, in the manner the *Saxon* guns were, whereby the tube cannot miss to reach the powder, provided it is of a sufficient length: besides, the cartridge being pierced in the bottom, some grains of powder may probably fall between the cartridge and the end of the bore, and so blow out the bottom with the rest.

It is to be observed, that the powder carts should be near the batteries, not only to supply them with powder, but likewise the troops near them, when that which they receive before the engagement is all spent; because batteries are objects or marks of such a nature as to be known at a great distance, whereas, when the powder is placed any where else, the troops do not know where to find it if they are in want. But at present every battalion has two field pieces to attend them, which I suppose have powder carts along with them, that contain a sufficient quantity to supply the battalions.

*The service of ARTILLERY in an attack.*

The first batteries erected in an attack are generally placed about a hundred yards before the first parallel upon a rising ground, if there is any that lies conveniently, and as they commonly are made for ricochet firing, must be at right angles to the faces produced of the works in the front attacked, and there being eight faces in the front, when there are ravelins and a covert-way, so there must be eight batteries, each of four guns at least, besides some mortars placed in the same batteries.

When ricochet firing is used, the pieces are elevated from three to six degrees, and no more; because if the elevation is greater, the shot will only drop into the work, without bounding from one place to another; they are to be loaded with a small charge, and directed in such a manner as just to go over the parapet.

Mr. *Vauban* says, that half a pound of powder is sufficient for a 12 pounder in most cases; which is one twenty-fourth part of the ball's weight: therefore wherever this firing can be practised, it should be done, since it saves much powder, and the pieces will not be heated let them be fired ever so much. The same batteries will likewise serve to dismount the besieged guns placed in the faces opposite to them; but in that case the charge must be one fourth, or one third of the shot's weight. The chief engineer and the commander of artillery consult together how to place these batteries, and when the places are fixed upon, the pioneers are set to work, under the command of an artillery officer in the *French* service, where they have a particular number called commissaries, who are not attached to the regiment of artillery, and when the ground is thrown up, the gunners make the inside facings with fascines themselves, as likewise the embrasures, and lay the platforms; for nobody can be a better judge how to do this work than



they, and therefore they ought to practise it in time of peace, as we have observed before.

The next batteries to be raised are those for making breaches, and to destroy the flanks: the first are placed upon the glacis, within 18 or 20 feet of the covert-way, directly opposite to the faces in which they are to make breaches, and the others also upon the glacis at the same distance from the covert-way, opposite to the flanks. This distance is left for the thickness of the breast-work or parapet.

It has been customary to charge the pieces with half the weight of the shot; but experience has shewn, that one third or less is sufficient; for provided that the shot just enters the wall, the effect will be greater than when it penetrates a great way. The manner of making a breach is to fire at first as low as possible, and to direct the pieces so as to hit in an horizontal line near each other; if they are fired together, and not one after another, the shock will be the greater.

The reason for battering so low is, that if the wall is cut low in an horizontal line, the part above falls down all at once; whereas if the wall above is beat down at first, the rubbish covers the lower part in such a manner, as not to be destroyed afterwards, and without which the breach becomes impracticable. When the wall is once beat down, it will be advantageous to fire shells into the earth, for each shell will produce the same effect as a little mine; whereas the shot will only make a hole of its own bigness, without any great effect. It has been found that the vents of battering pieces have been so much spoiled in a siege, as to render the guns unserviceable: this may be prevented by firing with tubes, as in quick firing it has been found by experience that they preserve the vent, for we fired a six pounder 300 rounds in 3 hours and 27 minutes, without widening the vent in the least; consequently this manner of firing saves great expence, since the same guns may serve in many

many sieges, without having them recast, as was the case heretofore.

The ancients made use of much larger calibers for battering pieces than we do; they knew very well that the breach is sooner made with them; but they imagined that the greater the force was, the quicker the work was done; for which reason they loaded their guns with as much powder as the shot weighed; and as the strength of the guns was made in proportion to the effort they sustained, they became so very heavy, as hardly to be managed; for which reason none but 24 pounders are used at present, whose strength is made so as to bear a charge of two thirds of the shot's weight; and though experience has shewn that one third was sufficient, yet their weight has not been diminished.

This was the reason that induced us to make the battering pieces lighter, for we made the thickness of metal but three quarters of the shot's diameter at the vent, instead of a whole diameter, as in the present. And as the strength of a piece is in proportion to the thickness of metal, that of ours will be to that of the present pieces, as 3 to 4; and the forces being nearly as the quantities of powder, ours will be acted upon but with half the force of the old; and consequently their strength is more than sufficient upon all occasions.

Now as our new 42 pounder weighs 47 : 1 : 0, and is 10 feet long, and the old 24 pounder weighs about 51 : 0 : 0, and is only 9.5 feet long, we conceive that our new piece is much preferable for making a breach to the old 24 pounder. For it enters farther into the embrasures by six inches, and of consequence does not destroy them so soon; it requires no more men to manage it, and no more horses to draw it; and as it will sooner make a breach, there can be no comparison made between their usefulness. As to the charge, I would never use more than ten pounds of powder, for the forces of shots are in proportion to their weight, multiplied by the weight of the powder; whence a 42 pounder

der loaded with ten pounds of powder will produce a force, which is to a 24 pounder loaded with the same charge, as 42 to 24, or as 7 to 4. This is the particular excellency of large calibers, that they produce a greater force with less powder in proportion; and consequently they are much preferable in most cases. And they have another advantage, which is, when you fire at a distance with a proportionable quantity of powder, the resistance of the air is reciprocally proportional to the diameters of the shots nearly; thus the diameter of a nine pound shot is 4 inches, that of a 49 pounder 7 nearly; and therefore the resistance of the 9 pounds is to the resistance of the 49 pounds, as 7 is to 4 nearly. Whence it appears, that the first will meet with a resistance near double that of the second.

### *Construction of batteries.*

To make a battery before the face of a vigilant enemy strong and durable, and to use no more materials and workmen than are necessary, is perhaps the most important work in a siege: though the enemy do not know their situations, yet may guess where they should be, and prepares his fire accordingly; and so soon as he hears the least noise of workmen, will do all he can to annoy them both by his fire and sallies; being sensible that when they are once made they will destroy all his defences, and dismount his guns; and when that is effected, the approaches may be carried on without any other obstacle than the fire of small arms, against which the workmen may easily cover themselves.

To proceed with order, the quality and quantity of the materials, as well as the number of workmen and their tools, must be determined as exactly as the nature of the subject will admit. From the known dimensions of a battery, the quantity of the materials may be determined and their kind from their situation. For the parapet or breast-work is 18 or 20 feet thick, and 7.5  
or

or 8 feet high; each gun takes up 18 feet parapet, and each end about 10: the embrasures are 3 feet from the ground, 2 feet wide within, and 15 or 16 without; so that the merlons or part between the embrasures are 16 feet long on the inside, and 4.5 or 5 feet high.

The dimensions of the fascines are various, but the following are in my opinion the most convenient in many respects; their diameters should be 10 inches or circumference 31.5, and their length 10.8 and 6 feet: because one of 10 feet and one of 8 make the thickness of the parapet; one of 10 and one of 6 the merlons; one of 10 the ends; and one of 10 and 8 the inside of the embrasures: lastly, 9 layers make up the height of the parapet. Another advantage of the above lengths is, that the ends of one layer will not be over those of the next above it, and they are made and carried with more ease than those that are longer, such as the *French* generally use.

Hence a battery of two pieces will be 40 feet long, and requires two fascines of 10 feet, one of 8, and two of 6 for each layer from the ground to the embrasures, and four layers 8 of 10, 4 of 8, and 8 of 6 feet, which are required for that height; because four layers make 40 inches in height, and the under one being sunk about 4 inches into the ground, there remains 3 feet.

The distance between the two embrasures being 16 feet, requires one of 10 feet, and one of 6, and each end one of 10, that is, three of 10, and one of 6 for each layer; and if we take 6 layers, 18 of 10, and 6 of 6, which makes the parapet 8 feet high; though 6 layers will be sufficient on most occasions, yet it is proper to have some spare fascines.

As the embrasures are likewise to be secured with fascines, each layer requires one of 10 feet, and one of 8; so that the six layers require 6 of 10, and 6 of 8 feet; and as two embrasures require four times that number, that is, 24 of 10, and 24 of 8; to which must

be added one to lay over each embrasure of 6 feet long, to cover the gunner against the plunging musket shot; which two added makes 24 of 10, 24 of 8, and 2 of 6, for the number of fascines required for the embrasures. The ends of the parapet are likewise supported with fascines, one of 10 feet, and one of 8: and the ten layers 10 of 10, and 10 of 8; and both ends 20 of 10, and 20 of 8 feet long.

So that a battery of two pieces requires 70 of 10, 48 of 8, and 16 of 6 in all. When a battery is enfiladed by some of the outworks, they must have flanks from 10 to 12 feet thick, and 18 long, which requires 10 fascines of 10 feet, and 10 of 8 each flank; and when the soil is sandy, it is scarcely possible to keep up the earth on the outside without fascines, at least from the berm to the embrasures; for which it requires 8 of 10, 4 of 8, and 8 of 6, in any battery of two pieces.

Besides these battery fascines, others of a smaller size are required, which I shall call *bavins*, to lay along the rope which traces the plan of the battery, and confines the earth till the other fascines are laid and picketed; as likewise to cover the powder magazines: their diameter may be 5 inches only, and length 6 feet. These magazines must hold as much powder as is expended in a day; supposing a 24 pounder to fire 100 rounds in a day, and loaded with 8 pounds each time, requires 800 lb. or 8 barrels; and as a barrel is about 15 inches diameter, and 30 long, 3 bavins will cover one; and as they are placed one over another, 12 bavins will cover the powder of one 24 pounder.

As it is also necessary to support the ends of the fascines in the front, the others being laid upon the bank of earth, and an upright post when the magazine is large: they are sometimes covered with planks when they can be had.

The length of platforms are commonly 18 feet, 8 broad before, 15 or 16 behind; the planks a foot broad, and from 2 to 2½ thick. The hurrier to stop the wheels from

from damaging the fascines 13<sup>5</sup> by 6 inches square, and 8 feet long. There are five sleepers to each platform to lay the planks upon, 3 by 4 inches square, and 18 feet long; each sleeper is fastened by pickets drove fast in the ground, two at each end, and two in the middle; and the last plank by 4 to keep them close together: there requires then 34 pickets for each platform.

The fascines must be well bound, those of 6 feet by 3 bands, of 8 by 4, and of 10 by 5: the length of the pickets to pin down the fascines must be from 3 to 5 feet, the diameters of the heads from 2 to 3 inches, well squared at the heads, and sharp at the points. There are three required for a fascine of 6 feet long, four for one of 8, and five for one of 10; which makes 590 pickets in all for a battery of two pieces.

A soldier may make 12 battery fascines a day with the pickets required, when proper wood is to be had conveniently: a horseman may make 20 bavins a day, bound in two places only, because they require very little care to make them neat; for it is the cavalry that generally make these kind of fascines.

Twelve soldiers will make a sufficient quantity of fascines in a day for a battery of two pieces, and three horsemen a sufficient quantity of bavins at the same time. Each man must be provided with a hand-bill and two hatchets for the whole detachment to cut the branches from off the trees.

In the construction of a battery of two pieces, it requires 10 mallets to drive the pickets, 15 spades, shovels, and pick-axes for digging, according to the nature of the ground. It has been found that 50 men are sufficient to make a battery of two pieces in one night, 70, 90 for one of 4 or 6 pieces.

The following table contains the number of men, their tools and materials, to construct in one night batteries from 2 to 20 pieces of cannon, as nearly as we could compute them; but as it is convenient to have some fascines and pickets to spare, and to repair the battery,

battery, we shall leave it to the engineer to make what allowance he pleases. We have not inserted the number of fascines and pickets required for the flanks; and if there are any, their number determined above must be added. We have neither marked the number of men or materials for batteries of an uneven number of pieces, because they may be easily found, by taking half the sum of the next greater and less, to have the number that is wanted.

### *Ricochet batteries.*

Formerly batteries were made at the opening of the trenches to protect the workmen, but so soon as the first parallel was made they became useless; and as they are expensive to make, and require much time and labour, this method has been rejected; and now none are made before the first parallel is finished. Besides, the approaches are now made the first night as far as the first parallel, and the parallel itself so far as to be finished and perfected the next day; and when that is done, the batteries are erected about 100 yards before them perpendicular to the faces produced, which they are to enfilade: when they are completed, do remain till the siege is finished. These batteries serve likewise to dismount the guns placed on the other faces nearly opposite to them.

As the besieged will spare no pains to fire upon the workmen, and retard their construction as much as they can, I would advise the engineer to continue the trenches of communication from the parallel to the battery by sap quite round it, in taking care to leave a sufficient space for the ditch before the battery to get the earth for making the parapet: then the workmen may go on night and day till the whole is finished with very little danger.

These first batteries must be made as substantial as possible, in order to resist all the fire the besieged can bring

bring upon them : as they are too far from the works of the fortification, they can scarcely be enfiladed, and therefore require no flanks.

*Batteries on the glacis.*

These batteries are made to make a breach in some of the outworks, or in the faces of the bastions, and to destroy the flanks ; and as by this time the besieged cannons have been or should be dismounted, except those placed in the flanks, their parapets need not be above 10 or 12 feet thick ; and as by this time the trenches are advanced upon the glacis within 12 or 15 feet of the covert-way, the batteries are placed in them ; by which less labour, less materials, and less workmen are required : but as they are generally seen in the reverse, they require flanks against the fire of small arms.

Sometimes approaches are made use of to place batteries in them ; in such cases they are widened backwards as far as is required for the recoil ; and if the approaches are too deep, the bottom must be raised to a proper height with fascines and earth to place the platforms upon them ; and the parapet or breast-work must be made of a sufficient thickness, and lined with fascines in the same manner as mentioned before.

*Mortar batteries.*

They differ from the former in having no embrasures, and may be sunk into the ground : so that whilst the workmen without, throw the earth inward to make the parapet, others within, may work to throw the earth forward ; by which the parapet is much sooner completed than those of cannon : the inside slope should be considerable, that the bombardier may place two pickets, one at the top, and the other about the middle, in order to mark the line of direction for each mortar.

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The platforms are about 6 feet square, 8 distant from each other, and as much from the parapet, sloping forwards, and are composed of 6 planks of 6 feet long, one broad, and 2 or 2.5 inches thick, 4 sleepers, and about 28 pickets. As our mortar beds are made of solid timber, they commonly make a bed of gravel and sand instead of a platform; but this method is disapproved by the most experienced officers, especially in sieges.

When mortars are placed in the approaches, it is only widened so much as to have room for the loading and firing the mortar, and the earth dug up serves to heighten and thicken the parapet without any other preparations.

### *Battery in a morass.*

To find a convenient spot of ground in such situations, as likewise to make a road for the cannon and ammunition firm and secure, meets often with great difficulties, and seldom can be done but on or near the causeway that leads to the town; and if the place is properly fortified, it has always a flank that enfilades the causeway from one end to the other: in that case a battery must be raised near enough to dismount the guns of the place, in order to carry on the approaches by zig-zagues on the causeway, till you come within a reasonable distance to make a breach: the situation of the battery being fixed upon, fascines, stone, and earth must be thrown in to make the foundation of the breastwork and platforms; when this is done to a proper height and levelled, the rest of the parapet is finished with gabions, some of 4 feet diameter, and as much in height; and others 3 feet high only for the embrasures.

It requires 10 for the first row, in a battery of two guns, and 5 for the thickness of the parapet, that is, 50 gabions for the under bed. The row towards the town must be placed first, and filled with earth brought in baskets and sand-bags, or else these gabions must be stuffed with wood; then the next row is placed close to

to the first, and filled as quick as possible; and when another row is placed over the middle of the two first and filled, the workmen will be covered against the fire of the small arms. When this is done the embrasures are marked, and gabions placed all round the merlons, beginning always with those towards the place; or else the embrasures may be made with fascines as before: and then the inside or coffers may be filled with gabions, bavins, or fascines, and earth to fill up the intervals, and make the parapet strong and solid. If the height of two gabions is not sufficient, fascines and earth may be used to make up the deficiency.

The beds of the platforms are made with fascines, and earth over them, so as to make it smooth and firm; and if that is not sufficient, hurdles may be laid upon that bed, and more earth, and then the platforms in the manner as described before: when the whole is finished, and the fascine over the embrasures fixed, the gabions that mask the embrasures are taken away, or else pushed with a pole into the ditch before it, or so as not to prevent the seeing the defence of the place.

If there is no situation near the causeway where the battery can be placed to make a breach, or to dismount guns which may see the breach, there is no other remedy than to carry a road made of fascines, hurdles, and earth, either from the causeway, or the nearest firm ground to the place where the battery is to be made.

It happens sometimes that the ground where the battery can be made is seen by a superior battery, that will dismount the guns of yours; in this case a breast-work must be made at 20 or 30 paces before your battery, and embrasures cut in it so as that you may fire through, and prevent the besieged from dismounting your guns: this may always be done if there is ever so little bias, as it happened at *Ostend*, when besieged in the former war by the *French*. There was a spot of ground above the water, which overflowed all the adjacent ground when the tide was in: from this spot the harbour could

be enfiladed. Upon the fall of the adjoining bastion to the harbour were placed fourteen 18 pounders, which bore obliquely upon the *French* battery of six 4 pounders; but by raising another breast-work about twenty paces behind the first, they fired during the whole siege into the harbour, without being seen or disturbed by the superior battery of the besieged.

*Battery upon a rock.*

Such a situation is the most difficult of any, because there is in many cases no earth to be found but at a great distance, so that the parapet must be made with stuffed gabions and blocks of wood; the platforms partly cut out of the rock with pick-axes, and partly filled with earth and fascines: and if the situation is seen by the besieged guns, which can scarcely be avoided, and the battery not finished in a dark night, it must be masked with large trees or pallisades, otherwise the besieged will pour all their fire upon the workmen, to make it in a manner impossible to finish it; since the splinters of the rock are no less dangerous than the shots.

If there is no road to the rock but what passes near the place, the first thing to be done is to convey the cannon and ammunition before the besieged have any notice of your intention, otherwise they will oppose all they can to prevent it; and if they cannot, will render the passage so dangerous, as scarcely to make it practicable.

The situation of batteries is generally determined by the object to be battered, yet the advantage of the ground is often taken, such as a hollow, hedge, bushes, or old building, if the besieged have neglected to clear the ground; but care must be taken that the battery is not too obliquely to make a breach, as it happened at *Carthage* in 1742, where a battery of twenty 24 pounders was made in a copse, and when finished its situation was so bad, that after a week's firing the breach was so little, that a single man could not mount it with-

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*Number of Men, Tools, Fascines, Pickets, and Planks for making BATTERIES, from two to twenty Pieces of CANNON, in one Night.*

# ARTILLERY.

Numb. of Pieces.	Length of the Battery.	Ment to make the		Tools.	Fascines in Feet.			Pickets.	Mallets.	Hand Bills.	Platforms.		Bavins.
		Battery.	Fascin.		10	8	6				Planks.	Sleeper Pickets.	
2	40 Feet	50	15	70	70	48	16	590	10	12	36	10	50
4	58	70	25	100	120	76	32	1000	18	16	72	20	100
6	76	90	35	130	170	104	48	1410	26	20	108	30	150
8	94	110	45	160	220	132	64	1820	34	24	144	40	200
10	112	130	55	190	270	160	80	2230	42	28	180	50	250
12	130	150	65	220	320	188	96	2640	50	32	216	60	300
14	148	170	75	250	370	216	112	3050	58	36	252	70	350
16	165	190	85	280	420	244	128	3460	66	40	288	80	400
18	184	210	95	310	470	272	144	3870	74	44	324	90	450
20	202	230	105	340	520	300	160	4280	82	48	360	100	500



out being supported. At *Minorca* the *French* made a battery under cover of some empty houses; and at the *Havannah* we made batteries against the fort *Moro* under cover of a wood. But when there is no cover, and you are obliged to make a battery near the enemy, the best method is to raise a great heap of earth by way of a cover, and make the battery behind it; and when it is finished, the earth is pushed forward in the ditch, if there is any.

To secure the gunners against the fire of small arms whilst they are loading the guns, shutters are made the width of the embrasures, either sliding in grooves, or fastened with hinges, so as to open or shut as occasion requires. As to the rest we refer the readers to our attack and defence, page 38, where they will find a plan, and a further explanation of every thing necessary not mentioned here.

## P A R T VIII.

*Calculation of the quantity of ARTILLERY and STORES necessary for a field equipage.*

THE estimates of an equipage either for the field or a siege, which have hitherto been made, are intermixed with so many other things, which the duty of an artillery officer has no immediate connection with, that it is scarcely possible to distinguish the one from the other. It is true that these things are necessary in the field, but then I would mention them in separate articles, and let the artificers determine what tools and materials each branch wants. We shall therefore compute here the quantity of artillery, ammunition, and stores; leaving the determination of the rest to those who are employed to do this business.

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The quantity of artillery required upon different occasions depends on so many circumstances, that nothing precisely can be determined; not only the strength of the army is to be considered, but likewise the particular circumstances in regard to the action they are about; the nature and situation of the country; the strength of places, whether sea-port towns or inland, great or small, strong or weakly garrisoned; their quantities of guns and stores; in general, every thing that makes it necessary to have more or less artillery must enter into the determination before a resolution can be taken. It was esteemed formerly, that an army of 50000 men should have 50 pieces of cannon, with all their appurtenances, and so more or less in proportion; but since that time a much greater number has been used, especially now, when two field pieces are allotted to every battalion, besides a separate equipage, to be employed upon particular occasions.

*The manner of computing the quantity of powder and shot for an army.*

It will be necessary that young officers should know the manner and principles upon which the quantity of stores for an army are determined; for which reason we shall begin with the common light field pieces.

The 3, 6, and 12 pounders light, are commonly charged with a quarter of the shot's weight; therefore a 3 pounder requires for 100 rounds 75 pounds of powder, and 300 pounds of shot neat weight.

A 6 pounder for the same number of rounds, 150 pounds of powder, and 600 pounds of shot. The 12 pounder for the same number, 300 pounds of powder, and 1200 pounds of shot. The 24 light pounder is loaded with 5 pounds, therefore requires 500 pounds of powder for 100 rounds, and 2400 pounds of shot. These four pieces, which are the only calibers used at present

present in the field, require therefore 1025 pounds of powder, and 4500 pounds of shot for 100 rounds.

The long heavy pieces require a charge of one third of their shot's weight, and no more even for making a breach, as found by experience. Hence, a 3 pounder heavy requires 100 pounds of powder for 100 rounds; a 6 pounder 200; a 12 pounder 400; and a 24 pounder 800. Total 1500 pounds of powder, and the same number of shot as before.

The quantity of powder required for howitzes and mortars is uncertain; for it depends on the distances the shells are to be thrown.

*Powder and shot for muskets, carbines, and pistols.*

29 musket bullets weigh 2 pounds; and hence 700 men, or a compleat battalion require  $24\frac{4}{29}$  pounds of lead for one round, or 2407 pounds for 100 rounds; muskets, carbines, and pistols require a charge of powder for loading and priming, equal to half the weight of the bullets; therefore a battalion requires 1203 pounds of powder to fire 100 rounds.

20 bullets for carbines weigh a pound, whence 120 men, or a squadron of horse require 600 pounds of shot for 100 rounds, and 300 pounds of powder. 34 bullets for pistols weigh a pound; so that a squadron requires 176 pounds of lead, and 88 pounds of powder for 50 rounds.

Now if the strength of an army is known, as well as the number of rounds allowed them in a campaign, it will be very easy to know the quantity of powder and bullets that is required. There is scarcely more rounds allowed than what we have mentioned here, which seems to be quite sufficient for the foot, especially when it is considered, that perhaps one third of an army does not act in an engagement. As for the horse there is more than what is necessary, since their action consists chiefly with the sword, whilst they are on horseback; but as



the dragoons fight also on foot in a close country full of hedges and ditches, where the horses cannot pass, they may be ranked with the foot.

It has been found by experience, that a man may raise a weight equal to his own, and that he may carry or draw about 50 pounds to a moderate distance; and it has been found, that one horse can draw as much as seven men<sup>3</sup>; therefore a horse will draw or carry 350 pounds, though it is commonly supposed, that a horse can draw but 300 for a length of time; and it is upon this supposition that the number of horses required in the artillery is computed. We have found likewise that six men will draw a light 6 pounder in the field backwards and forwards.

*Number of horses.*

Before we can compute the number of horses, it is necessary to know the weight of each piece; from whence it appears, that a 3 pounder requires but 1 horse, a 6 pounder 2, a 12 pounder 3, and a 24 pounder 6, of the light fort; and the heavy 3 pounder 4 horses, the six 7, the twelve 10, and twenty-four 17 or 18.

Therefore the number of horses for a set of light pieces is 12, and the number for a set of the heavy 38, which is above three times more than the former; and from thence one may imagine how much expence is saved by making use of these light pieces in a campaign in this article alone, besides what is saved in metal, workmanship, and in men to manage them.

Light Pieces.			Heavy.		
Caliber.	Weight.		Caliber.	Weight.	
3	2 : 2	12	3	11 : 0	0
6	4 : 3	10	6	19 : 0	0
12	8 : 3	8	12	29 : 0	0
24	16 : 3	13	24	51 : 1	12

\* *Belid. Hydraul.* vol. i. p. 44. art. 123.

It must be observed, that though horses may draw such a weight upon a common carriage, yet as those of guns are so injudiciously contrived, and the draught so disadvantageous, as we have shown in the construction of limbers, the 12 pounders and upwards require more horses than what we have set down here. But to give some idea of the number of horses required in the artillery, we shall set down here the number employed in the campaign of 1747, given to me by Colonel Miskeloff, where the reader will find many articles that could not be known without experience; and from thence it may be guessed what would be necessary in sieges.

*Number of horses used in the campaign of 1747.*

Number		Each	Total
1	Kettle drum	4	4
2	Tumbrels	2	4
6	Twelve pounders	15	92
6	Nine pounders	11	66
14	Six pounders	7	98
26	Three pounders	4	104
2	Howitzes	5	10
20	Ammunition carts	3	60
2	Forge carts	2	4
30	Pontoons	7	210
3	Spare carriages for guns	7	21

*Spare carriages for guns.*

1	Twelve pounder	7	7
1	Nine pounder	5	5
2	Six pounders	5	10
4	Three pounders	3	12
<i>Spare limbers.</i>			
		8	8
		1	1

3	Twelve pounders	2	6
N 2		3	Nine

3 Nine pounders	2	6
2 Six pounders	1	2
3 Three pounders	1	3
Spare horses		20
Total number of horses		738

*Baggage waggons for the officers.*

	Waggons	Horses
Colonel	3	10
Comptroller	3	11
Major	2	7
4 Captains	4	16
5 Captain Lieutenants	5	15
16 Lieutenants and Col. clerk	6	18
Quartermaster	1	3
Surgeon	1	3
Paymaster	1	3
Paymaster's assistant and surgeon's mate	1	3
Chaplain and Compt. clerk	1	3
Commissary and waggon-master	1	4
2 Assistants to ditto	2	3
2 Commissaries of stores	2	6
2 Clerks of stores	1	3
Conductors of stores	2	6
Bridgemaister	1	3
16 Engineers	12	36
5 Company's baggage	5	15
Contractors, artificers	6	18
Total	59	186

*Waggons for stores.*

Flag-waggon for the army and artillery guard	1	3
		Picket

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	Waggons	Horses
Picket and Provost	1	3
12 Pounders stores	9	27
9 Pounders ditto	7	21
6 Pounders ditto	12	36
3 Pounders ditto	10	30
40 Rounds for Howitzes and Petards	4	12
50 Rounds Royal, &c.	2	6
Ammunition for 35,000 men	122	360
Intrenching tools	24	72
Laboratory stores	2	6
Gin waggon	1	3
Small stores, artificers tools	20	60
Spare waggons	10	30
<b>Total</b>	<b>225</b>	<b>675</b>
From which is to be deducted		
20 Ammunition carriages	10	30
For three pair of boxes	12	36
<b>Total</b>	<b>22</b>	<b>66</b>
<b>Remains</b>	<b>203</b>	<b>609</b>
Add baggage waggons	59	186
Horses for the guns		738
<b>Sum total</b>	<b>262</b>	<b>1533</b>

N. B. Several remarks are to be made on this account, in order to understand it rightly. The flag gun, which is a 12 pounder, had 17 horses to draw it, although the rest had but 15, which makes up the number 92 horses for the six 12 pounders: with regard to the waggons, some were drawn by three horses, and others by four; thus the comptroller had two waggons drawn by four horses, and one by three. As to the ammunition carriages which were deducted, the colonel forgot on what account; all he remembers is, that they were

either detached, or were not brought into the field that campaign; but as to the number of horses employed, the account is right. Hence it appears, that there are many things necessary, which can no otherwise be known than by practice. We shall therefore add an account of the stores carried into the field the same year, where the reader will find how necessary it is to study that branch of business, if he intends to be a compleat artillerist.

*Stores for the army in 1747, alphabetical.*

Aprons of lead	_____	_____	66
		Fore Hind	
	_____	_____	1 : 2
Axle-tree bound, spare	$\left\{ \begin{array}{l} 12 \text{ pounds} \\ 9 \\ 6 \\ 3 \end{array} \right.$	_____	1 : 2
		_____	1 : 3
		_____	2 : 4
For tumbrels, forge, &c.	_____	_____	3
Axes	$\left\{ \begin{array}{l} \text{felling} \\ \text{pick} \end{array} \right.$	_____	150
		_____	1495
Bags for	$\left\{ \begin{array}{l} \text{shot, flints} \\ \text{sponges} \end{array} \right.$	_____	634
		_____	60
Barrels, budge	_____	_____	20
Banners for kettle drum	_____	_____	2
Bayonets	_____	_____	840
Barrows	$\left\{ \begin{array}{l} \text{wheel} \\ \text{hand} \end{array} \right.$	_____	50
		_____	50
Beds for	$\left\{ \begin{array}{l} \text{guns} \\ \text{mortars} \end{array} \right.$	_____	12
		_____	7
Bills, hand	_____	_____	1499
Bridles for kettle drum chariot	_____	_____	4
Brushes for harness to ditto	_____	_____	4
Buckets of leather	_____	_____	36
	_____	_____	7
Carriages, travelling with	$\left\{ \begin{array}{l} 12 \text{ pounds} \\ 9 \\ 6 \\ 3 \end{array} \right.$	_____	7
limbers, compleat		_____	23
		_____	26
For 8 inch howitzes	_____	_____	2

For

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For pontoons			33
Cartridges, flannel, fixed with grape	{	12 pounders	180
		9	192
		6	560
		3	1040
For howitzes			20
Ditto with round shot	{	12 pounders	30
		9	30
		6	70
		3	130
Empty paper cartridges	{	12 pounders	650
		9	650
		6	1550
		3	2220
Cartridges for muskets			76152
Carts	{	ammunition	20
		forge	2
Candles	{	wax lb.	50
		tallow	80
Crows, iron			15
Canteens			230
Caps for mortars			6
Cartouch boxes			1000
Chariot for kettle drum			1
Cloths	{	hair	24
		oil	2
Clouts, spare	{	body	104
		linch	100
Chains, draught	{	12 pounders	7
		9	7
		6	16
Chains for howitzes			2
Coals	{	char. bushels	12
		sea, sacks	22
Colours, quarter, with staves			40
Cord, whip lb.			1

Coins	{	12 pounders	_____	_____	14
		9	_____	_____	14
		6	_____	_____	32
		3	_____	_____	34
		for howitzes	_____	_____	4
Couples for chain traces			_____	_____	500
Deals	{	whole	_____	_____	40
		fit	_____	_____	40
Drums, kettle, pair			_____	_____	1
Esses for draught chains			_____	_____	60
Flags	{	union	_____	_____	2
		red	_____	_____	1
Flambeaux; doz.			_____	_____	5
Flints	{	musket	_____	_____	198510
		carbine	_____	_____	5720
		pistol	_____	_____	10000
Formers for	{	12 pounders	_____	_____	1
		9	_____	_____	1
		6	_____	_____	1
		3	_____	_____	1
		muskets	_____	_____	180
Forelock keys			_____	_____	423
Glue, lb.			_____	_____	6
Grease, firkins			_____	_____	33
Gins compleat			_____	_____	2
Hammers	{	claw	_____	_____	4
		small	_____	_____	4
Hand spikes			_____	_____	148
Hand screws			_____	_____	9
Hand grenades	{	fixed	_____	_____	2000
		empty	_____	_____	4000
Horse harness	{	thill	_____	_____	95
		traces	_____	_____	404
		wanties	_____	_____	95
		bit halter	_____	_____	484
Harness for	{	kettle drum chariot, 4 to a set	_____	_____	1
		men, 12 to a set	_____	_____	40
Hatchets, hand			_____	_____	1030
Haversacks					

Haversacks

# ARTILLERY.

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Maverfacks	—	—	—	216
Helves, spare, for pickaxes	—	—	—	100
Heads, spare, for kettle drums	—	—	—	2
Hemp rubbish, lb.	—	—	—	6
Hides tanned	—	—	—	42
Hooks, pairs	{	car	—	4
		sling	—	4
Hoops, hazle	—	—	—	1000
Horns, powder	—	—	—	39
Howitzes	—	—	—	2
Irons	{	flat	—	5 : 0 : 12
		hoop	—	0
		rod	—	2 : 2 : 6
		square	—	0 : 3 : 30
Iron priming, 4 to a fet	—	—	—	60
Irons for marking horses	—	—	—	3
Kettles, copper, with covers	—	—	—	40
Keys, spring	—	—	—	50
Ladles with staves	{	12 pounds	—	6
		9	—	6
		6	—	20
		3	—	26
Ladles for 8 inch howitz	—	—	—	2
Lanterns	{	dark	—	6
		Muscovy	—	6
		ordinary	—	6
		tin	—	12
Limbers spare	{	12 pounds	—	1
		9	—	1
		6	—	2
		3	—	3
		for howitzes	—	1
Links, dozens	—	—	—	12
Lines, Hamborough, lb.	—	—	—	60
Lint stocks	{	with cocks	—	60
		without	—	50
Locks, splinter, pad	—	—	—	80
Linch pins, pairs	—	—	—	56

Marlin



Marlin	{ tarred, sheets	_____	_____	42
	{ white	_____	_____	20
Mauls, large wooden		_____	_____	4
Match		_____	29 : 0 : 27	
Measures for powder,	{ 12 pounders	_____	_____	1
copper, from 3 lb.	{ 9	_____	_____	1
to $\frac{1}{4}$ oz. from 8 oz.	{ 6	_____	_____	1
to $\frac{1}{4}$ sets	{ 3	_____	_____	1
Measure for coals 1 bushel		_____	_____	1
Medicines, chests		_____	_____	2
Mortars, coehorn		_____	_____	6
Moulds for	{ carbines	_____	_____	2
	{ pistols	_____	_____	2
	{ muskets	_____	_____	4
	{ ditto	_____	_____	6
Muskets		_____	_____	925
	{ 40	_____	_____	20000
	{ 30	_____	_____	2800
	{ 20	_____	_____	6000
	{ 10	_____	_____	5000
Nails	{ 6	_____	_____	4000
	{ 4	_____	_____	4000
	{ clout	_____	_____	3500
	{ copper	_____	_____	300
	{ dog	_____	_____	500
	{ streak	_____	_____	128
	{ 12 pounders	_____	_____	6
Ordnance, brass	{ 9	_____	_____	6
	{ 6	_____	_____	20
	{ 3	_____	_____	26
Pannels for carrying mortars		_____	_____	6
Paper, fine, reams		_____	_____	2
Picket line, rope, 2 $\frac{1}{4}$ inch coils		_____	_____	5
Pickers, park, rhod		_____	_____	60
Petards fixed		_____	_____	12
Pails, wooden		_____	_____	6
Pontoons		_____	_____	30
				Powder,

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Powder, corned, barrels				666
Rods for	{	musket		680
		carbine		100
		pistol		200
Rings for forelocks				100
Ropes, drag	{	12 pounders		7
		9		7
		6		23
		3		30
		for howitzes		2
Rope tarred, 2 1/4 inch feet				30
Ropes, white, coils	{	5 inch		1
		4		1
		3 1/2		1
		2		1
Saws cross cut				6
Scales, brass, pairs				1
Screws for guns	{	12 pounders		6
		9		6
		6		20
		3		26
Shells, empty	{	8 inch		199
		5.5		294
Shells, filled	{	8		20
		5.5		120
Sheep-skins				117
Shovels				1000
Shot, lead	{	musket, tons		58 : 19 : 1
		carbine		0 : 11 : 2
		pistol		0 : 10 : 0
Shot, round	{	12 pounders		593
		9		599
		6		1390
		3		2594
Shot, grape	{	12 pounders		90
		9		90
		6		70
		3		750
				Slings

Slings for guns, pairs	_____	_____	7
Spikes for ditto	_____	_____	300
Spades	_____	_____	1934
Sponges with rammers	{	12 pounds	6
		9	6
		6	20
		3	26
Ditto for	{	howitzes	2
		mortars	6
Staves for	{	flags	3
		ladles	50
Shot iron for grape	_____	_____	8000
Steel	_____	_____	1 : 2 : 16
Sticks for kettle drums, pairs	_____	_____	3
Stilliard with weight to weigh hundreds	_____	_____	1
Swing trees, pairs	{	12 pounds	7
		9	7
		6	14
		howitz	2
Tampeons, with collars	{	12 pounds	6
		9	6
		6	20
		3	26
		howitz	2
Tilts, wadmill	_____	_____	22
Tarpaulins	_____	_____	70
Tents	{	field officers	2
		captains	7
		subaltern	7
		horsemen	28
		French	140
		bell	13
		laboratory	2
Thread	{	fine	1
		pack, lb.	30

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Tools for artificers	{	carpenters chests	_____	3
		wheelers	_____	3
		smiths	_____	3
		tinmens	_____	2
		collar-makers	_____	2
		coopers	_____	2
		miners	_____	2
Tin tubes	{	12 pounders	_____	214
		9	_____	214
		6	_____	500
		3	_____	1300
Tumbrels			_____	3
Twine, lb.			_____	20
Tug-pins, spare, pairs			_____	24
				Fore Hd.
Wheels, spare, pairs	{	12 pounders	_____	1 : 2
		9	_____	1 : 2
		6	_____	1 : 2
		3	_____	2 : 3
Ditto for	{	howitz	_____	1 : 2
		forge or tumbrel	_____	2
		ammunition waggon	_____	2
Wad-hooks	{	12 pounders	_____	6
		9	_____	6
		6	_____	20
		3	_____	26
Washers, pairs			_____	43
Weights, brads			_____	1
Whips for drivers			_____	3

## Laboratory stores.

Fixed fuses	{	7 $\frac{3}{4}$ inches	_____	250
		5 $\frac{1}{2}$	_____	3354
		hand	_____	3000
Iron drills for fuses	{	7 $\frac{3}{4}$	_____	4
		5 $\frac{1}{2}$	_____	6
		hand	_____	6

Hand

Hand mallets of sorts for ditto	_____	16
Small copper ladles	$\left\{ \begin{array}{l} 7 \frac{1}{2} \\ 5 \frac{1}{2} \\ \text{hand} \end{array} \right.$ _____	$\left\{ \begin{array}{l} 4 \\ 6 \\ 6 \end{array} \right.$
Setters of wood for fuses	_____	4
Mealed powder, lb.	_____	210
Sulphur sublimare, lb.	_____	74
Composition for fuses, lb.	_____	25
Quick match, lb.	_____	62
Port fires	_____	116
Rockets of 2 lb. for signals	_____	12
Rods for ditto	_____	12
Canvas, ells	_____	60
Cotton wick, lb.	_____	40
Spirits of wine, gallon	_____	1
Cutting knives	_____	10
Rasps with handles	_____	6
Scissars, pairs	_____	4
Pincers for fuses	_____	6
Small hand saws	_____	6
Copper	$\left\{ \begin{array}{l} \text{salting-boxes} \\ \text{funnels for shells} \end{array} \right.$ _____	$\left\{ \begin{array}{l} 2 \\ 2 \end{array} \right.$
Melting ladles of sorts	_____	4
Mealing table	_____	1
Trusses for ditto	_____	2
Rubbers for ditto	_____	2
Hand-brushes	_____	4
Sieves with tops and bottoms lawn	_____	2
Drawing knives	_____	3
Quadrants	_____	2
Machine to draw fuses	_____	1
Kitt	$\left\{ \begin{array}{l} \text{lb.} \\ \text{kettle} \end{array} \right.$ _____	$\left\{ \begin{array}{l} 45 \\ 1 \end{array} \right.$
Laboratory chest, with padlock and key	_____	1

I had this account from the Tower, but could have wished that the particulars of each sort had been in separate articles, which we might have done, were it not

not that we thought the reader would be pleased to see the order and the particulars as customary.

## *Order of General BELFORD's march of the ARTILLERY.*

1. A guard of the army.
2. The company of miners, with their number of tools, drawn by 2 horses.
3. The regiments of artillery front guard.
4. The kettle drums drawn by 4 horses, and two trumpeters on horseback.
5. The flag gun drawn by 17 horses, and five 12 pounders more, by 15 horses each.
6. Eleven waggons with stores for the said guns, and one spare, by 3 horses each.
7. Six 9 pounders drawn by 11 horses each.
8. Nine waggons with stores for the said guns, and one spare, by 3 horses each.
9. Five long 6 pounders, by 7 horses each.
10. Seven waggons with stores for ditto, and a spare one, drawn by 3 horses each.
11. Five long 6 pounders, drawn by 7 horses each.
12. Six waggons with stores for ditto, and a spare one, by 3 horses each.
13. Four long 6 pounders, by 7 horses each.
14. Five waggons with stores for ditto, and a spare one, by 3 horses each.
15. Two howitzes, by 5 horses each.
16. Four waggons with stores for ditto, by 3 horses.
17. Six short 6 pounders, by 2 horses each.
18. Three waggons with stores for ditto, by 3 horses each.
19. Six Royals with their stores in four waggons, by 3 horses each.
20. One 12 pounder carriage, by 7 horses; one 9 pounder carriage, by 5; one long 6 pounder carriage, by 5; two short, by 2; one short and one long limbers, by 1 horse; and two forges, by 2 each.
21. Twenty

21. Twenty ammunition carts, by 3 horses each.
22. Nineteen waggons with musket cartridges, and one spare, by 3 horses each.
23. Thirty waggons with powder, and one spare, by 3 horses each.
24. Thirty waggons with musket shot, and one spare, by 3 horses each.
25. Twenty-five waggons with intrenching tools, and one spare, by 3 horses each.
26. Twenty-five waggons with small stores, and one spare, by 3 each.
27. Six waggons for artificers, with 4 spare, each by 3.
28. Thirty-two baggage waggons, 9 by 4 horses, and 23 by 3.
29. Thirty pontoons and 3 spare carriages, each by 7.
30. The artillery rear guard.
31. The rear guard from the army.

It must be observed, that there are parties of gunners and matrosses marching with the guns; there are likewise some parties of pioneers interpersed here and there to mend the roads, when they are spoiled by the fore carriages.

There was then 1415 horses employed this campaign, 32 guns, 2 howitzes, 6 small mortars, 244 waggons and carts, and lastly, 30 pontoons, 20 of these last are esteemed sufficient for any part of *Flanders*, because there is no river in this country that requires more to make a bridge over it.

The *French* march their artillery much in the same manner, but divide it into brigades, each of which is commanded by its proper officers, has a detachment of pioneers to assist in bad roads, as likewise a guard of gunners and matrosses: the first brigade consists always of some light pieces, followed by their proper ammunition, and preceded by a waggon loaded with tools, in

in order to make and clear the roads, if there is any occasion; a gin follows each division loaded upon a spare carriage; the next brigade follows in the same order, and preceded with a carriage loaded with tools, with a detachment of pioneers.

The middle brigade consists of the heaviest pieces, and is called the park brigade; and as the others are only followed by so much ammunition as is sufficient upon a sudden occasion, the rest follow the park brigade. After this comes the baggage, and then the pontoons, with this reserve, that if the army is to cross a river, then as many pontoons march at the head as are sufficient to make a bridge.

*N. B.* The front guns should always carry 15 or 20 rounds in their lockers, to be ready to fire upon any sudden occasion, the pieces should be loaded, and the gunners have their matches lighted during the march.

The detachments which march at the heads of the brigades, are to take care that the army baggage does not cross the artillery, and the pioneers, if any carriage is overset or stoppt, to assist it; and in that case, word is given to the brigades before to stop, till all are ready to march, and when there is any stopping behind, those before draw up close at the side of each other, till the rest come up, and then march on a common pace. Regularity and order should be observed by all means to prevent confusion, which is almost impossible where there are so many carriages.

It must be observed, that the heavy 24 pounders, or upwards, and the mortars, must be carried upon block carriages; for they would require too many horses to draw them upon their own. Those who want a farther insight into these affairs, may consult *S. Remy's* Treatise of Artillery, where they will find every thing explained in a very ample manner; and which we could not do in



so small a work as this. We intended to treat of the most essential part only, and such as should be known to most artillery officers, who expect to have a command.

*To form a park of ARTILLERY. Plate XXVIII.*

The artillery is generally placed about 300 paces before the middle of the first line of the army, upon some rising ground, except a more convenient spot of ground happens to be before some wing; but let the situation be where it will, the manner of forming the park is the same, except that some artillery officers differ in the disposition of the carriages. Some place all the cannon and mortars in the front, with their spare carriages; others are for dividing the equipage into brigades, and place the first in the front line, the second into the next; and so on. But the best approved method is to divide the artillery into brigades, and to place the guns of the first to right of the front line, and their ammunition behind them in one or more lines; then those of the second brigade next to the first in the front, leaving five paces between them, and their ammunition behind them, as before; and continue placing all the rest in the same order, the pontoons forming the last line. General Belford's disposition in the last war was:

The first line consisted of 32 guns mounted upon their carriages, seven spare carriages, 20 ammunition carts, and two howitzes; the guns pointing forwards.

The  $\left\{ \begin{array}{l} \text{second line of 50 waggons.} \\ \text{third of 52 waggons.} \\ \text{fourth of 50 waggons.} \\ \text{fifth of 14 waggons, 30 pontoons, and three} \end{array} \right.$  spare carriages. Each carriage takes up two paces or yards, and they are placed at the same distance in the same line; the second line is 30 paces behind the first; the two next 20 from each other; and the last 30 again.

The

The artillery companies and miners are half intamped to the right, and the other half to the left of the park, in the usual manner, with some of the lieutenants in the rear of them.

In the rear of, and 12 paces from, the park are intamped the civil list all in one line; behind these; and at 30 paces distant, is a line of the remaining lieutenants; and behind these the captains and commissaries.

Opposite to the middle, and 30 paces behind the captain's line, is the major's tent; and behind this at 20 paces, the colonel's to the right, and the comptroller's to the left.

Opposite to the middle, and 50 paces before the park, is placed the army guard; and opposite to the right wing, the artillery guard at the same distance.

The *French* method is; the cart loaded with tools, which marches at the head, is placed to the right of the first line; next to that the guns of the first brigade, which commonly consists of 4 or 6 small pieces, with a spare carriage to the left of them; the ammunition carriages of this brigade are placed behind in one or more lines, at 30 paces distant from line to line. After this, the second and succeeding brigades are placed in the same manner, leaving five paces interval between the brigades: they continue thus to place all the guns, with their spare carriages, in the front line; the last line is made by the pontoons and other carriages.

S. Remy says, that seven pontoons will be sufficient to make a bridge over any river in *Flanders*; but I believe he did not mean the *Scheld* or the *Maeſe*, which seem to require more. It is however certain, that they carry no more than 20 pontoons and two spare carriages into the field; which is one third less than we do.

In the middle of the front two light pieces are advanced at a distance of 20 paces, loaded with powder for the alarm guns ready to be fired when required.

To the right of the park are placed the artificers, with their tools, materials, and baggage, in a line from

the front to the rear. To the left of the park, the commissaries and their baggage; to the right of the artificers is incamped the first battalion of artillery, with their baggage and officers behind them in the usual manner; and to the left of the commissaries, the second battalion in the same manner as the first.

The horses of the equipage are placed behind the first battalion, except those of the picket in the rear of the park.

What has been said here is sufficient to give a clear idea of a park for a field equipage to a young officer; but, with regard to one before a town besieged, we shall refer the reader to the works of *French* authors, who have wrote largely upon it.

#### REMARKS.

To determine the quantity of guns, ammunition, stores, and every thing else necessary in the field or a siege, so as to have enough, and no more, requires more knowledge and experience than can be found in one man. The *French* have a set of officers, whose business it is to manage these affairs; and who are gradually initiated into it. It is from their works that most nations of *Europe* copy the quantities of stores wanted upon different occasions. As our commissaries of stores are taken into the service when they are wanted, and discharged again so soon as the war is over, it is impossible we should ever have any one capable of making a proper estimate, unless the artillery officers would undertake that branch of business, which they conceive not to be their duty; but, as they have more opportunities to be informed than any body else, and if any material article should be wanted in an action they may be blamed, I imagine it would conduce much to their honour, and be at the same time for the public advantage, if they did. It was to assist them as much as in my power, that this work was wrote, which, by the help of experience,

rience, will, I hope, be sufficient to make an estimate of the most material articles, leaving the rest to the artificers to determine the quantities of materials and tools they want, or to those who have been employed in that business.

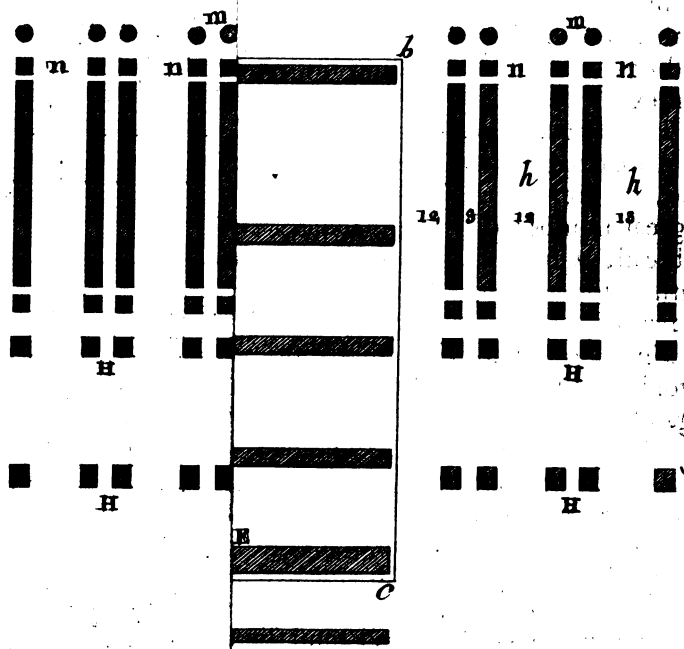
Before we leave this subject, we must take notice of some defects in our store carriages. As there are a great number of them not so well contrived as they should be, it not only increases useless expences, but likewise causes more trouble in the marching, and should be avoided. First, as our powder carts hold no more than four barrels, and a great quantity is required in all expeditions, they are not sufficient; for which reason there should be powder waggons to hold twelve barrels each. It is true, that the powder carts carry leaden bullets and flints at the same time; and are therefore more convenient to follow the battalions; but the rest should be carried in much larger quantities. The same thing may be observed in respect to all other carts; though they may be useful upon some particular occasions, yet they should not be used in carrying great quantities of any kind; for the whole weight lying upon one axle-tree, must require more horses to draw a weight, than when the same weight lies upon two. This every carrier must know; and therefore no more carts should be used than are necessary.

As to the pontoon carriages, we have observed, after their construction, how unskilfully they were made; the pontoons being twenty feet long, which is longer than any waggon, and yet are supported only by one axle-tree; therefore the shaft-horse is hardly able to support the weight laid upon it. As a pontoon cannot weigh above 1200 lb. with all its appurtenances, it appears very extraordinary, that there should be seven horses required to draw each, it can certainly be owing to no other cause than to the ill contrivance of the carriage: I would therefore make them with four wheels, and the fore ones but low, with a high bolster, that it

may turn with more ease in narrow roads ; this being done, I am persuaded, that four horses would be sufficient to draw them. The travelling forge is no better contrived than the pontoon carriages ; for, when it is to be used, it is supported before by two props fixed to the shafts, which, by the least accident, may give way, and down it goes. Nothing but the fondness for carts can excuse such a contrivance. [This has been remedied in some respect, as we have observed before.]

All carriages made use of in the artillery have shafts ; and, to prevent the great length of those that require a great number of horses, the rule is to draw by pairs a-breast, which is an absurdity no where else to be met with ; for when the road is frequented by carriages drawn by two horses a-breast, there is always a ridge in the middle, which the shaft-horse, endeavouring to avoid, treads on one side, whereby the wheels catch against the ruts, and stop the carriage ; and when the fore horses bring them back, he treads on the other side, where the same happens again ; so that the shaft-horse, instead of being useful any otherways than to support the shafts, becomes a hindrance to the rest : on the contrary, if the road is frequented by carriages drawn by horses all in a string, the fore horses must either tread in the ruts, or else the road must be quartered ; and in that case the shaft-horse must walk in the rut ; consequently, in all roads, except they are paved, either the shaft or the fore horses must draw with all the disadvantages possible. This has never been taken notice of by any of those who have the direction of these affairs, though no carriages require more perfection in their construction than these, on account of the great number wanting, and the heavy burthen that most of them are obliged to carry.

This defect may be remedied by making two pair of shafts in all four-wheel carriages, in the same manner as is done in waggon that carry great loads.



a b. c. d The boundary  
of the Park.

f. The Army quar

G. The Artillery g.

### *h. The Companies*

## G. The Civil List

## H The Lieutenants

K Captains & Commis.<sup>rs</sup>

## I The Major's Tent

### M The Comptrollers Tent

## N The Colonels Tent

## A The Line of Guns

**BCDE** *The lines of waggon*

**E** the line of Pontons

[illegible]

## LABORATORY WORKS.

My design is not to give here any more than what is just necessary for the young artillerist to know in the course of his duty, referring that part which regards the fireworks made for rejoicing to the excellent Treatise on Artificial Fireworks, wrote by *Robert Jones*, Lieutenant in the Artillery, who gives all that can be said on that subject, and has himself practised every part of it. Printed for *J. Millan*.

## GRAPESHOT.

The number of shot in a grape varies according to the service or size of the guns; in sea-service 9 is always the number; but by land it is increased to any number or size; from an ounce and a quarter in weight, to 3 or 4 pounds. It has not as yet been determined, that I know of, what number and size answers best in practice; which I think ought to be tried: for it is well known, that they often scatter so much, that only a small number take place. It would not be a useless experiment, to try at what distance they would do most execution, and what is the best charge of powder. In sea-service, the bottoms and pins are made of iron, whereas those used by land are of wood; for what reason this distinction is made, I cannot tell, unless that these iron bottoms are supposed to destroy the riggings of ships more than the wooden would do.

To make grapeshot, a bag of coarse cloth is made just to hold the bottom which is put into it; then as many shot as the grape is to contain; and with a strong packthread they are quilted to keep the shot from moving: and when they are finished are put into boxes for carriage, to be transported where-ever it is necessary. When the shot are very small, they are put into tin boxes that just fit the bore of the gun. Leaden bullets are likewise



used in the same manner. It must be observed, that whatever number or sizes of the shots are used, they must weigh with their bottoms and pins nearly as much as the shot of the piece.

### CARTRIDGES.

The loading and firing guns with cartridges is done much sooner, and less liable to accidents, than with loose powder. They are made of various substances, such as paper, flannel, parchment, and bladders. When they are made of paper, the bottoms remain in the piece, and accumulate so much, that the priming cannot reach the powder; and therefore they must be drawn from time to time, which retards the service. They have another inconveniency, which is, they retain the fire; and, if particular care is not taken in spunging the piece, they will set fire to the next cartridge, and the gunner that puts it into the piece will be in danger of losing a hand or arm, as has sometimes happened. When they are made of parchment or bladders, the fire shrivels them up, whereby they enter into the vent, and become so hard, that the priming iron cannot remove them so as to clear the vent. Nothing has been found hitherto to answer better than flannel, and is the only thing used at present, because it does not keep fire, and therefore not liable to accidents in the loading; but as the dust of powder passes through them, a parchment cap is made to cover them, which is taken off before this is put into the piece.

The best way of making flannel cartridges is, in my opinion, to boil the flannel in size; this will prevent the dust of the powder from passing through them, and renders them stiff, and more manageable; for without this precaution they are so pliable, that when they are large, and contain much powder, they are very inconvenient in putting them into the piece. The *Saxon*, who introduced our present light field pieces, had a particular method

method of preparing cartridges, which was such, that when laid into the fire they would not burn; and yet, by dipping them into water before they were put into the piece, would take fire as quick as powder; but how he did it nobody could tell; for he would not part with his secret.

In quick firing the shot is fixed to the cartridge by means of a wooden bottom, hollowed on one side so as to receive nearly half the shot, which is fastened to it by two small slips of tin crossing over the shot, and nailed to the bottom; and the cartridge is tied to the other end of this bottom. They are fixed likewise in the same manner to the bottoms of the grapeshot, which are used in field pieces.

#### PORTFIRES.

Portfires are used sometimes instead of matches, to set fire to powder or compositions; and are distinguished into wet and dry. The composition of wet portfires is, saltpetre 4, sulphur 1, and mealed powder 4; when the composition is well mixed and sieved, it is to be moistened with a little linseed oil, and well rubbed with the hands till all the oil is well mixed with the composition. The composition of dry portfire is, saltpetre 4, sulphur 1, mealed powder 2, and antimony 1. These compositions are drove into small paper cases, and so kept till they are used.

#### QUICKMATCH.

It is made with three cotton strands drawn into length, and put into a kettle just covered with white wine vinegar, and then a quantity of saltpetre and mealed powder is put in it, and boiled till well mixed. Others put only saltpetre into the water. After that, it is taken out hot, and laid into a trough where some mealed powder, moistened with Spirits of wine, is thoroughly wrought

wrought into the cotton, by rolling it backwards and forwards with the hands: when this is done, they are taken out separately, and drawn through mealed powder, then hung upon a line till dry.

### TUBES *used in quick firing.*

These tubes are here made of tin: their diameter is two tenths of an inch, which is so as just to enter into the vent of the piece; about 5 or 6 inches long, with a cap above, and cut slanting below in the form of a pen; and the point is strengthened with some solder, that it may pierce the cartridge. Through this tube is drawn a quickmatch, and the cap is filled with mealed powder moistened with spirits of wine. To prevent the mealed powder from falling out by carriage, a cap of paper is tied over it, which is taken off when used; but latterly this cap is made of flannel steeped in spirits of wine, and with saltpetre dissolved in it; and there is no occasion to take it off, since it takes fire as quick as loose powder.

An objection is made against these tubes, which is, that the tin is apt to spoil the quickmatch when they are kept for some time; and it is imagined, that salt water would soon corrode them, and therefore not proper to be used on board of ships; this however has not been tried as I know of. The *French* use a small reed, to which is fixed a wooden cap about two inches long; they are filled with mealed powder moistened with spirits of wine, and a small hole is made through them the size of a needle, through which the fire darts with great violence, and gives fire to the cartridge, which must be pierced beforehand with the priming iron. These tubes may be kept a great while without being spoiled; but the piercing the cartridge retards the quickness of firing. The forementioned *Saxon* made his of copper, tapering towards the end, so as to enter the vent about half an inch, which is made so far in the same form; and the rest

rest very narrow : they are filled in the same manner as the *French*, and when fired, the flame darted through the cartridge without being pierced.

### FUZES for shells and hand-grenades.

The composition for fuzes is saltpetre 3, sulphur 1, and mealed powder 3, 4, and sometimes 5, according as it is required to burn quicker. Fuzes are chiefly made of very dry beech-wood, and sometimes of horn-beam taken near the root ; the upper part of that wood splits very easily. They are turned rough, and bored at first, and then kept for several years in a dry place : the diameter of the hole is about a quarter of an inch, a little more or less is of no consequence ; the hole does not go quite through, leaving about a quarter of an inch at the bottom ; and the head is made hollow in the form of a bowl. The composition is drove in with an iron driver, whose ends are capped with copper to prevent the composition from taking fire ; and equally hard as possible ; the last shovel-full being all mealed powder, and two strands of quickmatch laid across each other being drove in with it, the ends of which are folded up into the bowl, and a cap of parchment tied over it till used. It will not be improper to observe, that, when shells are to be thrown at a small distance, the composition should be made quicker than when they are to be thrown at a greater ; for, by cutting them so as to burn but a short time, they might not be long enough to be well fixed into the shell, by which the blast of the powder in the chamber would blow them out, without the shell being able to burst. It must likewise be observed, that the custom of fixing the shells at home is very bad ; since it is not known how long they should burn ; and, if they do not burst as soon as they fall, the execution is but trifling. Another disadvantage attends this practice ; when they are carried into a hot climate the wood shrinks, though ever so dry before ; and the fuzes loosen  
so

so much, that they fall out in the flight of the shell before it falls to the ground.

When the fuzes are to be drove, the lower end is cut off in a slope, so as the composition may give fire to the powder; and they must have such a length as to burst nearly as soon as the shell touches the ground. When the distance of the battery from the object is known, the time of the shell's flight may be computed nearly; which being known, the fuze may be cut accordingly, by burning two or three, and making use of a watch or a string by way of a pendulum.

Before shells are loaded, they must be well searched within and without by means of a copper grater, to see whether there are no holes or cavities in them; after that they are put into a tub of water, so as to cover them, with an empty fuze drove into them; and the mouth of a bellows, being introduced into the fuze, and worked, will cause bubbles in the water, if there are any holes in the shell; but if no bubbles appear, it is a sign the shell is sound and fit for service.

When they are loaded, care must be taken that they are very dry within; and if the spike which supports the corp when they are cast, and which remains in them, is not beat down, it must be done then, otherwise it would split the fuze. Then the powder is put into it with a funnel, and not quite filled, that the fuze may have room to enter, which fuze is pressed in at first by the hand as far as it will go, and then drove with a mallet as hard as possible, taking care however not to split it; for if the least crack was in it, the composition would give fire to the powder, and the shell would burst either in the mortar or in the air, and so do no execution.

It is a query how much powder is to be put into a shell, so as to make it burst in most pieces? It is agreed by most officers that they should not be quite filled; one that has taken most pains to find it out is of opinion that they

they should be filled within one third part of what they can hold.

Lieutenant *Pirle*, a very ingenious mechanic, lost in the *Dodington* some years ago going to the *East-Indies*, had found out a method, so that as soon as the shell touched the ground it bursted; but being too modest a man, had not the assurance to propose it to the master general of the ordnance, whereby the world was deprived of so useful an invention.

If the fuses are to be kept for some time after they are drove, the top must be covered with a mixture of pitch 2, rosin 1, and bees wax 3, whereby no air can come to the composition; and it will keep as long as you please.

## CARCASSES.

None but round carcasses are used at present, the flight of the oblong are so uncertain, that they have been quite laid aside. The composition is pitch 2, saltpetre 4, sulphur 1, and corned powder 3. When the pitch is melted, the pot is taken off, and the ingredients well mixed put in; then the carcass is filled with as much as can be pressed in.

### *Light BALLS to discover the enemy's works.*

There are various sorts described by different authors. Some are made of tow dipped into a composition of sulphur, pitch, rosin, and turpentine; and worked up all together into a ball. Others take a ball of stone or iron, which is covered with several coats of composition much like that before-mentioned, till of a proper size; and the last coat is to be of grained powder. But the best sort, in my opinion, is to make a shell of paper the size of the mortar, and to fill it with a composition of an equal quantity of sulphur, pitch, rosin, and mealed powder; which being well mixed, and put in warm, will give a clear fire, and burn a considerable time.

There

There are many more things used in the defence of a breach; such as sacks filled with powder, bottles, barrels, &c. but as the chief intent of all these is to set fire, and blow up the assailants, and which every military gentleman may easily execute, we shall say no more here about them; our design being only to instruct the young artilleryist in the most essential parts of his business; and to make him master of these matters, he must work in the laboratory; for practice is the best master.

#### *FIRESHIP, how to prepare it.*

From the bulkhead at the fore-castle to a bulkhead to be raised behind the main chains, on each side and across the ship at the bulkheads, is fixed close to the ship sides, a double row of troughs, two feet distance from each other, with cross troughs quite round, at about two feet and a half distance; which are mortised into the others. The cross troughs lead to the sides of the ship, to the barrels, and to the port-holes, to give fire both to the barrels and to the chambers, to blow open the ports; and the side-troughs serve to communicate the fire all along the ship and the cross troughs.

The timbers of which the troughs are made are about five inches square; the depths of the troughs half their thickness, and they are supported by cross pieces at every two or three yards, nailed to the timbers of the ship, and to the wood-work which incloses the fore and main masts, and takes in an oblong in the middle of the deck, extending to the outside of both the masts, and in breadth is near one half of the deck; and is what makes the carpenter's room for his stores. The decks and troughs are all well paved with melted rosin.

On each side of the ship are cut out six small port-holes, in size about 15 by 18 inches, the ports opening downwards, and are close caulked up: against each port is fixed an iron chamber, which, at the time of firing the ship, blows open the ports, and lets out the fire.

At

At the main and fore chains on each side is a wooden funnel fixed over a fire barrel, and comes through a scuttle in the deck up to the shrouds to give fire to them; and between them are cut two scuttles on each side the ship, which also serve to let out the fire. Both funnels and scuttles must be stoppt with plugs, and have sail-cloth or canvas nailed close over them, to prevent any accident happening that way by fire to the combustibles below.

The port-hole, funnels, and scuttles, not only serve to give the fire a free passage to the outside and upper parts of the ship, and its rigging, but also for the inward air, otherwise confined, to expand itself, and push through those holes at the time of the combustibles being on fire, and prevent the blowing up the decks, which otherwise must of course happen from such a sudden and violent rarefaction of the air as will then be produced.

In the bulkhead behind on each side is cut a small hole, large enough to receive a trough of the same size as the others; from which, to each side of the ship, lies a leading trough, one end coming through a sally port cut through the ship's side; and the other, fixing into a communicating trough that lies along the bulkhead, from one side of the ship to the other, and being laid with quickmatch only, at the time of firing either of the leading troughs, communicates the fire in an instant to the contrary side of the ship, and both sides burn together. The communicating trough, which is fixed to the bulkhead, and the leading troughs, are the same size as the others.

### *Manner of preparing STORES.*

#### **FIRE-BARRELS.**

The form of the barrels should be cylindric, both upon the account of that make answering better for filling



filling them with reeds, and for stowing them on board between the troughs; their inside diameters are sufficient, if about 21 inches, and their lengths 33. The bottom parts are first filled with short double dipt reeds set on end, and the remainder with fire-barrel composition well mixed and melted, and then poured over them.

There are 5 holes of  $\frac{3}{4}$  inches diameter, and 3 inches deep, made with a drift of that size in the top of the composition while it is warm; one in the center, and the other four at equal distances round the sides of the barrel. When the composition is cold and hard, the barrel is primed by well driving those holes full of fuze composition to within an inch of the top; then fixing in each hole a strand of quickmatch twice doubled, and in the center hole two strands the whole length; all which must be well set or drove in with mealed powder; then lay the quickmatch all within the barrel, and cover the top of it with a dipt curtain, fastened on with a hoop to slip over the head, and nailed on.

The barrels should be made very strong, not only to support the weight of the composition before firing, in removing and carrying them about, but to keep them together at the time they are burning; for if the staves are too slight and thin, and should burn too soon, so as to give way, the remaining composition would be apt to separate, and tumble upon the deck, which would destroy the designed effect of the barrel, which is to carry the fire aloft.

#### IRON CHAMBERS.

They are 10 inches long, and 3.5 in diameter; and breeched against a piece of wood fixed across the port-holes, and let into another lying a little higher; when loaded they are filled almost full of corned powder, and have a wooden tompon well drove into their muzzles; are primed with a small piece of quickmatch thrust through

through their vents into the powder, with a part of it hanging out; and when the ship is fired, they blow open the ports; which either fall downwards, or are carried away, and so give vent for the fire out of the sides of the ship.

## CURTAINS

Are made of barras about  $\frac{3}{4}$  of a yard wide, and one yard in length; when they are dipped, two men with each a fork (on a shaft of the same size, with one prong in each if made on purpose) must run each of their prongs through a corner of the curtain at the same end; then dip them into a large kettle of composition well melted; and when well dipped, and the curtain extended to its full breadth, whip it between two sticks of about 5.5 feet long, and 1.5 inches square, held close by two other men to take off the superfluous composition hanging to it; then immediately sprinkle saw-dust on both sides to prevent its sticking, and the curtain is finished.

*N. B.* A copper fixed with a furnace is much better than a kettle that is not fixed, because it must be taken off from the fire for every dipping, to prevent the stripped off composition from falling into it, which would unavoidably give fire to the whole; and renders the use of a kettle tedious that way.

## REEDS

Are made up in small bundles of about 12 inches in circumference, cut even at both ends, and tied with two bands each; the longest sort is 4 feet, and the shortest 2.5; which are all the lengths that are used. One part of them are single dipped, only at one end; the rest are double dipped, that is, at both ends. In dipping, they must be put about 7 or 8 inches deep into a copper or kettle of melted composition; and when drained a

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little

little over it, to carry off the superfluous composition, sprinkle them over a tanned hide with pulverised sulphur, at some distance from the copper.

### BAVINS

Are made of birch, heath, or other sort of brush-wood, that is both quickly fired and tough; in length 2.5 or 3 feet, the bush-ends all laid one way; and the other ends tied with two bands each. They are dipped and sprinkled with sulphur the same as reeds, only that the bush-ends alone are dipped; and should be a little closed together by hand as soon as done, before they are sprinkled, to keep them more close, in order to give a stronger fire, and to keep the branches from breaking off in shifting and handling them.

### DISPOSITION of the STORES on board, when laid for firing.

The fire-barrels are placed under the funnels and scuttles, one to each; and are fixed between the cross troughs leading to the sides of the ship, and lashed to them, and well cleeted to the deck. Those at the funnels give fire to the main and fore shrouds; the rest rises over the deck through the scuttles. The plugs must be taken out of the funnels and scuttles before the ship is fired, and the curtains covering the fire-barrels cut open and rolled back, the quickmatch spread, and the top of the barrels well salted with priming composition. The curtains are nailed to the beams of the upper deck, hanging down over the troughs, bavins, and reeds.

The priming composition; a part of it is laid along the troughs, and the rest, after laying of the reeds and bavins, is regularly strewed over all. The short reeds double dipped, with some of the single dipped, are laid along both the sides and cross troughs, and communicate the

the fire both to the barrels and chambers. The rest of the single dipped reeds and bavins are set about the fire-barrels, and to the sides of the ship; and some flung upon the deck.

The quickmatch is laid two or three strands thick upon the reeds in the troughs, and about the fire-barrels and chambers, to communicate a general fire at once. The reeds in the troughs with the quickmatch are lashed on, to prevent their falling out by the rolling of the ship.

The leading troughs are both laid with 4 or 5 strands of quickmatch; as is likewise the communicating trough, that, by firing either of the leading troughs, the communicating trough may carry the fire to the other side of the ship; which then runs along the troughs by the quickmatch on both sides, and give fire to the whole in an instant.

*The COMPOSITION made use of for CURTAINS, REEDS, and BAVINS, are all the same, viz.*

Pitch	14	} N. B. For want of tar, take 3 lb; of tallow.
Sulphur	7	
Rosin	7	
Tallow	2	
Tar	1	

## *Fire-Barrel COMPOSITION for one BARREL.*

Corned powder lb.	_____	_____	120
Pitch	_____	_____	60
Tallow	_____	_____	19

Divide the composition into five pots; the pitch and tallow must be first thoroughly melted. Tallow well the outside of the pot to take off the heat; and then put in the powder by small quantities, stirring it well about.

## ARTILLERY.

*Priming COMPOSITION for one BARREL.*

Corn powder lb.	_____	_____	100
Petre	_____	_____	50
Sulphur	_____	_____	40
Rosin	_____	_____	6
Oil, pints	_____	_____	3

Take 20 lb. of powder, which mix well with the petre, sulphur, and rosin, work them well together, breaking it well in working; then put the rest of the powder in by degrees, and work it altogether: spread it in a trough, and through a hair sieve run 3 pints of oil all over it; then work it well together, and run it through a cane sieve.

*N. B.* In the following estimate for the quantity of stores requisite, the reeds for the barrels are not included; it will take 100 short double dipped more than these specified; but their value is included in the article of barrels.

*STORES for a FIRESHIP of 150 tons.*

	Numb.	Value.
		<i>l. s. d.</i>
Fire barrels	8	80 : 0 : 0
Iron chambers	12	12 : 0 : 0
Priming composition barrels	34	21 : 0 : 0
Quickmatch barrels	1	3 : 0 : 0
Curtains dipped	30	3 : 0 : 0
Long reeds single dipped	150	10 : 15 : 0
Short reeds { double dipped	75	2 : 18 : 9
{ single dipped	75	1 : 17 : 6
Bavins single dipped	209	10 : 0 : 0
		<hr/>
		144 : 11 : 3

*Quantity*

*Quantity of COMPOSITION for preparing the STORES  
of a FIRESHIP.*

	pe- tre.	fulp pow.	corn pow.	pit ch	ro- fin	tal- low	tar	oil pts.
For 8 barrels — —	0	0	960	480	0	80	0	0
For 3.5 barrels of priming composition — —	175	140	350	0	21	0	0	11
For the curtains, bavins, and reeds for the ship, and fulphur for salting them — —	0	200	0	350	175	50	25	0
Total —	175	340	1310	830	196	130	25	11

Total weight of the composition 3017 equal to  
C. 26 : 3 : 2.

Composition allowed for the reeds for the barrels one  
fifth of the whole of the last article, which is equal  
to 160 lb. and makes the whole 3177 pounds, or  
C. 28 : 1 : 13.

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of war, in eight volumes in *ottavo*, as promised. We  
have done all that lies in our power to treat them with  
perspicuity and clearness, in order to reduce the whole  
to as small a compass as possible, for the sake of those  
military gentlemen who have an inclination to be masters  
of their business in a short time. We could not en-  
large upon every particular so much as might be ne-  
cessary, yet whoever renders himself master of what  
we have said, will find that nothing very material has  
been neglected.

F I N I S.

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