IDEAS

AS TO THE EFFECT OF

HEAVY ORDNANCE

DIRECTED AGAINST

AND APPLIED BY SHIPS OF WAR,

PARTICULARLY

WITH REFERENCE TO

THE USE OF HOLLOW SHOT

AND LOADED SHELLS.

BY

CAPTAIN T. F. SIMMONS, R. A.

LONDON:

PUBLISHED BY F. PINKNEY, AT EGERTON'S MILITARY LIBRARY,
WHITEHALL.

1837.

PREFACE.

THE following ideas were thrown together with a view to their insertion in a widely circulating and deservedly popular periodical; but, having been undesignedly extended, are published in a distinct form. They were suggested by conversing with naval and other officers on the probable effects of hollow shot projected from the guns of high calibre, which have recently been introduced into the service.

Some apology will no doubt be demanded from a soldier who presumes to offer remarks on matters affecting the practice of the naval service. The hacknied proverb of Pliny—"Ne sutor ultra crepidam"—will again and again be objected, but can an artilleryman keep more religiously to his craft than in applying himself to the effects of great guns?

The author might perhaps have grounded an excuse and a satisfactory one,—satisfactory at all events to his own feelings,—in the encouragement he has received from officers of rank and experience in the navy. He might too observe, with Colonel Paixhans: "Étant artilleur n'ais-je-pas le droit de parler d'artillerie?" He would, however, rather rest his defence on the importance of the subject respecting which he is induced to put forth some ideas, and on the innate right which every Englishman possesses of interesting himself in the concerns of the navy.

The glory of the navy has long been the pride of England, and is legitimately the boast of every Englishman; he may then well be excused who adverts to a subject, which he believes to be connected with results the most important to the honour and reputation of the British navy; consequently, to the glory and safety of Great Britain; and, therefore, to the welfare and happiness of each individual Briton.

For the matter offered and the manner in which it is presented, the author might perhaps seek in vain for an excuse. He will only say, that having been compelled by the necessity of educating nine sons to withdraw, he would that it were for a time only, from the active avocations of his profession, he has been solicitous to devote a portion of his leisure to that which he would fain hope may not be without its use to His Majesty's service.

He trusts that the opinions he has hazarded in this essay, particularly as to the use of heavy guns and hollow shot, will be found neither inconsistent with the theory or practice of artillery.

It certainly is of vast and paramount importance, that British ships of war should be armed on a equality with those of other nations, especially as to the range of their guns and the penetration and effect of their projectiles: the author is confident that a consideration of the subjects referred to by him will force this conviction upon any competent and unprejudiced mind, though the truths he has contended for may have been feebly advocated.

CONTENTS.

ERRATA.

Page 59, *line* 14, *for* impractible *read* impracticable.
— 108, *last line*, *for* wikrung *read* Wirkung.
— 132, *line* 22, *in some copies*, for $c\ d$ read $c'\ b'$.

IDEAS

AS TO THE

EFFECT OF HEAVY ORDNANCE.

---

ever, adverted to the [illegible]
shot from the ordnance at present in use, nor from the guns which have been introduced, with this particular view, into our own and other navies; neither has he enforced the truth which, notwithstanding some remarks which have fallen from him as to the value of 18-pounders, he would readily admit, that the greater the calibre with guns alike charged, (that is, each charge having the same ratio to its shot,) and of equal length and windage, the greater the range. A few remarks upon these important subjects may not be uncalled for, since it is of the highest importance to Great Britain to take the lead and carry to the utmost any improvement in naval artillery, which may be introduced by other countries.

ERRATA.

Page 8, *line* 7 *from bottom, for* 320 *read* 360, *and again, for* 320 *read* 390.
— 36, *line* 6 *from bottom, after* penetrate, *insert* at 100 yards.
— 37, *line* 23, *for* 623 *read* 923.
— 56, *line* 3 *from bottom, for* 26 cwt. *read* 36 cwt.
— 59, *line* 14, *for* impractible *read* impracticable.
— 108, *last line, for* wikrung *read* Wirkung.
— 132, *line* 22, *in some copies,* for *c d* read *c′ b′*.

IDEAS

AS TO THE

EFFECT OF HEAVY ORDNANCE.

Sir Howard Douglas, in his valuable treatise on naval gunnery, has ably and effectually demonstrated the great advantage of accuracy of practice and length of range; he has brought this home to the feelings of Englishmen, by shewing that the principal, if not all the unfortunate encounters in the late American war, are attributable to defective equipment, to the greater range and power of the American guns, and to the skill and ability which the American commanders displayed in profiting by their superior armament. Sir Howard has not, however, adverted to the horizontal fire of shells or hollow shot from the ordnance at present in use, nor from the guns which have been introduced, with this particular view, into our own and other navies; neither has he enforced the truth which, notwithstanding some remarks which have fallen from him as to the value of 18-pounders, he would readily admit, that the greater the calibre with guns alike charged, (that is, each charge having the same ratio to its shot,) and of equal length and windage, the greater the range. A few remarks upon these important subjects may not be uncalled for, since it is of the highest importance to Great Britain to take the lead and carry to the utmost any improvement in naval artillery, which may be introduced by other countries.

So long as the maritime powers, with which we were at war, did not innovate by improving their guns, by extending the invention of carronades, or, above all, by projecting shells horizontally from shipping; so long was it the interest of Great Britain not to set the example of any improvement in naval ordnance, since such improvements must eventually be adopted by other nations, and not only would the value of our immense materiel be depreciated, if not forced out of use, but a probability would arise that these innovations might tend to render less decisive our great advantages in nautical skill and experience. Many of the defects which were known to exist, so long as they were common to all navies, operated to the advantage of Great Britain.

The system of our navy was at once to bear down on an enemy; and that manœuvre was esteemed the best which, in the least time, brought on the closest action. The science of artillery, with very few exceptions, was altogether neglected, if not despised by our navy; nor was it of importance, so long as our superior nautical skill and seamanship ensured, as it did in almost every case, an action at point-blank range.

The carronade is a weapon especially fitted for the favourite manœuvre of our navy,—a yard-arm action. Carronades were designed by General Robert Melville, and first constructed by Mr. Gascoyne, a director of the Carron iron company, as a matter of private speculation, and with a view rather to the merchant, than the king's, service; their introduction into the navy occurred in 1779, and was for some years attended by very beneficial and important effects, since, as if by the consent of all nations, the advantages which they possessed were not extended to other ordnance. At first they were cast with trunnions, which were afterwards superseded by a loop to bolt them to the carriage, as at present practised. For some time the British nation enjoyed exclusively the advantages they afforded; and until the latest period of the war, the French had not adopted any of a greater calibre than their 36-pounder. The peculiar advantages of this weapon may be stated to consist in projecting shot of large calibre, with tolerable accuracy, to such distances as vessels of war were supposed more frequently to engage, (from 400 to 600 yards,) with a saving of three-fourths the weight of metal and of powder, and of three-fourths of the gun detachment, or men to work the gun. These advantages were brought about by acting on the principle which had been particularly enforced by Dr. Hutton,—by a reduction of the windage, and by a more careful adaptation of the shot to its cylinder than had been previously attempted.

By degrees, the sloops and brigs in our service were, with the exception of two 6 or 12-pounders, entirely armed with carronades; the necessity of giving shot certain penetrative power at considerable ranges being apparently too much overlooked.

During the war, we never thought of overcoming the difficulties inseparable from the change which would arise in reducing the windage of our long guns, nor of establishing an artillery which might extend the advantages of the carronade, by projecting missiles of great volume with *satisfactory precision;* neither did we appear to be convinced of the importance of such guns generally as may command superior range and accuracy, since, until the Americans compelled their adoption, few of our largest frigates were armed with heavier long guns than 18-pounders.

It is not, unhappily, necessary to prove that, from the moment any hostile power shall arm her vessels of war with an artillery of *superior range* and *accuracy*, that her seamen shall possess a due knowledge of its pre-eminent advantages, and shall display such naval ability as may baffle the favorite manœuvre of "close engaging," that from this moment the value of the carronade must greatly decrease, and the advantage of superior calibre and of diminution of windage of long guns, conspicuously appear. Examples are afforded by the predicament in which the squadrons on the lakes Erie and Ontario were placed under Sir James Yeo and Captain Barclay. Sir James Yeo, on the 12th September, 1813, writes: "The enemy's fleet of eleven sail, having a partial wind, succeeded in getting within range of their long 24 and 32-pounders; and from their having the wind of us, and the dull sailing of some of our squadron, I found it impossible to bring them to close action. We remained in this mortifying situation five hours, having only six guns in all the squadron which would reach the enemy: not a carronade was fired." * Captain Barclay, in detailing the particulars of the gallant but unfortunate action of the 10th of September, 1813, says: "The weather-gage gave the enemy a prodigious advantage, as it enabled them not only to choose their position, but their distance also, which they did in such a manner as to prevent the carronades of the Queen Charlotte and Lady Prevost from having much effect; whilst their long guns did great execution, particularly against the Queen Charlotte."† An example terminating in our favor is afforded by the action between the Phœbe and United States frigate, the Essex.

Similar advantages to those, which must be admitted to have arisen from guns of superior range and accuracy, must inevitably attend that maritime power which may first adopt the projection of shells horizontally—

* James's Account of the War, Appendix, No. 51. † *Id.* No. 54.

not as an adjunct and from guns of low velocities, but as a principal means for the destruction of an antagonist, and from guns of the greatest range. The use of loaded shells being once introduced into any navy, their adoption by other powers will most assuredly follow ; thenceforward the character of naval warfare must be greatly changed, and if, at the æra of their introduction, a new propelling force, as steam, be applied to ships of war, there is no anticipating the many changes, the utter revolution in nautical warfare, which may occur. There are, however, facts connected with artillery, the truth of which is immutable, and which must, under all circumstances and all modifications, be of importance in deciding on the armament of ships of war. These truths are so well known and have been so clearly established, that they may almost be referred to as axioms, were it not that certain assertions have of late been made, and in some degree acted on, which tend to involve some of them in doubt.

The most eligible armament appears to be that which would protect our vessels from insult at the longest range ; which would ensure a reply to a distant fire of shells ; and which, on close engaging, would project a broadside of shot, shells and case shot, of the greatest practicable volume, with sufficient velocity and at the most accelerated rate of fire, which the utmost precision will admit.

These objects necessarily induce a consideration of many propositions connected with the practice of artillery ; analitical investigation will, however, be avoided, although some few practical deductions may be made from established principles. Any brief reference to algebraic formulæ will be included in parenthesis, and may be passed over.

ADVANTAGE OF GUNS OF GREAT CALIBRE.

THE greater the calibre of shot; density, elevation and initial velocity being equal; the greater the range and penetration, and the more accurate the practice.

This will appear evident when it is considered that the resistance of the air to shot of different calibre is as their surfaces, that is, as the squares of their diameters, whereas the weight of the shot or power to overcome the resistance of the air increases with their weight, or as the cubes of their diameters. The overcoming force is one power higher than the resisting force.* Thus, at the mouth of the gun, where the velocity does not vary, the shot, by increase of calibre, acquires greater force than it loses; and as it passes through the air, this velocity diminishes less; (this also appears from a consideration of the quantities of motion, at any given range, of shot of different weight, projected with the same velocity. Since the force of projection diminishes less in the greater shot, suppose it to diminish $\frac{1}{n}$ in the greater of two shot compared to $\frac{1}{n'}$, in the less; n and n' being any two indeterminate numbers, n' being greater than n; and let w denote the weight of the greater shot; w', of the less; v, the common initial velocity; and let m denote the quantity of motion of the greater shot, m' of the less; then

$$m = w\left(v - \frac{v}{n}\right); \text{ and } m' = w'\left(v - \frac{v}{n'}\right),$$

$$\text{where } v - \frac{v}{n} > v - \frac{v}{n'};)$$

consequently, the remaining velocity of the shot of the higher calibre must be greater, and it will obviously

* Dr. Hutton has given as a formula for the retardive force of the air $\frac{mv^2 - nv}{w} d^2$, where m and n are co-efficients denoting the law of the air's resistance; v, the remaining velocity of the shot; w, its weight; d, its diameter. Now, since the weights of shot are in the triplicate ratio of their diameters, it is obvious that the greater the calibre, the less the resistance. It is equally apparent, that the less the density, the more the resistance.

range further than the less shot. It will also penetrate deeper, for although the penetrations of shot are as their diameters, yet they are also as the squares of the remaining velocities; now, the remaining velocities augment with the calibre; the comparative depths of penetration of the greater shot must increase, therefore, as the ranges are considerable. It is equally obvious, that the shot of greater calibre, having a power to oppose the resistance of the air superior to the shot of smaller calibre, in proportion to their weights, must, in this ratio, be less susceptible of being deflected from the direction acquired on leaving the gun.

The truth of the maxim, the greater the calibre *(cæteris paribus)* the greater the range and accuracy has been brought in question, by certain tables of ranges of 24 and 18-pounders, particularly by those formed on the practice at Sutton Heath, in 1810, the general results of which are given in Major Elliot's edition of the pocket gunner, and by Sir Howard Douglas in his work on naval gunnery. According to the theory we have adopted, the range of the 24-pounder ought, with equal velocities or when alike charged, to have been greater, at all elevations, than that of the 18-pounder; whereas the media of the Sutton Heath practice, which offers no direct data as to velocity, presents the following view: (the 24-pounder was mounted on the common garrison carriage; the 18-pounder on an iron garrison carriage; both guns were on well-laid platforms, having a slope of one inch to the yard, and were charged with one-third the weight of shot respectively: the axis of the 24-pounder, when at point-blank, or horizontal, is 3 feet 4½ inches from that part of the platform tangent to the fore-trucks; the axis of the bore of the 18-pounder ½ inch less:)

PRACTICE AT SUTTON HEATH, AUGUST, 1810.

Nature of Gun.	Length of Gun.	Weight of Gun.	Weight of Carriage.	Gun & Carr. to 1 lb. Gun.	P. B.		1°		2°		3°		4°		5°	
					1st graze	Recl.	1st graze	Recl.	1st graze	Recl.	1st graze	Recl.	1st graze	Recl.	1st graze	Recl.
Pdr.	ft. in.	lb.	lb.	lb.	yds.	in.	yds.	in.	yds.	in.	yds.	in.	yds.	in.	yds.	in.
24	9 6	5635	1512	298	297	51	720	48	1000	44	1240	54	1538	45	1807	44
18	9 6	4774	1879	370	385	72	881	70	1060	67	1340	68	1603	62	1730	63

Nature of Gun.	Length, &c., as above.	6°		7°		8°		9°		10°		15°		21°	
		1st graze	Recl.	1st graze	Recl.	1st graze	Recl.	1st graze	Recl.	1st graze	Recl.	1st graze	Recl.	1st graze	Recl.
Pdr.		yds.	in.	yds.	in.	yds.	in.	yds.	in.	yds.	in.	yds.	in.	yds.	On Skids
24	....	2023	43	2100	39	2498	49	2638	43	2870	46	3510	44	4000	
18	....	1965	58	2192	53	2398	49	2562	49	2632	56	3190	54	3610	

It may be remarked, since the 24 and 18-pounder were of equal length of bore and alike charged, (that is, the charge for each gun bearing the same ratio to its shot,) that the initial velocities ought, according to admitted principles, to have been equal; there can however be no doubt but that there must have been a great disparity, since the 18-pounder had the advantage, as to range, up to 4° and 1600 yards; after which, the 24-pounder gradually gained upon the 18-pounder; at 5°, it had gained 77 yards; at 10°, 238 yards; at 15°, 320 yards; and at 21° it had gained 320 yards. It must be observed, that at 7° the 18-pounder appears to have outranged the 24-pounder by 92 yards, the ranges being 2192 and 2100 yards; the high average at this elevation is attributable to an extraordinary range in one of the three rounds on which the average is taken, it being reported at 2500 yards: this unusual range may have arisen from a variety of causes, from a shot of very high gauge; from deflection upwards, the shot striking the lower surface of the bore near the muzzle, being equivalent to increased elevation of the gun; or from the shot's not being pressed home, occasioning a vacant space between the powder and shot; by which, at the risk of bursting the gun, particularly with a high wad between powder and shot, velocity may always be increased. But lest this excessive range of the 18-pounder at 7° should be taken for more than it is really worth, on comparing the ranges of the 24 and 18-pounder, it may be stated, that at this very elevation, 7°, the medium range of the short 24-pounder of $6\frac{1}{2}$ feet, charged with $\frac{1}{4}$ the weight of shot only, was 2273 yards, whilst that of the 18-pounder, charged with $\frac{1}{3}$ the weight of shot, was 2,192. The three rounds with the three guns being as under:

NATURE OF GUN.	Length of Gun.	Ratio of charge to shot.	Elevation.	RANGE IN YARDS.			
				First Round.	Second Round.	Third Round.	Average
	ft. in.						
24-Pounder.......	9 6	$\frac{1}{3}$	7°	2000	2290	2010	2100
18-Pounder.......	9 6	$\frac{1}{3}$	7°	2115	2500	1960	2192
24-Pounder.......	6 6	$\frac{1}{4}$	7°	2420	2068	2340	2273

These great deviations prove nothing as to the value of the respective guns, nor do they invalidate any well supported maxim; but they forcibly inculcate, that before any practice can be resorted to with confidence, the utmost attention must be paid, not only to the gauge of shot, but to their surface and sphericity.

Very slight reflection must convince any man that the initial velocities of the 24 and 18-pounders, when alike charged, in the practice above presented, could not have been equal, but greatly in favor of the 18-pounder; for, since the 24-pounder gained ultimately upon the 18-pounder, although the 18-pounder was 88 yards a-head in the first 385, the same cause which produced this result must have commenced its action from the moment the shot quitted the gun. The recoils of these guns also incontrovertibly prove that the initial velocity of the 18-pounder must have been much greater than that of the 24-pounder. It is universally admitted that the elastic fluid generated by the combustion of confined gunpowder endeavours to expand itself in all directions; that its action is exerted equally on the bottom of the bore of a gun and on the ball during its passage through the bore. The gun, therefore, and the ball move in opposite directions, with velocities which are in the inverse ratio of the quantities of matter moved.

In the practice under consideration, the cylinders of the guns were of equal length, so that the elastic fluid and the shot had an equal space to pass over before quitting it, excepting that fractional difference which the length of the cartridge and shot in each might occasion. The masses moved were, in the one case, the 24-pounder and carriage weighing together 7147 lb., and its shot 24 lb.; the weight of the gun and carriage being to the shot as 298 to 1 nearly:—in the other case, the 18-pounder and carriage, weighing 6653 lb., and its shot 18 lb., the ratio of the gun and carriage to the shot being as 370 to 1 nearly; consequently, if the velocities of the shot had been equal, the velocity of the 24-pounder and carriage would have been greater than that of the 18-pounder and carriage, in the ratio of 370 to 298; that is, the 24-pounder would have recoiled with an initial velocity nearly one-fourth greater than the 18-pounder. And since these guns were placed on precisely similar platforms having an equal inclination, the friction between the trucks and platforms may be considered equal, though it may be admitted that the iron axles of the 18-pounder carriage must have facilitated its recoil; on the other hand, the power to overcome resistance in the 24-pounder and its carriage was greater than in the 18-pounder and its carriage, in the direct ratio of their weights. At all events, if the initial velocities of the 24 and 18-pounder shot had been equal, most assuredly the recoil of the 24-pounder would have exceeded that of the 18-pounder, whereas we find by the above practice that the recoil of the 24-pounder was less than that of the 18 by more than one-third of the space recoiled.

This practice then, if duly considered, would alone be sufficient to establish the great superiority of the 24-pounder as to range. To this, however, we shall again advert, as well as to its pre-eminent advantages over the 18-pounder in projecting shells, and the superior power of its shot to penetrate any opposed body. The deficiency of initial velocity in the 24-pounder, in the practice referred to, is in all probability, indeed it amounts to a presumptive fact, to be attributed to the greater windage and consequent escape of the elastic fluid. The diameter of the bore of the 24-pounder is 5·823 inches, the diameter of the shot, current in the service, 5·547 inches, the 24-pounder windage was therefore ·276. The diameter of the bore of the 18-pounder is 5·292 inches, of its shot 5·043, its windage ·249; the area of the windage ring of the 24-pounder is consequently 2·464 inches; of the 18-pounder 2·021; the difference of the space allowing the escape of the elastic fluid being greater in the 24-pounder by one-fifth. It appears from the experiments made at various times with a balistic pendulum, and particularly by those at which Dr. Hutton assisted, "That a very great difference in the velocity arises from a small degree in the windage; indeed, with the usual established windage only, viz. about $\frac{1}{20}$ of the calibre, no less than between $\frac{1}{3}$ and $\frac{1}{4}$ of the powder escapes and is lost, and as the balls are often smaller than the regulated size, it frequently happens that half the powder is lost by unnecessary windage." * This remark applies to difference of windage in shot from the same gun; but with guns of various calibre, a difference of windage necessarily occasions greater difference in the space surrounding the shot.

In the present case, if the 18-pounder were admitted to have lost $\frac{3}{12}$ of the effect of its powder, and the 24-pounder $\frac{5}{12}$, and this supposition cannot be far from the truth, the question would be set at rest, since the 18-pounder, having been charged with 6 lb., its *efficient* charge would be reduced to $4\frac{1}{2}$ lb., and the 24-pounder, having been loaded with 8 lb., its *efficient* charge would be reduced to $4\frac{2}{3}$ lb., and since velocities communicated to shot of different weights and projected with different charges of powder, are directly as the square roots of the weight of powder, and inversely as the square roots of the weight of shot; the velocity of the 18-pounder shot will be to that of the 24-pounder as $\sqrt{\frac{4\frac{1}{2}}{18}} : \sqrt{\frac{4\frac{2}{3}}{24}}$, and if it be assumed that the 18-pounder shot was projected with a velocity of 1600 feet, it follows that the 24-pounder will have been projected with a velocity equal to ($1600 \sqrt{\frac{7}{9}}$) 1410 feet. Adopting the formula of Dr. Hutton, $\left(x = \frac{w}{2gmd^2} \times \text{hyp. log.} \frac{V - \frac{n}{m}}{v - \frac{n}{m}}\right.$, where x denotes the space passed over in terms of the velocity; V, the initial velocity; v, the remaining velocity; w, the weight of the shot in pounds; d, its diameter in inches; g, the space fallen through in a second by the force of gravity; consequently $2g$, the velocity generated in the first second; m ($= \cdot 00000\frac{2}{3}$) and n ($= \cdot 001$) the coefficients of two terms denoting the law of the air's resistance;$\left.\right)$ it may be seen that the remaining velocity of the 18-pounder, projected with an initial velocity of 1600 feet per second, will, after passing through 1600 yards, be

* Hutton's Mat: Vol. III., p. 275.

reduced to 491 feet, whilst that of the 24-pounder shot, discharged with 1410 feet velocity, will, after passing through the same space, be reduced to 499 feet; after 1800 yards, the velocity of the 18-pounder will be 435 feet, of the 24-pounder 462, which velocities correspond, or nearly correspond, with the ranges at the Sutton Heath practice.

By the assistance of the above formula, changing it when the velocities become below 400, (for $x = \frac{w}{32cd^2} \times$ hyp. log. $\frac{V}{v}$, where $c =$ ·00000447 the co-efficient of the term denoting the air's resistance,) the following table may be formed, which answers satisfactorily to the details of the Sutton Heath practice, and offers an approximation as to what the remaining velocities would have been, had the initial velocities of the two guns been equal.

Nature of Gun.	Initial Velocity, per sec.	REMAINING VELOCITIES AFTER PASSING OVER SPACES OF														
		yds. 100	yds. 200	yds. 300	yds. 400	yds. 500	yds. 600	yds. 700	yds. 800	yds. 900	yds. 1000	yds. 1500	yds. 2000	yds. 2500	yds. 3000	yds. 3500
	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.
24-Pdr..	1410	1310	1220	1136	1058	987	921	860	804	752	705	518	400	304	231	175
18-Pdr..	1600	1475	1360	1255	1160	1072	993	920	853	792	737	523	385	284	210	155
24-Pdr..	1600	1486	1380	1284	1194	1112	1036	966	902	842	788	574	431	336	255	194

This investigation, the recoils, and the ranges recorded, justify the belief that the 24-pounder shot at Sutton Heath were projected with a less velocity than the 18-pounder shot; any deduction, therefore, which may be made from this practice in favour of the 18-pounder, and to the prejudice of the 24-pounder of the same length, must be fallacious.

It cannot be said that one gun is equal in range to another, unless discharged with equal velocity and with equal recoils. The *practical* limitation to augmenting velocity by an increased charge or diminished windage is the recoil or strain upon the breeching. Whilst, therefore, the recoil of a gun, the strain upon the breeching and ring-bolts, or the shock upon the carriage is less than that of the gun with which we are comparing its effects, we must, before we can declare it inferior in point of range, necessarily increase the velocity, which, within practical limits, is always possible. Sincerely as we defer to any opinion enunciated by Sir Howard Douglas, we cannot refrain from observing, because we think it calculated to effect very pernicious results, tending to involve in its practical consequences the reputation of the navy, that it appears to have been stated incautiously, that the ranges of the 18-pounder of 9 feet are about the same "as the long 24-pounder, with like elevations." *

In the action between the Guerrière, armed with 18-pounder long guns, and the Constitution, armed with long 24-pounders ; it appears that when the 24-pounder shot were telling on the Guerrière, on which "on the larboard side about thirty shot had taken effect, about five sheets of copper down,"† the 18-pounder broadsides of the Guerrière fell short.‡ Although there is no direct proof of the period of the action when the Guerrière received the wounds in the copper, yet it is more probable that it occurred when she was by the wind, as the copper would be thereby exposed, than when steering free, which, as appears by the official reports of Captain Dacres and Commodore Hull, was the steering of both frigates when the close action occurred. The falling short of the Guerrière's shot has been attributed to deteriorated powder, but it is as fairly assignable to the difference of calibre. That the Endymion's 24-pounder shot did not fall short of the President, is proved by the

* Naval Gunnery, p. 112, 113.

† Captain Dacres' address to the court on his trial.

‡ Captain Hull's report.

injuries of this ship;* this action may be quoted in proof of the superiority, in every respect, of 24-pounder over 18-pounder shot.

The comparative damage † experienced by the Macedonian and United States, also evinces the superiority of the 24-pounder, at great ranges; the Macedonian frigate had twenty-eight 18-pounders on her main deck; the United States, thirty 24-pounders. The 18 and 24-pounders were nearly, if not precisely, of the same length. The United States frigate had two other 24-pounders on the forecastle; the Macedonian, two brass French 8-pounders to answer to them. The Macedonian had eighteen 32-pounder carronades, and one 12-pounder carronade; the United States, sixteen 42-pounder carronades, and, in the tops, three 6-pounder howitzers. Mr. James, in his account, referring to the American report, observes: "Although, 'for the first half hour,' the United States did not use her carronades, the disabled state of the Macedonian, before that half hour had elapsed, proves that she was within fair range of the American 24's; and it is at long shot chiefly that the 'obvious superiority of gunnery' shews itself."

From the above practice, adopted by Sir Howard, it appears that after 4° and 1600 yards, the range of the 24-pounder is greater, and that too, as we think must be admitted, with initial velocity less by $\frac{1}{8}$ than that of the 18-pounder; the recoil, and consequently the strain upon the carriage, (or breeching, had it been employed,) being more than $\frac{1}{3}$ less. It may be remarked, with reference to the foregoing table, which, if not practically true, yet offers safe data for comparison, that the velocities progressively decreased in favor of the 24-pounder; and since the power or force in moving

* James' Appendix, No. 107.

† See the official reports of the action. James' Appendix, 18, 19.

bodies is in the compound ratio of the velocities and masses, it follows that the greater the range, the greater is the superiority of the 24 over the 18-pounder. Thus, although the initial velocity of the 24-pounder to that of the 18 was only as 7 to 8, yet its momentum was as 7 to 6; and, after passing over 1500 yards, the velocities were nearly equal, but the quantities of motion were in favor of the 24-pounder in the ratio of 3 to 2; at 2000 yards, more in its favor than 4 to 3; at 3000, as 3 to 2. In the naval service, it is at long ranges that the importance of momentum comes conspicuously in question, since, at short ranges, shot have generally power sufficient to break through the sides of vessels constructed in the ordinary method. Velocity too, as the range increases, is of especial consequence in point of accuracy. The less the velocity the greater will be the elevation to reach an object; and the higher the elevation, or the more curved the trajectory, the less the accuracy. No practical man will question the truth of this assertion.

Dr. Hutton has shewn that in the case of different velocities, the angles of elevation will be reciprocally as the square of the velocity, and it has been asserted and acquiesced in by artillery officers of ability and judgment, that the accuracy of shot projected at different elevations, all other circumstances being equal, will be as the angles of elevation reciprocally, 1 being added to the number of degrees.*

Taking all the circumstances into consideration, and comparing the results of extensive practice, it may confidently be asserted that the probabilities of hitting with round shot of equal windage and initial velocity at 1000 yards, are as the squares of the diameters, and that the

* Des déviations du tir des projectiles, par L. N. Prosper Coste, capitaine d'artillerie.

ratio is greater as the range increases. Thus, in any given number of rounds at 1000 yards range, a 42-pounder shot may be expected to strike a target 11 times, when the 32-pounder strikes it 9 times, the 24-pounder $7\frac{1}{2}$ times only, and the 18-pounder 6 times.

It appears from a series of nine years experiments made at Metz, Strasbourgh, and La Fère, from 1816 to 1825, that, at a range of 1490 English yards, the probabilities of hitting with the 12-pounder and 6-pounder are as 8 to 3; of the 8-pounder and 6-pounder as 979 to 648.* Now, the diameters of the 12, 8, and 6-pounder, are 4 *in.* 4 *p.* 9 *l.*, 3 *in.* 10 *p.* 0 *l.*, 3 *in.* 5 *p.* 6 *l.* The squares of the diameters of the 12-pounder and 6-pounder are therefore nearly as 8 to 5, and of the 12-pounder and 6-pounder as 979 to 796. The probabilities of hitting, if estimated as the squares of the diameters, are therefore much less than that evinced by this practice.

A practical proof of the superiority of the range of guns of great calibre is afforded by the fact that the British artillery, on taking the field in Spain and Portugal, were chiefly armed with 6-pounders, but that the experience of the Peninsular campaigns, and that, be it observed, in a mountainous country, caused nearly all these 6-pounders to be superseded by 9-pounders. Now, when it is considered that 6 and 9-pounder shot, *taking effect against troops*, are nearly equally destructive; (penetration is not of that consequence as against shipping, except where a column, or a square, can be attained from ground nearly of the same level with the column, in which case, the advantage of penetration, even in the field, may be judged from the recorded fact, that at the battle of Zornsdorff, forty-two men of the 2d regiment of Russian grenadiers were mowed down by one round

* Instruction sur les effets des bouches à feu, par M. Poumet, chef de bataillon d'artillerie, p. 4.

shot;*) that three hundred rounds of 6-pounder ammunition can be conveyed as easily as two hundred rounds of 9-pounder; that the 9-pounder gun and carriage weigh 37 cwt., the 6-pounder only 26 cwt.;—taking these facts into consideration, it must at once be admitted that the range and accuracy of the 9-pounder is very superior to that of the 6-pounder; and in a ratio exceeding what we have ascribed to shot of different calibre.

The diameter of the 9-pounder is 4 inches, of the 6-pounder shot 3·498, their squares (or chances of hitting by the above rule) are nearly as 4 to 3, but the 6-pounder brings three rounds into the field at the same original cost, and at the same cost of carriage or animal labour, that the 9-pounder brings up two rounds. Where the 9-pounder employs two shots, the 6-pounder may, therefore, expend three, the advantage of the 6-pounder in this respect, as compared to the 9-pounder, is as the weights, or as the cubes of the diameters of their shot, inversely. Combining, therefore, the chances of hitting, as estimated above, with the increased number of disposable 6-pounder-shot, and the probabilities become in favor of the 6-pounder as 9 to 8. Why then, it may be asked, were 6-pounders superseded by 9-pounders? The answer inevitably must be,—because the range and precision of their shot is in a greater ratio than their weights, that is, greater than as 3 to 2.

DENSITY OF SHOT, &c.

The greater the density of shot of like calibres, projected with equal velocities and elevation, the greater the range, accuracy, and penetration.

This must appear evident from a consideration of the facts adverted to in the last section. If the velocity of the shot of great calibre diminishes proportionally less

* Tielke, vol. i, p. 145.

than that of smaller calibre and equal density, on account of its greater weight, although the resistance of the air is greater to the shot of higher calibre in the ratio of their surfaces; much less, proportionally, will the shot of greater weight be deprived of its velocity when the resistances are equal; consequently, it will range further and with greater accuracy than shot of less density. Hence too it is, that heavier shot with *less velocity*, within certain limits, will range further than lighter shot of equal calibre and greater velocity. This is often proved when shot and shell are fired from guns of the same calibre, at considerable elevation, with the same charge. The shell acquires an initial velocity greater than the shot, in the inverse ratio of the square roots of their weights, and since the resistance of the air, the velocities being great, is in a higher ratio than the squares of the velocities,* it follows that the velocity of the shell will decrease more rapidly than that of the shot; but this is much assisted by the fact before adverted to,—that the power of the shot to overcome the resistance of the air is superior to that of the shell in the direct ratio of their weights;—consequently, from the point where the remaining velocities become equal, the shot will continue to be deprived of its velocity less rapidly than the shell, notwithstanding that the law of the air's resistance to different velocities now tells against it, and in favor of the shell.

* The exponent of the velocity indicating the resistance, is always above 2; at 200 feet, it is 2·028; at 500 feet, it is 2·042; at 1000 feet, it is 2·115; from thence it gradually increases up to the velocity of 1500 or 1600 feet per second, when the exponent is 2·153; and from this velocity, the exponent gradually diminishes, being 2·136 at 2000 feet, the limit of the experiments.—*Hutton's Tracts*, vol. iii, No. 35.

The following practice supports this reasoning:

68-PDR. CAR. PRACTICE.—SUTTON HEATH, SEPTEMBER 6 & 7, 1811.

NATURE OF GUN, &c.	Nature of Shot.	Elevation.	Charge.	Media of 3 Rounds. First Graze.	Media of 3 Rounds. Second Graze.	Media of 3 Rounds. Extreme Range.
			lbs.	yards.	yards.	yards.
68-pounder carronade,—length, 5 ft. 2 in.; weight, 35 cwt., 3 qr., 4 lb.; weight of block-trail garrison carriage, 17 cwt., 1 qr., 26 lb.	Shot, weight 68 lb.	P. B.	5¾	300	653	2097
		1°	5½	580	1107	2187
		3°	5½	1036	1427	2195
		5°	5½	1391	1765	1957
		10°	5½	2090	..	2147
		15°	5½	2623	..	2623
		16° 40′	5½	2825	..	2825
	Shell, weight 44 lb.	P. B.	4	275	553	1559
		1°	4	521	967	1807
		3°	4	887	1257	1973
		5°	4	1192	1467	1883
MEM.—*The charges being 1/12 and 1/11 the velocity of the solid shot to that of the hollow, must have been at least as 900 : 940.*		10°	4	1570	1625	1819
		15°	4	2090	..	2090
		16° 35′	4	2053	..	2053

It is often stated in too general terms, and without due consideration as to the cause, that a hollow shot will range farther, in its first graze, than the solid shot of equal diameter. This is only true, where the initial velocity of the hollow shot is much greater than that of the solid shot. If the charges of powder are in proportion to the weight of the projectiles, the initial velocity will be equal, in which case the solid shot will range farthest in the first graze. This will scarcely be questioned, when it is considered that the resistance of the air is as the surfaces of the shot, and the force to overcome the resistance as the weights; for, in this case, the resistance of the air is equal, but the overcoming power in the solid shot is greater than in the shell, often as 2 to 1, and never less than 7 to 5. For example, the shell or hollow shot answering to the 32-pounder, weighs

15 lb. $4\frac{1}{4}$ oz.; if the windage and length of bore be equal, the initial velocities of the shot and shell will be equal with *like charges*, that is, with $10\frac{2}{3}$ lb. and $5\frac{1}{4}$ lb. of powder. Assuming the initial velocity to be 1600 feet per second, after passing over 500 yards, the velocity of the shot will be 1148 feet, of the shell only 820, the momentum of the shot to that of the shell being nearly in the ratio of 3 to 1. At 1000 yards, the velocity of the shot will be 838 feet, of the shell 460, the momentum nearly as 4 to 1. At 1500 yards, the velocity of the shot will be 624 feet, of the shell only 293, the momentum of the shot to that of the shell being more than as $4\frac{1}{2}$ to 1.

If the 32-pounder shot and shell were discharged from carronades with the highest charge, (4 lb. of powder,) having the same windage with the gun to which, in the last paragraph, an initial velocity of 1600 feet is attributed, the shot might be projected with a velocity of 700 feet, the shell with a velocity of 1010; after passing over 500 yards, the velocity of the shot would be 529, of the shell 547, the momentum of the shot to that of the shell greater than 2 to 1. At 1000 yards, the velocity of the shot will be 411 feet, of the shell 333 feet, the momentum of the shot to that of the shell being nearly as 5 to 13.

The advocates of carronades, on their first introduction, very zealously propagated the belief, that their first graze and destructive effects with hollow shot was superior to the first graze and destructive effects of the ordinary long guns with solid shot. This theory gained ground at the time, from the repeated exhibition of comparative practice, with equal but low charges, usually 4 lb., from the 68-pounder carronade, (then termed *smasher*,) and from a 32-pounder. The carronade hollow shot weighed from 40 to 45 lb., having a windage of only ·06 of an inch, or ·1 at most. The solid shot used with these carronades were cast in a spherical iron mould of the same diameter as the carronade, so that the windage was exactly equal to the shrinking or contraction of the shot in cooling. The windage of the 32-pounder solid shot was at least ·32 of an inch, $\frac{1}{20}$ of the calibre, that being the regulated windage. This very great difference of windage might account for the apparent deviations from admitted principles. The board of ordnance appears to have strenuously insisted, in its conferences with the navy board, on the superiority of the old long guns; had it at the time reduced the windage of these guns, so as to approach that adopted for the carronades, it is probable that the employment in the service of the carronade would have been extremely limited.

This high idea of the value of carronades and of hollow shot, appears still to be entertained by individuals whose opinions are entitled to consideration; indeed much the same reasoning has been reiterated, which was advanced by the constructors of the carronade and the advocates for employing hollow shot from them. Lieutenant-Colonel Paixhans, in his work entitled "Nouvelle Force Maritime," says: "Quant on combat à des distances moyennes, et surtout à des distances rapprochées, le tir horizontal des obus* (lancés à charge suffisante) a plus de justesse que celui des boulets massifs de même calibre;" (*lancés à charge insuffisante* ought, in candour, to have been added, but M. Paixhans continues;) "parce qu'un projectile moins dense a, pendant un certain temps, une plus grande vitesse, et par conséquent une trajec-

* We seem to have adopted, or rather revived, the term "hollow shot" as a translation and in deference to the French "boulet creux." The *obus*, or French howitzer shell, is not, as in our service, cast with its interior and exterior surfaces concentric; it has a *culot* or reinforcement of metal opposite the fuze hole. The *boulet creux* is cast concentric, and for this reason needed a distinguishing appellation.

toire d'une moindre courboure, qui permet de tirer sous un angle moins élevé, pour arriver à la même distance." The plain meaning of which, divested of all ambiguity, is, that if hollow shot are fired with comparatively high charges, they will acquire a greater initial velocity than the solid shot fired with comparatively low charges, will retain for *a certain time* a greater velocity than the solid shot, and, to the extent of range covered by such greater velocity, will require less elevation, and, consequently, be more accurate. No man can doubt the truth of this assumption, but it is difficult to imagine how the admission can be made to tell in favor of the range of hollow shot. In the experiments published by M. Paixhans himself, it appears that, with *equal charges*, where the initial velocity must have been in favor of the hollow shot nearly as 1340 to 1100, the ranges, on an average of six rounds at 3°, the lowest elevation he records, were slightly in favor of the hollow shot.* M. Paixhans goes on to say: "Quand on combat de loin, les obus ayant plus de volume que les boulets de même poids, ou moins de poids quand ils ont le même diamètre, sont plus retardés par la résistance de l'air; ils ont alors moins de justesse et donnent des portées moins étendues;" this reasoning is unquestionable, and must entirely remove any favorable impression as to hollow shot, which a cursory reading of the previous remark might have occasioned. If, as Colonel Paixhans observes, shells, having greater volume than shot of equal weight, or less weight when of the same diameter, are more retarded by the air *quand on combat de loin*, it must inevitably follow, that they will be more retarded *quand on combat à des distances rapprochées.*

The resistance to the air, *arising from the volume* of a shot passing through it must be the same in every part

* Expériences faites par la marine Française, p. 64.

of its course, and will operate from the instant the shot quits the mouth of the gun. If hollow and solid shot, then, are projected with equal velocity, (which they will be, if alike charged, the *windage being equal*,) there can be no "certain time" during which the hollow shot can retain a greater velocity than the solid shot; neither can there be any range at which the trajectory being less curved, less elevations will be sufficient for the shell. Colonel Paixhans proceeds: "Mais on peut obtenir les mêmes portées au moyen d'un calibre plus considérable, et peut-être que l'explosion des obus peut compenser leur infériorité de justesse." It is theoretically true that equal range may be obtained by means of a higher calibre, but there is a practical difficulty, if not impossibility, in resorting to this alternative; be it observed, that a French 24-pounder will, with equal initial velocity, always range further than the *boulet creux* of M. Paixhans' 80-pounder, and so of other shot and shells bearing the same ratio to each other as to weight and calibre; the inferiority of the shell as to accuracy of practice, at great ranges, is conceded by M. Paixhans; it has been shewn that it cannot be withheld at any range. The compensation offered, bursting the shell, is admitted to a certain extent, and will be more particularly considered in what follows.

Captain Chamier, of the navy, when speaking of 68-pounder carronade shot, says: "Repeated experiments have shewn, that a hollow or cored shot, weighing 50 lb., or even 40 lb., would range further in the first graze, or that at which the shot strikes the surface of the water, and the only range worth attending to in naval gunnery. The hollow shot would, also, owing to its diminished velocity in passing through a ship's side, and the consequent enlargement of the hole and increased splintering of the timbers, produce more destructive effects than the shot in the solid form; one of the principal objections against which was, and still continues to be, its being so cumbrous to handle." * The power to overcome the resistance of the air, which in this case is equal, the surfaces being alike, is the weight of the projectile. It is, therefore, difficult to imagine how the hollow or cored shot of 40 lb. or 50 lb., with "diminished velocity," (by which is understood final velocity less than that of the solid shot,) can range further in the first graze than the shot in the solid form. The 68-pounder carronade practice, given in a preceding page, shews the great advantage of the solid shot as to range, its initial velocity, even were the windage equal, being less than that of the shell, by more than one-twentieth.

Supposing the 68-pounder hollow shot, which weighs 48 lb., be compared, in its effects, to a solid shot of the same weight, the diameter of this shot would be 6·988 inches. If the charges to project the shell and shot be equal, and the windage equal, their initial velocities may be expected to be the same. Let the initial velocity of each missile be 1200 feet per second. The projectiles will proceed in their course, their weight being alike, with equal power to overcome the resistance of the air: this resistance, at the mouth of the guns, will be greater to the shell in the ratio of their surfaces, or as the squares of their diameters. As they proceed, each shot will, by degrees, be deprived of velocity, the solid shot obviously less rapidly than the hollow, having less to overcome. The resistance of the air will consequently cease to be as the surfaces, the velocity being different, for it is also higher than in the duplicate ratio of the velocities. The penetrations too would be no longer as the diameters, for the depths are likewise as the squares of the velocities. To ascertain the effects of the shot at

* James's Naval History, edited by Captain Chamier, R.N., pp. 34, 35.

different ranges, it is, therefore, necessary to determine the remaining velocities and penetrations at those ranges, to approximate which we may again resort to the formulæ of Dr. Hutton, and must forestall a part of what will be considered in the following section. The velocity and penetration of the hollow and solid shot, each weighing 48 lb., assuming that an 18-pounder shot, with 1200 feet velocity, will penetrate 30 inches into oak, is as follows :

Nature of Shot.	Initial Velocity.	At 250 yds.		At 500 yds.		At 750 yds.		At 1000 yds.		At 1500 yds.		At 2000 yds.		At 2500 yds.	
		Velocity.	Penetration.	Velocity.	Penetration.	Velocity.	Penetration.	Velocity.	Penetration.	Velocity.	Penetration.	Velocity.	Penetration.	Velocity.	Penetration.
	ft.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
Solid.....	1200	1151	31·89	923	24·59	832	19·98	727	15·25	575	9.54	463	6·19	380	4·16
Hollow...	1200	998	23·23	835	16·26	703	11·59	597	8·31	441	4·53	340	2·69	..	..

The orifice of the shot holes made by the hollow and solid shot, if circular, will, necessarily, be as the squares of the diameters, that is, as 4 to 3 nearly. This is the only point of view in which, at any range, the hollow shot appears, *with equal charges*, to have the advantage over the solid shot ; the momentum, excepting at the mouth of the gun, is always in favour of the solid shot, and obviously, as the velocities.

The penetration of the denser shot compared to that of a shot of less gravity and the same calibre, the *initial* velocity being equal, is greater, because the depths are not only as the densities, but in the duplicate ratio of the remaining velocities ; which velocities are, as before repeatedly observed, greater as the densities are greater ; the solid shot will penetrate deeper at 1500 yards than the hollow shot will at 1000.

The accuracy too of the solid shot will be much greater, both on account of its greater velocity, and because the hollow shot, to obtain the same range, must have greater elevation; since the elevation, to obtain the same range, will be reciprocally as the squares of their velocities. It is said that practice at Lens and at La Fère has established, that the deviations of shot of different density, but the same diameter, are inversely as their densities.* If the guns are of the same weight, and mounted on similar carriages, the recoils will be equal; but as the advocates for hollow shot usually advert to the less weight of the guns to project them, the recoils will consequently be in favour of the solid shot, as its gun and carriage is heavier than that of the hollow shot.

It is very true that the *least* velocity with which a shot may pass through a ship's side is decidedly the most advantageous,—"it will produce the more decisive effects;" the shot, however, must *pass through*; if it stick in the side, it will be comparatively, and perhaps altogether, harmless. But are low velocities peculiar to hollow shot? Cannot solid shot be projected with equally low velocities? Is there any difficulty or any inconvenience attending the reduction of the charges for solid shot? or, on the contrary, is not the recoil thereby lessened, and with it the labour of the gun detachment? It is very certain that hollow shot *cannot be forced* through a ship's side at ranges greater than those to which carronades of their calibre are available with round shot. It has been incontestibly proved, that there are other ranges than these "worth attending to in naval gunnery;" that, where carronades were useless, vessels have received important injury, and even been disabled: witness the Macedonian, the Guerrière, the Queen Charlotte, the Lady Prevost, the Essex, &c. Captain Porter, the commander of the Essex, (the armament of which was forty

* Des déviations du tir des projectiles, par L. M. Prosper Coste, capitaine d'artillerie.

32-pounder carronades and six long 12-pounders; opposed to twenty-six long 18-pounders, four long 9-pounders, fourteen 32-pounder carronades, one 18-pounder carronade, and one 12-pounder carronade,) says, in his official report: "The enemy, from the smoothness of the water, and the impossibility of reaching him with our carronades, and the little apprehension that was excited by our fire, which had now become much slackened, was enabled to take aim at us as at a target. His shot never missed our hull, and my ship was cut up in a manner, which was, perhaps, never before witnessed. In fine, I saw no hopes of saving her, and at twenty minutes past six p. m. gave the painful order to strike the colours." He adds: "I must, in justification of myself, observe, that with our six 12-pounders only, we fought this action; our carronades being almost useless."*

This inquiry justifies the belief that hollow shot ought only to be used (if ever without being loaded) at very limited ranges. At such ranges their velocity is sufficient, their *smashing* effects, (to retain the term of their inventor,) from their volume, very great; and they possess that great advantage of being more readily handled than the solid shot of equal weight.

At considerable ranges, solid shot are available where hollow shot would be useless. At medium ranges, the practice with solid shot and heavy guns is accurate, where the practice with carronades is wild and uncertain.

PENETRATION.

PENETRATION is a subject of paramount importance, when the destruction of shipping is in question; it may therefore be desirable particularly to advert to it.

The penetrations of shot are not proportional to their momenta. Percussion has often been confounded with

* James, Appendix, No. 73.

penetration.* The quantities of motion of shot, velocity and density being equal, are as the weights, or in the triplicate ratio of their diameters, whereas the penetration of shot, *(cæteris paribus,)* are as the diameters only.

In the service of artillery in the field, range and accuracy is, in general, all that it is necessary to attend to; if the shot be sent home with precision, its momentum must be ample against men and horses uncovered: hitting, not penetrating, is the consideration of consequence. Far different is the case in naval warfare, or when batteries on shore are opposed to shipping: a shot may, by passing in at a port or between the timbers of a ship, produce great effect, although its velocity may be low; but, commonly speaking, a shot, to be efficacious, must have power to break through the side, and *loaded* shells to lodge in it.

Mr. James, in his very valuable account of the naval occurrences in the late American war, quotes a report of Captain Stewart, of the American navy, where it is observed: "A shot, which would sink a frigate, might be received by a seventy-six with but little injury. It might pass between wind and water through a frigate, when it would stick in the frame of a seventy-six." Mr. James, speaking of the English frigate, the Leander, says: "The flimsiness of that ship's top sides, and the smallness of her scantling, generally, also took the attention of the American officers," (who were captured by her in the Rattlesnake,) "most of whom had served on board the Constitution. Thin sides, however, have their advocates. It is said that when a ship is closely engaged, the thinner her sides, provided they can resist grape, the less destructive they will be in their passage through. The case of this very same Leander, when so gallantly

* See Bousmard, vol. iii, p. 276.

engaged at Algiers, is brought forward. There, most of the shot, that struck her, passed through both sides, without splintering, leaving a hole no larger than the shot itself. But, had the Leander come to action with one of the American forty-fours, she having the weather-gage, and being determined to preserve, for the first half hour at least, that distance, at which her skill in gunnery could best display itself, the latter's 24-pounder shot, or the greater part of them, would have found their way through the Leander's side, quite slow enough to splinter; while the 24-pounder shot, or the greater part of them, would have lodged in the sides of the American ship. Had the Algerines commenced firing when they ought, the Leander would have had splinters enough."* It may be added, had the Algerines reduced their charges as they ought, the Leander would have had abundance of splinters. All the remarks in favour of thin sides rest upon two assumptions, neither of which can be admitted. The first is, that one charge only can be employed by naval gunners; the second is, that "the only range worth caring about is the point-blank range." Now that gunnery has become a subject of consideration by the naval officers of all countries, it is highly improbable that it will ever again be advanced as an argument in favor of thin sides, that shot, from having too much velocity, will pass through them without splintering.

Before it is possible to form a sound opinion as to the relative advantages of solid and hollow shot, and of the ranges at which each should be preferred, both from long and short guns and carronades, it is absolutely necessary to ascertain what *remaining* or *striking* velocity is requisite with each particular calibre, as well as with each description of projectile, to pierce the sides of ships of war.

* James' Account, pp. 133, 134.

The results which may be obtained from a course of practice conducted with this particular view, would, there is little doubt, amply compensate for the expense incurred by it.* The recorded practice differs widely, and the theories on the subject, which are extant, are not more satisfactory.

The *initial* velocity of penetrating shot is only of consequence as it regards the particular range to which it may apply. It is the remaining or striking velocity which it is important to ascertain, because data will thereby be established, which may be applied to all other ranges and under all circumstances.

Mr. Moore has shewn, that to produce the greatest damage by a shot fired against a ship's side, it should lose all motion just as it ceases to be resisted by the wood, which happens when the shot has forced its first hemisphere out of the further side: he has given a formula for finding the charge to effect this object, but such refinements can never be reduced to practice, since a variance in the angle at which the shot might impinge on the ship's side, or an alteration in the range, would instantly upset the calculation; besides which, even in ships of the same rating, the thickness of the several parts of the sides differs much. It is, nevertheless, necessary that some definite ideas should be arrived at respecting the velocities necessary, with the several calibres, to pierce a ship's side.

The side of a line of battle ship, from the inside of the lining to the outside of the planking between the middle and lower decks, may be about 2½ feet,—the side of a frigate about 20 inches; at the wales, and immediately under the decks, the thickness is still greater; the cutting through a mast may also merit

* The line of battle ships lately offered for public sale, might, previous to being broken up, have rendered good service as excellent buts.

consideration; an American 44-gun frigate's mainmast appears to be 35 inches in diameter:* besides which, on the modern plan of building, the timbers, below the lower deck of a line of battle ship, or main deck of a frigate, are close to each other, and may, on a wind, be exposed to shot. It cannot, therefore, be admissible to estimate the requisite penetration at less than 30 inches into solid oak, when opposed to line of battle ships; and 18 inches when opposed to other ships of war; particularly when it is considered that ships are seldom so placed that their shot strike an antagonist at right angles.

The penetration of shot, of equal diameter, density and velocity, into oak and fir, is said to be in the proportion of 10 to 18.† Their specific gravity, when seasoned, according to Mr. Edye, is as 696 to 491, being the number of ounces respectively in a cubic foot. Mr. Edye also states, that the average weight of the timber materials in a vessel of war is about 800 oz. the cubic foot, and for the masts and yards about 640.‡ Muschenbroek§ states that the strength of beech oak to that of fir is as 17300 to 8330, which numbers express in pounds the strength of a square inch, or the weight required to separate its parts. The splitting and splintering of fir is also greater than of oak, so that for practical purposes it may perhaps be considered that the effect of shot against fir is twice as great as against oak.

Dr. Hutton ascertained by repeated experiments that a cast-iron ball of 2 inches diameter, fired perpendicularly into the end of a block of elm with a velocity of 1500 feet per second, penetrated 13 inches; and that the resistance of oak to elm is as 19 to 17, the one being

* James, p. 20. † Aide Mémoire, p. 332.

‡ Edye's Equipment of Vessels of War, p. 17.

§ Encyclopædia Britannica, vol. xix.

1900 times the force of gravity, the other 1700. (He also states that the depth of penetration of shot is proportional to $\frac{dnv^2}{f}$, where d is the diameter of the shot, n its specific gravity, v the velocity with which the shot strikes, and f the force of resistance, or the strength or firmness of the substance penetrated. If, therefore, d, d' be the diameter of two shot; n, n' their specific gravity; v, v' their velocity; p, p' their penetration; then will

$$p : p' :: \frac{dnv^2}{f} : \frac{d'n'v^{2\prime}}{f'}$$

$$\text{whence } v' = \sqrt{\frac{p'dnv^2f'}{pd'n'f}}, \text{ and } p' = \frac{pd'n'v^{2\prime}f}{dnv^2f'}.$$

On comparing the effect of shot and shell of the same nature, d, d' are the same; f, f', the force of resistance, the same; and the penetrations p, p' may be taken as constant, consequently the velocities will be $v^{2\prime}n' = v^2n$, and $v' = \sqrt{\frac{nv^2}{n'}}$.)

The weight and diameter of shot and shells, when uncharged, charged, and filled with lead, are as under; shot of the new gauge are not yet in use:

NATURE OF PROJECTILE.	68-Pounder. In curr. service.		68-Pounder. Serv. at Bermud:		42 Pdr.		32 Pdr.		24 Pdr.		18 Pdr.	
	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.
Weight of Shot	68	0	..		42	0	32	0	24	0	18	0
Weight of Shell: Empty	33	6¼	48	0	20	0	15	4¼	11	15	9	1¾
Weight of Shell: Filled with Powder	36	0	50	13½	21	7	16	5¼	12	14	9	12
Weight of Shell: Filled with Lead	86	2½	82	8	53	8	40	12½	30	4	22	10½

Upon Dr. Hutton's data, and adopting his proportion, it will be found that shot and shell, to penetrate 30 inches into oak, require to strike the object perpendicularly and with the following velocities:

NATURE OF PROJECTILE.		68 Pdr.	42 Pdr.	32 Pdr.	24 Pdr.	18 Pdr.
		feet.	feet.	feet.	feet.	feet.
Round Shot		1208	1317	1378	1446	1517
Weight of Shell	Empty	1714	1909	1972	2050	2132
	Filled with Powder	1660	1844	1929	1974	2061
	Filled with Lead	1073	1167	1220	1288	1345

These approximations may afford *comparative* data on which to ground an opinion, but, by referring to actual practice, it will be found, that the increased resistance to augmented velocities gives to the shot above the shell, as intimated by Dr. Hutton himself, a greater value than is here assigned to it; and many of the recorded experiments would lead to the supposition, or rather confirm the belief, that less velocities are effectual to produce this penetration.

By the theory of penetrations and the above formula, the depths ought, with shot of equal calibre, to be as the squares of the velocities. Now, the velocities are as the square roots of the charges, the penetrations ought, therefore, to be as the charges; but Dr. Hutton deduces from his practice, that with higher charges than $\frac{1}{4}$ the weight of the shot, or rather, where the velocities exceed 1200 or 1300 feet, they are as the logarithms of the charges.

According to Mr. Robins, shot from an 18-pounder, with 6 lb. of powder, at a range of 30 yards, penetrated from 37 to 46 inches into a mass of seasoned beams of English oak, bolted together. The *remaining* velocity could not have been greater than about 1750 feet per second.

With 3 lb. of powder, the penetration was near 33 inches, the remaining velocity probably about 1240 feet.

With $2\frac{1}{2}$ lb. of powder, the penetration was 28 inches, the velocity 1130 feet.

With 1 lb., the penetration from 14½ to 15½ inches,* and, in this case, the remaining velocity might have been 710 feet.

Now, according to these experiments by Mr. Robins, the 18-pounder shot, to penetrate 30 inches, would not require more than 1200 feet per second *remaining* velocity; whereas, by Dr. Hutton's practice, 1500 feet would be required. Dr. Hutton observes: "It is to be suspected that the great penetration in Mr. Robins' experiments was owing to the splitting of his timber in some degree." Sir Howard Douglas, in the same page in which is recorded the above practice with 18-pounder shot by Mr. Robins, states: "A 6½ feet 24-pounder, double shotted, was fired with 4 lb. of powder, at a butt of timber 5 feet 2 inches thick, placed 100 yards from the gun: most of the shot perforated the butt, and ruined 2 gun carriages placed behind it."† Now, these 24-pounder shot could not have had a greater remaining velocity than 750 or 800 feet, and yet, although some did not penetrate at all, yet others passed through 62 inches. "The penetration was, on an average," Sir Howard says, "4 feet." It is rather to be inferred, that the perforation of the butt and the destruction of the gun carriages behind it, is attributable to the successive effects of several shot, than that any one shot could have passed through 62 inches.

By the subjoined table of French practice, the 24-pounder shot, (28 lb. English), with a charge of powder equal to ½ that of the shot, (the final velocity being about 1660 feet,) at 109 yards from the gun, penetrated only 59 inches; and, at the same range, with a charge equal to ⅓ the weight of shot, not quite 56 inches. The following table is from the new Aide-Mémoire;

* Robins, p. 310; edition edited by Dr. Hutton.

† Douglas on Naval Artillery, p. 126.

the ranges and penetrations are reduced to English measure; fractions of a yard, and minute fractions of an inch, are discarded :

PENETRATIONS, BY FRENCH SHOT, INTO OAK.

Nature of Shot.	Proportion of Powder to Shot.	RANGES IN YARDS.								
		27	54	109	218	328	437	656	874	1093
		inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.
36	$\frac{1}{3}$	65·35	64·17	62·20	58·35	54·42	50·78	44·09	37·40	31·49
24	$\frac{1}{2}$	62·99	61·41	59·05	54·72	50·78	47·24	40·15	33·46	27·55
	$\frac{1}{3}$	59·05	56·87	55·90	51·57	47·63	44·09	37·40	30·70	24·80
	$\frac{1}{4}$	55·51	54·42	52·36	48·24	44·88	41·33	34·54	28·34	22·83
	$\frac{1}{6}$	49·21	48·42	46·45	42·91	39·37	36·22	29·52	24·01	19·29
	$\frac{1}{8}$	42·52	41·73	40·15	36·61	32·67	30·31	24·40	19·68	15·74
16	$\frac{1}{2}$	54·72	53·15	50·78	46·45	42·52	38·97	31·89	25·59	19·68
	$\frac{1}{3}$	51·18	50·00	48·03	43·70	40·15	36·61	29·92	23·62	17·50
	$\frac{1}{4}$	47·63	46·45	44·48	40·94	37·40	33·85	27·55	21·65	16·92
	$\frac{1}{6}$	42·12	41·33	39·76	36·22	32·67	29·52	23·22	17·71	14·17
	$\frac{1}{8}$	37·00	36·22	34·25	30·70	27·55	24·40	19·29	14·96	11·81
12	$\frac{1}{3}$	46·06	44·88	42·91	38·58	35·04	31·89	25·59	19·68	14·56
	$\frac{1}{4}$	43·30	42·12	40·15	36·61	33·07	29·92	23·62	18·11	13·38
	$\frac{1}{6}$	37·79	37·00	35·43	31·89	28·34	25·19	19·29	14·96	11·41
	$\frac{1}{8}$	33·85	33·07	31·10	27·55	24·40	21·65	16·53	12·99	9·84
8	$\frac{1}{3}$	39·37	38·18	36·22	32·28	28·34	25·59	19·29	13·77	10·63
Howit. Shells.										
24	$\frac{1}{7}$	27·55	26·77	25·19	21·65	18·11	14·96	10·23	7·87	6·29
	$\frac{1}{14}$	18·89	18·11	16·53	13·38	11·02	9·44	7·48	6·29	5·11
12	$\frac{1}{14}$	14·96	14·17	12·59	10·23	8·26	7·08	5·90	4·72	3·93

By Dr. Hutton's experiments it may be computed, that 24-pounder shot, with the charge of $\frac{1}{6}$, doubly shotted, would penetrate only 9 inches; by Mr. Robins, about $14\frac{1}{2}$ inches; by Mr. Moore's formula, the penetration might be about 10 inches.

The two men of all ages, and of all countries, who have rendered the greatest benefit to the scientific practice of artillery, are Mr. Robins and Dr. Hutton. The practice at which Dr. Hutton assisted, appears to have been invariably conducted with the utmost accuracy; indeed, all the artillerists of Europe quote Dr. Hutton as the highest authority, and rest on his data and deductions. It is, therefore, most desirable that the penetration of shot with the striking velocities should be ascertained by the most careful practice, before the momentum of shot be too much reduced, of which there is now much risk, by the introduction of hollow shot.

Taking Mr. Robins' practice, as favorable to the penetration of shot, and applying the formula of Dr. Hutton, the following table may be constructed:

NATURE OF PROJECTILE.			Requir: strik: velocity for penetrating	
			30 inches.	18 inches.
32-Pdr.	Shot		1090	845
	Shell	Empty	1579	1223
		Filled with Powder	1526	1182
		Filled with Lead	860	748
24-Pdr.	Shot		1144	886
	Shell	Empty	1622	1579
		Filled with Powder	1570	1478
		Filled with Lead	1019	623

The formula used above favors penetrations with high velocities, as Dr. Hutton himself intimates, and is, therefore, unfavorable to solid shot.

General Scharnhorst states, that a 7-pounder* howitzer shell (the weight of which may be about 12 lb.) from a 24-pounder, with a charge of $5\frac{1}{4}$ lb. of powder, penetrated, at a range of 500 paces, $1\frac{1}{2}$ feet into a stone wall; and that the 24-pounder solid shot, with $1\frac{3}{4}$ lb., had the same effect.† Now, the initial velocity of the shot was about 750 feet; and the initial velocity of the shell about 1800 feet,—a much greater disparity in favor of density than that which appears in the table.

* The Prussians, Austrians, Bavarians, and Saxons, name their howitzers from the weight of a sphere of stone of equal diameter with the shell.

† Scharnhorst über die Wirkung des Feuergewehrs, p. 28.

It appears that General Millar's new 12-inch gun, with a charge of 11 lb., and at a range of 400 yards, pierced quite through the *fac simile* of the side of a ship of war. The weight of the hollow shot is 122 lb.; its initial velocity might be assumed to have been somewhat about 1000 feet per second; and its final velocity about 790 feet; its penetration, therefore, according to the data afforded by Mr. Robins' practice, would be 16 inches. Now, the scantling of the ship's side serving as a butt to General Millar's gun is not known, but it is very possible that shot might pass between the timbers of the top sides of any ship of war without encountering 16 inches of solid wood; indeed, the thickness of the midship main deck port sill of the Hero, 74-gun ship, built in 1816, appears to be 17 inches, and of her foremost quarter deck port sill 13 inches. Of the Eurotas, 46-gun frigate, built in 1813, the midship main deck port sill 15 inches, and the foremost quarter deck sill only 11.* This practice then, so far as its results are known, does not invalidate the practice of Mr. Robins or the theory of Dr. Hutton.

It appears by the report of M. Paixhans' practice against the Pacificateur, a French 74-gun ship, that his 80-pounder, with 10 lb. of powder, at 600 yards, threw the shell of 56 lb. through the side of the ship, and that, to stick the shells in the side, the charge was reduced to 4 lb. The windage was rather less than one line (·88 of an English inch). The initial velocity, with 10lb., may be taken at about 1350 feet, and the remaining velocity at 900 feet. The penetration into solid oak, according to the preceding data, would therefore be about 20 inches; but, as the Pacificateur was an old vessel, and her timbers wide apart, it would not be surprising if the shell made its way through her sides. It appears

* James, p. 18.

that with 4 lb. of powder, the shot lodged between her timbers. The initial velocity might have been about 850 feet, the remaining velocity probably 580; consequently, by Mr. Robins' practice, the penetration would be rather more than 8 inches, which, by the report of the practice, appears to have been the fact.

Upon Mr. Robins' data, with solid 32-pounder shot, at 750 yards range, an initial velocity of 1800 feet will be required to afford a striking velocity of 1090 feet, which is requisite to penetrate 30 inches into oak, or 54 into fir. A velocity of 1800 feet is more than is obtained by a charge of $\frac{1}{3}$ the shot's weight and our present windage; it is that commonly attributed to $\frac{1}{2}$ the shot's weight of powder; it may probably be obtained by even less than $\frac{1}{3}$, when the windage is reduced to $\frac{1}{10}$ of an inch.

A range of 750 or 800 yards is, therefore, according to Mr. Robins' practice, the utmost range at which a 32-pounder shot can confidently be relied on to penetrate 30 inches into solid oak, or 54 inches into fir. By using the shell filled with lead, and increasing the charge proportionally, still keeping it $\frac{1}{3}$ the weight of the projectile, the range, with this penetration, may, at the expense of more than doubling the recoil or strain upon the breeching, be extended to 1400 yards. By retaining the charge of $\frac{1}{3}$ the weight of the solid shot and using the empty shell, or hollow shot, as it is the fashion to term it, the penetration of 30 inches can only be relied on as far as 350 yards.

Where it may be sufficient to ensure a penetration of 18 inches into oak, or 32 inches into fir, 32-pounder shot are efficient at a range of 1150 or 1200 yards, the striking velocity required being about 850 feet per second. The leaded shell, with the proportional charge of $\frac{1}{3}$, the required striking velocity being 750 feet, may be used to twice this range; but the hollow shot, with the solid shot's charge of $\frac{1}{3}$, only to 550 yards, the required striking velocity being about 1220 feet.

It must be observed, that the increase of the charge to obtain the greatest effect with the leaded shell, will necessarily increase the recoil or strain upon the breeching to an inconvenient, if not impracticable, degree; so that leaded shells should be employed only when essentially necessary.

Reviewing the data of Mr. Robins, it appears that a 32-pounder, to penetrate 30 inches into solid oak or 54 into fir, at a range of 500 yards, requires $7\frac{1}{2}$ lb. of powder, or $\frac{1}{4}$ the shot's weight;—with the hollow shot, a velocity which never has been given to any military projectile.

To penetrate 18 inches into oak or 32 into fir, at a range of 500 yards, the 32-pounder requires, with round shot, 4 lb. 7 oz., or $\frac{1}{7}$ the weight of shot; with the empty shell, a charge of 9 lb. 7 oz.; and with the shell filled with powder, a charge of 9 lb. 10 oz.; the recoils or strain upon the breeching, in each case, being nearly equal.

Thus, when similar results are obtained, the superiority is with the solid shot, as to accuracy and as to the expenditure of powder; the only advantage, even at the shortest ranges, in using *hollow shot* of the same calibre, arises from the less exertion necessary in handling it, in transmission to the gun, and in loading; there can be little benefit, therefore, in introducing hollow shot into the service; it is even to be feared that, if persevered in during war, very deplorable results may ensue.

It is probable that the very great occasional penetration of shot (which may be attributed to shot of extraordinary high gauge, or to a high wad over the powder not rammed home,) has given rise to the very general impression, that the velocity of shot from long guns, for naval purposes, is always sufficiently great. This supposition is not, however, corroborated by referring to actual practice. In the action between the Shannon and Chesapeake, the fire was not opened on either side until far within point-blank range;—Sir Philip Broke, in his report, says: "The enemy hauled up *within hail* of us on the starboard side, and the battle began, both ships steering full under topsails." Yet many shot were seen, after the Chesapeake had arrived at Halifax, sticking in her side; and of several that struck the Shannon, most of them lodged in the starboard side, (the side opposed to the American,) ranged in a line just above the copper, five only passing through, one of which was below the main deck. Until the shot holes were stopped, the Shannon made a good deal of water upon the larboard tack.* If these shot, which stuck in a line above the copper, had struck with a velocity sufficient to break through the side, the results to the Shannon might have been very fatal; and, on the other hand, effects equally destructive might have resulted to the Chesapeake, had the majority of the Shannon's shot, which so "battered her hull," penetrated. The velocity of the American shot is understood to be greater than our shot from similar calibres, their windage being less, the strength of their powder equal, and the charges alike.

With a knowledge of these well-attested facts, as to the inadequacy of the British and American 18-pounder solid shot from long guns, within hailing distance, Mr. James says "within half pistol shot," it is strange that any officer can advocate the use of uncharged hollow shot. If, however, the shell be loaded, very great must be its destructive powers. Had one or two only

* James, p. 224.

of the shot that stuck in a line just above the Shannon's copper been charged and burst, what must have been the inevitable consequence? The importance of loaded shells will be the subject of a particular discussion; but it may be observed, that if loaded shells were employed, the only penetration necessary, or even desirable, would be to the depth of the diameter of the shot, or perhaps, generally about 6 inches. To this depth into oak, 32-pounder shells may be expected to penetrate at a range of 850 yards; and into fir, at a range of 1100, if the round shot charges of $\frac{1}{3}$ are used, the striking velocity required being about 680 feet per second.

WINDAGE, &c.

THAT windage is a consideration of paramount importance has long been admitted in theory, but, with the exception of the advantage secured to carronades, the practical value of diminishing it has, till lately, been neglected in the ordnance regulations for the calibre of guns and shot.

The less the windage, with equal charges, the greater is the velocity and consequent range; and more especially will the accuracy and precision of fire be effected by the degree of windage.

That the velocities are greater as the windage is less, has been proved by the most satisfactory experiments (this question has been adverted to at page 11): it requires little exertion of mind to be convinced, that the greater the windage, or the greater the aperture occasioned by the difference of the diameters of the bore and shot, the greater the waste or escape of the elastic fluid generated by the ignition of the powder. The invention of carronades depended on this truth, and the advantages of the recently introduced artillery of Colonel Paixhans and General Millar (notwithstanding assertions to the contrary) are mainly assignable to it.

The great deviations which arise in the practice of artillery, or the irregularities in the trajectories of shot, are attributable to the resistance of the air acting on their irregular and uneven surface, to their want of sphericity, and, chiefly, the deviations are supposed to arise from the shock occasioned by their striking against the cylinder of the gun. By a combination of these causes, a doubly incurvated trajectory, or even a zigzag motion, is sometimes produced; so that a shot projected to the right is, by the oblique pressure of the air, aided perhaps by want of sphericity, again and again, or repeatedly, deflected, and finally falls either to the right or left of the axis of the bore produced.

It is easy to conceive that the greater the windage, the greater will be this shock. The shot, when placed in the gun, rests on the lower surface of the bore; the elastic fluid will give it velocity proportioned to the space it passes through; now, the lateral space of action of the shot, at the first moment of the ignition of the powder, is the windage; if the windage be double, the shock will be double, since it is equal to the product of the weight of shot into the velocity. So also, it may be imagined that where the axis of the shot does not correspond with the axis of the bore, that the force of the elastic fluid will urge it obliquely rather than in the direction of the bore. It is from the unequal pressure of the elastic fluid upon the shot's surface; in other words, from the particles of the shot having unequal velocities, that the rotary motion of the shot is produced.

To obviate the striking of the shot against the bore and to protect that part of it where the shot is seated, it is sometimes conical; so that the shot, when pressed home, has no windage. The guns recently introduced by Lieut.-Colonel Paixhans into the French service, and by General Millar into our own, for the projection of hollow shot or shells, are upon this principle. The Russians have a howitzer denominated *licorne*, the bore of which is, in its whole extent, the truncated frustrum of a cone: the only field guns in the possession of the artillery at Corfu, in 1822, were Russian guns of this description.

The Paixhans guns have a cylindrical chamber and cylindrical bore, except that the seat of the shot is conical.

The chamber of General Millar's new howitzer and howitzer guns are conical, with a hemispheric bottom, the remainder of the bore being cylindric. The new long guns have altogether a cylindrical bore.

As the charges of common long guns seldom vary except for ricochetting, when the charge is considerably reduced, there is perhaps no good reason why the bore should not, in every case, be formed as the new howitzers are, and, as it may be observed, upon the old Gomer principle. It may be said, that when the charges are so reduced as to leave a space between the powder and shot, there would be some risk of bursting the gun. It must be admitted, that by leaving a space between the powder and shot, the elastic fluid, before it reaches the shot, will have acquired a certain degree of velocity, and, instead of acting by pressure, as it does when the shot is seated on the charge, it will act by sudden impulse or percussion, and, therefore, with considerable charges, incur a risk of bursting the gun. Upon this ground, space is left about the powder in the chamber of a mine, and it is to this cause that the frequent bursting of fowling pieces is to be attributed. A high wad between the powder and shot, not rammed home, has no doubt often been the immediate cause of the bursting of a great gun. It may also be remarked, that with carronades upon the non-recoil principle, when there is no play or no *slack* to the breeching, the gun is steadier, and the breeching suffers less; but, if there be the least slack, there will be a risk that the carronade may break from its breeching, or draw the bolts. In the one case, the tension of the breeching is gradual; in the other, the elastic fluid has developed itself and given great impetus to the gun, which takes effect abruptly on the breeching. Notwithstanding these facts, there is little occasion to fear the bursting of a gun with the very reduced charges required for ricochetting, and it is only with such charges that there would be a space between the powder and ball.

By the word *ricochetting*, as here employed, is intended that description of fire, which, by reducing the charge to $\frac{1}{12}$ and as low as $\frac{1}{30}$ of the weight of the projectile, with elevations from 6° to 12°, affords, at ranges of from 400 to 800 yards, a probability of rebounding on hard level ground or water, from 5 to 15, or 20 times in an extent of 100 yards. This description of fire would be admirably adapted against a flotilla of gun boats, but can never be employed with advantage against shipping; the momentum being absolutely deficient, when opposed to a ship's side. The Germans have distinct terms for ricochetting with the full, and ricochetting with reduced, charges: they have *Rollschüsse* (roll-shots); and *Ricoschetchüsse* (ricochet shots). Some such technical distinction is desirable in our service. General Scharnhorst prefers, when firing against troops, the ground being hard and even, the *Rollschüss;* in our service, the direct fire, or hitting the object without a graze, is generally preferred. Captain Hastings observes: "I always prefer ricochet against shipping in smooth water."* Ricochetting with effect against shipping must, it is imagined, partake of the *roll-shot* of the Germans, rather than ricochetting

* Memoir of the use of shells, &c., p. 16.

with reduced charges. This may possibly be desirable in smooth water, because the elevation being less than when the object is attained by the first graze, the altitude of the curve of the shot would be less, and consequently, if the direction be good, the chances of attaining the object may be greater. With velocity efficient to pierce a ship's side, shot will not rebound from the water, if they strike it at an angle exceeding about 7°. Twelve or fourteen hundred yards is the greatest range against shipping at which this practice should be attempted.

An objection may be raised to the truncated conical chamber, since it may be said that guns, with such chambers, cannot so effectually be spunged in quick firing, as guns with a cylindrical bore and cylindrical spunge heads; that, in consequence, fire may more easily remain unextinguished in the bottom of the bore, and thereby occasion accidents in loading; a little attention in using spunges sufficiently high would obviate this danger. The risk, at all events, is not at all commensurate with the advantage resulting from superior accuracy and increased velocity. By recent regulations, the windage of our field artillery is reduced, or rather, is to be reduced, as the shot in store is consumed, to one-tenth of an inch, and of our garrison artillery, to one-tenth and a half; but from the disparity of the bore of ship-guns and carronades, it appears, by the work of Sir Howard Douglas, that some hesitation exists, or did exist, as to the course to be adopted with naval artillery. Unquestionably, the better plan would be to ream out the bore of such carronades as may be required, since it would be preposterous to admit two kinds of shot for the same nature of gun and carronade, or to relinquish the great advantages of reducing the windage; equally ridiculous would it be to have a different shot for sea and land service.

During the whole war, the windage of our ship-guns was more than twice that of the French and Americans, whereby our shot was discharged with a velocity at least one-fourth less ; to this fact it is much more reasonable to attribute the falling short of our shot in some of the actions with the Americans, than to inferiority or deterioration of powder. The windage of the English 24-pounder was ·276 of an inch ; of the 18-pounder, ·249 ; of the American and French 1½ line, equal in English measure to ·13323 of an inch.

Windage is limited by the dilation of shot at a white heat ; by the incrustation of rust, and by the dirt which may adhere to them ; by the soiling of the bore by repeated firing ; and, when shot are fixed by tin straps, by the thickness of the tin. Foreigners make some account for alteration in the shape of the bore of guns by continued firing ; but iron guns, in the longest actions, retain their cylindrical form, though they may be slightly indented at the seat of the shot. The limitation arising from the strapping of shot may, in the British service, be thrown out of the account ; shot are not usually fixed for heavy guns ; nor, by the present regulations, for the field ; but if they were, they may be luted to the wooden bottom, without interference with the windage.

When shot are manufactured with that care which is desirable,—when more attention is paid to their sphericity and gauge, and to the smoothness of their surface,—it is probable that the objection from rust will cease to be important ; they will merit lackering or paint, and the results of irregularities of surface will not be attributed to rust. Sir Howard Douglas has proposed some excellent methods for preserving shot from rust ; he would keep those intended to be first used when, more particularly, accuracy and range are important, in "water-tight metal pipes, wooden spouts, or timber troughs, lined with copper and placed in gentle inclination on the edges of the hatchways, &c."* As to any allowance from the adherence of dirt, this can be proportioned only to the inattention of the individuals who may have them in charge. The objection arising from the fouling of the bore is of less importance; water on board ships, at all events, is continually at hand, and if the foulness should attain to an inconvenient extent, the cylinder of the gun may be spunged out with water with delay not much exceeding the time necessary to discharge a well laid round.

It appears by the Aide-Mémoire that a 24-pounder shot, the diameter of which is 794 points, expands at white heat 11 points, which is about $\frac{1}{72}$ of the diameter; the 16-pounder shot, the diameter of which is 693 points, expands 9 points, being exactly $\frac{1}{77}$ of the diameter. One-sixteenth of the diameter of the shot would, therefore, in every case, be more than ample allowance for the dilation of shot by heat; but if it were fixed at one-tenth of an inch for guns of the higher calibres, the service would be infinitely benefitted by the accuracy and range of artillery. The windage of the French 8-inch howitzer shell, which was ·002 of a metre, has been reduced to ·0015 of a metre, equal to ·059 of an English inch. The French have also reduced the windage of their heavy guns from one and a half to one line, that is, to ·0888 of an English inch. Captain Hastings used red hot shot from guns which, with cold shot, had a windage of only ·05 of an inch.† And Sir Alexander Dickson, with very important results, at the siege of Cuidad Rodrigo, used cold shot from 24-pounders with windage considerably less than ·08 of an inch, that is, less than the seventy-second part of the diameter, (the dilation of the shot by heating,) for, when heated, the shot would not

* Page 98. † Memoir on the use of shells, hot shot, &c.

pass into the guns, as may be seen from the extract of a letter which is inserted in the following page.

One remark connected with windage, and with reference to the charge of guns, remains to be made. It is quite clear, whether windage be regulated in proportion to the diameter of the shot or at a fixed limit, that the windage, or space by which the elastic fluid escapes, will be greater as the calibre increases. The areas of circles are to each other as the squares of their diameters; consequently, as is now the case in a very serious degree with English ordnance, the larger gun, when *alike charged*, will discharge its shot with less velocity than the smaller gun; its regulated charge is alike, but its *efficient* charge is less. If the present windage were continued, the charges of the guns of higher calibre should, to produce like initial velocities, be considerably more than $\frac{1}{3}$ the weight of the shot, to make up the loss by the proportionally greater windage-ring. If the charge of the 18-pounder be $\frac{1}{3}$, that of the 24-pounder ought to be $\frac{3}{7}$; the initial velocities will then be about equal; the guns will be *alike efficiently* charged. Until the windage of shot be reduced, the accuracy of practice may be much assisted by enveloping the shot in greased linen or canvass, or the paper bags that cartridges are sometimes packed in. Caution is, however, necessary, or the shot may be jambed.

The following table, extracted from the new *Aide-Mémoire*, shews the great importance of windage: it is taken from Lombard; the velocities and windage are in French measure, and may be converted into English by multiplying by 1·065977; as a table of comparison, it is equally useful in French measure. The axis of the gun is supposed to be horizontal. With great elevation the velocity is considered greater, from the pressure of the shot on the charge, and the consequent development of a greater quantity of the elastic fluid, generated by ignited gunpowder, before the displacement of the shot :

WINDAGE.	Initial Velocities.			WINDAGE.	Initial Velocities.		
	12-Pdr.	8-Pdr.	4-Pdr.		12-Pdr.	8-Pdr.	4-Pdr.
li. p.	feet.	feet.	feet.	li. p.	feet.	feet.	feet.
0 0	1680	1694	1808	1 9	1281	1240	1213
1 0	1442	1422	1446	1 10	1264	1221	1188
1 1	1423	1401	1419	1 11	1247	1202	1164
1 2	1405	1380	1392	2 0	1230	1183	1141
1 3	1387	1359	1365	2 1	1213	1165	1118
1 4	1369	1338	1339	2 2	1197	1147	1095
1 5	1351	1318	1313	2 3	1181	1129	1072
1 6	1333	1298	1287	2 4	1165	1111	1050
1 7	1316	1279	1262	2 5	1150	1093	1028
1 8	1299	1259	1237	2 6	1134	1054	1007

The windage of the English 12-pounder is ·22 of an inch, equal to 2·4777 French lines ; it appears, therefore, by this table, that no less initial velocity than 542 feet French, equal to 577 feet English, is lost by the windage of our current shot ; whereas the 12-pounder French, having a windage of 1 line, loses only 238 feet. The loss of initial velocity by windage is, however, only a waste of so much powder as might make up the initial velocity ; it is, therefore, of minor importance. But the disadvantage, from excess of windage, not to be remedied, arises from the comparative inaccuracy of the practice.

The immense importance of diminishing windage to the utmost degree is, as it regards the accuracy of practice, most powerfully illustrated by the following extract from a letter of Sir Alexander Dickson, of the artillery, whose experience and opinion, all will admit, is of the utmost possible value, and cannot be too highly appreciated or too often adverted to : "I remember a very convincing proof of the advantage of high shot, which, I think, is worth mentioning. The battering train was assembled at Almeida, previous to the siege of Cuidad

Rodrigo, and there being a great deficiency of transport to bring forward the shot from the rear, it became a very important object to collect as many as possible from the shot belonging to the fortress, of which there was a considerable quantity, and of an infinity of calibres. In order, therefore, to obtain every shot that would answer, gauges of the full diameter of our 24-pounder bore were used, and every shot was selected as serviceable that passed through these gauges; so that many of the highest balls chosen would not, when heated, go into the gun; and this I ascertained by trial. When this operation had been completed, the selected shot were again tried with a guage rather smaller than the ordinary 24-pounder shot gauge, and all that went through it were rejected as too small. The number of very high shot, however, amounted to two or three thousand; and as I know they were brought forward in the latter part of the siege, it has always been to the use of these shot that I have attributed the singular correctness of the fire in making the smaller breach, for, although the battery was 500 to 600 yards distant from its object, every shot seemed to tell on the same part of the wall as the preceding one. Now, this was not the case in firing with common shot at such a distance; for, some struck the wall high, and others low, although the pointing, as the best gunners have assured me, was carefully the same."* It may be observed, that the calibre of the Spanish 24-pounder is 5·907 English inches; of the English 24-pounder, 5·823 inches. The Spanish 24-pounder shot gauge is 5·812, so that the Spanish 24-pounder shot, fired from an English 24-pounder, would have only ·011 of an English inch for windage. This satisfactorily accounts for the fact referred to in the letter of Sir Alexander Dickson, and

* Sir Howard Douglas on Naval Gunnery, p. 84.

corroborates the deduction, that the windage, in this case, was reduced to the least practicable quantity.

LENGTH OF GUN.

MUCH stress is laid by many on the length of gun. A long gun favors the laying, and heavy guns recoil less than light, in a higher ratio than their weights, taken inversely; but extensive opportunities of practice with guns of different length has not carried conviction as to the surpassing importance, in point of range, of guns beyond a medium length, provided the weight of metal be such as to admit, without inconvenience from the recoil, the charge of $\frac{1}{3}$ of the shot's weight. The ordinary length of 18 or 20 calibres is convenient, in the naval service, to clear the rigging;—in the land service, to favor the cheeks of the embrazures. It would be impossible to dispose of the weight of metal, which is necessary with the higher velocities, so conveniently in any other form, even if no advantage were derivable from length of bore.

The theory of Dr. Hutton is, there is little doubt, practically correct, when he states that "the range is nearly as the fifth root of the length of the bore; which is so small an increase, as to amount only to about a seventh part more range for a double length of gun." This maxim is based on the supposition that "with equal charges, the velocities are in a ratio somewhat less than that of the square roots of the length of the bore, but greater than that of the cube roots of the same, nearly in the middle ratio between the two."

The experiments as to velocity from length of bore presented by Sir Howard Douglas,* are embodied in the annexed table, the spaces required to reduce the velocities to 1000 feet per second being added; also the

* Naval Gunnery, second edition, p. 110.

weight, length of bore, calibre of the 24-pounders, diameter of shot and windage:

Nature of Gun.	Length of Gun.		Length of Bore.		Weight of Gun.			Calibre.	Diameter of Shot.	Windage.	Charge.	Initial Velocity	Velocity reduced to 1000 feet in
	ft.	in.	ft.	in.	cwt.	qr.	lb.	in.	in.	in.	lb.	feet.	yards.
Long 6-Pdr..	6	0	5	7⅝	12	1	16	3·668	3·498	·17	1½	1497	304
Short do. ..	4	9	4	4½	9	3	0					1451	296
Long do. ..	6	0	5	7⅝	12	1	16	3·668	3·498	·17	2	1761	445
Short do. ..	4	9	4	4½	9	3	0					1676	407
Long 24-Pdr.	9	6	8	11½	50	0	0	5·823	5·547	·276	4	1292	360
Short do. ..	7	6	6	11½	40	0	0					1242	305

From this table it appears that by adding $\frac{4}{15}$ to the length of the 24-pounder, and $\frac{1}{4}$ to its weight, the velocity is not augmented $\frac{1}{25}$; which is much less than in the middle ratio between the square and cube roots of the length of the bore, on which hypothesis Dr. Hutton considered that the range is as the fifth root of the length of the bore. Now, the fifth roots of the lengths of the bores of the two 24-pounders, are in the ratio of 18 to 17 nearly; but a velocity somewhat in the proportion of 10 to 9 is calculated to produce ranges in this ratio; whereas the ratio of the velocities of the 24-pounders, by the same table, is less than 26 to 25, which may increase the range $\frac{1}{50}$, and would require in the shorter gun, with elevations of from 4° to 10°, an increase of elevation, on the average of $\frac{1}{4}$°; but with elevations less than 4°, the required augmentation is too minute to be applied by a gun tangent.

The following table exhibits the practice with a long and short 24-pounder equally charged. The recoils are added, by which it may be seen that more importance attaches to the long gun from weight, as affecting the recoil, than from its range. The report states, that the facility with which the short gun was worked, more than compensated for the increase of its recoil, but this remark could not be extended to the sea service, for there the recoil is of paramount importance. Both guns were mounted on common garrison carriages, weight 13½ cwt., and on similar platforms of wood, having an inclination of one inch to the yard. The range, which was nearly level for 1200 yards, and afterwards rose and fell inconsiderably, was pegged every ten yards; every 50 yards were marked by a bannerol which had the distance from the battery branded on it. The elevation was given by a spirit quadrant. The guns, all laid by the same officer, were carefully loaded. The powder, (Red L. G.,) was filled in paper cartridges, and one wad was used above the shot:

PRACTICE AT SUTTON HEATH, AUGUST 7 to 11, 1810.

Nature of Gun, &c.	P. B.		1°		2°		3°		4°		5°	
	1st graze	Recl.	1st graze	Recl.	1st graze	Recl.	1st graze	Recl.	1st graze	Recl.	1st graze	Recl.
	yds.	ft. in.	yds.	ft. in.	yds.	ft. in.	yds.	ft. in.	yds.	ft. in.	yds.	ft. in.
24 Pdr.—9ft. 6in.	240	3 3	710	3 2	825	2 9	1245	3 5	1700	3 2	1700	2 9
50 cwt. 1 qr. 7 lb.	230	3 3	695	3 2	815	2 11	1080	3 3	1319	3 1	1570	2 8
Charge, 6 lb....	275	3 3	580	3 9	900	2 11	1315	3 4	1398	2 9	1500	2 8
24 Pdr—6ft. 6in.	240	5 11	680	5 5	775	5 4	1250	5 8	1319	5 5	1680	5 3
33 cwt. 1 qr. 7 lb.	225	5 9	580	5 4	800	5 2	1100	5 4	1360	5 4	1475	5 0
Charge, 6 lb....	200	5 10	586	5 6	920	5 3	1050	5 1	1250	5 4	1580	4 10

	6°		7°		8°		9°		10°		15°		21°	
	1st graze	Recl.	1st graze	Recl.	1st graze	Recl.	1st graze	Recl.	1st graze	Recl.	1st graze	Recl.	1st graze	Recl.
	yds.	ft. in.	yds.	ft. in.	yds.	ft. in.	yds.	ft. in.	yds.	ft. in.	yds.	ft. in.	yds.	ft. in.
Long 24 Pdr. &c. as above.	1996	2 7	1865	2 10	2210	2 10	2510	2 6	2900	3 0	3350	28	400	Hind trucks off.
	1780	2 7	1800	2 9	2215	2 10	2595	2 7	2580	3 1				
	2040	2 8	2025	2 9	2440	2 10	2505	2 6	2540	2 10				
Short 24 Pdr. &c. as above.	1680	4 10	2420	5 0	2140	4 8	2246	4 7	2895	5 0	3150	43	3890	
	1745	4 9	2060	4 8	2260	4 8	2185	4 5	2350	4 9				
	1800	4 9	2340	4 11	2351	4 7	2180	4 6	2440	4 9				

ARMAMENT OF SHIPS OF WAR.

Sir Howard Douglas has satisfactorily shewn that random broad sides are very inefficient, but that a deliberate fire of single guns is highly important. Now, if this be admitted, it would follow that all ships of war should be armed with a certain number of long guns of the greatest velocity and of the highest calibre which the tonnage of the vessel might admit; more especially is it necessary with reference to the projection of shells, as shewn when alluding to the penetration of shot. If, however, the introduction of steam does not altogether supersede the necessity of line-of-battle ships; if they are destined for other duties than that of "carrying coal," and serving as "transports when protected by steam vessels;"* the total of their broadside, particularly if loaded shells are used, need not, it is conjectured, be entirely composed of guns of the highest velocity.

The total weight of guns, their shot and stores for each particular class of vessel, likewise the weight of the heaviest gun which the deck and scantling of the particular vessel may admit, being determined by naval constructors, accustomed to the adaptation of weight, to buoyancy and sailing: the number of long guns, to be used singly, not by broadsides, being also ascertained by experienced seamen long conversant with the realities of war and of sea fights, the remainder of the guns, excepting a limited number of heavy howitzers, may be of the same calibre with the long gun, but shorter and of less weight of metal, (since the required ranges being less, the initial velocity may be less,) and in such number as may make up the total weight prescribed by the constructor as the proper burthen for the decks.

Instead of determining the armament of a ship from the length of her decks and crowding as many guns together as space may admit, *determining the number* of guns by the extent of the battery, and subjecting their

* See the letter addressed to William Blackwood, Esq., (Whiting, Strand, London,) 1835; and subsequently acknowledged by Captain Sir John Ross. R.N.

nature and description to their number; making, in fact, the weight of the gun to depend, not on the services required from it, but on the quotient which may arise from dividing the total weight to be supported by the decks by the number of guns previously fixed; it might be safer to place on board every ship a certain number of guns of the full length of bore, and of the highest calibre which her particular construction might admit; and to regulate the total number of guns by their aggregate weight, thus making the number, and not the nature of *broadside*-gun, to depend upon that which is inevitably fixed—the capability of the vessel.

It has been observed that the number of long guns being determined, the broadside guns may be of equal calibre but of less length and weight. The present carronade is too short and too light. Accurate experiments having especial reference to windage, and necessarily to velocity, can alone determine the question. A trunnion gun, easy on its carriage and affording an initial velocity of about 1100 feet, might be sufficient; its length may be about twelve or fourteen calibres. The new French 24-pounder howitzer had ten calibres; since 1829, it has had more than twelve; it is 2 cwt. lighter than ours.

Many years ago, satisfactory experiments were made to establish the feasibility of reaming out the bores of iron guns to the next superior calibre. This appears by the following extracts from proof reports, dated Woolwich, 18th April, 1776:

A 12-pounder, weight 29 cwt. 1 qr., length 7½ feet, was bored up to an 18-pounder, and then weighed 28 cwt. 1 qr. An 18-pounder, weight 40 cwt., length 9 feet, was bored up to a 24-pounder, and then weighed 36 cwt. 1 qr. 4 lb. Eleven rounds were fired from each gun. The 12-pounder, charged with 9 lb. of powder, and nine 18-pounder shot. The 18-pounder, with 12 lb. of powder and ten 24-pounder shot. They were subsequently proved, in the usual manner, by the proof master, and again fired forty-five times with the above charges and the same number of shot, that is, as many as they could contain. The guns were then carefully searched, and not the least flaw or defect could be discovered in either of them. This experiment did not lead to any immediate result.

On the recommendation of Colonel Paixhans, in the French service, each nature of long gun has, within these few years, been reamed out to the next greater calibre; and recently the same measure has been resorted to in our own service, 24-pounders having been reamed up to 32-pounders, and 18-pounders to 24-pounders, in order, as it is understood, to enable line-of-battle ships to throw the same shot from each deck, the lower decks being armed with the ordinary heavy guns.

M. Paixhans' object in reaming out the several natures of French guns, is different from that contemplated by us. M. Paixhans bases his system upon the weight of the gun at present in such numbers assigned to each class of vessel. The ordinary armament of a French 74-gun ship, at the time he wrote, (1822,) was:

36-pounders	28
18-pounders	30
8-pounders	14
6-pounder carronades	14
Total	86 guns, discharging 2250 lb. in solid shot.

M. Paixhans would substitute:

48-pdrs., reamed up from 36-pdrs.; or the new guns, having the weight of the ordinary 24-pdr. or 36-pdr., i.e. 5100 or 7200 lb.	28
48-pounders, having the weight of the ordinary 18-pdr., i.e. 4200 lb.	30

48-pdr. carronades, having the weight of the common 36-pdr. carronade, i.e. 2340 lb. 28

Total ....86 guns, discharging 3010 lb. in 48-pounder shells, weighing 35 lb. each.

The new French 24-pounder frigates, in 1822, were armed with

24-pounders	30
12-pounders	12
36-pounder carronades.....	8
Total	50 guns, discharging 1200 lb.

For which M. Paixhans would substitute:

48-pdrs., equal in weight to the common 24-pdr.	30
48-pdr. carronades, having the weight of the ordinary 36-pdr. carronade.	20

Total ....50 guns, discharging 1750 lb. in 48-pdr. shells, each weighing 35 lb.

Thus he would throw from 74-gun ships and frigates entire broadsides of 48-pounder shells; but M. Paixhans makes no provision for those deliberate shots at considerable charges, which Sir Howard Douglas considers so efficient. It is very certain that, with *equal windage*, the velocity of the 36-pounder, before reamed up to the 48-pounder, would be much greater than he could by any means insure to the 48-pounder shell from the reamed gun; but if the initial velocities were equal, since the weight of the 36-pounder shot and the 48-pounder shell are nearly equal, the difference being in favour of the shot, the resistance of the air would be greater to the shell, in the duplicate ratio of the diameters of the two projectiles, that is as 5 to 6 nearly; and hence the remaining velocity, the range, and accuracy of the 36-pounder shot would be much greater than that of the 48-

ounder shell. The marvellous results of M. Paixhans' ractice must vanish when solid shot from heavy guns re projected with *as little windage* as he has adopted. hen a ship partially armed with the old 36-pounder, aving the wind in her favour, or being otherwise enabled o choose her distance, would disable a ship armed exclu-ively with M. Paixhans' new 48-pounders, without being erself even touched. By firing shells filled with lead, he range of the 36-pounder might, if necessary, be ncreased, but to give the 48-pounder solid shot or filled hell equal velocity from the reamed up gun, with the 6-pounder shot from the old 36-pounder, the charge nust be increased to an inconvenient, if not, from the ecoil, impractible extent.

It is very certain that the heavier the gun, the less will be its recoil and strain upon the breeching and carriage, and the more accurate the practice; it does not, therefore, appear that it would be desirable to reduce the weight of guns intended for the most exten-sive range and highest velocities; on the contrary, it may be found necessary, when the windage is what it ought to be, to give them greater inertia than at present.

To produce sufficient initial velocities with solid shot and *loaded* shells against shipping, at very short ranges, such as the greatest modern battles have been fought at, the reamed up guns appear to be both heavier and longer than necessary; and at great ranges, the neces-sary charge would render them inefficient from the recoils. It has been observed, that 1100 feet initial velocity may be sufficient for these reduced ranges, and this, or perhaps even 1300 feet, may be obtained by a charge not exceeding $\frac{1}{6}$ the weight of shot, from a gun 12 or 14 calibres in length, having a gomer-chamber with ·075, or ·05, of an inch windage. The recoils or strain upon the breeching with this gun and the

$\frac{1}{8}$ charge, may probably be about the same as with the heavy gun and $\frac{1}{3}$ charge.

English long guns vary, in proportion to their shot, from 420 to 1, to 170 to 1, the proportion increasing in the inverse order of their natures, the 6-pounder having the highest ratio to its shot, and the 42-pounder the lowest. The 32-pounder of 9 feet 7 inches, and the 24-pounder of 9 feet, have 220 lb. of gun to one of shot. The 24-pounder of 9 feet 6 inches, 235 lb.; the 24-pounder of 6 feet 6 inches, 155 lb. to one of shot: it may be seen, from the practice table at page 54, that this difference in the weight of 24-pounders to their shot occasions, with equal charges and elevations, nearly double recoils. This insulated fact ought to be sufficient to occasion some hesitation before the advantages of the old heavy gun be abandoned. Carronades are from 62 to 52 times heavier than their shot. General Millar's new 32-pounder of 8 feet has 168 lb. of metal to 1 lb. of shot. The reamed up guns, recently introduced, from 160 to 190 times heavier than their shot, the lower calibre having the greatest ratio. The French 36-pounder has 200 lb. of gun to 1 of shot; the 30-pounder, 206; the 24-pounder, 213.

Whatever may be the armament of shipping, it is conceived that long heavy guns cannot altogether be dispensed with. M. Duhamel du Monceau has well observed: "Il est certain que ce sont toujours les gros canons qui sont les plus avantageux dans un combat, et ainsi il est préférable de mettre sur un vaisseau un petit nombre de gros canons qu'un plus grand nombre de petits."* If a ship of war were to be armed exclusively with one description of gun; if each gun must necessarily be of the same weight and inevitably loaded with the same charge; it might become a question

* Elémens de l'Architecture Navale, p. 16.

hether the additional thickness of the decks and sides, e increased labour in working heavy guns, the additional expenditure of powder, and the tonnage of guns nd shot, might not more than counterbalance the dvantages of superior accuracy and effect at great anges. All that is here contended for is, that each lass of vessel should have a *portion* of the most effiient guns which her construction may admit, lighter uns of similar calibre being substituted for the broadide work. If, however, guns of great capacity are bly directed, it is difficult to imagine how many, or ather, how few, guns may be required, or how few roadsides discharged: it is, perhaps, questionable wheher a few very heavy guns, as 48-pounders, with a roportion of 10 or 12-inch guns, longer and heavier han those already in the service, may not be the best node of arming any line-of-battle ship. But these are considerations for naval officers. It is not, it may again be observed, within the scope of these remarks to hazard an opinion as to the positive amount of guns, or their especial nature, on board any particular class of vessel, it being a proposition combining too many questions connected with nautical science. What we desire to allude to is, the relative effect and value of ordnance and their projectiles.

It appears not to be generally reflected on that there is a great advantage in favor of the French, on comparing their guns to ours of the *nominally* similar nature, arising, in some degree, from their pound being greater in the ratio of 7561 to 7000, but more particularly from the fact, that their shot are heavier than their nominal weight, whereas ours, when new even, are only the exact weight. We learn from the *Aide-Mémoire* the calibre of French guns, and from the same source we ascertain that the French windage is reduced to 18 points, and for guns of lower calibre than the 16-pounder, to one line:

FRENCH GUNS.			FRENCH SHOT.		
NATURE.	FRENCH MEASURE.		DIAMETER.		WEIGHT.
	Calibre.	Windage	Fr: Mea:	Eng: Mea:	Eng: Mea:
	metre.	metre.	metre.	inches.	lb. oz.
48-Pounder	0·188	0·003	0·185	7·2835	54 5
	p. li. p.	li. p.	p. li. p.		
36 „	6 5 6	1 6	6 4 0	6·7499	43 4
30 „	6 1 0	1 6	5 11 6	6·3514	36 0
24 „	5 7 8	1 6	5 6 2	5·8736	28 8¾
18 „	5 1 6	1 6	5 0 0	5·3298	21 4½
16 „	4 11 3	1 6	4 9 9	5·1301	18 15¾
12 „	4 5 9	1 0	4 4 9	4·6859	14 7

Thus it appears that the French 24-pounder shot weighs 28½ lb. English. The difference of weight between a French and English 24-pounder shot is less only by 1½ lb. than between an English 24 and 18-pounder shot. That this difference is of vast importance, nautical skill being equal, the actions between the Constitution and Guerrière, the United States and Macedonian frigates, sufficiently demonstrate. It may also be observed, that our 32-pounder shot is lighter by 4 lb. than the French 30-pounder, and only 3½ lb. heavier than the French 24: that our 24-pounder shot is only 2¾ lb. heavier than their 18-pounder shot; that we have no nature of heavy gun to answer to the French 36-pounder, the 42-pounder being obsolete, and that even this shot, nominally so much higher than the 36-pounder shot, is 1¼ lb. lighter than it.

As it may be desirable to ascertain the calibre of foreign guns in English measure, and to judge of the weight of shot which each nature is competent to project, the following table has been constructed. The windage allowed by the several nations, and even of the same nation, varies; it is, therefore, assumed to be one ine and half French, for all guns above 12-pounders; and one line for 12-pounders and all inferior calibres. In future wars it will, no doubt, be at least this. The weight of shot which English guns *might* project, if the windage were similarly reduced, is also given to facilitate comparison:

NOMINAL NATURE OF GUN.	NATION.	CALIBRE OF GUN.	WINDAGE.	WEIGHT OF SHOT.
		inches.		lb.
48-Pounder	France	7·2835	One line and half = ·13324 of an English inch.	54·3375
36-Pounder	Sweden	6·9947		45·4293
	Denmark	6·9163		43·8887
	France	6·8811		43·2108
	Russia	6·8390		42·3958
32-Pounder	England	6·4100		34·7751
30-Pounder	Russia	6·4349		35·1911
	France	6·4846		36·0312
24-Pounder	Sweden	6·1107		30·1048
	Denmark	6·0437		29·0362
	France	6·0068		28·7511
	Holland	5·9745		28·0269
	Russia	5·9738		28·0177
	Austria	5·9127		27·1472
	Spain	5·9072		27·0699
	Prussia	5·8705		26·6557
	England	5·8230		25·9026
18-Pounder	Denmark	5·4930		21·6516
	France	5·4630		21·2919
	Russia	5·4276		20·8694
	Holland	5·4076		20·6270
	Austria	5·3719		20·2182
	England	5·2920		19·3062
16-Pounder	France	5·2633		18·9843
12-Pounder	Sweden	4·8508	One line.	15·2765
	France	4·8190		14·8889
	Denmark	4·7765		14·4905
	Russia	4·7414		14·1685
	Holland	4·7204		13·9777
	Spain	4·7080		13·8643
	Austria	4·6931		13·7303
	Prussia	4·6758		13·5764
	England	4·6230		12·1133

It is remarkable that, of similar calibres, English shot are by far the lightest, even with this *unauthorized* reduction of windage. The average weight of a 24-

pounder shot, current in the British service, is under 23½ lb.; this appeared from the weight of several shot, which had been stored under cover and not exposed to the weather.

The Americans arm their lower decks with 42-pounders; the Russians with 36-pounders, which answer very nearly to our obsolete 42-pounder; it is said in the public journals, that they have frigates mounting fourteen 36-pounders on the main deck, with 13 short and 1 long 36-pounder on the forecastle and quarter deck. The French either have introduced, or have determined to introduce, 48-pounders (long guns) on their lower decks; the English weight of the French 48-pounder, as has been shown from the *Aide-Mémoire*, is more than 54 lb. English. The French 36-pounder even, as to range and as to effect, is very far superior to the 32-pounder English. The only advantage of the 32-pounder over the 36 or 42-pounder arises from its being lighter, consequently less trying to decks and sides of the ship, more easily run up and trained, and its shot more conveniently handled. Notwithstanding these important advantages, we shall most certainly be compelled, in the event of war, to place on board our ships a certain number of guns equal in calibre, length and weight, to any which the enemy's vessels of the same class may be armed with, otherwise the catastrophe which occurred to the Macedonian may be repeated.

The new 32-pounder frigates are understood to be magnificently armed ships, and to exceed, as floating batteries, any frigate which has hitherto borne our flag; it is not, however, known whether their armament embraces a portion of heavy 32-pounders. It is as true as any proposition in Euclid, that the new 32-pounders of 48 cwt. can never range with the 32-pounder of 63 cwt., *windage being equal*, and their carriages of the same construction. The only *practical* limitation to an increase of initial velocity, by increase of charge,* is the recoil or strain on the breeching. With equal recoils, the initial velocity of the two 32-pounders will be nearly as the weight of each gun and carriage respectively; that is, as 8064 to 6272, (supposing the carriages of the guns to weigh 9 cwt. and 8 cwt.) or as 9 to 7. With equal recoils, therefore, the heavy 32-pounder may have 1800 feet initial velocity, whilst the light 32-pounder has only 1400. The heavy 32-pounder, at 1150 yards, will consequently penetrate 18 inches into oak, whilst the light 32-pounder can be expected to produce this effect at 800 yards only. It ought also to be remembered, that there is a far greater difference in calibre (nearly twice as great) between the English 32-pounder and the French 36, than between the English 18-pounder and American 24; consequently, the disparity as to range and to effect, between the 32 and 36-pounders, is much greater than between the 18 and 24-pounder.

It has been asserted, that the efficiency of shot is not in proportion to their weights, but to the squares of their diameters only.

A writer in the Quarterly Review, adverting to American line-of-battle ships, observes:

"But then it may be urged that our first and second rates have only 32-pounders, whereas all the Americans have 42-pounders. We may be permitted to doubt whether an adequate advantage be gained by the great calibre of these guns, to that which is lost in the inconveniencies attending the use of them. In the first place, their enormous weight makes an additional thickness to

* Dr. Hutton found that for the gun of 20 calibres, the velocities continued to increase till the charge amounted to ⅛ of the weight of the shot and ·25 of the length of the bore, after which they decreased. That with the gun of 15 calibres, ½ the shot's weight and ·275 of the length of bore gave the highest velocity.

the decks and sides of the ship necessary; they require more men to work them; great exertion in lifting such heavy shot into the gun, and in training and running it out; a considerable additional expense of powder and shot, and a delay in firing, which we think we do not over-state, when we say, that a 32-pounder will fire three rounds, while a 42-pounder fires only two. If, however, the effect produced by a shot was in proportion to its weight, the objections we have stated might not be considered to weigh against its adoption; but, unquestionably, it is not. The weights of shot are as the cubes of their diameters, and a 32-pounder being about 6·12 inches in diameter, and a 42-pounder no more than 6·75 in diameter, it follows that the holes made in a ship's side by these two shots will be of the same diameter within six-tenths of an inch; that is to say, the difference, if the shot goes fairly through, will not be perceptible by the eye, scarcely even by measurement. The difference between a 24-pounder and a 32-pounder is still less, not exceeding five-tenths of an inch. In fact, the efficiency of shot, in passing through a ship's side, will be in proportion to the squares of their diameters, and not to their weights."*

These enumerated difficulties attending the use of 42-pounder shot, we fully admit, and have before adverted to them, except that we deny, "that a 32-pounder will fire three rounds while a 42-pounder fires only two." It is urged as an objection to the 42-pounder, that it requires more men. This being granted, and the extra men appointed to the 42-pounder, we see no reason why it should fire less frequently than the 32-pounder. The time employed in spunging, serving the vent, pointing and elevating, will be the same. The extra power being applied to run up the 42-pounder, it will fire in equal times with the 32-pounder.

* Quarterly Review, lxxiii, p. 275.

But this argument might have been spared, since, if it can be shewn that the effect produced by a shot *is* in proportion to its weight, the reviewer himself admits that the objections advanced by him cannot fairly be made to weigh against the adoption of the 42-pounder.

It cannot be questioned but "that the holes made in a ship's side by 42 and 32-pounder shots, will be of the same diameter within *about* six-tenths of an inch;" it is equally true that the opening or orifice of shot holes, if answering to their shot and circular, are as the squares of their diameters; but at considerable ranges, it is absolutely necessary to take into account the penetrating power of shot and the superior accuracy of practice with guns of great calibre. The splintering or shattering of the wood, where shot, with equal velocity, take effect on the hull or masts, or any considerable spars, is also, as the calibre increases, greater than as the squares of the diameters, but this may be disregarded.

Continuing to use Dr. Hutton's equation for ascertaining the remaining velocity of shot and the ordinary formula for penetration, the following results appear upon the data afforded by Mr. Robins' practice:

Nature of Shot.	Initial Velocity.	At 500 yds.		At 1000 yds.		At 1500 yds.		At 2000 yds.		At 2500 yds.	
		Velocity.	Penetration.	Velocity.	Penetration.	Velocity.	Penetration.	Velocity.	Penetration.	Velocity.	Penetration.
	ft.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
42-Pounder	1600	1184	39	887	21¾	676	12¾	525	7½	427	5
32-Pounder	1600	1116	31½	815	16¾	608	9¼	465	5½	367	3¼

The practice table, inserted at page 36, offers results nearly corresponding to the above calculations.

It has been shewn, (pages 16 and 17,) that the chances of hitting at ranges exceeding 1000 yards with shot of different calibre, initial velocities being equal, are at least as the squares of the diameters. Supposing D, d, to denote the diameter of two shot of different calibre projected to ranges exceeding 1000 yards; V, v, their remaining velocity, or that with which they impinge upon the object fired at, then

The orifices will be .... $D^2 : d^2$
accuracy.................. $D^2 : d^2$
penetration .... $DV^2 : dv^2$
general effect .... $D^5V^2 : d^5v^2$

The diameter of the 42-pounder in use is 6·684 inches, and of the 32-pounder 6·105;* the velocities, at 1500 yards, 676 feet, and 608 feet. The compound effect, therefore, would be as 195 to 100, or as 2 to 1 nearly. Without, however, contending that the values of the 42 and 32-pounders, at ranges exceeding 1000 yards, are in this ratio, it may fearlessly be asserted, when their superiority as to accuracy of practice, extent of range and depth of penetration, are conjointly considered, that the 42-pounder is superior to the 32-pounder in a ratio fully proportioned to their weights; consequently, by the admission of the objectors to heavy guns, 42-pounders may consistently, and with advantage, be admitted into use.

The substitution of the 9-pounder for the 6-pounder, in the campaigns of Portugal and Spain, has been adverted to, (page 17,) in proof, that the range and precision of the 9-pounder is held to be superior to that of the 6, at least, in proportion to their weights: it may thence fairly be argued, that if field pieces are efficient in the ratio of the weight of shot, in a much higher ratio ought the value of ship guns to be estimated. In the land service, the transport of ammunition is

* The shot gauges, established in 1825, for land service, are for the 42-pounder, 6·795 and 6·729; for the 32-pounder, 6·207 and 6·147. These shot have not come into use.

attended by great labour and expense: in the sea service, the transport of ammunition is comparatively both cheap and easy. In the field, generally speaking, the penetration of shot is of little moment: against shipping, and particularly at considerable ranges, the penetration of shot is of the utmost consequence.

In admitting the advantage of the 32-pounder over the 36 and 48-pounders, as to the comparative celerity and ease with which it may be fought, it should be observed, that these guns ought only to be used with the full charge when a great range is required, at which time precision is infinitely more important than quickness of firing. Deliberate shots make efficient practice. On close engaging, to produce, with heavy guns, the greatest effect, the charges must be reduced, when the decrease of recoil will make up for the exertion in running up: at this crisis of an action, shells (or hollow shot, if it must be so,) may advantageously be substituted for solid shot. The gun tackles for heavy guns may probably, with great advantage as to labour, be furnished with the Garnet's blocks for decreasing friction by rollers. These blocks, which have been invented many years, and which appear to stand every practical and scientific test, have not come into general use, as it may be assumed, from their cost; but it must be admitted, that if the perfectioning a block, or a system of blocks, for the tackles of a gun, can spare the labour of only two men, their adoption, however great the expense, must be rigid economy.

To reduce the velocity, and at the same time to project a heavier broadside, guns are often doubly shotted; but it is very questionable whether this practice is desirable, unless the object be within a very short range. The custom of doubly and trebly shotting guns may, in some measure, account for the comparatively little damage to the hulls of line-of-battle ships in general actions. Not a single line-of-battle ship was, it is believed, sunk in action during the whole war. The velocity of a 32-pounder shot from a double-shotted gun, with a charge of one-third the single shot's weight, cannot, *with the present windage*, be expected to penetrate more than 30 inches, at a greater range than 100 yards. It is very possible that an occasional shot, perhaps a very high shot, may sink deeper, but the penetration of double shot at this range will generally be less. At a range of 500 yards, the double shot may penetrate to the depth of 18 inches. The writer in the article in the Quarterly Review on the United States of America, before referred to, states, that the sides of the American ships are about one-third thicker than ours, and that the live oak is carried up to the top of the bulwark. On any collision with America, this fact will become a consideration in naval gunnery.

In Sir Howard Douglas' treatise on naval gunnery,* it is given, from the French, that two round shot should not be used at a greater range than 852 yards.

Against boats or men uncovered, double-shot, if they attain their object, (of which, from the frequent irregularity of their flight, there is much reason to doubt,) may at this range be available; but it is not the *first graze* of shot which will meet all the desiderata of a cannonade against shipping. Round shot from heavy guns can be employed with satisfactory accuracy to ranges of a mile, but would any man, on this ground, attempt to build an argument for battering in breach at this range? If, indeed, penetration were in proportion to the momenta of shot, there might be good reason for using two shot at much greater ranges than we would apply them, but this is not the case; it is the less necessary to dwell on the

* Second edition, p. 173.

ubject, as it has been already adverted to.* Since ecoils from guns with different weights of shot, initial elocities being equal, are necessarily (page 10) as those weights, a double-shotted gun will recoil twice as far as a single-shotted gun, the penetrating power of the shot being equal. Consequently, as far as relates to the running up the gun,—the most laborious of the duties of the gun detachment,—the single-shotted gun has a double advantage over the double-shotted gun. On the other hand, the doubly and singly-shotted guns are loaded and fired in the same space of time. The general result, therefore, as to celerity in discharging shot, is greatly in favor of the doubly-shotted gun.† Against which must be set the infinitely greater accuracy of the single shot, the diminished strain and trial of the breeching and of the ship's sides, and the decreased exertion and labour of the men. The double-shotted gun will obviously require, for the same velocity, a double charge. The single shot, with a charge of $\frac{1}{6}$, will penetrate as deep, at the same range, as the double shot with the full service charge of $\frac{1}{3}$; the expenditure of powder will, therefore, be the same, to project, with equal velocities,

* Page 28 to 42.

† The author is not competent to form a correct opinion as to the exact time necessary for the performance of the several duties of a gun detachment with takles and on board ship. Much may be supposed to depend on the state of the sea and the steadiness of the ship. A garrison 24-pounder may be pointed, fired, loaded and run up, a wad-hook as well as spunge being used after each round, in rather less than two minutes; the usual time of quick firing is twenty times in an hour, at which rate of firing, if a wet spunge be occasionally used, there is no fear of the guns becoming too hot for use, as sometimes supposed. At the siege of St. Sebastian, 300 to 350 rounds were constantly fired from an iron 24-pounder, in battering, during the day of 15½ hours; this appears from the work by Sir John May, of the artillery, (*Observations on the mode of attack at Cuidad Rodrigo, Badajoz*, &c., p. 21,) from which also we learn, that 150 rounds, from a 24-pounder with a charge of 8 lb., were fired in 8 hours and 57 minutes; the thermometer in the air standing at 62°; after 50 rounds it was 83° in the gun, 24 minutes being consumed in examining the bores and vents; after 100 rounds, 92°, 72 minutes being employed in the examination; after the 150, 90°. In another gun similarly fired, the thermometer, after 50 rounds, was 82°; after 100 rounds, 92°; after 150 rounds, 89°: 100 rounds were fired, each 25, in 96 minutes; the thermometer in the gun, after each 25, was, respectively, 71°, 79°, 78°, 71°. A field gun may be fired nine times, and regularly spunged and loaded eight times in the minute.

the same quantity of shot, whether from double or single-shotted guns.

Treble shots can never be expedient, unless it be to rake the stern of an antagonist. From treble shots, a penetration of 30 inches cannot be expected at the closest range, nor even 18 inches at a greater range than 150 yards: there is the less reason, therefore, to be surprised at the facts occasionally appearing in official reports of actions. In that detailing the resistance made by Le Guillaume Tell against the Penelope, the Lion and the Foudroyant, it is said, "the Lion was run close alongside, the yard-arms of both ships being just clear, when a destructive broadside of three round shot in each gun was poured in, luffing up across the bow, when the enemy's jib-boom passed between the main and mizen shrouds." The report further states, that after a short interval the ships disengaged, and the Lion maintained a position across the bow, firing to great advantage; that after a continuance of the action for about forty minutes, the Foudroyant came up, and a heavy fire from both these ships and the Penelope was poured in; yet, after this raking cannonade of forty minutes, at a very inconsiderable distance, with trebly-shotted guns, the Guillaume Tell was enabled to cripple the Foudroyant, for it is said in the dispatch: "The crippled condition of the Lion and Foudroyant made it necessary for me to direct Captain Blackwood to take possession of the enemy and proceed to Syracuse."*

Reverting to the propriety of reducing the charge of heavy guns as the range lessens, it is imagined that advantage would arise to the service if the filled ammunition were made up in three different coloured cartridges to contain three different charges, $\frac{1}{3}$, $\frac{1}{4}$ and $\frac{1}{6}$,

* See the official report of Sir Manley Dixon on the capture of Le Guillaume Tell.

he weight of solid shot. The $\frac{1}{3}$ may be filled in white lannel; the $\frac{1}{4}$ in blue; the $\frac{1}{6}$ in red: these cartridges nay be packed in cases of the same colour; a general rder from the admiralty and ordnance might make nown the design of the conventional colours and precribe that with round shot; *the windage being reduced*, he white cartridge should be used at long ranges; the blue from 600 to 200 yards, where 30 inches penetration into oak may be required; and the red within that distance. Where a penetration of 18 inches may be considered sufficient, blue cartridge may be used from 800 to 600 yards, and the red within that range. With the present windage of $\frac{1}{20}$ the diameter of the shot, the ranges to produce these penetrations must be reduced about 150 yards. So far from confusion or perplexity arising from this arrangement, order and simplicity must proceed from it, since a simple instruction, as to colour, to the gunner, or persons appointed to serve ammunition from the magazine, would at once secure the employment of the intended cartridge by every gun in the ship using round shot.

The charges for the shells, both from the guns and howitzers, might similarly be made up in flannel of different colour; and, as it is advisable that the momentum should be so regulated that shells, *if loaded*, may not pass through the side of a ship, it would be desirable that cartridges should be filled to correspond with fuzes for certain ranges, the case containing the shell and that containing the cartridge may be painted of the same colour with the cartridge. Each range for shell as well as shot having, throughout the navy, a particular colour attached to it. Further, the range may be lettered on each shell and cartridge case.

It is said that the Americans make up their ammunition in very thin sheet lead. This must certainly be an admirable plan, as it affects the preservation of the powder and the avoidance of danger from the ignition of the cartridge when in transit to the gun. If introduced into our service, and the measure above adverted to be adopted, the ends may be painted of the conventional colour.*

It has occurred to the author that copper cylinders, with a cover to fit over each end, may beneficially supersede those of wood now used for the transmission of cartridges to their guns. The covers to the cylinder may have small loops to run a cord through, by which to suspend it; the cylinder itself having similar loops, as near one end as may be without interfering with the cover. On the springing of the spunge, the top cover may be slipped off, and the end of the copper cylinder inserted in the bore of the gun; the bottom cover, that near the loops of the cylinder, may be then taken off and the cartridge thrust by the left hand, the body of the man who loads being clear of the gun, through the copper cylinder into the bore: or the cylinder may have only one cover, the bottom being made to run in it, checked at the top by a projection; the cartridge may, therefore, be pressed forward by the bottom into the bore of the gun. This operation can be effected in as little time as the spunge can be turned or exchanged for a rammer. It must always be of importance to guard against the accidental explosion of powder, and particularly so when the use of live-shells is at all contemplated; the slight additional trouble in loading, (it consumes no time,) must, therefore, it is conjectured, be amply compensated by the additional security offered

* It is said that cartridges of lead obviate the necessity of spunging after each round; this is probable, but it requires to be established by conclusive experiments. The old Hanoverian rammer, the upper part of the stave made like a winch, may be used for the experiment. At the same time, it may be determined how often the fouling of the gun will require the spunge.

o it. The author has seen a cartridge take fire and explode, from the fire of a contiguous gun, at the moment the gunner was about to put it into the bore; this crisis, the only one to which it is believed the unprotected cartridge has hitherto, *by authority*, been exposed on board ship, may therefore be provided against. To ensure the cartridge being placed in the gun correctly, that is, with the seam down and the choke towards the muzzle, the cylinders may have a painted line inside and out, and a notch on the top of this line; or a line may be stamped, convex outside and concave in, but not extending far enough to interfere with the covers: in the dark, therefore, the cartridge may be placed in the cylinder choke foremost, with the seam in (some degree) corresponding with the notch or line. The line or projection on the surface of the cylinder, being kept under when inserted in the bore, the cartridge must be placed correctly in the gun, for the loops of the cord at the bottom will render it impossible to place the wrong end in.

EMPLOYMENT OF SHELLS AND THEIR EFFECTS.

A GREAT necessity for the employment of long guns of great calibre has arisen from the introduction of shells into the marine of foreign countries. It has for many years been an impression with some artillery officers in our own service, that shells might be used on board ships of war without any extraordinary risk and with very important results. In the commanding and triumphant position of our navy, an introduction of this formidable weapon could not, however, have accelerated her triumphs or rendered them more easy; but might have abstracted from their certainty, and must have rendered her victories more ensanguined.

It is no longer a matter of opinion whether *filled* shells shall, or shall not, be employed on board ships of war; they are admitted into other navies, and must, sooner or later, be resorted to by us. Lieut.-Colonel Paixhans, of the French artillery, first introduced them to the notice of the French government, as applicable to naval warfare, when he proposed his, *canons à bombes*, or heavy iron howitzers. These guns, with a substitution of the gomer or truncated cone chamber with hemispheric bottom, for a cylindrical chamber with conical junction to the cylinder of the gun, have been introduced into our own service by Lieutenant-General Millar, whose improvements in the carriage department had brought the materiel of our field artillery to that high perfection, which has called forth the admiration of all Europe, and has led the French to adopt it almost in every particular, the only important difference being the retention of the pole.

Colonel Paixhans' system, to a certain extent, revives the opinions of the inventor of the carronade, with this great difference, he has wisely augmented the weight of the gun. His plan, if divested of all extraneous matter, is simply this, to introduce into the navy iron howitzers of very reduced windage; and, in fixing the weight and dimensions of these *bouches à feu*, to construct guns of an equal weight with the long guns with which they are, by him, destined to act and ultimately to supersede, and of the greatest calibre which the fixed weight of metal may admit.

Upon this principle he constructed a gun, which has since been received into the French navy, six being placed on board each line-of-battle ship; its weight is that of the 36-pounder, (7200 lb. French,) discharging a concentric shell, *boulet creux*, weighing from 54 to 56 lb. loaded; the weight of gun to projectile being, as 130 to 1; its length rather more than 12 calibres; the calibre, 8 *in.* 2 *l.* 9 *p.* The ordinary charge of this gun was designed to be from 10 to 16 lb., but was fired with 26 lb. and a solid shot of 80 lb. without producing the most minute alteration in the bore, subsequently submitted to the most critical examination.

The following guns and projectiles were likewise proposed by M. Paixhans; the weights and measures are French:

Weight of Projectile.		Length of Gun.	Calibre of		Windage.	Proposed charge of Gun.	Powder contained in Shell.	Weight of Gun	answering to	Number of pounds of gun to each pound of	
Solid.	Holl:		Gun.	Projec:						Filled Shell.	Solid Shot.
lb.	lb.	pouces.	po. lg. pt.	po. lg. pt.	lg.	lb.	lb. on.	lb.	Pdr.		
150	102	100	10 1 6	10 0 6	1	12	6 4	10800	48	100	72
80	50	91	8 3 0	8 2 0	1	8	4 0	7200	36	133	90
48	33	86	6 11 6	6 10 6	1	6	2 4	5100	24	144	106
39	27	83	..	..	1	..	..	4200	18	155	107

Colonel Paixhans at first, with much discretion, proposed that his guns should project *hollow shot;* he evidently feared to shock long established prejudices, by at once proposing charged shells. His real design, however, he is at no pains to conceal; he even goes so far as to express an opinion, that the use of shells will absolutely supersede the use of shot in every case against shipping. In reply to the supposed question, whether a vessel, armed with his guns and provided with shells, shall continue to retain the power of using common shot, he commences by observing: "Cette objection ressemblerait beaucoup à celle-ci: un bataillon armé de bons fusils, aura-t-il la faculté de tirer avec des arbalètes?" In another place, he observes: "Mais l'incomparable avantage du nouvel armement, serait l'action comme fougasse des projectiles creux, dont l'explosion produit des effets destructeurs auxquels nuls autres effets ne sauraient être assimilés."* Much as we advocate the propriety of using shells, since other nations will certainly do so, we cannot go to the full extent of M. Paixhans' reasoning; we conceive that no ship of war should be without the power of enforcing respect at great ranges; therefore, the ordinary long gun (even of increased calibre) and solid shot are indispensable.

M. Paixhans proposed that the fuze should be of metal, and made to screw into the shell; he borrows from the Saxon artillery, the plan of filling the shell by a small orifice near the fuze hole. This would be an improvement in our own service, as it is very difficult, if not impossible, to fix the fuze in a shell charged with the whole of the powder which its capacity may admit. This inconvenience is the more felt when Valenciennes, or other incendiary composition, is placed in the shell, which, with large shells, would usually be the case against shipping. The filling hole may also be beneficially applied to the Shrapnel-shell. M. Paixhans proposes that this hole should be conical and plugged with wood: but it may be better to apply a screw of iron or copper, the top of which may be assimilated to the surface of the shell; the screw may have two small holes, as the joint screw of a common pair of compasses, but larger, to receive a corresponding instrument for its insertion or removal. Similar screws may be made for the fuze hole, a few of which may be furnished to each gun, as, in the event of great range and accuracy being required, it may be desirable to fill the shells with lead, when $\frac{1}{4}$ and $\frac{1}{6}$ the solid shot's weight, (a blue and a red cartridge,) will together make up a charge equal to $\frac{1}{3}$ the weight of the leaded shell. Screw fuzes have long been used with Shrapnel-shells; no good reason appears why they should not become general in the service; it would certainly be

* Page 261.

advantageous if they were all of metal, and in the end the expense may not be greater: not only do fuzes, fixed in the ordinary way, sometimes come out, but it often happens, that the wood of the fuze decays when the composition is as good as when driven; this especially occurs in warm climates. A well-conceived economy might embrace the proposition, that in war, especially in naval warfare, the effect of a few, or even a single, shot, is sometimes so important, and the machinery so complicated and so expensive to project this shot, that any expense attending the refinement of the projectile itself is as a mere straw in the balance, a subject unworthy of consideration.

The subjoined practice presents the average of three rounds, shot and shell, from Colonel Paixhans' 80-pounder; weight of solid shot, 80 to 83 lb.; of hollow shot, 56 to 58 lb. Also the media of an equal number of rounds from the 36-pounder, current in the French service; weight of shot, 38 to 39 lb.; of hollow shot, from 26 to 27 lb. The weights are in French measure; the ranges in English yards:

80 AND 36-POUNDER PRACTICE, AVERAGE OF THREE ROUNDS.—BREST, OCTOBER, 1824.						HOLLOW SHOT.		
NATURE OF GUN.	Charge.		Elevation.	RANGE.		Computed inl: velocity.	Computed rem: velocity	Computed penetration.
				Solid.	Holl:			
	lb.	oz.		yards.	yards.	feet.	feet.	feet.
80-pdr. *Canon à Bombes.*	10	0	3°	1682	1670	1340	462	5·36
36-pounder............	7	3	3°	1760	1704	1608	391	3·01
80-pdr. *Canon à Bombes.*	10	0	5°	2127	1965	1340	397	3·96
36-pounder............	7	3	5°	2416	1920	1608	341	2·29
80-pdr. *Canon à Bombes.*	12	6	8°	2304	2418	1440	336	2·83
36-pounder............	9	0	8°	2348	2350	1800	287	1·61
80-pdr. *Canon à Bombes.*	12	6	10°	2418	2558	1440	318	2·54
36-pounder............	9	0	10°	2752	2504	1800	267	1·40
80-pdr. *Canon à Bombes.*	16	8	16°	3630	3096	1662	277	1·91
36-pounder............	12	0	16°	3800	3330	2078	207	·84

MEM.—*The guns were of equal weight, 69 cwt. 1 qr. 20 lb. English; the 80-pounder, 8 ft. 1 in.; the 36-pounder, 9 ft. 7 in. English.*

This practice offers, by the ranges, very satisfactory evidence as to the great effect of diminished windage; but the results, if looked into, offer no encouragement for the use of uncharged hollow shot against shipping, or in any case where the penetration of the projectile is necessary, except at very limited ranges. With a view to facilitate comparison, the computed initial and remaining velocity, and penetration of the hollow shot at the several ranges, are added. Although these calculations may be erroneous, yet they offer tolerable grounds for comparison; it is probable, where error exists, that it is common to each result. Dr. Hutton's formula, by which, with Mr. Robins' penetrations, these results are obtained, also leads to the belief that M. Paixhans' 80-pounder hollow shot, with the charge of 16½ lb., will not penetrate 25 inches into oak, at a greater range than 800 yards; and to a depth equal to its diameter, at a greater range than 1700 yards.

The following table presents a comparison of the probable effect of hollow and solid 36-pounder French and 32-pounder English shot; the 36-pounder shell weighing 29 lb. English; the 32-pounder shell, 15 lb. 4¼ oz.

Nature of 36-Pounder Projectile.	Range.	Initial Velocity.	Remaining Velocity.	Penetration.	Nature of 32-Pounder Projectile.	Range.	Initial Velocity.	Remaining Velocity.	Penetration.
	yards.	feet.	feet.	inches.		yards.	feet.	feet.	inches.
Hollow.	500	1600	1004	19·84	Hollow.	500	1600	820	8·09
Solid...			1178	39·45	Solid...			1148	33·23
Hollow.	1000	1600	654	8·41	Hollow.	1000	1600	450	2·44
Solid...			880	22·02	Solid...			838	17·71
Hollow.	1500	1600	447	3·93	Hollow.	1500	1600	293	1·03
Solid...			668	12·68	Solid...			624	9·82
Hollow.	2000	1600	325	2·07	Hollow.	2000	1600	216	0·56
Solid...			517	7·60	Solid...			476	5·71
Hollow.	2500	1600	253	1·26	Hollow.	2500	1600	180	0·38
Solid...			410	4·78	Solid...			375	3·54

The diameters of these 36-pounder and 32-pounder shells, are 6·75 and 6·015 inches; their specific gravity, as 4 to 3 nearly; the vast importance of the specific gravity of shot, as it affects remaining velocity, as well as penetration, is therefore apparent from this table. In fact, the adoption of hollow shot is tantamount to recurring to projectiles which have long been exploded by all nations but the Turks; it is equivalent to using granite shot. It matters little, for practical purposes, what the projectile be formed of, so that its density be what we desire. Whether it be hollow iron or solid granite, if its volume and specific gravity be the same, the effects will be nearly identical. Now, the granite shot which fell on board the Windsor Castle, in forcing the passage of the Dardanelles, in 1807, and nearly cut her mainmast in two, is said to have weighed 800 lb.; consequently, its diameter would be 24·1473 inches. A shell of iron of this diameter, and 3·8265 inches thick, will exactly weigh 800 lb. The historian Guicciardini, who was also distinguished as a general officer, writing in the beginning of the sixteenth century, speaks of the introduction of iron shot, by the French, in the campaign of 1494, as a vast improvement in the service of artillery, and this belief has never since been questioned, except by the inventors of the carronade and the promoters of this same system, improved by M. Paixhans. The invention of hollow shot did not stand its ground on the introduction of carronades, nor will its use, it is firmly believed, be extended to the end of the first year of a war.

Before the introduction of iron shot, it was necessary to use guns of vast calibre to obtain the requisite momentum; such shot as that thrown into the Windsor Castle were by no means uncommon. Mr. Robins, in the preface to his *Principles of Gunnery*, speaking of the great advantage of iron shot, adverts to the fact, that Mahomet the Second battered the walls of Constantinople, in 1453, with stone shot weighing 1200 lb.; an iron shell of this volume and density would contain 224 lb. of powder; the projectile of the *Antwerp monster*, and of the famed *Foul-wench of Dresden*, were nothing to this. All people, using stone shot, have had recourse to guns of great calibre, and all, except the Turks, have relinquished the use of stone for iron. The great gun removed, in 1803, by order of Lord Lake, from Agra, and which broke through the raft, employed to convey it down the Ganges, is said to have been 14 feet in length, and, like the Dardanelles gun, 24 inches in calibre.

The diminished density of shells is compensated by their charge; but, take away this charge, and their value is that of granite shot. *If loaded shells were prohibited*, hollow iron or solid granite shot, of high calibre, would be admirably calculated to defend a narrow passage against shipping, because the required velocity being low, the greatest damage would be occasioned to an enemy at the least possible cost of ammunition and of labour. Similarly, *if the use of loaded shells from shipping be prohibited*, it would be advantageous, at very short ranges, to project granite shot, or any missile of great volume, with small charges and from comparatively light guns; but as a ship, unlike a battery commanding a narrow strait, is not always at the same range, the inefficacy of light guns and hollow shot, for general purposes, (bearing in mind the necessary penetration and not the range only,) is not compensated unless the projectile be charged. The efficiency of the hollow shot cannot obviously be diminished by its charge, and that it may be much augmented may possibly be conceived, if we attempt to imagine the result, had a shell of iron, of the same size and weight as the Dardanelles shot, filled with the powder which it is competent to contain, 150 lb., been burst on board the Windsor Castle. What vestige of her would have remained?

The following tables contain some particulars respecting General Millar's guns à la Paixhans :

Calibre of Gun.	Calibre of Projectile.	Windage.	Length of Gun.		Length of Chamber, or altitude of Frustrum of Cone.	Powder contd. in Shell.	Weight of Project: Hollow.	Weight of Project: If Solid.	Weight of Gun.	Weight of Carriage.		Weight of Slide.		Number of lb. of Gun to each lb. of Projectile. Hol:	Number of lb. of Gun to each lb. of Projectile. Sol:
in.	in.	in.	ft.	in.	in.	lb.	lb.	lb.	cwt.	cwt.	qr.				
12	11·85	·15	9	2	16	9	122	234	100	17	2	..		91	48
10	9·88	·12	9	4	15	4	72	135	84	13	2	25	2	130	70
8·05	7·95	·1	9	2	13·25	$2\frac{1}{2}$	$33\frac{1}{2}$	70	60	..		..		200	96

PRACTICE WITH SHELLS FROM THE ABOVE GUNS.

12-Inch.

Charge.	Elevation.	Time of Flight.	Range.	REMARKS.
lb.			yds.	
10	$1\frac{1}{4}$°	..		
11	1°	..	400	....
	$\frac{3}{4}$°	..		
		$2\frac{3}{4}''$	750	
		$2\frac{3}{4}''$	750	Medium at 2°.
	2°	$2\frac{3}{4}''$	843	Range, 806 yds.
		3″	818	Flight, $2\frac{17}{20}$.″
		3″	872	
		$4\frac{1}{2}''$	1032	
		$3\frac{3}{4}''$	1000	Medium at 3°.
12	3°	4″	976	Range 1030 yds.
		4″	1087	Flight, 4″.
		4″	1060	
		$5\frac{1}{4}''$	1233	
		5″	1247	Medium at 4°.
	4°	$4\frac{3}{4}''$	1141	Range 1232 yds.
		5″	1210	Flight, $5\frac{1}{20}$.″
		$5\frac{1}{4}''$	1330	

10-Inch.

Charge.	Elevation.	Time of Flight.	Range.	REMARKS.
lb.			yds.	
	1°	..	400	
		3″	856	
		$2\frac{3}{4}''$	816	Medium at 2°.
	2°	3″	782	Range, 775 yds.
		$3\frac{1}{4}''$	795	Flight, $2\frac{9}{10}''$.
		$2\frac{1}{2}''$	630	
		..	1027	
		..	1006	Medium at 3°.
8	3°	..	970	Range 1027 yds.
		..	1150	Flight, 4″.
		$3\frac{3}{4}''$	1034	
		$4\frac{1}{4}''$	1020	
		..	1215	
		..	1300	Medium at 4°.
	4°	..	1237	Range 1231 yds.
		..	1107	Flight, $4\frac{1}{4}''$.
		$4\frac{1}{4}''$	1280	
		$4\frac{1}{4}''$	1250	

The practice with these guns has not been carried to an equal extent as in the French service, nor does it appear desirable to attempt an extreme range, by means of high elevation, with the low velocities which the proportional metal of these guns admit; the practice would become too uncertain. If the charges were increased to obtain the higher velocities, the recoil of the gun, or the strain upon the breeching, would be productive of much inconvenience. Practice with the 8-inch gun, the weight of metal of which bears the highest ratio to its shot, and therefore admits of greater velocity, could not conveniently be procured. The precision of fire from a gun of this description on board the Phœnix, at St. Sebastian, in May last, at a range of about 1200 or 1300 yards, is highly spoken of; this might have been anticipated from its small windage. The Christino infantry, under the orders of General Evans, had much cause to extol the effects of its loaded shells. All accounts, Carlist, Christino and British, concur in attributing to the unexpected arrival of the steamers, the recovery of the day and the success of the attempt made by the Christino general to carry, by a front attack, the formidable intrenched positions of the Carlists.

The relative effects of shells may, in some measure, be judged by the powder contained in them respectively; but, without a filling hole independent of the fuze hole, the quantities, as detailed below, or near those quantities, cannot be used with mortars or for vertical fire, since a fuze of the required length could not be fixed:

Powder contained in Shells for Guns.								Powder contained in Shells for Mortars and Howitzers.				
12 in.	10 in.	8 in.	42 pdr.	32 pdr.	24 pdr.	18 pdr.	12 pdr.	13 in.	10 in.	8 in.	5½ in.	4⅔ in.
lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.
13 13	6 8	2 9	1 8	1 2	0 15	0 12	0 6	11 4	5 9	2 14	0 13	0 6½

There is no attainable range where the effects of aded shells will not prove highly important, if ably nd judiciously employed. A shell, deriving its destructive force from its explosion, is most efficient when enetrating to that depth in the side of a ship, at which olid shot would absolutely be ineffective.

The great objection made by many to the introduction f the use of shells on board ship, is the supposed risk rom the accidental ignition of the fuzes of fixed shells. This difficulty has been met and answered by a naval officer of much experience in this respect, and of great listinction in the service into which he entered, and in which he fell. Captain Hastings, of the Greek steam vessel of war, the Karteria, says: "An objection which I have frequently heard made to the use of shells on board ship, is the danger of having a quantity of loaded shells continually on board. To me loaded shells have always appeared less dangerous than powder in cartridges, or in any other form. I placed each loaded shell in a box; these were stowed in the shell-room in rows, retained by stanchions and shifting battens; and on the lid of each box was written the length of the fuze and nature of the shell; each shell was handed up in its box, and only taken out of it at the moment of being placed in the gun; how there can be any danger in using shells thus, sufficient to justify an objection to their use, I am at a loss to conceive; certainly, there is danger in using gunpowder at all, but there is a less liability to accident from a shell than from a cartridge; and I am prepared to prove, however paradoxical it may appear at first sight, that the liability to accidents from explosion on board a ship, is much diminished by the use of shells. I have fired about eighteen thousand shells from this ship, and have never had the slightest accident from explosion; the guns have never broken a breeching, drawn a bolt, or injured a carriage. I was but in two naval actions in the British service, in each of which we had accidents. In the Neptune, in the battle of Trafalgar, an explosion on the lower deck killed and wounded sixteen men. In the Seahorse, with the Badla Zaffar, a gun, going off while loading, killed one or two men."*

To the necessary precaution of a box for each shell, the French introduced into their service, in 1824, a cap with a screw for the top of the fuze, which is only taken off when the shell is actually placed in the muzzle of the gun; this fuze has been adopted into our own service: so effectually does this plan secure the fuze composition, that a loaded shell, fixed with a copper screw-fuze and screw-cap, has been placed for some seconds, without exploding, in a flame occasioned by the burning of chips and shavings; subsequently immersed in water without injury, and immediately after fired with effect. As it is advantageous, so to fix the fuze as to offer no projection above the surface of the shell, which might easily be effected if the fuzes are of copper, the cap to the fuze should have a ring or projection by which to unscrew it.

Without the precaution of the screw-capped fuze, there can be little risk of explosion, if the fuzes are never uncapped but in the muzzles of the guns. If uncapped at the muzzle, and at the instant of uncapping a spark should ignite the fuze, a port being immediately at hand, the fuze must be very short not to afford time for hurling the shell into the sea, and for allowing it to sink a sufficient depth to be innoxious to the ship's side. It must be observed, that it is only at long ranges that shells would be fired, from the long guns, with high velocities. Neither the 10 or 12-inch guns at present employed in the service, or those broadside-guns which

* Memoir on the Use of Shells, &c., p. 12.

is proposed to introduce, project their missiles at high elocities; the fuze, therefore, at short ranges, would e, proportionally, much longer than those at great anges. Unless the shell were home on the powder, here would be some chance, particularly if the shell vere high, of bursting the gun by immediately firing it; otherwise, there is no reason to fear that the shell by ursting in the gun, will do any harm, as the splinters re necessarily thrown forward. The author has more han once seen a shell burst in a brass howitzer without loing further harm than slightly injuring the metal near he muzzle.

If shells, even in very limited numbers, are introduced into our navy, it ought to form part of the exercise of seamen to set fire to fuzes fixed in empty shells, or shells only charged with blowing powder, and to practice throwing them, that in the event of any accidental ignition to the fuze of a loaded shell, they may be prepared to act with that promptness and assurance which may avert the danger.

It has been proposed to burst shells by percussion; if it were desirable to ensure the bursting of the shell on striking the ship's side, it may be effected by a contrivance which the author carried into practice in the year 1809; and which is not liable to the objections made to the use of percussion powder. The plan is not given, for, although very simple, it is not generally known.

It is possible to suppose many cases, both on board ship and ashore, where, in the hands of very steady seamen and in limited numbers, advantage may arise from the use of grenades and the capability of seamen to throw them. The American Lieutenant Budd, who succeeded to the command of the Chesapeake on the fall of Captain Lawrence, in his official report to the secretary of the navy, ascribes the confusion on board the Chesapeake, which led to her capture, to the blowing up of an arm chest on the quarter deck by a grenade said to have been thrown from the Shannon. It is not known whether or not a grenade was thrown from the Shannon; but it appears highly probable that the confusion, of which Captain Sir Philip Broke so nobly took advantage by boarding, was occasioned by an explosion.

The introduction of shells on board ship would obviously render additional magazines or shell-rooms necessary: it may be desirable, as a general principle, that shells should be charged and fixed on shore, or in a boat at a distance from the vessel, although, with screw fuzes, greater liability to accident could not attend the insertion of a fuze in a shell than the filling an ordinary cartridge; and if the filling hole, as used in the Saxon artillery and before referred to, were adopted, no greater danger could arise from the loading of the shell.

An idea seems to prevail, but as it is believed erroneously, that steam ships are alone fitted for the projection of shells. If, indeed, the use of loaded shells were, by the consent of all naval powers, limited to steamers, and if their armament embraced one long heavy pivot gun, or two heavy carriage guns, as well as their capacious howitzers, it is very credible that line-of-battle ships would soon be known only in the records of by-gone times: most assuredly, however, self-defence will, after the first few months of a naval warfare, compel the appropriation of a proportion of shells to every ship of war that puts to sea, and to guns of the greatest range. It will then be seen whether steam ships prove as efficient as many naval officers anticipate.

Captain Sir John Ross is of opinion that steam ships will indubitably supersede line-of-battle ships, because they have a decided advantage over sailing vessels under *every* circumstance; can obtain, without difficulty, *any* elative position; may be rendered proof against shot, he paddles even being fully protected, of which he has eceived satisfactory proof; and are not impeded in their velocity by any additional weights, added to strengthen their construction, or to render them proof against shot at a particular distance; while shot thrown from them at this distance would be effectual against a sailing vessel, which cannot be so protected without injury to her sailing qualities.*

If the hypothesis and practice of Sir John Ross be admitted, it will be difficult to arrive at a conclusion different from that to which he has been led.

Upon the nautical opinions enunciated by him, we presume not to obtrude a remark. We should be much gratified by the sight of a shot-proof steamer. Colonel Paixhans, in a work published in 1825, expressed an opinion that line-of-battle ships may be cuirassed against cannon shot by sacrificing a tier of guns, and that seven or eight inches of iron would be sufficient to effect it.† But, in his work, "*Force et Faiblesse de la France*,"‡ published in 1830, he recounts some trials made against masses of iron formed of old axle trees, fifty inches thick, from which he appears inclined to deduce, that all protection from forged iron against heavy guns must be abandoned. *When* steamers are constructed shot-proof, it will remain to be decided whether their sides will be proof against shells of large calibre, filled with powder, and burst at the moment of impingement on the ship's side. The effect of petards, and, within a few years, of a bag of powder suspended to a heavy gate, is well known. May not the effect of a shell burst against a ship's side be, in some degree, similar? That a shell

* *See* a letter addressed anonymously to William Blackwood, Esq., of which Sir John Ross has since acknowledged himself the author, pp. 7, 8.

† Expériences faites par la Marine Française. Note 19. ‡ Page 445.

may be burst the *instant* it impinges, on any substance affording as great resistance as the side of a ship, there is little doubt.

In whatever view the employment of shells is considered, it is equally apparent that their use, once admitted by any nation or on board any class of vessel, must become general. One of our most distinguished naval officers, on witnessing the effect of shells against the side of a ship, is reported to have remarked, that the introduction of shells in naval warfare would have the effect of placing ships of war, of whatever force, much on a footing; as pistols, by superseding swords, have rendered individuals, however otherwise unequal in strength and in agility, on a par in duelling.

This same idea is embodied in a report made by *L'Académie des Sciences;* after expressing an opinion that the gun, proposed by M. Paixhans for the projection of shells, may be adopted without danger, the report states that the evident effects of this arm will be to establish a kind of equilibrium between vessels of different force and different size, resulting entirely to the advantage of that power which has the less number of heavy ships, but the greater population, and consequently, to the advantage of France over England. Although the iron works of England, and her fabrication of steam engines, are far superior to that of any other European power, and though the facility with which coal can be procured for working steam engines is much greater in England than elsewhere, yet she has every reason to regret the change which *has* taken place; it more especially becomes Great Britain, therefore, to take the lead, and, by perfecting the armament of her shipping, to prepare the way for future victories.

The first actions in the next naval war will indeed be of vital interest; they will either strengthen and conirm the general impression of our naval superiority, or vill give confidence to an enemy, which it may cost nuch to shake. Nothing ought to be left to chance vhich prudence and foresight can at all controul. A proportion of well formed shot and shells, of very educed windage, should, at all events, be placed forthwith on board every vessel in the service; to distinguish hese shot from those at present in use, as they would be ndispensably required only for deliberate practice at considerable ranges, they may be painted white; or, if the suggestion before offered were adopted, of the colour of the cartridge which may contain the highest charge.

The immense results which must arise from the use of shells, can with difficulty be imagined by those who have not witnessed their effect. On shore, the bursting of a shell is imposing, but on board ship, it must be infinitely more formidable.

The emperor Napoleon was so fully convinced of the value of shells projected horizontally against shipping, that he ordered from thirty to one hundred 36-pounder shells to be furnished to all 36-pounders mounted on sea batteries. He considered that it would be advantageous to substitute 48 for 36-pounders, and caused some guns of this calibre to be cast and sent to Antwerp, to arm the most important batteries. On the 4th of October, 1810, he commanded, that well-informed officers of artillery be charged with making experiments with guns, and in throwing hollow projectiles. He wrote to the minister at war: "Faites faire pour ces pièces des obus et boulet-creux de 48, ce doivent être des bombes de plus de sept pouces; ces bombes vomées par vingt pièces doivent être du grand effet." The 21st August, 1811, Napoleon reiterated his order, and wrote: "Je désire que vous me fassiez couler comme essai, à la fonderie de Douai, un canon qui puisse tirer des obus de huit pouces. Faites faire également quelques boulets du calibre de 78, pour tirer avec les nouvelles pièces, et voir l'effet que cela produrait."*

Guns similar to the celebrated Cadiz gun, which is now mounted in St. James's Park, were first cast with a view to the projection of shells against shipping, by Colonel Villantroys and General Ruty, and this in obedience to the orders of Napoleon, who had directed that means be sought by which to throw shells to great distances, to keep the English cruizers from closing with the coast.

General Gassendi, the talented author of the *Aide-Mémoire*, has given his opinion, in very decided terms, of the great efficacy of heavy guns to *obtain range*, and to project shells against shipping, and no man appears more opposed to innovation, for the sake of innovating, than he does. At page 530, he says: "The sole and real advantage of guns of great range is, that of causing an important point of coast to be respected by the enemy's cruizers, by compelling them to keep at a distance from it from the fear of hollow, and above all of heavy, projectiles; of which a single one may consummate in an instant the loss of a vessel."

In 1798, a construction of wood of the dimensions and scantling of an 80-gun ship was erected at Meudon, to serve as a butt to practice at. From a 36-pounder, whether at a range of 400 or 600 yards, is not certain,

"Three shells struck this ship and burst in it. The first, having passed through 18 inches of wood, carried away two splinters of the lining, one of which was 8 feet long.

"The second sprung four planks, the separation between them being 3, 6, and as much as 30 inches; then tore away 3 feet of one of the timbers; threw a part of

* Nouvelle Force Maritime, p. 143.

he planking to a distance of 26 feet; started one of the taunchеons, and forced out 4 bolts, screws, nails, &c.

"The third shell passed through 24 inches of wood, ore a couple in pieces, carried away 22 inches of the ining, capsized a stanchion, broke several bolts; then, changing its direction, lodged in a standard of the bits nd there burst, and, by a single splinter, raised the cross-piece which passes above the standards of the bits.

"A trial was also made with howitzer shells from a 24-pounder; and although these shells were of such low calibre, their effect, notwithstanding, made such an mpression, that General Gassendi wrote the same day to General Bonaparte, then commanding in chief *l'armée d'Angleterre*, as follows (27th April, 1798): 'You will perhaps be well pleased to know the effect of a howitzer shell fired against the side of a vessel and bursting in it, such as the experiment of this day has demonstrated. A brass 24-pounder, firing at 410 yards,—24-pounder howitzer shell, weighing 16½ lb.,—charge of the gun, 3 lb.,—charge of the shell, 1 lb.,—the *butt* of oak, 76 lb. the cubic foot, of the dimensions of the sides of an 80-gun ship,—the timbers being 12 inches thick,—the interior planking 5 inches, and the exterior 8 inches. The gun pointed at 10 feet above the water line; struck the butt at 5 feet from this line; the shell penetrated and burst in the middle of the side, at the height of the fourth streak above the main-wale; a timber of 12 inches was torn all to shatters, to an extent of 2 or 3 feet. Three streaks on the inside (5 inches thick) were entirely unnailed and torn down, and three on the outside of 8 inches thickness were started.'"*

The following experiments are those on which the guns proposed by Colonel Paixhans were introduced into

* Pièces originales, signées: Rosily, La Place, Missiessy, Fabre, et Gassendi. Nouvelle Force Maritime, p. 99.

the French service; they are given as recorded in M. Paixhans' pamphlet:

"Effects produced on a vessel of the line by the *canon à bombes*, of the calibre of 80, (projectile containing nearly 4 lb. of powder,) at the first trial made at Brest, in January, 1804.

"The object of fire, the Pacificateur, was moored in the roads. On board her, and in surrounding boats, fire engines, water tubs, empty casks, cables, &c. and men were placed, so that she could neither be sunk or burnt.

"The *canons à bombes* was on board a small lighter, at 600 yards from the ship. From the first shot, an opinion was formed; but, in order to judge more correctly, twelve rounds were fired in succession. The following is a summary of the effects described in detail in the minute of the experiment.

"The first shell struck the vessel towards the lower part; the explosion was immediately heard, and we went on board. A dense smoke filled the between-decks, where the shell had burst: a fire engine was applied: the smoke continued 10 or 12 minutes. The shell had made an aperture, of 8 inches in diameter, in the side of the ship, which at this part was more than 28 inches thick; it had raised two feet of a shot-locker; then, in bursting, had opened a hole two or three feet square into the orlop deck, and had torn down and broken in small pieces more than 150 square feet of the uprights and planks forming the wing of the orlop deck.

"The second shell crossed the forecastle and carried away two planks, one of which was 5 feet long; then striking obliquely the mainmast, it tore away a splinter 3 or 4 feet long, and 9 inches thick; then burst, carrying away a hoop of the mast, 10 feet in circumference, weighing 130 lb., and driving this mass of iron with such force, that one-half of the hoop was thrown to a distance of 16 feet against the opposite side of the vessel, where it flattened and buried itself. The splinters of the shell broke the bits, carried away blocks, &c., and would have encountered many men and much gear if the vessel had been armed.

"The third shell passed through the ship's side between two ports, tore up and carried away a knee of oak 7 feet in length, and 6 by 13 inches scantling, which, with its iron bolts, weighed more than 200 lb.; then exploding, its splinters struck the planks fixed up to represent men at their guns: more than forty were knocked down. The explosion had, moreover, broken one of the stanchions which support the upper deck, and had raised many of the planks, one of which was 10 feet long, another 6 feet. To shorten this account, of the nine other shots I shall only quote the two most remarkable.

"Seeing that the shells invariably passed through the ship's side, the charge was diminished each round: with that of 4 lb. of powder and at the unvarying distance of 600 yards, a shell lodged in the ship's side between two ports, there burst, and caused great havoc amongst planks and lining, opened a breach many feet wide and high, its edges very irregular and splintered. All the persons present thought that this shell, if it had struck near the line of flotation, must have compromised the existence of the vessel. Besides this decisive effect, the explosion had driven in two masses of iron, weighing together more than 80 lb., and had knocked down nineteen images of men.

"Finally, the twelfth and last shell, with the same low charge and at the like distance, grazed the corner of a port, forced back a heavy iron, and struck on the other side of the ship against an iron knee 5 inches in breadth, firmly supported. This shock caused three fractures in the iron, two of which were 4 inches deep; and the shell, far from being broken, penetrated the side of the vessel, then burst, and capsized the images of more than twenty men."

Effects produced on a ship of the line by shells from an 80-pounder, at the second course of experiments, made at Brest, the 27th, 28th, and 29th September, 1824:

"Of the shells fired at 800 yards, the first, having passed through two ports, burst on the other side of the vessel. The second struck without exploding. The third caused very great damage. The sixth broke the upper sill of a port; and the *procès verbal* says of the fourth: 'Having penetrated at 3 feet above the water, its explosion forced out the end of a plank which caused an opening of nearly 3 feet square. Moreover, two streaks below this opening and one streak above it were unnailed and separated from the timbers more than 5 inches at the place of explosion, and more than 2 inches towards the scarfs, and to an extent of 21 feet. Similar effects at the line of flotation would cause the immediate submersion of the vessel.' To conclude, as to the fifth shell, the *procès verbal*, after detailing considerable ravages, adds: 'that fire divulged itself with flames, so as to compromise the vessel, had not prompt assistance been afforded.'

"Of the fourteen shells fired at 1000 and 1200 yards, nine burst short, or blind; but, almost always, this accident was caused by employing experimental fuzes which were not in common use. As to the shells, the fuzes of which had their customary action, the effect was in every case, more or less, remarkable. The *procès verbal* says of one of those fired at 1200 yards: 'That it had penetrated the ship's side, where it had exploded, breaking two timbers of the vessel, the thick stuff placed under the clamps, two planks and two pieces of ining, and leaving a large hole of more than 2 feet surace. The knee of the corresponding beam was broken nto three pieces, one of which was thrown into the niddle of the vessel.' The *procès verbal* says also of ne of the shells fired at 1000 yards: 'After having truck the water, it embedded itself in wood between wo ports of the lower deck. Its explosion blew out ne plank between the ports, two-thirds of a second, nd unnailed a third plank in its whole length, and roke a piece of the timbers which was very sound: noreover, extending its effects to the inside, it displaced he ends of three pieces of thick stuff used for filling, nd the bolts and rings for the gun of the adjoining ort.'"

The reports made upon this practice are interesting, s expressing the opinions of men of the greatest science nd experience in France. The report, after the second ractice at the Pacificateur, observes:

"Que l'effet en est tellement terrible, qu'il suffisait robablement qu'une ou deux bombes de cette espèce" the French 80-pounder bomb is equal in calibre to a 96-ounder English,) "éclatassent dans une baterie pour ompromettre la défense du bâtiment attaqué."

It must be observed, that the only view with which hells have been admitted into the French navy, is in ontemplation of their being charged; no experiments vith uncharged shells appear to have been made.

The effect of uncharged and plugged shells, or, as it s the fashion to call them, hollow shot, may at short anges, in some measure, be judged by the following emarks, made at the time of the practice, by an offier who witnessed it: "14th October, 1828.—General Millar's 12-inch gun;—charge, 11 lb.;—elevation, 1°;— ange, 400 yards; six hollow shot were thrown at a rustrum of a ship's side, in all respects a *fac simile* of a ship of war. The effects were very imposing, *four* shot struck the vessel and made breaches in it, which, at sea and in action, it would have been impossible to repair. The side next the battery was pierced quite through; the knees were broken, and the whole of the interior covered with splinters, from the effect of which it is difficult to imagine that any of the men at the guns could have escaped. The shot then pierced the further side, (with the exception of one which lodged,) making greater breaches than at their entry, breaking and destroying the ship's side in such a manner as to render it quite hopeless to save any ship so damaged from immediately foundering. The splinters were immense; one of them, picked up at a considerable distance, weighed 50 lb. The gun was worked with ease by six men. The recoil was to the extent of the breaching, but not so as to strain it—about $4\frac{1}{2}$ or 5 feet."

The French practice, above given, affords tolerable grounds on which to estimate what the result would have been, had the hollow shot been loaded with 8 or 10 lb. of powder, which they are capable of containing, and burst on board this vessel; the French shells, be it observed, were charged with 4 lb. of powder only. The author remembers to have seen a remarkable result from the bursting of a shell under a heavy garrison gun. It occurred in the Boullet redoubt, in the attack on Fort Bourbon, in 1809: the gun and carriage were completely thrown into the air and capsized; the carriage rested on the metal, with the trucks upwards; the excavation, occasioned by the shell, did not indicate that it was of the largest calibre.

As to the sphere of action of splinters, it may be noticed, that Sir Alexander Dickson, in his report of the practice against M. Carnot's wall, in August, 1823, observes: "The splinters of the shells being inconvenient to the men in the batteries, the bursting powder was reduced from 5 lb. in the 10-inch howitzer to 3 lb., and from 2 lb. 8 oz. in the 8-inch howitzer to 2 lb." These howitzers were 400 yards distant from the wall where the shells were burst. It was further observed: "Many of the splinters not only inconvenienced the men in the batteries, but ranged even considerably beyond them, and this after the bursting powder was reduced to the regular quantity." If splinters range considerably beyond 400 yards, their effects between decks must be indeed terrific; and if the smoke, occasioned by the bursting of grenades only, render a block-house untenantable, what must be the effects of shells burst on board ship?

Lieutenant-General von Scharnhorst, of the Prussian artillery, who was killed in 1813, was esteemed an excellent artillerist, and an acute observer. He made many experiments at Glatz, in September, 1810, to ascertain the effects of splinters of shells against infantry when uncovered; their effect by explosion in masses of earth and in block-houses; and likewise their general effect from penetration, explosion and splinters.

To determine the effects of splinters, he placed shells near the centre of two concentric circular screens, 6 feet in height, the diameter of the interior circle being 20, and of the outer circle 40 feet. As the result of his observations, he remarks: "The effects of 7 and 10-pounder howitzer shells," (the diameter of these shells being 5·66 and 6·55 inches,) "were about equal; even the 50-pounder" (10 inches in diameter) "had no greater advantage than the howitzer shells with respect to the hitting pieces. They overthrew, however, the interior screen, and sometimes a part of the exterior, by the explosion of the powder. The distances to which the howitzer shell splinters fell, when bursting, extended with ordinary charges to 300 paces, and with stronger ones to 450." The ordinary charge of the 7-pounder is 12 ounces of powder, and of the 10-pounder 1 lb. General Scharnhorst also remarked: "The danger of being hit by splinters decreases, as the squares of the distance of the station from the shell increases, and is, therefore, in inverse proportion to the squares of the distances of the station from the shell."*

As to the effect of shells bursting in a block-house, General Scharnhorst says:

"In a block-house, the length of which is 33½ feet, breadth 19¾, and height 7 feet, a 10-pounder howitzer shell, which was loaded with 1 lb. 5½ oz., was first burst, and afterwards a 7-pounder, the charge of which was 1 lb. of powder. On the bursting of the 10-pounder shell, the smoke, as we opened the door, was very dense, and at first intolerable; it disappeared after six minutes, partly through the opening of the door, partly through the loop-holes. The shell burst into 18 or 19 pieces; we found 16, and these weighed $\frac{16}{18}$ of the whole shell.

"On the bursting of the 7-pounder, the smoke was not so dense and withdrew in two minutes. The shell was burst into 24 pieces; we found 22 which weighed $\frac{22}{24}$ of the whole shell. On the bursting of the 10-pounder shell, the shaking of the block-house was more violent than with the 7-pounder. The splinters had partially penetrated deeply into the wall and top of the block-house, but had not absolutely injured them."

To ascertain the effects of shells when bursting in the sides of a block-house: "There were fired, at 425 paces, a 7 and 10-pounder howitzer shell, into the wall of the block-house before described; the former with a charge of 1¾ lb., and the latter 2½ lb.; the 7-pounder shell was

* Über die wirkung des Feuergewehrs für die königlichen Preussischen Kriegs-Schulen. Fünftes Kapitel. § 34.

loaded with $\frac{3}{4}$ lb. of powder, penetrated $1\frac{1}{2}$ feet, and had nearly broken the beam struck, as well as that laying on its top, and had driven splinters out of the joints. The 10-pounder howitzer shell, charged with 1 lb. 4 oz., had penetrated 2 feet 8 inches into the wall, dashed in pieces the beams struck; raised the superincumbent beams, yet broke none."*

The 7 and 10-pounder Prussian howitzers answer, as to calibre, very nearly to our 24 and 32-pounder guns; the above practice, therefore, is interesting, from the analogy between a block-house and a ship. It may be observed, that the beams of the block-house were composed of rough trunks of trees, probably of fir, which is much more easily penetrated, than oak, of which the sides of ships are usually built.

In the second volume of the United Service Journal is a paper by General Sir Samuel Bentham, detailing the very important advantages gained by the Russians over a very superior force of Turkish ships of war, in 1788, which success is attributed to the use of shells. Sir Samuel, who bore a conspicuous part in these actions, in his letter to the editor transmitting the details, says: "The engagement affords, in my view of the subject, an additional degree of interest, as evincing the splendid results which may be obtained by the employment in naval warfare of shells, carcasses, and shot of the largest size, when fired point-blank, from vessels drawing little water, against ships of the largest size; points which I have, for more than thirty years past, never failed to point out and recommend on every occasion where there appeared a chance of drawing attention to the subject." It appears that in the action of the 18th of June, seven Turkish ships were burnt; the account says: "They were not burnt on purpose, but as all our vessels were,

* § 35.

for the most part, furnished with shells, like bomb-shells, or others filled with combustible matter to be used instead of shot, there was no *avoiding* the burning any vessel we fired into. Three or four of the largest were burnt and blown up, without being able to save scarce any of the people on board; about 3000, however, were taken out of the eleven ships destroyed on this and the foregoing day." Although the Russian armament is described as a heterogeneous fleet of small vessels, brought together in a hurry and manned in a great degree by soldiers, yet it does not appear that any accident occurred from this indiscriminate use of shells. Many of the guns used in the smallest vessels were 36 and 48-pounders, and 8 and 13-inch howitzers, and this Sir Samuel observes at his suggestion.

Captain Hastings, whose opinion has been given in detail as to the feasibility of using shells from shipping with as little risk as that which attends the use of common shot, offers many practical illustrations of their advantage; he particularly adverts to a case in which his own ship was the sufferer; he says: "I went into the Piræus to support Colonel Gordon, who was attacked by Kertagi Pashaw: the Turks had several pieces of artillery, and fired chiefly grenades from howitzers at us; several of these struck us without exploding; but one from an 18-pounder exploded in the counter, and tore out the planking of two streaks for a length of six feet, and started out the planking from the two adjacent streaks: in a sea way, a ship built in the usual manner*

* "The Karteria was built with her timbers close, and caulked together; and would, therefore, have floated without planking. I had several opportunities of remarking the advantage of building thus, to resist shot; nothing less than an 18-pounder ever came through us; this, 'tis true, might be partly attributed to Turkish bad powder, but those shot that did come through, always made a nice clean round hole without a splinter. However, against shells it would have a disadvantage, as they would be more likely to stick in it. Perhaps if shells become generally used, it will be proper to make the upper works of a ship as slight as is consistent with strength, and iron ribs might perhaps be good. The Karteria had another peculiarity in her build—

ould have been sunk by the explosion of *nine ounces* f powder; what then might not be expected from the xplosion of 2½ lb. of powder, which a 68-pounder shell ontains, even with space for some incendiary composiion."

To these examples of the effect of shells many may e added, but enough has been offered to shew their mmense destructive power as arising from their immeliate explosion, from splinters, and from smoke. The nconvenience arising from the smoke occasioned by two small shells, General Scharnhorst describes as intolerable; these shells contained gunpowder only, and were burst in a block-house constructed without pitch or any fumiferous unguent. On board ship, a shell could not burst without acting on much pitch; the sides and seams of the decks of the ship are all payed with it; in the composition of smoke balls, pitch is a very important ingredient; its combustion, as it is well known, creates a very dense and suffocating smoke. In shells of the higer calibres, destined for use against shipping, no doubt smoke or incendiary composition would be generally added.

Although it is in some measure foreign to the object of this essay, which has particularly in view the use of heavy ordnance against shipping, yet it may be admissible to allude to the great results, which may be looked forward to, in future sieges, from the employment of the improved howitzers, the effect of the projectiles of which have been considered; nor is the effect of

two solid bulk heads enclosing the engine room, and caulked and lined, so as to be water-tight: the intention of this was, in the event of one part of the ship being leaky from any cause whatever, the water could not flow into another part of the ship. This arrangement, which is due to the ingenuity of Mr. Brent, the builder, once saved this ship from fire, which broke out with great force in the after part of the engine room, and would have communicated to the shell room very quickly, but for this bulk head, which kept the fire forward, and gave us time to subdue it. I see no reason why all men-of-war should not be furnished with similar partitions. The same builder saved another ship (the Rising Star) from sinking by this contrivance."—*Memoir*, &c., pp. 29, 30.

shells against works an unimportant question, as affecting the application of the fire of shipping; since, during the late war, their broadsides were often brought to bear against batteries on shore, and even against permanent fortifications.

The practice, before referred to, carried on by Sir Alexander Dickson, against twenty-two feet of M. Carnot's wall, supported by an additional buttress at each end of four feet square, created at the time an interest amongst the artillerists of Europe which probably has never been excited by any previous gun practice.

The question to be determined by this practice was, whether M. Carnot's wall, protected by his counter-guard, could be "breached at considerable distances by fire at high angles."

The result proved incontestibly that the wall may be breached at 400 or 500 yards. Shot and shells were thrown with small charges and high elevations, so as barely to clear the crest of the counter-guard and to tell against the wall, the top of which was 90 feet from, and on a level with, the crest of the counter-guard.*

The guns used, the first day, were eight 68-pounder carronades, firing shot at a range of 500 yards, charge 1 lb., elevation $11\frac{1}{2}°$ to 13°; three 10-inch howitzers, charge 19 oz., elevation 12° to 13°; three 8-inch howitzers,

* It may be observed, that the system of M. Carnot has received its rudest shocks from England. Sir Howard Douglas demonstrated the fallacy of many of M. Carnot's assumptions, particularly of his fire of musquet and 4 oz. iron balls, projected at 45°, to distances comprehended within the third parallel; and Sir Alexander Dickson has practically proved that M. Carnot was mistaken when, speaking of the besiegers of his work, he said: "Cependant celui-ci ne découvrant pas encore les maçonneries, comme il le fait dans le système ordinaire, dès qu'il est sur la crête des glacis, ne pourra faire brèche au bastion, sans s'être préalablement rendu maître des contregardes." Equally at fault was he, when he observed: "Il faut donc que l'assiégeant fasse sauter la contregarde presque toute entière, pour voir et abattre toute l'escarpe du bastion avant que de tenter d'y donner l'assaut." (p. 486.) From considerable practice with 4 oz. iron balls, at high elevations, we are led to believe that at distances of from 100 to 150 yards, these balls projected at 75° are efficient, but that no advantage can be anticipated from their use, fired at an angle of 45°, at less distances than 250 yards.

charge 11 oz., elevation 13° to 14°, throwing shells at 400 yards. A practical breach of fourteen feet was formed by one hundred rounds, the buttresses presented much additional resistance to that which the ordinary profile of M. Carnot's work affords. The second day, a 10-inch howitzer having replaced one of the 8-inch, the elevation being increased and the charge diminished from the decreased height of the wall, fifty rounds were fired, effectually to open the breach and to complete the destruction of the buttresses. Previous to the third day's practice, the foot of the breach being cleared of rubbish, a portion of the wall, about nine feet in height, presented itself. The remaining 8-inch howitzer being replaced by a 10-inch, "eighty-five rounds from each howitzer, and one hundred from each carronade, were fired in three hours and a half, at which time the wall and buttresses were one mass of ruin," not a vestige of the wall and a very small part of the buttresses being distinguishable from the chaotic heap. The 10-inch shells, excepting a few rounds, were charged with 2 lb. 10 oz. of powder. Of 536 shells fired on the third day, 91 were found not burst.* Of the 800 shot fired the first day, 180 took effect against the wall and 192 against the counter-guard: of the 600 shells fired this day, 158 took effect against the wall, 190 against the counter-guard.

The value of accurate practice and of loaded shells appears from this experiment, but the proposition enun-

* Captain Hastings observes, (*Memoir on the Use of Shells*, p. 11,) that when the charges of the guns from which he threw 8-inch shells exceeded 4 lb., the fuze generally came out, to obviate which he tied a piece of leather round that part of the fuze which is below the interior surface of the shell. The leather, being forced in with difficulty, expanded and prevented the fuze from coming out: he proposes that the fuze should have a wooden spring to effect this object, but the screw fuze would render any contrivance of the kind unnecessary. Common shells have hitherto been seldom used in the land service from guns with high charges. The screw fuzes of the Shrapnel shells have not been observed to come out; nor the common fuze, when carefully driven, from shells projected from mortars with high charges.

ciated by the Duke of Wellington, then master-general, did not involve, even collaterally, any proof of the necessity or advantage of weight and length of the metal of howitzers. The question to be determined was, whether the wall could be reached by a plunging fire sufficiently low to breach it ; this could only be effected by low velocities, the weights of the guns employed were therefore ample. The increased length in the howitzers, the velocities which may be given to their projectiles, and the large quantities of powder which they contain, raise the inquiry,. as to whether they may be made efficient to sweep away the counter-guard of M. Carnot ; (which he considered practicable only by mines ;*) to destroy and lay open traverses and to uncover and expose the terre-pleins of ordinary works. With such view, M. Bousmard proposed a horizontal fire from mortars, to be used on gun carriages in the breaching and counterbeating batteries ; but it has been well observed, that it would be impossible in such situations so to employ mortars, from their want of length ; either the embrazures must be formed so wide as entirely to expose the mortars and men, or the fire of the mortar will assuredly destroy the cheeks of the embrazure, and by this means render the battery untenable. One remark of M. Bousmard is of general application, when using shells against masses of earth ; he observes, that to obviate, as much as possible, the falling of the exploded earth into the craters formed by the shells, it will be advisable to direct the shells so low into the mass of earth that the line of least resistance may be never vertical, and as nearly horizontal as possible.†

It is very possible to imagine that the attack of works may be assisted by the use of the new howitzers,—they are admirably adapted for ricochetting,—but the defence

* De la défense des places fortes, pp. 480, 486.

† Vol. i, pp. 279, 285.

ill also be much benefitted by them. If shells pro-
cted horizontally are efficient to open the parapets of
e besieged, they will be equally so to destroy the
paulemens of the besiegers. Ricochet batteries must
e well within the reach of very accurate practice from
e new howitzers, for at 600 yards, these howitzers
ust ensure ample penetration into earth. They are
lso well calculated to emit a very destructive fire of
ase shot. M. Paixhans seems to think that a ricochet
re of case shot may be maintained upon the glacis, but
his cannot be received without practical proof, as it is
robable that the momentum of case shot, after repeat-
dly rebounding, will be inefficient.

The sieges in Spain have shewn that where the escarp
an be seen at 600 or 700 yards, (probably this distance
may be considerably extended,) places may be taken by
n artillery rather than an engineer attack; and the
works which have been recently constructed on the Mon-
alembert principle, particularly those by the Prussians,
seem to indicate that the trial in future sieges will be
between the besieged and besieging artillery; whether,
in fact, the besieged can put forth such a fire as may
annihilate the approaches of the besiegers and capsize
their guns at all such distances as may be rendered avail-
able for the destruction of the besiegers' gun-casemates,
the revêtemens of which are constructed *en décharge* or
in a series of arches, and thereby offer much greater
resistance than has hitherto been opposed to breaching
batteries. If the defence prevail, it will no doubt be
chiefly attributable to the horizontal projection of shells.

It appears to be a desideratum of the greatest interest
to ascertain by practice at what ranges and to what
extent shells projected horizontally may be rendered
efficient for the sweeping away considerable masses of
earth. Some experiments, already referred to, were

carried on at Glatz, in 1810, with a view to ascertain the practicability of breaching ramparts or parapets of earth. The mass of earth on which the experiments were made was 20 feet thick, 18 feet in height, the slope from the horizontal line 75°, from the vertical 15°. The guns were 130 yards from the object: six 10-pounder howitzer shells from their howitzers, and twenty-eight 7-pounder howitzer shells from 24-pounders were fired into the butt. Four of the 10-pounder shells, and twenty-two of the 7-pounder shells burst in the work: two of the 10-pounder and six of the 7-pounder shells did not burst. The 7-pounder shells were loaded with 12 oz. and the 10-pounder with 1 lb. of powder. The charge of the 24-pounder guns was 1 lb. of powder; when 2 lb. were used, the shell penetrated so deep into the earth that it occasioned no crater on bursting. These few howitzer shells effected a breach, which was 26 feet broad at the foot, and above, in the middle of the superior slope of the parapet, 8 feet. The inclination of the breach was about 45°, it was easy of access even for cavalry.*

The vertical fire of shells is well known to be very formidable, but its uncertainty and the great expenditure of ammunition to produce any marked effects, has prevented the employment of shells by the besieged in such numbers as to produce any decisive or memorable results. Sir John Jones narrates, that at the siege of Cuidad Rodrigo, the garrison "adopted the expedient of firing shells filled with powder and having long fuzes in salvos. Some of these falling together into the parapets, blew away in an instant the work of hours." If vertical fire be thus efficient, much more must horizontal fire be so, for the reason assigned in the remark of M. Bousmard, above adverted to.

* Über die wikrung des Feuergewehrs. § 32.

Since the introduction of ricochetting by Marshal anban, the superiority of the attack has held its ground, ecause the besiegers can always so direct their works iat their prolongations may fall without the defences of ie attacked; at the same time, that they are always iasters of the prolongations of the besieged, unless ome natural obstacle present itself. The direct fire of aded shells may go far to lessen this great ascendancy.

HOT SHOT.

CAPTAIN HASTINGS, in the memoir to which we have epeatedly adverted, refers to his use of hot shot and hells from the steam ship which he commanded. Within attainable ranges, against shipping, it is coneived that the effect of loaded shells would be more ertain and much greater than the effect of hot shot. If so, this, without questioning their comparative efficiency, would be a sufficient reason for not using heated shells. The reason assigned for the use of heated shells, by Captain Hastings, is, that solid shot broke through the side of the ship he was opposed to, but the velocity of shot can always be reduced by a reduction of the charge.

Inasmuch as the range of shot is much greater and more accurate than that of shells of the same calibre, the use of hot shot will always, at great ranges, be resorted to *against shipping*, where convenience is afforded for heating them. The battering ships at the siege of Gibraltar, which were destroyed by red hot shot, were moored at a distance where the horizontal fire of shells, from the guns used, could have made no impression—from 900 to 1200 yards. The advantage or feasibility of using hot shot *from shipping* is a nautical rather than an artillery question. Steam ships, having long guns, may probably turn them to a good account. With the furnaces used ashore, it requires from 30 to 40 minutes to make a 24-pounder shot red hot, when the furnaces are heated, and double that time if the furnace be lighted when the shot are put in.

The only difference, in the practice with hot and cold shot, arises from the decrease of windage by the dilation of the shot; the advantage, therefore, is with the hot shot, particularly as to accuracy. The penetrations of hot and cold shot are considered equal. No danger attaches to the use of hot shot where a dry junk wad is placed next the cartridge, and a soaked junk wad next the shot. The flannel cartridge is sometimes placed in a paper bag or case, lest the powder should work through; if this precaution, which, with the soaked wad, is scarcely necessary, be resorted to, the wad-hook ought to be used after each round. The less the penetration of the hot shot, the sooner will its effects be evident; if the penetration be too great, the aperture, closing from the elasticity of the wood, prevents the action of the exterior air.

GENERAL DEDUCTIONS.

From a general review of the subjects which have been adverted to in this essay, it is confidently believed that no reliance ought to be placed in the use of hollow shot, of half the solid shot's weight, against shipping, at a greater range than 400 yards; and of two-thirds the solid shot's weight, at a greater range than 500 or 600 yards, and to this extent only with guns of great calibre and affording high velocities:

That the employment of loaded shells by ships of war would induce little risk to those on board:

That loaded shells are the most formidable projectile which can be opposed to ships of war:

That the only penetration required in a loaded shell is to the depth of half a diameter, or to such depth as may cause it to stick in a ship's side:

That the small remaining velocity of shells at a medium range would, therefore, be efficient :

That guns of great calibre, length and weight, are indispensably necessary to every class of man-of-war :

That windage is of paramount importance, and its reduction more urgent than ever, adverting to the tremendous consequences which may result from *one well-directed shell :*

That it is inexpedient to make up cartridges of one weight only ; that charges for shot and shell may advantageously be filled in flannel cartridges of different colour ; such colours being rendered conventional, and their import declared by a simultaneous order from the admiralty and ordnance :

That copper cylinders, in which to carry cartridges to the guns, may be applied in placing the cartridges in the bore, so as to obviate all danger from their accidental ignition :

That until the shot in store be consumed, a portion of well-formed shot, of very minute windage, ought to be issued for the guns of the highest velocity and calibre, (that is, guns having the highest ratio to their shot,) on board each ship ; which shot may be painted white, or the colour of the cartridge containing the highest charge.

It appears not improbable that a small number of guns of great calibre and weight, and, consequently, high velocity ; of diminished windage and carefully formed shot, and, therefore, increased accuracy ; together with a few heavy howitzers, will eventually supersede the present armament of ships of war.

That if the armament of our ships of war continue to embrace a great number of guns, a gun heavier than the carronade, and *proportionally* lighter than the reamed up guns, may be beneficially employed ; that the present carronade has too much affinity to the late light $5\frac{1}{2}$-inch howitzer, that it is too light and too short; that the reamed up guns will not, from the recoils, admit high initial velocity, and, for short ranges, are heavier than necessary.

CONCENTRATING AND CONTROLLING THE FIRE OF SHIPS OF WAR.

IF it be determined to adhere to the present armament of our ships of war, the only feasible plan (speaking as an artilleryman and without presuming to touch any nautical question) of effecting results commensurate with the tremendous weight of shot which a broadside of a line-of-battle ship projects, is to endeavour to concentrate its fire, under all circumstances and at all ranges, which will admit of this disposition of the guns.

Many of the great actions have been fought at anchor; amongst others the Nile, Copenhagen, Algiers, Navarino; such a contingency must, it is believed, be favorable to the application of concentrated fire. In the great battle of Trafalgar, the hostile ships, in many cases, were actually touching, and, during a great part of the engagement, at such ranges as may be deemed favorable to the adaptation of cross broadside fire. It is not so much the simultaneous discharge of a concentrated broadside which appears a desideratum, as a means by which to enable an officer in command to keep in hand his fire, and the men at the guns to lay them under the disadvantage of smoke, fog, or darkness.

It must of course be desirable that the focus of fire should be in the side of an adverse ship, but it is not essentially necessary that it should be so to produce good practice from a battery laid for concentrated fire.

Little reflection is necessary to lead to the conviction, that although a ship may change her relative situation or distance with her antagonist, (all the guns of a broadside being trained to effect a focal fire previous to the change of direction or distance,) yet, that a very favorable fire will be preserved, without any alteration in the laying of the guns, so long as the flank guns or the outer gun bear on any part of the enemy's ship.

At any range, if a fire be concentrated upon so wide a target as fifty feet a-midships of a line-of-battle ship, her distance, in the direction of fire of the gun of direction, may be doubled without an alteration in the laying of a single gun or the loss of a single shot.

The ship fired at may fall off any number of points; yet, if one of the conflicting ships does not shoot ahead or drop astern exceeding half her length, the fire, without any alteration in the guns or the ship's head, will be efficiently concentrated.

If an enemy's line-of-battle ship shoot ahead her own length, the fire of a ship's battery being concentrated at 200 yards, it will be only necessary to bring up the ship's head about, or even less than, a point, without altering a gun, in order to preserve the concentrated fire; if she shoot ahead or drop astern two lengths, about two points and a half; if three lengths, rather more than three points; if four lengths, four points. At 400 yards range, two points are sufficient, when the ships vary their position, three lengths. At 100 yards, a change of direction of the ship's head of two points will be only sufficient for little more than a change of one ship's length in the relative position. These and many similar facts may be proved, without having recourse to geometry, by varying the position and distance of the tracing paper attached to the diagram, which represents radiating lines of fire.

To effect a concentrated fire, many plans have been proposed within these few years, but most of them require an alteration in the carriages at present in use.

If the carriage be connected by a beam or bar, in the same vertical plane with the axis of the bore, traversing on a bolt in the centre, or in the vertical plane, of the port, this beam will obviously be a radius to any arc, concentric with the pivot, which may be described, or imagined within its action, on the deck, and may consequently be employed to give direction to the fire, the arc being graduated at pleasure.

To facilitate the concentration of fire, without describing an arc on the deck, the author saw a few years since, on board the Excellent, an instrument which he understood was highly approved; it consisted of a piece of flat board, either a quadrant or some other sector, painted black, with white lines radiating from the centre. It was used by placing it in the rear of the gun, a particular radius of course being coincident with the vertical plane passing through the axis of the bore, supposing the gun to be laid perpendicular to the ship's length.

With good locks, percussion tubes, little windage, heavy guns, and disparts or tangent sights, nothing but common attention can be wanting to produce accurate practice *where the object of fire is distinctly seen:* yet will these advantages fail, particularly will the employment of complicated tangent sights (and especially where the aim depends on cross hairs or wires, as the line of collimation of a sextant,) be worse than useless, where a steady view cannot be obtained. The accuracy of naval practice must have been exceedingly assisted by the introduction of locks, and this advantage is likely to be extended by the introduction of percussion tubes. Whatever accelerates the ignition of the charge must, particularly on board ship, where the object fired at and the gun fired from are often both in motion, necessarily increase the chance of hitting.

To obtain some approximation to a concentration of fire at point-blank ranges, to lessen the difficulties occasioned by smoke between decks, and to ensure to the officer in command the control of his batteries, the following plan was designed many years since, and in October, 1827, submitted to his present Majesty, then lord high admiral of England. In 1830, it was transmitted to the admiralty, when a dozen copies of a memoir on the subject were printed. The author has been repeatedly asked for copies of this memoir; but being unable to comply with the request, he takes this opportunity of reprinting it. It is as follows:

The results attainable by concentration of fire are made evident in sieges. Breaches are commonly effected by comparatively a small number of guns and no very great expenditure of shot. Taking the medium afforded by the three principal sieges in the Peninsula, it will be found that at a range of 600 yards, it required about thirty rounds, or 7 cwt. of shot, to batter in breach a superficial yard of revêtement and parapet, taking one with the other; and that such yard, when breached, on an average, produced about 5 cubic yards of rubbish. At Badajoz, "the extent of front of the three breaches open was 500 feet, the greater part of which was as good as can be formed."* The expenditure of shot to effect these breaches, from a distance of between 600 and 700 yards, amounted to about 230 tons.†

At a range of 300 yards, it is not too much to assert, that the space comprised between two gun-ports and two decks of a ship of war, the battery and object being stationary, would rarely or never be missed; and the penetrating power of a 24-pounder shot, fired with the ordinary charge of $\frac{1}{3}$ its weight, would, at this range, be sufficient to perforate the side of an enemy.

* Journal of the Sieges, &c., by Colonel Sir John Jones, p. 148.

† Observations on the attack of Cuidad Rodrigo, Badajoz, &c., by Colonel Sir J. May, pp. 23, 25.

Such being the results attainable by the fire of artillery on shore, it must strike every man who considers the expenditure of shot in naval engagements, where ships have been closely engaged, and particularly when at anchor, as at Copenhagen, the Nile, Algiers, &c., that the results have not been proportional to the means employed. In the battle of Navarino, the Albion alone is said to have expended 52 tons of shot, considerably more than a fifth of the quantity used at Badajoz for opening 500 feet of breach, yet she did not sink a ship.

It is not a solution of this difficulty to assert, that the marked difference of the practice ashore and afloat arises from the constant state of motion in which, more or less, ships must necessarily be when afloat. In some of the battles referred to, the ships were anchored both ahead and astern, and were engaged frequently within 50 yards, and in none of them at a range so great, or nearly so great, as that from which the breaches were effected at the sieges in the Peninsula. The degree in which the precision of the practice might have been effected from the existing motion, cannot be supposed so great as that which would arise from the excess of range in 300 yards and in 50 yards.

The difference resulting from an equal expenditure of shot afloat and ashore, when vessels are at anchor, and particularly when the object of fire is at rest, (for this is more important to precision of fire than even the steadiness of the batteries themselves,) will be found to arise from the different mode in which these means are employed.

It is believed that the navy, generally speaking, have hitherto been satisfied if the fire of their batteries told on any part of the enemy's hull, without attempting to produce a focal or concentrated fire on a particular point; the smoke incidental to a general engagement rendering difficult to take a more precise aim, particularly with he guns to leeward.

The primary object in a general engagement must be o silence the enemy's vessel, opposed to a particular hip. This is most effectually promoted by sinking an ntagonist; and it scarcely can be contended, that if hirty shot could be so directed as to converge upon a space of one superficial fathom, situated on the level of, or below, the water mark, that this result must follow.

Such were the reflections which led to the following plan, which, as before observed, was designed many years since, and actually submitted, in 1827, to the Lord High Admiral, and to Sir George Cockburn, one of the lords of the admiralty. The latter, in the reply which he very politely made to the communication, was pleased to designate the attempt to concentrate the fire of ships of war "a very ingenious and sure method of obtaining the object proposed;" he continued to remark: "I have, however, much doubt of its proving of any material advantage at sea, where ships are constantly changing their relative positions; but, as you justly observe, it will probably prove of more decided benefit when used by ships at anchor, or acting against batteries on shore."

The battle of Navarino, and the incidents connected with it, as gathered from the evidence on the trial of Captain Dickinson, have since tended to confirm the opinion, that the adoption of concentrated fire by the navy, would, under certain circumstances, be highly serviceable. Commander Thomas Smith, who was first lieutenant of the Genoa, at Navarino, deposed, that on letting go the anchor, "the Genoa swung with her head to the west of north, or head to wind, and had her enemy on her starboard quarter. By hauling on the larboard springs before the fight commenced, the Genoa was brought parallel, and her whole starboard broadside bore on her opponent with complete effect. She did not diverge from this position for above two hours. They were close to the enemy; the whites of whose eyes they could see as plainly as he could see those of the honorable court."*

Now, had *focal and depressed* fire been resorted to, at such a distance as enabled the combatants to see the whites of each other's eyes, could a ship have floated after a second discharge?

The Genoa continued in action with the Turk "*about three hours and a half, she did not diverge from the parallel position for above two hours.*"† By the evidence before the court martial, it appears that the Genoa expended 7,089 lb. of powder, and the Albion 11,092 lb.‡ It is asserted that the Albion expended 52 tons of round shot; if the expenditure of the Genoa was in the same proportion, she must have discharged more than 30 tons of round shot, enough to open 65 feet of breach in the ramparts of Badajoz, at a range of six or seven hundred yards.

It was affirmed by some of the witnesses for the prosecution, that the shot of the Genoa were received by the Albion: the fact can scarcely be doubted; yet it is quite clear, from the evidence of Captain Smith, that the occurrence could not have happened if the fire had been at all under the absolute control of an officer on deck.

The battle of Navarino, fought at anchor and in smooth water, may, if reflected on, suffice to demonstrate the importance of concentrated fire, and the advantage of enabling an officer on deck to keep in hand his batteries, when armed in the usual manner.§

* United Service Journal, October, 1829. † *Ib.* ‡ *Ib.*

§ It tends to strengthen the presumption that the penetration of double and treble shots is often inefficient. The third British line-of-battle ship engaged at Navarino, the Asia, consumed 9,298 lb. of powder; her quantity of shot expended, if in proportion to that consumed by the Albion, would be 40 tons. It is obvious that the Albion must have fired double and treble shot, unless she reduced her cartridges, to have consumed the shot expended; it is, therefore, to be inferred that the others did so also.

In any plan for concentrating or controlling fire on board ship, simplicity and ease of construction must be peculiarly attended to. Economy, adaptation of the proposed means to the carriages at present in use, without interfering with their make, with the breeching of the guns, or the mode of working them, are also objects to be kept in view.

These desiderata are, it is believed, attained in the following plan; and it may be observed, that though applied to any particular ship, its employment or disuse would be optional with the commander.

To achieve the proposed ends, it is imagined that it would be necessary only to contrive an arbitrary base, against which the seamen may run up their guns; such base being, with ease and certainty, laid at right angles to the intended line of fire, by order of an officer on deck or situated advantageously for judging the effect. The base being correctly fixed, the accuracy of the practice (not depending on elevation) would *be independent of the seaman*, who, to ensure his aim, would, as before inferred, have only to run up his gun till the trucks of the carriage, (or the breast, were the base so high,) were close and even with the arbitrary base. In other words, the seamen would bowse away upon the gun tacles until brought up by the intervention of the base, and having done this, the gun must be laid. Thus, besides the control and precision of fire obtained by this method, the rapidity of the fire would be greatly increased; and it is scarcely possible to conceive too rapid firing at close ranges, where precision is attended to, and regularity preserved. "Lord Collingwood was accustomed to tell the seamen of the Dreadnought, that if they could fire three well directed broadsides in five minutes, no vessel could resist them."*

* Correspondence and Memoir of Lord Collingwood, p. 125.

The base may be either a modification of the present breast choke,* or it may consist simply of a piece of oak, against which the trucks may run: it may be termed a *truck-stop* or *heurtoir*, from its affinity to that used on shore to protect the genouillère of parapets; if found to answer, it may be constructed of cast iron or copper. Copper may be the most desirable, but for trial, truck-stops made of wood may answer every purpose. It may be about 5½ feet in length, varying with the breadth of the fore axle tree, or of any length which may prove convenient. If made of wood, its height may be ¼ of the diameter of the fore truck, its breadth ⅓, bevelled off to half a right angle, and subsequently hollowed out to fit the fore trucks; it would not, therefore, project beyond the vertical tangent to the truck of the gun. If made of copper, it may be concave, to receive the trucks; the back and bottom may be ⅓ the diameter of the fore trucks.

For convenience in moving the truck-stop, a ring is placed at each end.

At each extremity of the back of the truck-stop, and in a line with the bottom, are eyes *a*, *a′* *Pl.* 2 to receive bolts, (as *b*) to fix it to the deck. These eyes are reciprocally pivot, or traversing as the fire may be ahead or astern.

To fix the position of the pivot end of the truck-stop, it is proposed to let eyes *x*, *x′* into the deck, or projecting from the side *x″* *Pl.* 3, to receive the bolt *b* *Pl.* 2 passing through the eye *a* or *a′*.

If the eye *x″* *Pl.* 3 be let into the side, the eyes *a*, *a′*

* It may be observed, that this was officially proposed in 1827, it had been imagined in 1809; that Mr. Kennish, carpenter of the Hussar, obtained the Gold Isis Medal from the Society of Arts, during the session 1831-32, for a plan to concentrate a ship's broadside by a moveable breast choke. It is not at all intended to insinuate that Mr. Kennish borrowed the idea, but it is a corroborative evidence of the practicability of the suggested project, when a practical seaman thus proposes to lay guns by an arbitrary base.

Pl. 2 may then be double, so as to admit the eye x'' *Pl.* 3 between them.

The eyes x, x' may be about nine inches from the line of the cheeks of each port; the gun being run up and laid at the extreme angle of traverse, the truck-stop being applied to the trucks, the eye a or a' *Pl.* 2 will determine the position.

To regulate each end of the truck-stop, when traversing, a pair of arcs, $c\,d$, $c'd'$ for each gun are let into the deck. These arcs are pierced with holes, to receive the bolt b, which passes through the eye a or a', as the fire may be ahead or astern.

The position of these holes must necessarily depend on the distance of the object against which it is intended to direct a focal fire, and on the situation of the gun of direction, or of that gun, in the line of fire of which may be the proposed focus: they may be determined by calculation or by actual trial, the ship being in port and in smooth water. The arcs are graduated and pierced for each gun respectively, but the holes of the arcs for all the guns on the same side being lettered to correspond, so as to produce a convergence of fire at a given distance, the officer directing the fire will have only to name the particular letter.

The ninth from the bow may be the gun of direction, and the range at 400, 300, 200, 100, 50 yards; these details can be better determined on the execution of the project.

It may be observed that, if from the change of distance, by the swinging of the ships at anchor, the fire cease to be completely focal; yet as long as the gun of direction bears on any part of the enemy, so long will each gun of at least one wing have the widest field for its influence: the superiority of an oblique over a direct fire is too obvious to require proof. In carrying into execution a converging fire, it would, therefore, be advisable to post an officer at the outer flank of the converging guns; for so long as the outer gun bears on any part of an antagonist, (the distance is immaterial,) so long will all the guns *inside* it have the most ample scope for their effect. An outer gun ceasing to bear on the enemy, the officer will order its truck-stop to be cast off, and the fire to be independent; and directing his particular attention to the next gun, will, according to circumstances, either remove the truck-stop or not.

If it should be deemed desirable to produce a parallel fire, it may readily be effected by inserting a second pair of arcs into the deck, and a second pair of eyes into the truck-stops at *y*, *y′* *Pl.* 2, the distance between the centre of the pivots and the centre of the eyes *a y′*, *a y*, may be 4 feet $9\frac{3}{11}$ inches, which is the radius of an arc, each inch of which answers to a degree.

If inconvenience be anticipated from the insertion of the arcs in the deck, or from permitting them to be fixed permanently on it, the end may equally be answered by fixing each arc by two bolts only to the deck, that bolt of the truck-stop which forms the centre of the arc being one, and by removing them when not at quarters. If this mode, or any modification of it, be preferred to letting the arcs into the deck, the iron must be made sufficiently thick to give the truck-stop bolt (traversing with it) a hold by a screw; the eyes of the truck-stops must be raised accordingly, and a groove cut in them to admit its traversing over the arc.

It would obviously be desirable that the guns should be depressed when battering an enemy's ship within point-blank; but the degree of depression depending on the height of the several decks above the water (as well as on the range) will vary with every class of vessel. All calculations in gunnery, but more particularly in naval

gunnery, can amount only to approximations in prac-
tice; but the focus of fire should evidently be about the
level of the water, and it is with this view that depres-
sion should be resorted to.

Elevation tables, for the converging fire, *lettered to correspond with the converging arcs*, may be fixed close to each gun.

Sir Philip Broke's practice in the Shannon is the best evidence that the elevation of the gun (and consequently the graduating of the coins or means employed for elevating) may have reference to the horizontal position of the axis of the bore of the gun, as shewn by a spirit level, the ship being in harbour, without motion, and perfectly upright.*

It is suggested, whether the coins or elevating screw, or whatever means may be employed to elevate the gun should not be so constructed as to be fixed sufficiently firm, at any desired degree, not to be displaced by the recoil of the gun, or the jarring of the carriage on firing. It is conjectured that after being engaged some time, the number of the officers necessarily decreasing, and the men also diminishing and becoming fatigued, the guns will be often too much elevated, the seamen being more anxious to discharge their guns in the direction of the enemy, than to replace coins or stool-beds. Though it may be desirable to cut away the rigging (which case and dismantling shot from the forecastle and quarter deck will effect), yet it is fancied that the hull is the grand object of fire, and as near the water level as possible.

If it be considered what number of shot must harmlessly pass through the rigging, compared to the number actually taking effect on masts or yards, and stays or principal rigging; on this account alone, the superior

* See Sir Howard Douglas. Sec. 75.

advantages of aiming at the hull must be evident. Indeed, the advantage here contended for was practically demonstrated during the course of last war, as officers in the navy constantly attribute their success, in a great degree, to the contrary systems prevailing in the French and British navies; the one directing their fire chiefly at the rigging, the other at the hull.

It has been observed, that elevation tables may be placed near each gun; perhaps it may be advisable to fix to the beams pendulums or indices of brass, which, by hanging freely on a pivot, may retain their vertical position on the rolling of the ship, and indicate, by means of a graduated arc on a plate of brass, to which the index may be affixed, the moment when the ship may be *laterally* on an even keel; or, this crisis may be denoted by the coincidence of a bar at right angles to the shank of the pendulum, with a white streak painted on the beam, as in the pendulum proposed by Sir Howard Douglas to be attached to the first reinforcing of guns. By means of this index or pendulum, the necessary allowance may also be made for the heeling to or heeling off of a ship on a wind.

The guns, being elevated according to the intended horizontal range and with reference to the height of the battery above the water, (their training being controlled by the truck-stops,) would be fired at the moment when the index might denote that the axis of the bore of the gun is at the desired angle with the horizontal plane indicated by the pendulum. It is imagined that very little practice would be sufficient to enable a seaman, keeping his eye on the index, to time the firing so as to make it synchronous with the *lateral* horizontal position of the ship. By this means, therefore, guns may be exactly elevated as well as pointed, by order of an officer on deck, under all contingencies arising from the rolling or heeling of the ship, fog, darkness, smoke, &c.

There is an inconvenience attending all tangent scales or sights regulated by tangents, when used on board ship; the object of fire must be seen at the time of firing, and the smoke frequently interferes with the view. In elevating a gun by tangents, the plane or line of sight is always the same, be the angle of elevation what it may, it is parallel to the plane coincident with the axis of the bore when the gun is horizontal, or when laid point-blank at an object.*

The elevation or depression of a gun is equal to the angle formed by the intersection of two planes; the one, the plane of sight; the other, the plane parallel to the axis of the bore cutting the plane of sight at the notch on the swell of the muzzle, or at the distant point of sight of the elevating instrument; for this angle is obviously equal to that formed by the intersection of the axis of the bore with the plane, coincident with the chamber extremity of the axis of the bore and the point as much below the centre of the bull's eye of the target, as the chamber extremity of the axis of the bore is below the plane of sight.

Parallel to the plane of sight is a third plane, which is tangential to the wheels or fore trucks of the gun; it passes as much below the bull's eye of the target, as the tangential point of the circumference of the truck (or, which is the same thing, as the deck or platform,) is below the plane of sight. On this plane are estimated the first grazes, as on a horizontal plane, when the axis of the gun at point-blank is horizontal. For practical purposes, the tangent scale dispenses with the necessity of taking into account the difference of level of the gun,

* A gun is said to be laid *point-blank at an object*, when the axis of the gun produced falls on the bull's eye of the target, without reference to the level of the gun and of the target.

and the object fired at; and as the position, or rather level of field artillery, in connection with the object of fire is very uncertain, being often many feet above or below an enemy, the trunnion axis of the gun being generally horizontal or nearly so, the adaptation of tangent scales is peculiarly fitting to this service: but it is questionable whether tangent sights are equally appropriate or as much required at sea.

The relative height of the batteries on board ship, when opposed to floating objects, is always known, provided the ship be on an even keel; if, therefore, the guns be fired when in that position only, the necessity of tangent scales or sights, so far as relates to elevation, is at once obviated.

When an enemy's ship or the flash of an enemy's gun can be only glimpsed through the smoke, of what use can tangent sights be? A steady view of the object is absolutely essential to the use of sights, because the eye must be kept steadily on the object until the vertical and horizontal cross wires are in one with it; at which instant the gun must be fired. Since this refined result is to be obtained by the motion of the vessel, the difficulty of the view is enhanced by the necessary position of the man who points and fires; he cannot be less than eight or ten feet from the port. The same objection applies to any modification of tangent sights or scales and to the use of disparts.

By the method proposed, the gun is laid by alligning the fore trucks upon the truck-stop; the elevation ascertained by the individual who fires, his position being immaterial, so that he has in view the elevating pendulum, which may be placed where most convenient.

It must, at all events, be admitted, that it is more difficult to fire at the instant when three points coincide, which is necessary in the use of tangents, than to fire at the crisis when the proposed index shall point out that the ship is *laterally* on an even keel. But were the facility in elevating equal, when the object of fire is seen, this equality would vanish with the object. Besides which it may be observed, that by the means proposed the elevation of the gun is certainly given; whereas in the use of sights and disparts, the required elevation is only given when the *trunnion axis* of the gun happens, at the moment of firing, *to be horizontal.*

The author wishes it to be clearly understood, that he does not presume to say what method may be most expedient to ascertain the lateral horizontal position of the ship; this is a collateral minutia connected with the plan he proposes, but independent of the general principle for which he contends. He would rather be inclined to prefer a spirit level above any pendulum, since the movement of the air bubble is easily perceived and the crisis for firing may be readily ascertained by it. We have never seen an artilleryman evince any difficulty in the use of a spirit level or spirit quadrant, the air bubble being about an inch long, and the opening, in which the action of the bubble is seen, about three times that length, having bars indicating its situation when horizontal. The level would occupy little room; it may even be let into a beam or into the gun-carriage itself; it could not be put out of order, and is little liable to be broken; the casing may be of any strength, and the part of the glass tube, through which is seen the air bubble, may be covered by a sliding cylinder, as it generally is, when not in use.

If the gunner's spirit quadrant, the level of which is attached to an index, were used instead of a common spirit level, the long radius being fixed or applied so that the level at 0° may correspond with the axis of the bore of the gun when horizontal, the elevation may be given, when the ship rolls, or heels on a wind, from the quadrant, the coins of the gun being fixed at point-blank.

The pendulum, however, appears to be approved by Sir Philip Broke, by Sir Howard Douglas, and by Sir Samuel Pechell, whose tract on naval gunnery we regret never to have seen, having often, but in vain, attempted to procure a copy of it.

Whatever be the desired elevation or depression of a gun, whatever the means used for obtaining the elevation, the same difficulty exists; the gun must, if the ship have a rolling motion, be fired at a particular crisis.

Sir Howard Douglas has well observed: "The direction of the discharge with respect to line may frequently be well regulated by sight, when the elevation cannot; hence it is of vast importance to be able to ascertain the precise moment when the ordnance become horizontal by attaching some simple expedient to each piece."*

This desideratum attained, why limit the advantages secured by it to point-blank or horizontal fire? why not extend its application to every required degree of elevation or depression? And, again, if it be of vast importance to ascertain the precise moment when the ordnance become horizontal, the object of fire being indistinctly seen, is it not of still greater importance to ascertain the correct pointing as well as elevating of the gun, the object being absolutely concealed from the view of the seamen stationed between decks?

The admiralty, in September, 1830, issued an order to the dock-yard authorities at Portsmouth to construct truck-stops, with a view to their trial on board the Excellent; the author was not enabled to attend their construction, nor, so far as he is aware, has the order ever been acted on, further than in the construction of a

* Naval Gunnery, p. 220.

single truck-stop, which, however, he has never seen. The only satisfactory method of making the experiment, would be from the broadside of a ship of war.

In 1831, a committee of naval and artillery officers, directed to examine the proposition, "made their report and stated that they do not consider that the projects could in any degree afford the advantage proposed from it."*

The projector has heard the truck-stop objected to as "additional gear on a ship's decks;" it has also been remarked, "there is a difficulty in getting the gun into a position to run fair upon the truck-stop," but he never, either previous or subsequent to the report of the committee, has heard it advanced, that if applied it could have no tendency to effect its object. He would not have been surprised at hearing that he had over estimated the utility of the suggestion he had offered, and that, for certain naval reasons, it might not be expedient to admit the heurtoirs on board ship, but that "the project can in no degree afford the advantage proposed by it," he is prepared to deny and to disprove either theoretically or practically. It is very certain in target practice that, inasmuch as a gun may be run up upon different parts of the heurtoir or truck-stop, limited by the width of the port or embrazure, so will the fire be less exact than when the prolongation of the axis of the bore falls upon the vertical of the bull's eye; but as this difference on the truck-stop does not form the subtense of an angle, but is the perpendicular between two parallel lines of fire, the deviations will be inconsiderable, as it never can be imagined that the focus of any fire can, in practice, be reduced to the limits of a foot or eighteen inches, which may be the extent of the variation which a ship's port might admit.

* Extract of a letter from the Secretary to the Master General, dated 2d February, 1831.

The report of the naval and artillery committee is certainly discouraging, but it is satisfactory to know that the introduction of gun locks was at first unequivocally condemned. The rudder of Captain Lihou was also strongly reported against, but now that a patent is obtained for the invention, and that the improvement is universally admitted to be of vast importance to the navy, all the rudders of His Majesty's ships are ordered to be fitted by him.

Opposed to the opinion of the naval and artillery committee, the projector has also the satisfaction of having had his project approved by some of the most able judges in both services.

A naval officer, particularly competent to form a just estimate, and to whom many plans for concentrating fire had been officially submitted, writes: "It is one of the best and most efficient plans I have seen for effecting the desired end." Sir George Cockburn was pleased when at the admiralty, as before noticed, to designate it "a sure method of obtaining the object proposed." This opinion of Sir George Cockburn has been participated in by several officers of rank and standing in the navy, who have been engaged in several general actions, and one of them particularly distinguished by attention to gunnery. Without adverting to the expressed opinions of several artillery officers, it may be observed, that although the naval and artillery committee "did not consider that the project could in any degree afford the advantage proposed from it," yet the principle has been approved and enforced by the most eminent writers on the subject of enfilading and ricochet batteries; nay, it has been acted on by every man who ever correctly laid a heurtoir. In all services, except our own, the construction of batteries and the laying of platforms is exclusively the duty of the artillery; it is, therefore, nly in works on artillery, in any foreign language, that ve are likely to meet observations on the subject.

General Gassendi says: "Le heurtoir doit être *perpendiculaire à la directrice* de l'embrazure, et le plus près possible de la batterie, *pour que la pièce ait la direction qu'elle doit avoir.*"*

The Prussian General Decker remarks: "On placera ensuite le heurtoir le plus près possible de l'épaulement, *bien perpendiculairement à la directrice*, et de manière à ce qu'elle partage sa longeur en deux parties égales *afin que l'axe de la pièce en batterie se trouve bien coincider avec l'axe de l'embrazure.*"†

The principle condemned by the naval and artillery committee is that which is admitted to determine the preferable position of all flanking works. The flanks of bastions are only perpendicular to their lines of defence from the influence of their position to produce a fire *perpendicular* to them, and in the direction of the line of defence.

All that the projector claimed credit for was a new application of a principle admitted, until the naval and artillery committee made their report, to be universally true; namely, that the heurtoir, in quick firing, is at least as influential upon the direction of the fire as the interior crest of a parapet is upon that of a fire of musquetry. If the heurtoir be perpendicular to the line of fire, the trucks of the gun-carriage cylindrical and even with it, it is difficult to imagine how the gun can be badly laid, the axle tree of the carriage being, as it invariably is, at right angles to the axis of the bore.

The projector can assert, that having to use howitzers throughout two or three nights, and the ribands of wood which were nailed to the platforms to direct the

* Aide-Mémoire, p. 117.

† Traité Elémentaire d'Artillerie, par E. Decker, traduit par J. Ravichio de Peretsdorf et A. P. F. Nancy, p. 561.

fire being quickly broken and knocked off, he was only enabled to lay them by setting off a certain distance, each round, from the head of the platform, or from a chalked line parallel to it, on each side of the breast of the carriage. By this means the fire was rendered efficient. Much trouble would have been spared had a base been laid upon the platform perpendicular to the line of fire upon which the howitzers might have been aligned.

With reference to the objection made to the truck-stops as additional gear and consequent liability to obstruct the decks, the author would speak very diffidently. It is impossible for him correctly to judge what may or what may not, in this respect, amount to an insuperable objection. It may be observed, that as the truck-stops do not, when applied, project beyond the vertical tangent to the fore trucks, (*see Pl.* 3, *x*) they can scarcely in that position be conjectured to be much in the way, and they will extend only a few inches beyond the arm of each axle tree. The guns may be run out three inches further than the present horns on the breast of the carriage will admit, as may be seen by the line *c′ b′*, without any interruption from the truck-stop. The only interference with the waterways, (which are now understood to be concave,) will be at the spot where the bolts are fixed, *Pl.* 3, *x*, but even this may be avoided, if of any consequence, by making the eye for the bolt to project longitudinally from the ends of the truck-stop, instead of from the back as in the drawing. These minute details may be best determined on trial. When the truck-stops are not in use, they may be hung up to the side of the ship by two staples, there to be fixed to receive the eyes, *a a Pl.* 2, of the truck-stop; or perhaps they may occasionally be beneficially applied under the rear trucks, as a cleat to prevent the guns from fetching way when the ship rolls violently. The author feels that he is here treading on uncertain ground; he is however fully persuaded, that if the value of the truck-stops in controlling and facilitating broadside fire does not far outweigh the inconvenience resulting from the objection to them as "additional gear," that the project can indeed "in no degree afford the advantage proposed from it."

The question mooted by the objection, "there is difficulty in sleuing round the gun so as to run fair upon the truck-stop," is an artillery as much as a naval question. It has also been said, "a gun cannot be run up against the truck-stop without being first placed in a particular position, which requires time and demands attention to minutiæ, which it is the professed object of the truck-stop to avoid."

We are most willing to admit, that if the truck-stop presents any obstacle or occasions the least difficulty in the running out the gun, that it is sufficient reason for discarding it; but before this objection be admitted as valid, it would be but wise, observing the result, to direct that two guns be laid obliquely in *the same degree*, (so many points abaft or ahead,) one furnished with a truck-stop placed at right angles to the intended line of fire, the other gun without a truck-stop.

Whatever the difficulty be in running up a gun upon the truck-stop, it must be proportioned to the obliquity of the line of fire. If there be no truck-stop to one gun and a truck-stop to another, and it be desired to fire obliquely in the same degree, the guns must, in each case, be thrown into the oblique direction; the axle trees of both guns must eventually be at right angles to the line of fire; the breadth of the ports being similar, the guns must, with reference to their ports, occupy precisely, or within a very few inches, the same spot.

The truck-stop cannot impede this operation nor directly assist it, except that it will be a sure index to the commander of the gun and to every man at it, particularly to those with handspikes, of the degree of traverse required. The right position once attained, it will be preserved; of which there is much reason to doubt, where there is no truck-stop. In training guns, but particularly when obliquely to the front, men are apt, from eagerness or inattention, to throw the rear of the carriage too much to the right or left.

It is much easier to sleu a gun into an oblique direction when running up, than to cross-lift it (or by the application of the side tacles to drag it to the right or left,) when actually run up, which would be necessary, either at a port or an embrazure, when the angle of traverse is considerable.

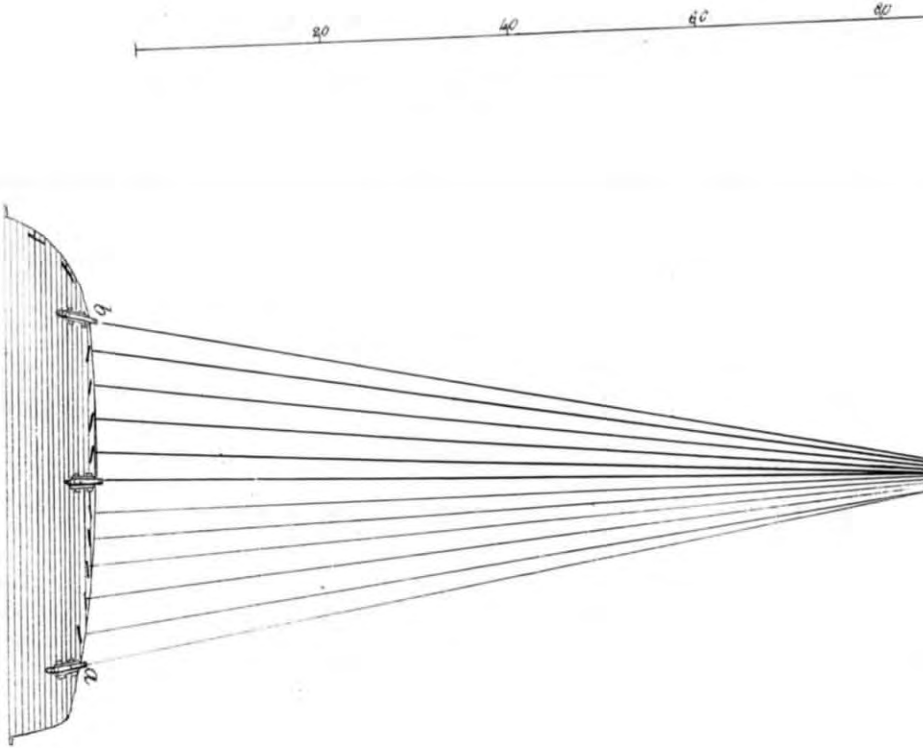
If this be admitted, and it can scarcely be questioned, it is impossible that the truck-stop can offer any impediment to the running out the gun. The charge against the truck-stop, though made in the best spirit, would be too like the old fable of the fox and the lamb: the fox being higher up the stream than the lamb, accused it of rendering the water turbid and unfit for use. With equal reason might it be objected against the truck-stop, which is without, and, as it were, above the due sphere of the gun trucks and carriage, that it obstructs the placing of the gun. The interference or obstruction of the truck-stop can only arise when the trucks are forced out of their due position; in which case, it must be beneficial.

If it were considered easier to throw the gun into the oblique direction when run up and square with the port, the truck-stop need not interfere with this operation, as the gun may be thrown, or dragged by the side tacles, *for the first round*, into the desired direction, or nearly so, when the truck-stop may be applied and the laying of the gun corrected upon it. The adjusting of the breeching being attended to, the gun will recoil perpendicularly to the truck-stop, and for subsequent rounds, very little attention will obviate all difficulty. It is not for a single round that the truck-stop is proposed, much less for deliberate shots, the object being distinctly seen; but, as before repeatedly observed, at short ranges, to ensure the laying of the guns in very dense smoke, or in the most impenetrable fog; and to give to the officer in command the direct and absolute control over his guns by the helm, but more especially when at anchor, by means of springs on his cables.

Note, page 54.—Erroneous impressions, as to the effect of long and short guns, have arisen from the line of metal ranges of such guns. The dispart of the short gun is greater than that of the long gun of the same calibre; the line of metal elevation is, therefore, greater, and consequently, with equal initial velocities, the line of metal range of the short gun will exceed. The disadvantage of increased elevation has been adverted to.

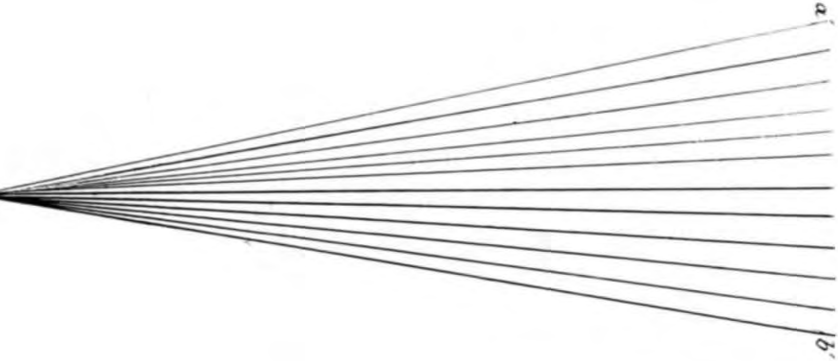
Note, page 70.—It might have been noticed that Lord Howe, in his official report of the French ships captured on the 1st June, 1794, returns Le Vengeur with this remark: "Sunk almost immediately upon being taken possession of." It is asserted by the Rev. John Hughes, in his continuation of Hume and Smollet's History of England, (vol. iii, page 240,) that this ship, "even after the lower deck guns were immersed in water, rapidly discharged the upper tier, and when the engulphing waves finally closed over her, they went down to the bottom with an enthusiastic cheer, and cries of Vive la Republique! Vive la Liberté! Vive la France!" The version of the reverend gentleman reads well, but we prefer that of the gallant admiral.

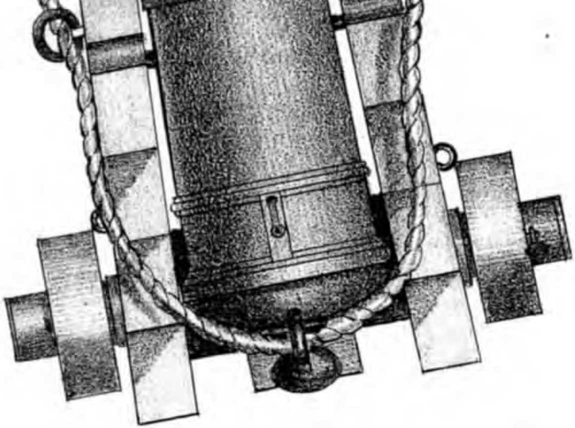
BARBET, PRINTER, NEW-STREET.


20
40
60
80

Pl. 1.

100 yards.

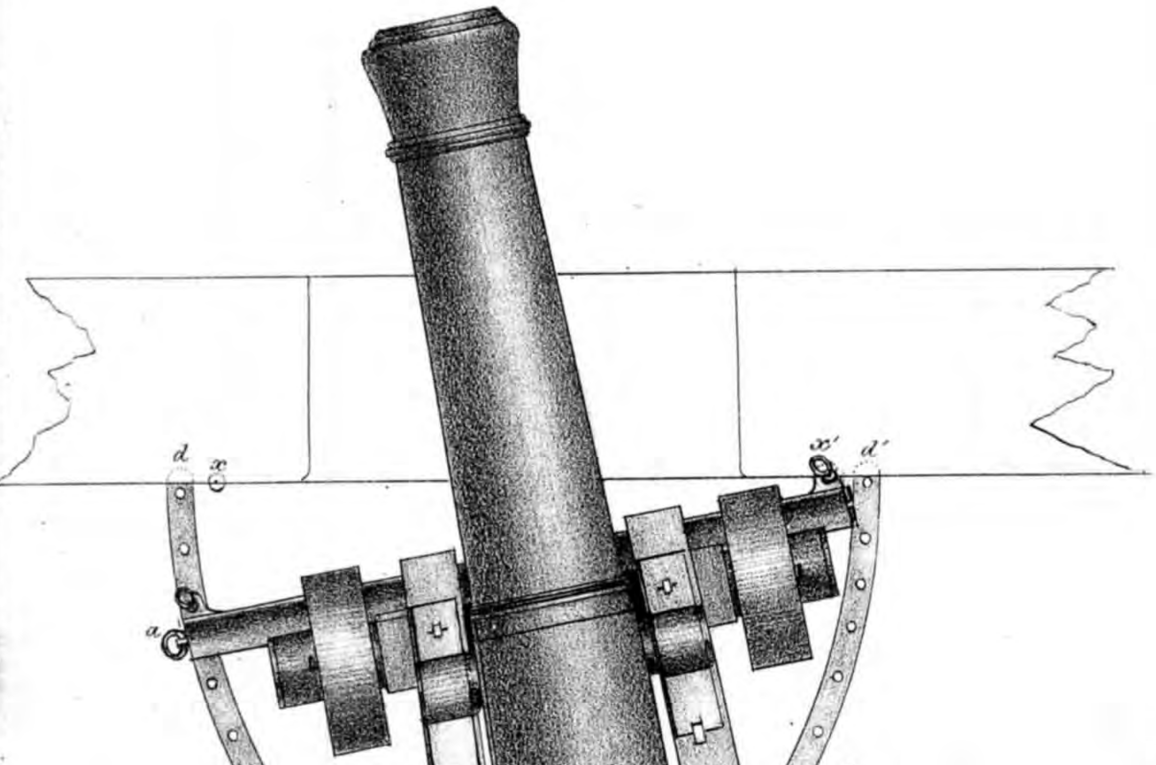


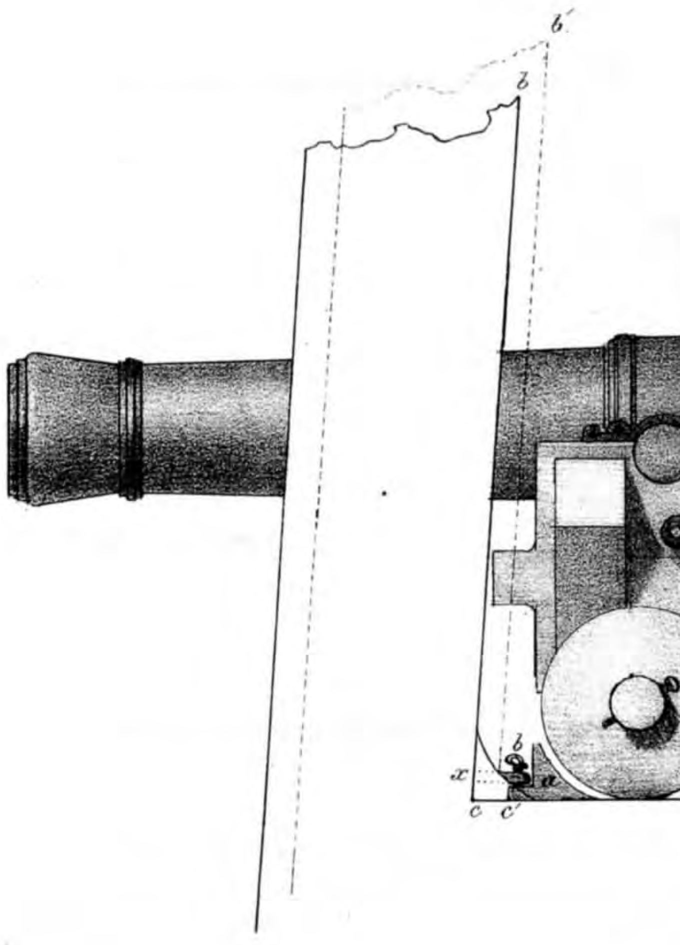


a y
y' a'

b

Pl. 2.





b'
b
b
x
a
c
c'

Pl. 3.