

however, not to exceed this charge so as not to injure the bore too much and too rapidly, around the seat of the projectile.

The service charge adopted for the Woolwich steel gun is 1lb. 12oz. There is obtained with a 2lb. charge an increase of 65 feet in the initial velocity, and of 164 yards in range at 14° elevation. With equal range of about 4,400 yards the angle of elevation is diminished by about 1° and the angle of descent by 1° 30'. The accuracy in range is rather greater; the accuracy in height improves both by the greater accuracy in range and the diminution of the angle of descent.

It seems, therefore, that there would be a manifest advantage in employing the 2lb. charge, and this because the bore is not thereby enlarged, and is but very slightly injured; the carriage also stands well, and the length of recoil (6ft 7in. with 1lb. 12oz., and 8ft. 3in with 2lb.) is still not so great as to become inconvenient. The gun and carriage would support a still larger charge; but beyond 2lb. initial velocity increases slowly, and the increase in useful effect would not be proportionate to the greater strain put upon the gun. It seems, therefore, for a, undesirable to exceed the 2lb. limit.

11. It was desired to make the comparison between the Vasseur rib rifled gun and the Woolwich steel gun more conclusively by firing both pieces with the same projectiles (those of Woolwich). The comparison will be still better established by using the same charge, viz., 2lb. It would not be just to allow the 2lb. charge for the rib-rifled and that of 1lb. 12oz. only for the Woolwich gun, since the latter piece supports the 2lb. charge at least as well as the rib rifled gun.

The initial velocities may be estimated at 1,460 feet per second for the altered Woolwich shell in the rib-rifled gun, and at 1,444 feet per second for the common shell in the Woolwich steel gun.

The ranges and elements of accuracy are shown in the following tables—the figures therein being obtained by adjustment and expansion of the results of the firing.

RANGES.

Angle of Elevation.	Woolwich Gun Charge, 2lb.	Vasseur rib-rifled Gun. Woolwich Shell altered. Charge, 2lb.
	Yards.	Yards.
5°	2312	2372
10°	3598	3707
15°	4561	4714
20°	5316	5501
25°	5906	6113

MEAN DIFFERENCE OF RANGE.

Range.	Woolwich Gun.	Vasseur Gun.
Yards.	Yards.	Yards.
2187	174	173
2734	209	208
3281	269	263
3828	341	330
4375	422	408
4921	518	490
5468	600	569

MEAN REDUCED DEFLECTION.

Range.	Woolwich Gun.	Vasseur Gun.
Yards.	Yards.	Yards.
2187	3.7	1.6
2734	5.1	2.2
3281	6.7	2.9
3828	8.5	3.7
4375	10.6	4.6
4921	13.0	5.6
5468	15.9	6.8

MEAN VARIATION IN HEIGHT.

Range.	Woolwich Gun.	Vasseur Gun.
Yards.	Yards.	Yards.
2187	2.1	2.0
2734	3.5	3.1
3281	6.1	5.8
3828	10.5	9.6
4375	16.9	15.2
4921	25.8	23.0
5468	38.2	33.3

Probable number of shells per 1000 which would strike a target 656 feet high and of unlimited breadth.

Range.	Woolwich Gun.	Vasseur Gun.
Yards.	Shells per 1000.	Shells per 1000.
2187	305	336
2734	197	225
3281	115	121
3828	70	75
4375	43	48
4921	28	32
5468	19	22

It is shown from the first table that the increase in range of the altered Woolwich shell rises gradually from 60 yards at 5° elevation to 207 yards at 25° elevation. The initial velocity being very nearly the same in both cases, the increased range is due to the less resistance of the air to the motion of the projectiles, which, instead of having projecting studs, have grooves sunk in them.

On comparing the second and third tables it is seen that the rib rifled gun, while maintaining its superiority as regards the accuracy in direction, becomes as accurate, and even slightly more so, in range and in height than the Woolwich gun.

The rib-system is therefore superior to the groove system from a ballistic point of view.

This superiority is attained at an inconvenience which we must now point out.

In the Woolwich guns, ease in loading is rendered certain with a windage of 0.0197 in. and even of 0.0157 in. in diameter in the grooves, but any difficulties which may arise are always overcome by using the rammers.

The projectiles in the rib-rifled gun with the same windage of 0.0197 in. in diameter and in width, have nearly all given very great difficulty in loading: in fact two projectiles jammed in the middle of the bore, and it was absolutely impossible to make them go in any further. Loading became easy after increasing the windage in diameter and in width to 0.0315. The rib-system

* Recent experiments show that it is only necessary to increase the windage in the width of the groove to .01 inch, and that a windage in diameter of 0.2 inch is ample to ensure easy loading.

A 7-in. gun rifled on this system has been fired 25 rounds. On three occasions 25 rounds were fired as quickly as the gun could be served, and no difficulty occurred loading at any one round. The windage allowed in this gun was the same as in the English service, viz., .08 over the body of the projectile, and .05 over the ribs, and any difficulty in loading inherent to the system would be much more apparent with a 7-in. gun than with a 12-pounder.

In the previous experiments the windage allowed was .015 inch in diameter, and the same in the width of groove; notwithstanding this the Committee state as follows: "Compare the Canons de Woolwich, le Canon Vasseur a cotes saillantes d'une un peu plus de portee et justesse en direction, mais moins de justesse en hauteur et une probabilité de tir contre les troupes plus faible."

This superior uniformity of range of the Woolwich gun is entirely due to the superior uniformity of the projectiles, they being turned exact to gauge, a difference in diameter of only .02 inch being allowed. Referring to page 6 of the Report we find the Vasseur projectiles were not turned, and variations in diameter amounted to .063 inch, more than three times that allowed with the Woolwich projectiles.

At pages 72 and 73 we find that an enlargement of the bore of the Woolwich bronze gun of .016 inch made a difference of 25 feet in the velocity of the projectile; four times this difference in the diameters of the projectiles would therefore make a notable difference of 25 feet in the regularity of the ranges.

thus requires more windage than the groove system.

But, on the other hand, as too much freedom of the projectile in the bore would diminish not only the range and accuracy, but would be still more fatal to the durability of the piece than in the groove system, we may say that the windage should be kept within very narrow limits, and that the rib system necessitates more precision in the manufacture of the projectiles and more care in inspecting them than the groove system. Without such care and precision, but which may be sometimes neglected in hurried manufacture in time of war, there might be in the limber boxes of a battery projectiles which would jam in the bore, and would have to be fired at random with range very much diminished and quite unknown, a very serious inconvenience with guns of long range which have often to fire over friendly troops.

111. The comparative trials have shown, that with 14° elevation the modified Woolwich shells have a mean range greater by 131 yards than the 12lb. shell of Mr. Vasseur's first pattern. This increase of range becomes greater as the elevation becomes lower, and becomes less as the elevation increases. Both projectiles have the same maximum range, 6780 yards or 6890 yards at about 35°; it is chiefly in the considerably increased accuracy that the superiority of the modified Woolwich shells consists. This is due to better centring, consequent upon more careful manufacture, and also to better distribution of the weight through better regulated thickness, and to turning the body of the projectile. But does the reduction in the weight of the projectile tell favorably upon the accuracy? In the experiments with three bronze canons de 4, Olry's system (see 'Revue d'Artillerie,' June 1873), the Calais Commission fired in a gun of 3in calibre shells weighted to 9lb. 15oz., 10lb. 9oz., 11lb. 4oz., and 11lb. 14oz. It was found that by increasing the weights of the projectile, the mean variation in direction diminishes slightly, whilst the mean variation in range appears to increase. The mean variation in height follows very closely the mean variation in range. Should this be the fact, we should prefer, in the case before us for a muzzle loader of 3in. calibre, a projectile weighing nearly 9lb. to one weighing nearly 11lb., because with equal elevation and up to the limit of fighting distances, the range of the lighter projectile is decidedly greater, its accuracy in range and height is rather greater; again, its destructive effects are sufficient for a divisional piece, and, for an equal number of rounds carried the weight of the limber boxes is less.

In support of this view, we cite the fact that the English gun of 8 cwt. and 3in. bore was at first intended to fire 12lb. projectiles, but it was afterwards decided to adopt 9lb. projectiles.

VASSEUR'S NEW ELEVATING GEAR.

Mr. Vasseur has presented a new elevating gear which has been found satisfactory, and which might be advantageously used in the service.

This apparatus consists of two screws, one attached to the cascable of the gun, the other attached to the carriage. These screws, one of which is right handed and the other left-handed, both take into the ends of one nut, suitably screwed to receive them. By giving one turn to the nut the screws are each caused either to go into or out of the nut by a distance equal to the pitch of its