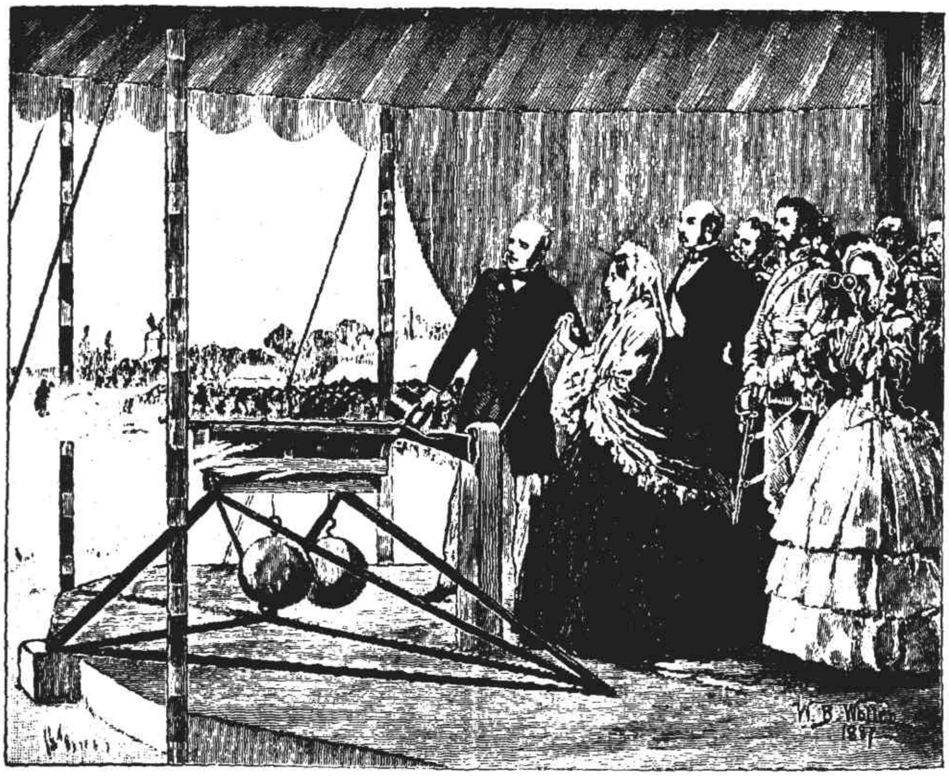

1. Queen Victoria firing the opening shot at Wimbleton in 1860. From W.W. Greener, *The Gun and Its Development*, 9th Edition.

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Joseph Whitworth and His Guns

William E. Brundage

Sir Joseph Whitworth became connected with arms more by accident than by design. His business was running a factory which specialized in making machine tools. The British government was having problems with the production of their new regulation musket and asked him to design machinery, not guns. The final result was not only the machines but rifles and rifled ordnance, along with the discovery of *why* they worked and *what* they could do.

Whitworth was born in 1803 and started work as a mechanic in Manchester and London. He invented the method of fabricating true planes, done by intercomparing three plates as they were scraped to form the flats. Along with other devices, this permitted measurements, and therefore work, to be performed to a previously impossible accuracy. The standard tolerance at his Manchester Works was termed a "division" and was in fact one ten-thousandth of an inch. If required, they were capable of measuring to one millionth of an inch. Whitworth's name might also be recognized for the British standard screw thread system, which he devised and published in 1841.

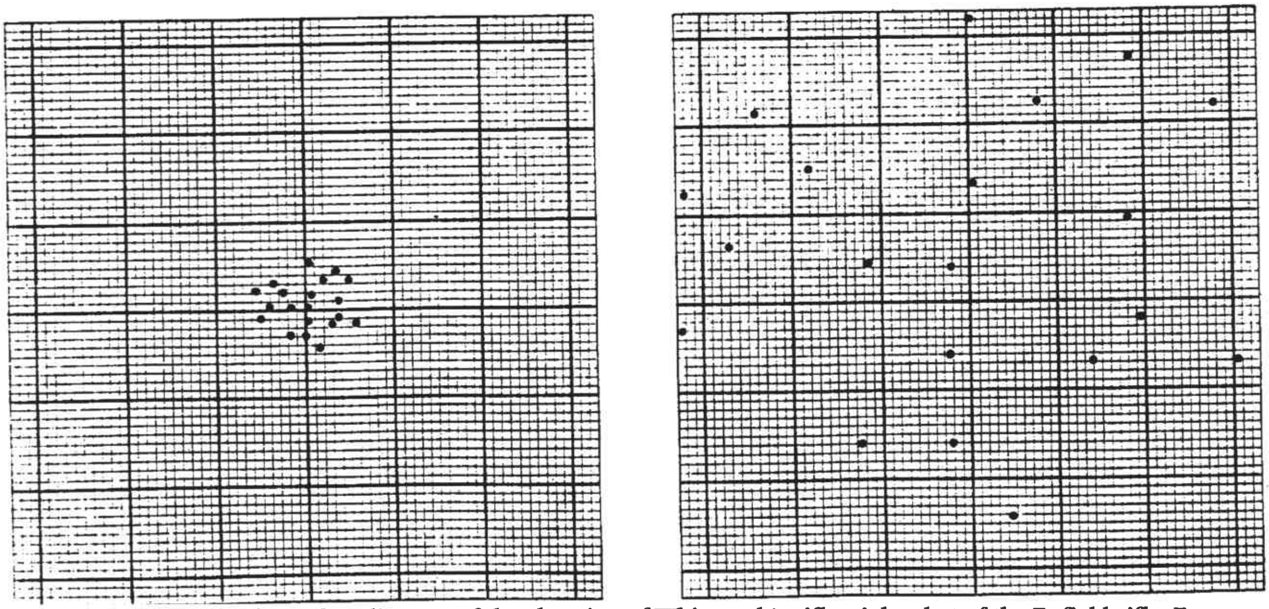
Improvements in arms were just one of the many changes which took place in the world during the middle of the 19th century. Far-flung empires required military actions to protect or enlarge them. Guns that shot faster, farther, and more accurately were wanted. The advantages of a rifled musket firing an elongated bullet were appreciated, but the problems of forcing a tight-fitting bullet into a fouled bore restricted military adoption. Inventions such as the French carabine-á-tige, the Prussian needle-fire, the Hall breech-loader and the Minie ball were attempts to overcome the military deficiencies of the rifle.

A few comments on the effectiveness of military guns[1] may illustrate the problems of the period: (1) *The Edinburgh Review*, reporting on an 1838 test of Service muskets by officers of the Royal Engineers, termed it "the most amusing result" and stated that with a target three feet wide and eleven and a half feet high only three-quarters of the balls hit at 150 yards and at 250 yards none hit the target, even though it was widened to six feet; (2) the French fired over 25 million cartridges during the Crimean campaign (1854-56), but certainly less than 25 thousand men were hit; (3) during the Caffre war, 80 thousand cartridges were fired in a single engagement but only 25 of the enemy fell; (4) finally, at Salamanca, while 3,500,000 cartridges were fired, along with 6,000 cannon balls (and charges of both cavalry and the line), only 8,000 men were put *hors de combat.*

To keep up with the Continent, Britain had adopted a .70 caliber Minie rifle in 1851 and then superseded it in 1853 with one of .577 caliber. While the 1853 Enfield was believed superior to any arm yet adopted by another country, its velocity was lower than desired and it had a strong tendency to foul. The real and pressing problem with the musket was the large variation in the accuracy of the guns.

In 1852, Viscount Hardinge, Master-General of Ordnance, began a comprehensive inquiry into the subject of rifled arms and projectiles, but the solution still eluded them. Lord Hardinge wrote "One rifle shoots well, another ill, and the eye of the best viewer can detect no difference in the gun to account for it." Since they surmised that the variance arose from some subtle manufacturing imperfection, the advice and assistance of "Mr. Whitworth of Manchester" was sought.

Whitworth had no gunmaking experience at that time, but after returning from a visit to the New York Exhibition and an inspection of the Springfield Armory operation in Massachusetts, he had expressed an opinion on the suitability of machine manufacture of firearms. The Government therefore proposed that Whitworth should design a complete set of machinery



2. The 1857 Trial results. Left, a diagram of the shooting of Whitworth's rifle; right, that of the Enfield rifle. From Tennant, *The Story of the Guns.*

for Enfield. The armory would then produce the rifles, instead of the usual procedure of contracting them to the gun trade. The main requirement would be that all of the guns produced were of high quality, but exactly *what* the machines should do to produce this quality was an unknown. Whitworth therefore emphasized that before any satisfactory machine could be constructed, the first principle of this unknown secret must be discovered.

He visited the establishments of the leading gunmakers, both London and Birmingham, attempting to find this secret. The state of the gunmaker's art in 1854 seems well summed up in his subsequent report to the Secretary of State of War: "I found great difference of opinion among them, and the statements I received so contradictory, that I was unable to come to any satisfactory conclusion".[2] Since he felt that the secret could only be found by a scientific approach, he intended to test the muskets, select the most accurate and then make precise measurements of these to find the reason for their excellence. He offered to conduct the preliminary experiments, donating his own time and efforts if the government would defray the direct costs, one of which was building an enclosed shooting gallery for the tests.

When this request was considered by the Committee on the Small Arms Factory, they reported that they felt the cost of Whitworth's experiments would be excessive. Since at that time England was planning to produce one million new muskets, the cost of the experiments would have been only a drop in the bucket. The usual procedure of contracting these out to the gun trade would cost at least two million pounds sterling and require twenty year's production. A reasonable procurement time could only be achieved if these were produced by machine. Prodding by Lord Hardinge did manage to get the experiments authorized in May of 1854.

On October 13, Whitworth reported the completion of the gallery. It was 500 yards long, 16 feet wide, and 20 feet in height, built on grounds of his residence. The target frame was movable and the firing was done from a fixed rest. Screens were placed between the gun and the target to delineate the flight of the projectiles. Misfortune struck before any useful results could be obtained, as much of the gallery was destroyed within a week of its completion by an extraordinarily violent storm. It was not until March in the following year that the experiments could again begin. For these experiments Whitworth obtained the services of the well known and respected gunmaker, Westley Richards, as his assistant.

As most of us know, the final results of Whitworth's experiments was a gun rifled with a hexagonal cross section and firing elongated bullets, but it should be noted that none of this was original with Whitworth. Polygonal bore guns had been made by several makers and the better range and penetration of the longer bullet was certainly well known. The claim of General Jacob, in command of the Scinde

Irregular Horse of the Indian service, was that "a tolerably good shot can certainly strike an object the size of a man, once out of three times, at 1,000 yards distance" with a rifle he had developed. While Whitworth discovered how to stabilize a projectile of any desired length, he was able to patent only the *combination* of a projectile fitted to the shape of the bore.

During the initial experiments with the 1853 Enfield rifles, trying to find that "first principle" of accuracy, Whitworth also tried lengthening the projectile in order to obtain accuracy, range and penetration. The paper screens between the gun and the target showed that these bullets "turned over" or tumbled in flight. After experimenting with many combinations of materials and shapes, he finally came to the conclusion that the rifle was as much at fault as the projectile and that perhaps the rotational velocity was too low.

As an experiment, a new barrel was made rifled with one turn in 60 inches rather than the 78 inches of the Enfield. The results proved encouraging and so another with a turn in 30 inches was made and it proved even better. Many more experiments followed with different twists, some as fast as one turn in 5 inches. Whitworth finally concluded that the optimum results for a bullet of the required 530 grain weight were obtained by propelling it with 70 grains of powder through a barrel with a bore of .451 inches and a twist of one turn in 20 inches. This not only produced excellent accuracy, but a range of 2,000 yards.

Whitworth's preference for the hexagonal bore is apparently due to his appreciation of the fact that this shape has a much larger bearing surface to rotate the projectile when compared to shallowly cut grooves. Pre-shaped bullets were not a necessity as lead bullets were found to satisfactorily upset into the bore. Tin-hardened prefitted bullets did provide the best accuracy.

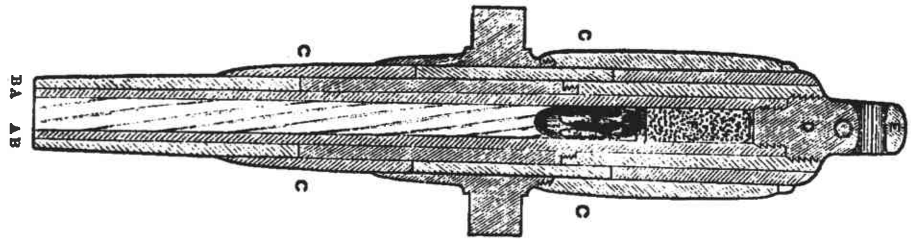
Whitworth's recommendation was so far from the ideas then in vogue that it was bound to draw heavy criticism. The slow twist traditionalists argued, "anything quicker was liable to impede the ball by producing friction to an injurious if not dangerous extent". Whitworth easily disproved this by producing and successfully firing a barrel with one twist per inch. He solved the fouling problems by the invention of a grease wad placed at the base of the bullet and further by the use of a ramrod with a bore-fitting scraper pivoted at its end. Only time was able to overcome the prevalent objection that the bore diameter was too small.

If the proof of the pudding was in the eating, then the proof of a rifle is in the shooting. 1857 saw the Whitworth rifle formally tried in competition with the best of the Enfields. High level observers, including the Minister of War, the Superintendent of the Enfield factory and the chief of the School of Musketry for the Army, were present at trials held at Hythe. With the guns mounted in a machine rest, twenty shots were fired from each at a square target, six and a half feet on a side, and 500 yards away. The results were very convincing. Figure 2 allows a comparison of the results achieved with a good Enfield and a Whitworth. Improved accuracy was not the only benefit, as the Whitworth's range was 2,000 yards against 1,400 for the Enfield. It was also proved superior in penetration tests, passing through 15 inches of elm, while the service rifle could penetrate only 6 inches.

A committee acknowledged the superiority of the Whitworth rifle over all others of similar calibre but recommended against its general adoption noting "that a partial issue of arms having such superior precision would be attended with advantage". Their objection was largely because of the bore diameter, although the higher cost of the Whitworth was a consideration. Since Whitworth held no patent, other makers, even the Enfield Arsenal, began making rifles using the bore diameter and the fast twist of Whitworth's system. The smaller bore did prove superior and was recommended for adoption within the next dozen years.

Although some 9,000 Whitworth rifles were purchased and issued to a number of British army units,[3] their main military fame came from use by the Confederacy during the Civil War in America. Telescope mounted sniper rifles were credited with eliminating several Union officers[4]. The rifle itself was made in several other forms: sporters, muskets, and target rifles built in both military and long-range style.

The year 1860 saw the newly formed National Rifle Association holding the first of the annual rifle competitions on Wimbleton Common. The importance of this meeting, then limited to military competitors, is indicated by the fact that it was attended by the Queen. Figure 1 shows the Queen as she pulled the silken cord which fired a rest-mounted Whitworth rifle to open the matches. This shot provided an amazing endorsement of the Whitworth, as it not only hit the



3. A sectional view of a 70-pound gun. From Tennant, op. cit.

target, 400 yards away, but struck within one and a quarter inches of dead center! Whitworth rifles not only won most of the prizes during this meeting but continued to do so for another 10 years.[5]

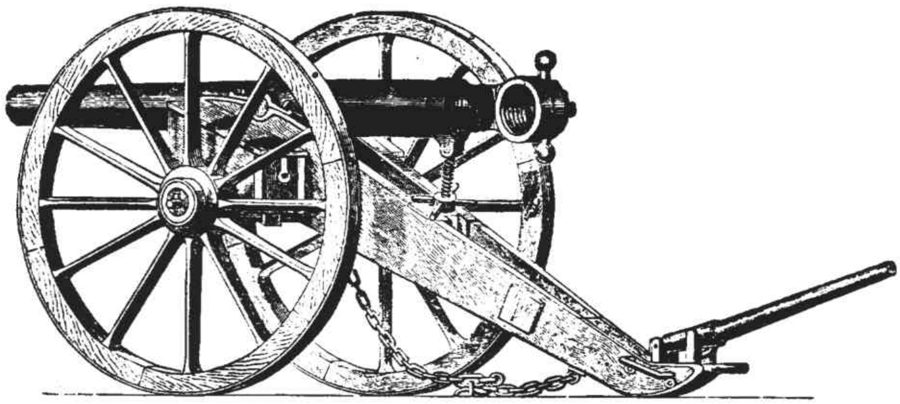
Whitworth's system allowed the use of unyielding projectiles and in 1857 he fired a flat-fronted steel projectile from a rifle and found that it would penetrate a plate of wrought iron six-tenths of an inch thick, while a steel round ball formed only a shallow indentation. Based on this test, he predicted that "projectiles of wrought iron, steeled, might be made for pieces of ordnance, capable of piercing the sides of floating batteries." [6] The status of ordnance had been seriously degraded by the new rifle, as its range and accuracy was now better than the round ball cannon, but Whitworth had no intention of continuing with ordnance development, as he had other irons in the fire.

At the request of the Government, Whitworth's Manchester establishment hexagonally rifled seven brass smooth-bore guns and bored and rifled three 24-pounder brass howitzer blocks, all of which had been cast at the Woolwich arsenal. These were then returned to the Government for trial. The 24-pounder howitzer was first tested on the beach near Mersey. The range for a standard 24-pounder fired at an elevation of 8 degrees and with 8 pounds of powder was 2,200 yards. The Whitworth rifled howitzer was tested with only 2½ pounds of powder and a 8¼ degree elevation. The shot went 3,500 yards, ricochetted off the sand, crashed through the window of a seaside house and ended up lying on the carpet in its drawing room! Fortunately, the only damage done was the demolished window and a throughly startled lady who had been seated at the fireside. However, it was thought best to move the test site. The navy, testing the howitzer, accomplished a feat previously considered impossible: a shot maintained its course through thirty feet of water and, three feet below the surface, penetrated eight inches of oak.

While all of the tests on the brass guns which were hexagonally rifled were favorable, the bulk of the British field guns were of cast iron and a system of converting the existing stock to rifled guns was desired. The Government sent Whitworth two blocks for 32-pounders to be bored and rifled. Both burst under trial. Whitworth also rifled an iron 68-pounder in order to try a new projectile he had invented. This also failed after a few shots (but not before proving the success of his new projectile) and he reported on the unsuitability of cast iron for rifled ordnance. In reply, the Secretary of State directed Whitworth to discontinue experiments with ordnance rifled on his principle.

The summary dismissal of a system which could do so much annoyed Whitworth. Use of his patent had been donated to the Government, so it was a matter of honor rather than money to him. At the time Whitworth was hardly the only inventor considering artillery. Several models had been proposed and the Committee on Rifled Cannon, appointed in 1858, reported that of seven guns submitted by inventors, none was considered suitable for cast iron but that two systems were worthy of further consideration: Whitworth's and one designed by William Armstrong. Armstrong was also a manufacturer and inventor, although trained as a lawyer. One of his inventions was the hydraulic crane which was being profitably manufactured at his works at Elswick.

Armstrong's system for artillery was essentially an enlargement of the rifled musket to the standard of a field gun and firing elongated projectiles of lead. As the projectile had to be forced into the rifling, the gun was by necessity breech loaded. The closure was by a separate "vent piece" forced into place by a hollow jack screw and Armstrong chose to make his guns



4. The Whitworth muzzle *or* breechloading gun. From Tennant, op. cit.

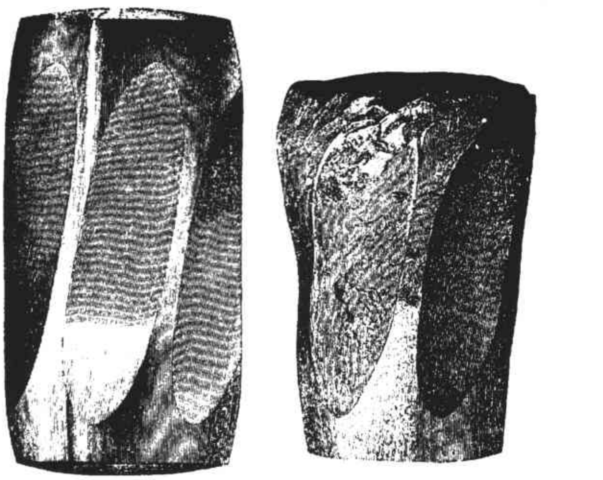
from welded coils of wrought iron. In 1855 he produced a wrought-iron 3-pounder which the War Office Select Committee recommended be experimented with further. It was rebored to 5-pounder and then 12-, 18-, and 32-pounders were made and satisfactorily tested. These guns were rifled in a saw-tooth or ratchet form and fired elongated shot of iron, clad with lead.

As usual, the choice between the two systems was to be made by a committee. The committee felt that they should visit the respective factories, inspecting the modes of manufacture at each. A time was arranged for a visit to each but the visit to Whitworth's Manchester works was never made. They visited Elswick to see the Armstrong guns and were given the understanding that Whitworth had no actual proposal for manufacturing guns at all, having only rifled some muzzle loaded blocks. Without further communication with Whitworth the committee recommended the immediate introduction of Armstrong's gun for special service in the field.

The Armstrong pattern was officially adopted for the light field gun and since Armstrong claimed that only he knew how to fabricate them, he was engaged as Director of Rifled Ordnance. As such he was to develop and perfect his guns while directing their production on a part time basis. Although donating the use of his patents to the Government, he received reimbursement for his development expenses, was engaged at salary of £2,000 a year (back dated to 1856) and was provided with an assistant, Mr. Anderson, to take direct charge of the practical work at Woolwich. At this time he also received the honor of Knighthood and the Companionship of the Bath. At a later date Armstrong was appointed Superintendent of the Royal Gun Factory.

Whitworth stated that it was this summary rejection of his system that turned him into a manufacturer of ordnance. At that time Whitworth had no guns to offer, so a public trial would have to be deferred. As the rifling needed no more development, he felt that the success of his system would depend upon the material and design of the gun itself. Whitworth chose to use "homogeneous iron", bars of the finest charcoal iron cut up and melted in crucibles, then cast into ingots and forged by huge steam hammers. He had satisfied himself with the value of this material for guns by testing a rifle-barrel made from it that was 1 inch in diameter at the breech and with a bore of .49 inches. This was fired with an ordinary charge of powder but with an 18 inch lead plug driven tightly in the bore. The lead plug stayed in place with all the gas escaping through the small platimum-lined touch-hole. Finding no damage, the plug was melted out and the test repeated three more times without harming the barrel.

Since the size of ingots of this material was limited, he started with a tube, slightly tapered on the outside. Hoops of homogeneous iron, similarly tapered on the interior, were hydraulically pressed over the tube as required to build up the required thickness. Figure 3 illustrates the sectional view of a gun intended for a 70 pound projectile. Figure 4 illustratres a complete gun. The screw-thread breech closures



5. The projectile of the Whitworth gun before and after passing through the mock-up of the *Warrior*. From Tennant, op. cit.

were supported by a hinged hoop when opened. Breech loading seems to have been the rage of the day, but Whitworth's opinion was that it only added complexity and his guns could be satisfactorily loaded from either end.

Within a year, Whitworth had ready a series of field guns, 3-, 12-, and 18-pounders, together with an 80-pounder, ready for trial. A five day demonstration of the guns was held on the coast near Southport in Lancashire during February of 1860. Ranges were indicated by poles set on 100 yard spacings out to 10,000 yards. The crowds of spectators who arrived by train to view the tests included military men from France, Austria, Sweden, Brazil and the United States. For the first time, impartial observers could observe rifled guns being fired repeatedly and record the result of each shot. The show was a great success and the smallest of the guns, a 3-pounder weighing only 208 pounds, threw a shot 9,688 yards, an achievement never before equalled.

The War Department still offered only a cold shoulder to his guns, even refusing to furnish copies of the official Ordnance Select Committee reports on rifled ordnance. Public pressure had now put the Government in the difficult position of having to justify its very recent hurried adoption of a gun which might be outclassed. Official trials were proposed but Whitworth refused to submit his guns to what he considered unfair trials before a prejudiced committee. One of the members of the committee which had ignored his system and chosen the Armstrong was even a member of the new committee.

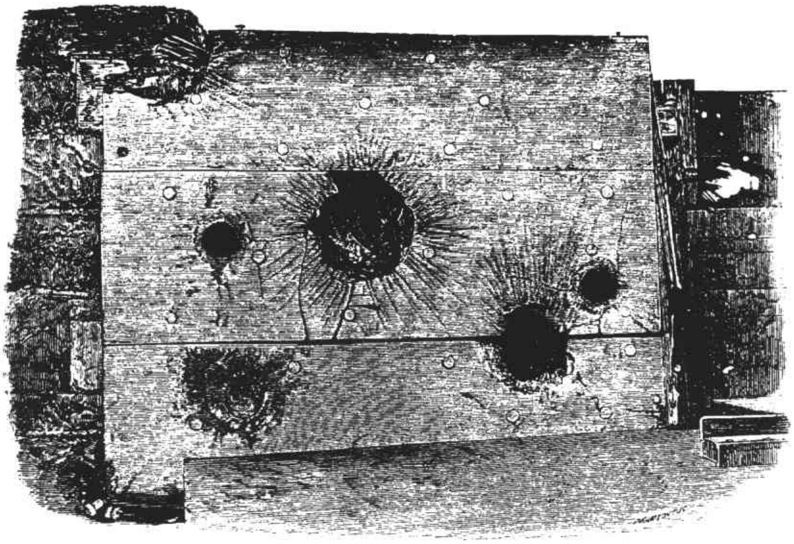
Fortunately for Whitworth, it seems that the naval authorities were more open minded. A major question for naval authorities at the time was how much armour plate was required to protect their ships. Adding weight of plating might protect from heavier shot but reduced the weight of ordnance carried and slowed the ships. An Armstrong 80-pounder had been tested against a floating battery, the *Trusty*, which was plated with 4 inches of iron over 25 inches of oak. No great damage had occurred, as, of the 22 projectiles fired, some weighing over 100 pounds, only 3 were able to penetrate the plate and lodge in the side.

Whitworth managed to get a trial arranged and his 80-pounder (5½-inch bore) was therefore taken to the Thames to try the effectiveness of his newly invented flat-fronted projectile on this target. From Whitworth's standpoint the test was very successful: the trial was halted after only four shots were fired for fear of sinking the *Trusty*! All four shots had cleanly penetrated the armor and two went completely into the ship, one additionally carrying with it part of an iron main deck knee.

So much for the indestructibility of iron-clads. Although proved vulnerable to solid shot, the clad ships were still felt to be impervious to explosive shells. In April of 1861 Whitworth wrote a letter to *The Times* in which he audaciously predicted that his 150-pounder (7-inch bore) would not only penetrate plates thicker than those of the *Trusty*, it would do it with hollow shells. The size of this gun was beyond Manchester's capacity to make from homogeneous iron. It was therefore constructed of wrought iron at Woolwich. Armstrong's assistant, Mr. Anderson, supervised the fabrication, constructing it to Whitworth's design. Although rifled hexagonally, Sir William referred to it as an "Armstrong gun", but Mr. Whitworth strongly disagreed.

Whitworth's newly-invented shell looked very similar to the shot. It was hollowed with a screw closure at the rear and had a flannel wrapped charge of black powder placed inside. The shot had been found so hot after passing through plate that Whitworth realized powder inside would be ignited and that the delay time could be simply controlled by varying the thickness of the cloth wrapping. The lack of a separate fuse had the added advantage that the shells could be simply and safely handled.

The tests of the shells began in September, when his 12-pounder was tested against a target of 12 inches of oak clad with two inches of iron. The first shell passed completely through without exploding. One layer of flannel was removed from the next shell and this one passed through the target and exploded in the



6. The *Warrior* target hit by the Horsfall and Whitworth guns. From Tennant, op. cit.

rear. These were "firsts", as previously no hollow projectile had successfully passed through more than one inch of wrought iron. The 70-pounder test came next, firing at a mock-up of a ship's side: 4 inches of wrought iron over 9 inches of oak with another 4 inches of wood faced with two inches of iron placed three feet behind this. One 68 pound shell with a bursting charge of 2½ lbs. of powder was fired which penetrated and exploded against the back plate, completely shattering the box target.

The new 7-inch gun was next to be tested. Its target was one which had recently been used to test the 24 ton wrought-iron "Horsfall" gun, which fired a ball weighing over 300 pounds from its 13 inch smooth bore. This target was a mock-up of the side of the ship *Warrior*, consisting of 4½ inches of armour plate over 18 inches of teak, backed with ⅝ inch iron plate and supported by angle irons 18 inches apart. The Horsfall gun had been able to break the plate and damage the backing but the Whitworth, firing from 600 yards, first sent a solid shot weighing 129 pounds through, snapping one of the heavy angle irons and coming to rest against the broken brace. An engraving of the projectile before-and-after passing through the target is reproduced in Figure 5.

The real test was with a shell weighing 131 pounds, loaded with 3½ lbs. of powder. When this was fired, it again penetrated, apparently bursting near the rear. The inner skin was completely blown away and the wood splintered and set afire. The condition of the front of the *Warrior* mock-up following the tests is illustrated in Figure 6. The large holes are from the 300 pound balls and the small ones from the 7-inch Whitworth. It became apparent that no practical armour could be considered impregnable.

Whitworth had proven his point. His system worked, his guns were safe and effective. The hexagonal bore became obsolete in a relatively short time and bigger and better breech-loaded ordnance soon replaced both the Whitworth and the Armstrong but the basic principle of using the the proper rotation to stabilize a given projectile still works well. Whitworth's successful career allowed him to become a baronet and to acquire a fortune sufficient to endow 30 scholarships. The world is indebted to him for many advancements, not only in the arms field, but in measuring, machinery design and thread standardization.

Much or most of this material is excerpted from *The Story of the Guns* by Sir J. Emerson Tennant. London: Longman, Green, Longman, Roberts and Green, 1864. This concerns the competition between Whitworth and Armstrong, and is now available as a reprint. It's worth reading.

NOTES

1. Tennent, Sir James, *The Story of the Guns,* p.6.

2. Tennant, *The Story of the Guns,* p. 31: "Whitworth's report to Lord Panmure, June 13, 1857".

3. Bailey, DeWitt II, *The Gun Digest,* 25th Edition, 1971.

4. Howell, Cleaves Jr. *The American Rifleman,* Jan. 1952, p. 34.

5. Greener, W.W., *The Gun and its Development,* 9th Edition, 1910.

6. Tennant, page 57, quoting a letter written by Whitworth.