RANGE-FINDERS.[1]

NAVAL and military authorities are agreed that for accurate shooting almost everything depends upon the range being known with sufficient exactitude. It is not surprising, therefore, that an immense amount of attention should have been devoted to methods of rapidly determining the ranges of distant objects, whether stationary or in motion. These methods may be classified as follows:—

(1) *Mechanical.*—In this method a trial shot is fired from a gun, and so far as is practicable observation is made as to whether the shot strikes the ground (or the sea) on the near or the far side of the target. The results of the observation are used to correct the next trial shot, and so on. The method is clumsy and (at all events on board ship) costly; it is inapplicable in a naval engagement where the ranges frequently alter with great rapidity, and is, of course, totally inapplicable for purposes of navigation. On the other hand, it involves the use of no instrument beyond those ordinarily used in warfare.

(2) *Flash and Sound Method.*—Here the time-interval between seeing the flash and hearing the report from one of the enemy's guns is measured by a suitable chronograph or, by starting to count at the rate of eleven in three seconds immediately on seeing the flash; the number arrived at on hearing the report will roughly give the number of hundreds of yards in the range. This method is, of course, inapplicable amid the din of a general engagement, and besides it permits the enemy to have the first shot.

(3) *Optical Range-finders.*—In the determination of a distance by an optical range-finder, *length of base* and *time* available are very important factors. Given plenty of base-length and plenty of time, a theodolite, such as is used in surveying, satisfies all the conditions except that of portability. However, *time* is usually so important a factor for military operations that the theodolite is completely excluded even for field service. If the time is restricted, but the extent of base unrestricted, recourse may be had to long-base, two-observer instruments, such as those now in use by infantry and field artillery. When both base and time are restricted, as they are on board ship—and moreover the observer's station is itself in motion—the problem becomes at once much more difficult and much more interesting. We need not then be surprised that while military range-finders are usually simple and cheap, naval range-finders are comparatively costly and complicated.

The operation of all optical range-finders depends upon the measurement, by some device or other, of the angle subtended by a known base-length at the distance to be determined, the base being almost invariably "broadside-on" to the point. Where the known base is at the target and the point is at the observer's station, the operation of determining the distance consists simply in measuring the angle subtended by the base at the point. Instruments of this class measure, say, the angle subtended by the height of a man (assumed to be of mean stature) at the observer's station, and require for their successful employment the co-operation, willing or otherwise, of the enemy, and are therefore seldom applicable under the conditions of modern warfare. Men who have returned from active service in South Africa have stated that sometimes they never saw a Boer in an engagement. Where the known base is at the observer's station, which is an essential characteristic of all range-finders of general application (the instruments previously described being in reality mere angle-measurers), the operation of determining the range consists almost invariably in swinging the base round until it is "broadside-on" to the target, and then measuring the angle subtended by the base at the target. The measurement of the angle at the target is very commonly effected by making one of the base-angles a right angle, and observing how much the other is "off" the right angle (mekometer, &c.), or else by observing how much the sum of the base-angles is less than two right angles (naval range-finder, &c.).

Since a mere enumeration of the names of inventors of range-finders would occupy the whole of the available time for a lecture, it will be necessary to restrict the selection of examples to those instruments which are, or promise to be, in actual operation for warlike purposes. Attention then will be confined to the following instruments:—

(1) The Watkin mekometer, used by our troops in South Africa.

(2) The Watkin depression range-finder, used at certain stations for coast defence.

(3) The Zeiss tele-stereoscope.

(4) The Barr and Stroud range-finder, used in the British and other navies, in coast fortifications, and to some extent in the field.

Restrictions of time unfortunately render it impossible to describe the Watkin artillery range-finder, as well as the Fiske instrument which is used to some extent by the U.S. Navy.

(1) *Mekometer.*—This instrument consists of two parts connected by a cord 25 or 50 yards long, which is kept tightly stretched by two observers, each of whom supports one of the parts. These two observers are designated respectively the right-angle man and the range-taker. The former carries a small optical square or instrument in which two mirrors are fixed at 45° so as to set out a right-angle.

The part carried by the range-taker consists practically of a box-sextant in which one of the mirrors is adjustable by means of a graduated micrometer-screw, on which the ranges are marked for the base specified, the infinity mark corresponding to the case when the mirrors are exactly at 45°. Each of the parts of the instrument carries a prominent mark in a suitable position, and the operation of taking a range on a fixed object is as follows:—The two observers supporting the instruments connected by the taut cord set themselves in such positions that the cord is nearly "broadside-on" to the target; the range-taker now stands still, while the right-angle man—by moving forwards or backwards, with the cord always taut—adjusts his position accurately, so that the image of the mark on the range-taker's instrument, seen through his optical square, coincides with the target viewed directly. He now shouts "On," when the range-taker adjusts his micrometer-screw so as to bring the mark on the other instrument into coincidence with the target, and then the reading on the graduated scale gives the range.

For objects in motion the range-taker remains steady, while the right-angle man, as far as possible, continuously shifts his position so as to keep the mark on the range-taker's instrument and the target in coincidence. In cases of rapid motion at right angles to the line of sight, difficulties are experienced in keeping continously "on," and in such cases the right-angle man shouts "On" whenever the mark passes the target, and the range-taker then seizes the opportunity of taking the range.

There are several serious objections to two-observer instruments. In the first place, they cannot be used for the measurement of the distances of sky-lines, trenches, hedges, &c., of a more or less horizontal character, with no prominent vertical features about them. Secondly, it not infrequently happens that the two observers are working on different objects altogether or on different portions of the same object, in which case an entirely fictitious range is obtained. Most important of all, they necessarily expose the range-takers. It has been stated that several casualties have occurred in South Africa among men engaged in range-finding. Under such conditions as those pertaining in South Africa, it is obviously most risky to expose men in the open. Single-observer instruments are free from all these defects.

(2) *Depression Range-finder.*—If we have a vertical base, and if the target is constrained to move in a horizontal plane, we may dispense with the right-angle man altogether. The only case where this plan can be adopted in practice is when we wish to determine the range of a ship from a hill near the coast. The base-line is now the vertical height of the observing station above sea-level, and the range is obtained very simply by observing the angular depression of the water-line of the ship. Allowance has to be made for the effect which the tides produce in varying the equivalent height of the base. Unfortunately, the water-line of a ship—especially if the waves are at all high—forms an exceeding bad object upon which to observe, and this uncertainty can only be compensated by having a very long base—*i.e.* by having the range-finder at a very considerable altitude, say 150 feet or so. We therefore cannot use such an instrument on a flat coast, nor can we use it for determining distances at night, unless we can sufficiently well illuminate the water-line of a ship by means of a search-light.

(3) *Zeiss Range-finder.*—This is the first of the two single-observer instruments which it is proposed to describe in the prescribed limits of time. The credit of the idea underlying the construction of the instrument is due to the late Herr Grousillier of the German Army, but as the firm of Zeiss, of Jena, have spent many

[1] An evening lecture delivered at the British Association meeting at Bradford by Prof. W. Stroud.

years in working out the details of the instrument, it will probably be known in the future by their name. In the tele-stereoscope of Helmholtz two parallel reflectors are placed with reference to each eye, in such a position as to produce the optical equivalent of an increase in distance between the two eyes. This increases the stereoscopic effect. In the next place, by placing a telescope before each eye (and the two telescopes may conveniently be incorporated in the frame-piece supporting the reflectors), we multiply the stereoscopic effect still further, *e.g.* if the distance between the eyes has been artificially increased tenfold by the reflectors, and if the telescopes magnify tenfold, the stereoscopic effect will be increased altogether one hundred-fold. In this way immense stereoscopic solidity is imparted to the picture in the field of view.

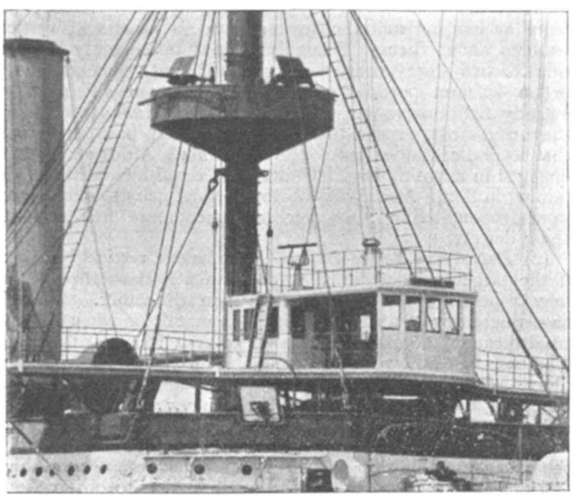

FIG. 2.—Bridge of H.M.S. *Royal Sovereign*, showing Barr and Stroud range-finder on the top of the chart-house.

This instrument may be adapted to range-finding in the following way:—Suppose we imagine for the moment the instrument fixed, and that we see in the field of view of each eye the image of a pole 1000 yards away. Let permanent marks be made in the focal plane of each telescope exactly coincident with these images. Then, whenever we look into the instrument we shall apparently see a pole at a distance of 1000 yards. Let a similar pair of marks be fixed corresponding to 1100 yards, and so on. Then when we look into the instrument at a distant landscape we shall get the appearance shown in Fig. 1. If this picture be viewed stereoscopically we shall obtain a mental impression as to the distance of any part of the landscape by comparison with the marks, and in this way get its approximate range.

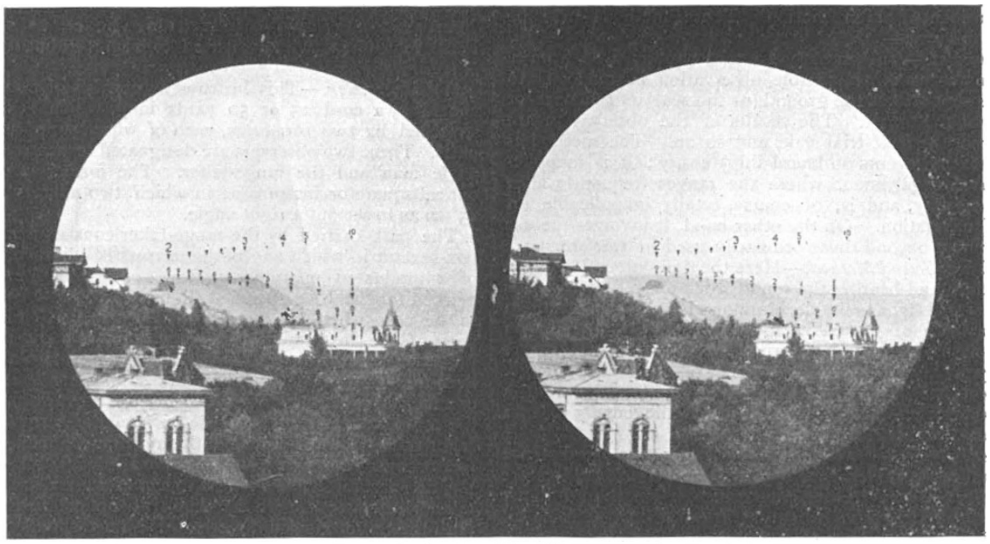

FIG. 1.—Field of view in the Grousillier-Zeiss stereoscopic range-finder.

The instrument is highly ingenious and very pretty, and it will no doubt offer a solution of the problem of military range-finding should it prove sufficiently accurate in practice.

(4) *B. and S. Naval Range-finder.*—This instrument, with a base of 4½ feet, has been adopted in her Majesty's Navy, and nearly all the larger ships are now equipped with one or more of them. Fig. 2 shows a view of the charthouse of H.M.S. *Royal Sovereign*, on the top of which the range-finder will be seen near the Kelvin compass.

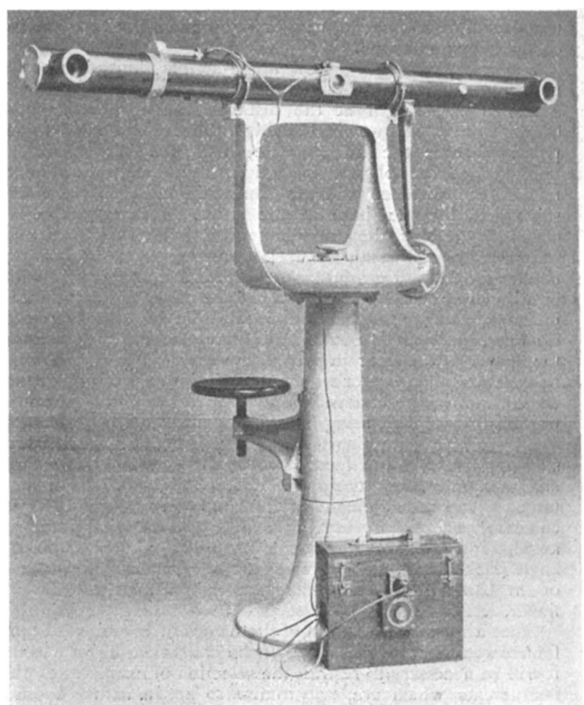

FIG. 3.—Barr and Stroud range-finder on fortress mounting.

This instrument, in favourable circumstances of weather, will measure ranges in a few seconds of time with an accuracy of something like 3 yards at 1000 yards, 30 at 3000, 120 at 6000, and so on. Prof. Barr, of the University of Glasgow, and the lecturer devised the instrument in its main features in 1888; it took, however, a period of five years to make a satisfactory naval instrument, and for the past seven years the improvement of the optical and mechanical details has been going on.[1]

Fig. 3 shows the same instrument mounted for fortress observation.

It is claimed for these instruments that they offer a solution—of course not necessarily the only or the best—of the problem of range-finding in all cases where want of portability is not a drawback.

B. and S. Field Range-finder.—Fig. 4 shows a smaller instrument of the same type with a base of 3 feet, which weighs 12 lbs. One of these instruments has been used by Major Guinness in South Africa since the beginning of February, and that officer reports that after carrying the instrument on his ammunition wagon over all sorts of ground for six months it was in no way damaged or deranged. The figure shows how

FIG. 4.—Barr and Stroud field range-finder.

the range-finder can be used for taking a distance with practically no exposure of the man.

The lecturer concluded by describing and exhibiting the electrical telegraph for naval use which Prof. Barr and he had devised at the request of the Admiralty, so as to enable the captain of the ship in the conning tower to receive from the range-taker continuous records of the enemy's distance and to transmit the same and also orders to the guns. The importance of trustworthy means for transmitting orders and other communications from one station to another on a warship is now fully realised. Thus, for example, it is reported that in the opinion of Admirals Fournier and de Beaumont and the officer in command, the loss of the French torpedo-boat destroyer *Framee*, which occurred about a month ago, was due to the fact that the apparatus on board the vessel for the transmission of orders was inadequate. The need for continuous and almost instantaneous transmission of ranges to the gunners will be obvious when it is remembered that in naval engagements the range is continually and rapidly altering.

The lecturer concluded by expressing his thanks to Mr. J. J. Hicks, of London, Mr. Steward, of London, and Messrs. Zeiss, of Jena, for the loan of range-finders to illustrate the lecture.

[1] Readers unacquainted with the instrument are referred for details of its construction to *Transactions* of Inst. of Mech. Eng. (1896), or *Engineering*, 1896 Part i. p. 233, &c.

MECHANICS AT THE BRITISH ASSOCIATION.

ALTHOUGH no very striking paper was presented to the section at this meeting, still several papers of value and of considerable interest were dealt with.

In the committee of the section two very important pieces of work were carried out. The committee on small screw gauges, which has now been at work for some years, presented an interim report in which the difficulties the committee had met with in obtaining standard gauges were very fully discussed, and an account of some experiments on different forms of threads, made by Mr. T. M. Gorham and Mr. W. A. Price in the laboratory of Prof. Hudson Beare at University College, London, were described. The committee stated in their report that they have now every hope of bringing their inquiry to a successful conclusion, and the committee was therefore re-appointed and a grant was secured for the necessary expense of completing the work.

A committee was also appointed at Bradford to deal with the question of the resistance of road vehicles to traction. Prof. Hele Shaw read a short paper before the section, drawing attention to the need of modern experiments on the nature of the resistances encountered by vehicles on the common road. He pointed out how the growth of the cycle and motor car industry made information upon this point a matter of the greatest importance.

There is no doubt that we are on the eve of a very considerable increase in mechanical propulsion on common roads, and at present designers of such vehicles have to rely largely upon old experiments with solid steel tyres, and carried out on roads very different indeed from the modern roads. The powerful auto cars which can now be obtained make it comparatively an easy matter to determine the tractive power necessary to move a vehicle with any load upon any type of road, and no doubt the work of the committee will largely consist—after a suitable dynamometer and speed indicator have been arranged for—in carrying out exhaustive experiments with different types of vehicles and different types of tyres on all the various classes of roads now in use.

A grant of money was secured from the Association for the purposes of this committee, and we have every hope that when the committee submits its report it will justify its appointment.

In the work of the section papers by local engineers bulked largely. Perhaps the two most interesting and valuable were a paper by Mr. J. Watson, the Waterworks engineer at Bradford, in which the new Nidd Valley Waterworks were described, and the paper by Mr. J. MacTaggart, the Superintendent of the Cleansing Department of the City of Bradford, entitled "The Disposal of House Refuse in Bradford."

In Mr. Watson's paper a short historical summary of the various schemes for supplying Bradford with water was given, followed by a very exhaustive and complete account of the Nidd Valley scheme. This scheme, now rapidly approaching completion, is one which will cost the City of Bradford nearly 1,500,000*l*. and will afford a supply of about twenty million gallons of water per day, and in addition will provide a large compensation reservoir (Gouthwaite) for the land-owners along the Nidd Valley.

It is essential for such a city as Bradford, where the chief industry is that of the woollen trade, that the water shall be very soft, and, of course, this led to some difficulty in finding a suitable collecting ground for the city supply.

The section had the opportunity of visiting, under the guidance of Mr. Watson, portions of the works on the Saturday of the meeting.

In Mr. MacTaggart's paper very valuable information was given as to the most modern methods in a big manufacturing city for the disposal of the daily city refuse. So successful have the various arrangements been, mostly due to the author, that it is hoped in time the destruction of the whole of the refuse of the city will be carried out, not only without creating any nuisance, but without any cost to the ratepayers. The refuse is chiefly dealt with by destructors, and the great merit of the Bradford system is in the utilisation of the clinker produced in the destructor furnaces for various useful purposes, the power to work the machinery required for these purposes, and the lighting of the works all being obtained from the steam generated by the surplus heat of the destructors. A large number of specimens were shown to the section of concrete paving-slabs,