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THE FISKE RANGE-FINDER.

IT has long been recognized as a prime necessity of effective gunnery at sea that the gunners shall know at each instant the exact distance of the ship or object at which they are to shoot. To realize this, we must reflect, that, if two ships are approaching each other at the rate of even twelve knots each, their distance apart is changing at the rate of 13⅓ yards per second. This means that in less than 4 seconds the distance or range will change 50 yards, which represents the distance apart of two consecutive graduations of the sight-bar of a modern rifle-gun: in other words, the sight-bars of high-powered guns are usually graduated to 50 yards, and it is necessary for effective shooting that an error of 50 yards must not be made in estimating the distance and timing the discharge of the gun as the ship rolls from side to side. But if this change of 50 yards be made in 4 seconds, it is plain that we must have an instrument that will give the range with less than 4 seconds' delay, and give it, at the very least, with less than 50 yards error. Such an instrument is called a "range-finder." A description of a new and exceedingly clever, as well as thoroughly scientific device, for ascertaining the range and position of distant objects, designed by Lieut. Bradley Allan Fiske, forms the subject of this article.

The invention consists of a new method of finding the range and position of a distant object, which depends upon the determination of a fractional portion of a conducting body bearing in length a ratio to the angle included between two lines of sight directed upon said distant object and the measurement of the electrical resistance of said length.

The accompanying drawings are (Fig. 4 excepted) all electrical diagrams, not drawn to scale, and symbolically represent the invention. In Fig. 1 is shown a Wheatstone bridge, in one member (a) of which is arranged a body of conducting material in arc form, and a movable arm traversing the same. In Fig. 2 is shown a Wheatstone bridge having arcs and movable arms arranged in two members, a b. In Fig. 3 is shown a Wheatstone bridge in which arcs connect adjacent members, as a c and b d, and movable arms sweeping over said arcs are connected to the battery. Fig. 4 is a mathematical diagram illustrating the method of determining the angle ATC. Fig. 5 shows a disposition of the range-finder in connection with a dead-beat galvanometer; and Fig. 6, the same in connection with the slider. Similar letters of reference indicate like parts.

In Fig. 1, let a b c d represent the four members of an ordinary Wheatstone bridge, and g the transverse member, in which is connected the galvanometer g'. A battery f is also connected to the bridge in the usual way. In the members c and d are placed the fixed resistances c' and d', and in the member b the variable resistance b' also, as usual. One wire from battery f, however, connects to the end of member c, and also to the pivot l of a swinging arm i. The extremity k of arm i moves over and maintains electrical contact with an arc h of conducting material, which has one extremity j connected, as shown, to the member a of the bridge. It is obvious that when the arm i is in the position shown in full lines in Fig. 1, then the current will traverse the whole arc h; and when said arm is in the position indicated by dotted lines (Fig. 1), then the arc h will be cut out, and the current will pass directly to member a. Now assume the arc h to be made of such material, and so proportioned that its electrical resistance to a current traversing it will be proportional to the length of arc included between the contact end k of arm i and the connecting-point j of member a with said arc. Therefore the resistance interposed in the member a of the bridge will be commensurate with the angle j l k; and if this resistance be known, the angle is also known. Let it now be assumed that the galvanometer g' and variable resistance b' be located at some point distant from the moving arm i, from which said arm is invisible or inaccessible. Clearly, then, an observer stationed at the galvanometer g' and resistance b' can, by noting the galvanometer and adjusting the resistance in the usual way, determine the resistance equilibrating any position of arm i along the arc h, and so discover the angle of adjustment of said arc; or, having adjusted the resistance b' at some given figure, the observer may, by simply noting the galvanometer or any other suitable indicating device, visual or audible, determine when the arm i is placed at a desired angle corresponding to the adjusted resistance, and this indicating device may obviously be at the place where the moving arm is located, so that the operator there may thus know when he has placed the arm at the predetermined point or at the distant station, so that the operator in charge of the resistance b' may know that the arm has been adjusted properly; or two indicating devices in the same circuit may give warning to both operators, as above, simultaneously.

Referring now to Fig. 2, it will be apparent, that, in lieu of the variable resistance b' in the member b, there is arranged an arc h' and swinging arm i'. The arc h' is connected at one end j' to the member b, and the swinging arm i' makes contact at one end k' with said arc, and to its pivot l' is connected the member d. The arrangement and construction of arc h' and arm i' are similar to those of arc h and arm i: consequently, when the arm i is set at a certain point on the arc h, the arm i' must be set at the corresponding point on the arc h', in order that the resistance of the lengths of the arcs h h' respectively between the point k and point h and point k' and point h' may balance; hence, if the arm k be set at a certain angle, the observer at arm k may recognize that angle by noting the position of the arm k and the galvanometer, as before. It will be observed, however, that the effect of moving the arm i over arc h is practically to lengthen or shorten or to interpose more or less resistance in the member a of the bridge, and by operating the arm i' a like effect is produced in the member b. The resistances or lengths of the members c and d remain unchanged.

Referring now to Fig. 3, there is shown an arrangement which forms the basis of the specific embodiment of the invention, more particularly hereinafter described. In said Fig. 3 the arc h is connected at its respective ends j J to the members a c, and the arc h' is similarly connected at j' J' to the members b d. The battery-wires connect to the pivots l l' of the arms i i', as before. Now, when the arm i is moved from its middle position on its arc toward j, less resistance is caused in the member a, and more resistance in member c; and when moved in the opposite direction, the reverse occurs. So, also, a similar effect is produced by moving arm i'; and thus the resistance offered by all four members of the bridge may be affected instead of that due to only two of them, and differential results may be obtained, as will more fully be apparent in the following description of a device for measuring distances, such as a range-finder for guns.

Referring to Fig. 4, let T be the position of the object the distance of which from the point A it is desired to ascertain. Let AB be any short base-line. Draw AC at right angles to BT, EA parallel to BT, and prolong AT as to D. By trigonometry

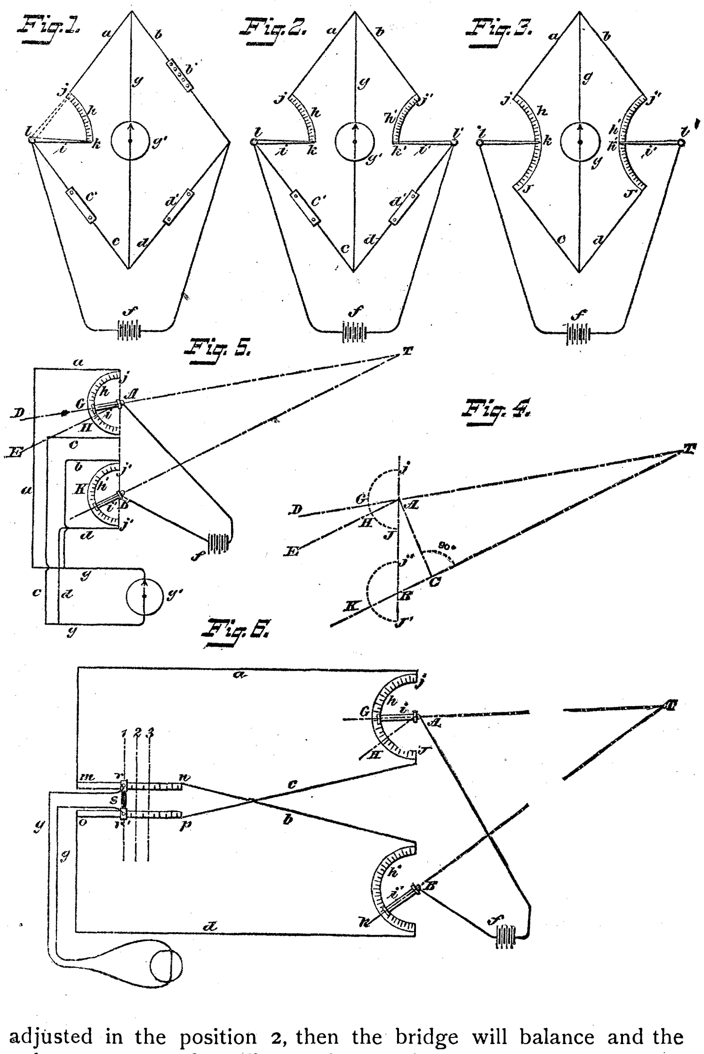
$$\left.\begin{array}{l}\mathrm{AC}=\mathrm{AT}\sin\mathrm{ATC}\\ \mathrm{AT}=\mathrm{AC}\operatorname{cosec}\mathrm{ATC}\end{array}\right\}\text{ and }\left\{\begin{array}{l}\mathrm{AC}=\mathrm{AB}\sin\mathrm{ABC},\text{ whence}\\ \mathrm{AT}=\mathrm{AB}\sin\mathrm{ABC}\operatorname{cosec}\mathrm{ATC}.\end{array}\right.$$

AB, being the measured base-line, is known, and the angle ABC at the point of observation is easily determined, so that the angle ATC remains to be found; but ATC=DAE, and DAE is subtended and measured by the arc GH. Arc GH=arc jH–arc jG, and arc jH=arc J'K: hence arc GH=arc j'K–arc jG.

In Fig. 5 the diagrams Figs. 3 and 4 are combined; i i', as before, being swinging arms traversing the arcs h h', and the connections a b c d of the bridge being present also, as before. Let the arms i and i' represent alidade-arms or telescopes, both directed upon the object T. The arcs jG and j'K not being equal, the bridge will not balance; but when the telescope i is moved to the line EH, then the bridge will balance; but the distance thus moved is the arc GH, the length of which may be read off from the arc h itself. It will be seen, therefore, that the operation of determining the distance AT becomes, by the aid of this apparatus, exceedingly simple. The observers at the respective telescopes i and i' direct their lines of sight upon the object. The observer at i notes the angle jAG, or length of arc jG. He then moves the telescope i until the galvanometer g', which may be placed conveniently near his position, shows no deflection, and notes the angle jAH, or length of arc jH. The difference between the arcs iG and jH equals the arc GH, whence the angle ATB, and hence the distance AT, is found by the observer at the arm i, or, in other words, by an observer at the base-line. The disposition of the apparatus whereby an observer at a point distant from said base-line may at once read off the distance AT from a suitable scale will now be explained.

Referring to Fig. 6, the members a and b of the bridge are connected to opposite extremities of a bar m n of conducting material and the members c d are connected to the extremities of a similar and parallel bar o p. Adjustable upon said bars o p and m n is a slider r r', having a middle portion s of insulating material, so that the current from bar m n, for example, does not pass across said slider r r' to bar o p, but proceeds by the wire g through the galvanometer g''. Suppose, now, that the telescopes i and i' are sighted upon the distant object T, as before, and that the slider r is at the middle point 1 of the parallel bars m n and o p: the resistances in the bridge will obviously not balance. It has already been explained in connection with Fig. 5, how, by moving telescope i to the point H, the resistances might be balanced; and if that were done, with the arrangement shown in Fig. 6, the fact would obviously be indicated by a deflection of the galvanometer-needle; but now let it be assumed that the telescope i, after being sighted upon the object T, is not moved, or, in other words, that the observers respectively at the two telescopes i and i' simply adjust their instruments in line with T. Obviously, then, the distance of the bridge from r to G (member a) is less than the distance from r to k (member b) by the length of the arc GH. Similarly the distance on the bridge from r' to G (member c) is greater than the distance from r' to k (member d) by the length of arc GH.

Now let the resistance per unit length of the bars m n o p be made equal to or with some definite relation to the resistance per unit length of the arcs h h', and lay off on bar m n a distance r 3 and on bar o p a distance r' 3, said distances being such that the resistance due thereto will be equal to that of the arc GH. Clearly, if the end r of the slider be moved to the position 2 on bar m n, the member a will be increased and the member b will be diminished by the distance r 2, which offers a resistance equal to one-half that of arc GH; and if the end r' of the slider be moved to the position 2 on bar o p, then the member c will be decreased and the member d increased by the distance r' 2, which also has a resistance equal to one-half of arc GH. As both ends of the slider move simultaneously, it follows that when its extremities are



adjusted in the position 2, then the bridge will balance and the galvanometer-needle will again be at zero. Applying this practically, let the bars m n o p be laid off in suitable scale-divisions from r to n and i' to p. The two telescopes i and i' being sighted on the object, the distant observer watches the needle, and moves the slider r r' along the bars m n o p until it returns to zero. The scale marked on the bars then shows an indication corresponding to the length of arc GH, or, if desired, actual distances corresponding to such indications.

If the object be moving, the operation of determining its distance is as easy as though it were stationary, and the indications are instantaneous and continuous. With a 290-foot base-line on board the "Chicago," one instrument being mounted in the bow and one in the stern, the average error in the official trial before a board of electrical and gunnery experts was less than six-tenths of one per cent. The set of instruments about being sent to the "Baltimore" is expected to give still more accurate results.