April 6, 1948. A. S. HALSEY 2,439,209

TORPEDO DIRECTOR

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FIG. 1

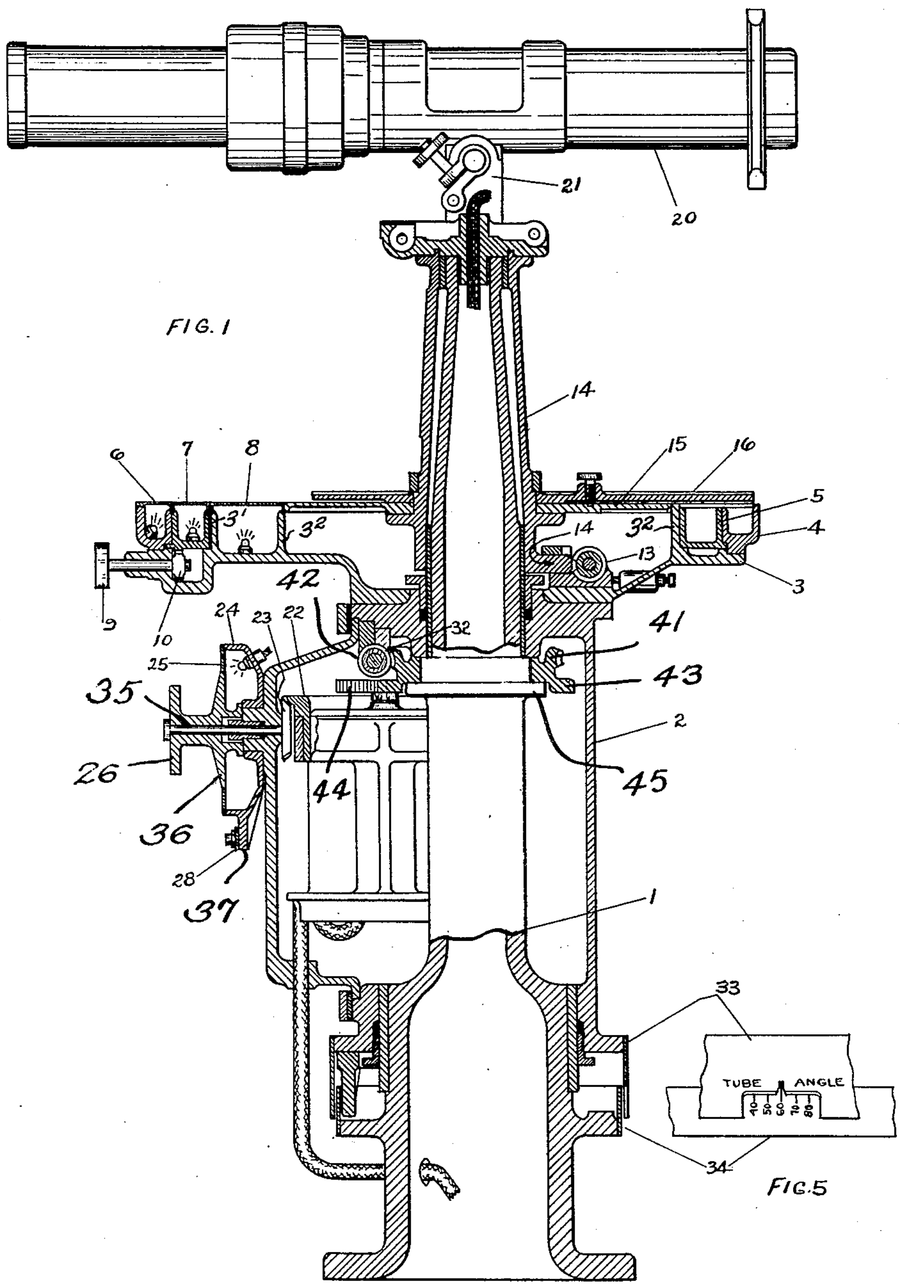

FIG. 5

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FIG. 2

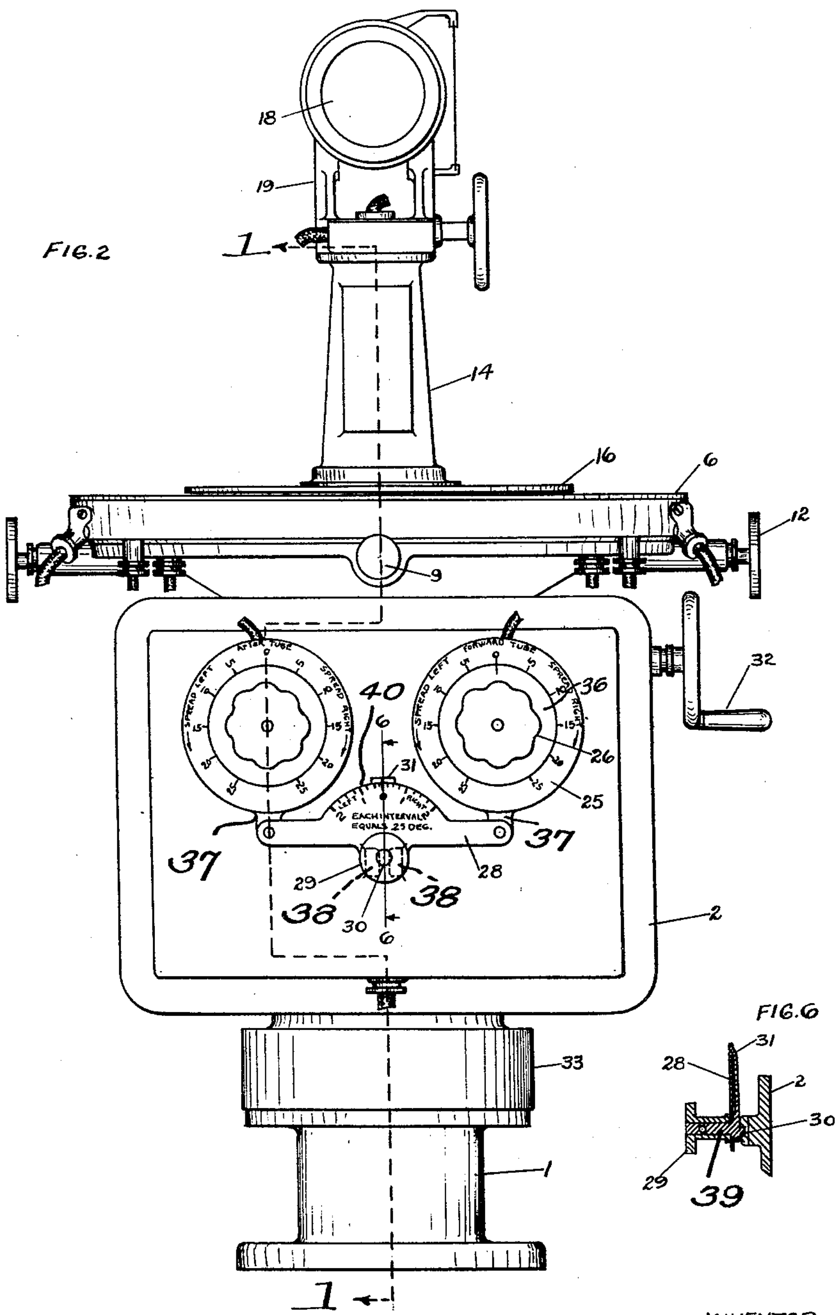

FIG. 6

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FIG. 3

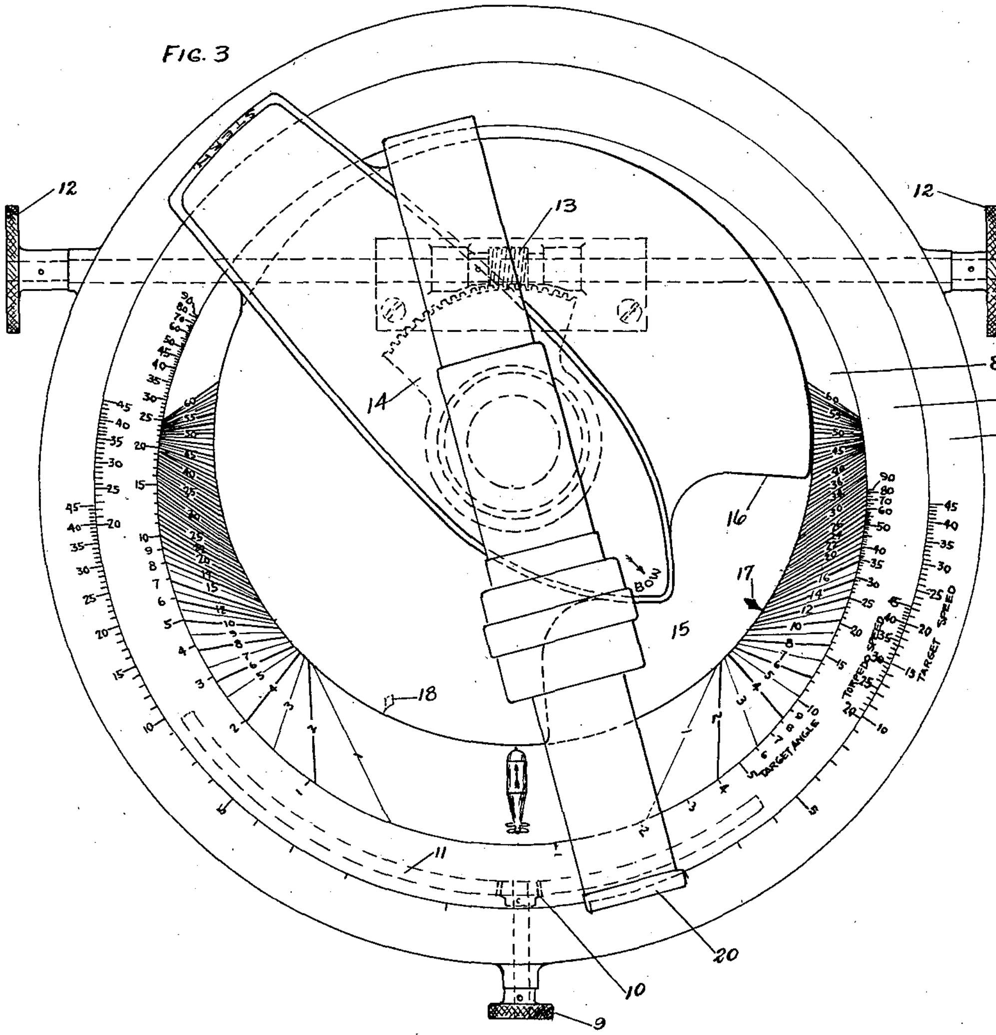
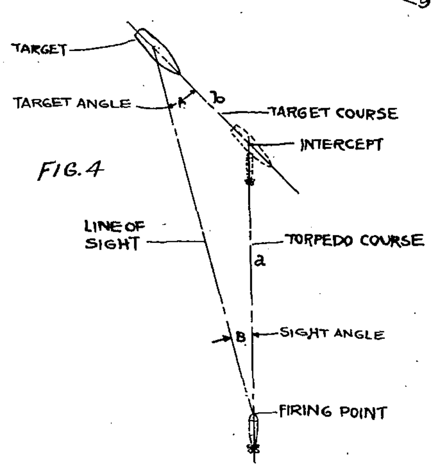


FIG. 4



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Patented Apr. 6, 1948 **2,439,209**

UNITED STATES PATENT OFFICE

2,439,209

TORPEDO DIRECTOR

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Application June 15, 1925, Serial No. 37,401

3 Claims. (Cl. 235—61.5)

This invention relates to improvements in torpedo directors and more particularly to apparatus for accurately determining the angle of the torpedo tube with respect to the line of sight on a moving target whereby the torpedo will intercept the target at a predetermined point in its course depending upon the speed and course of the torpedo and the speed and course of the target.

One of the objects of the present invention is to provide a simple and practical torpedo director of the above general character for obtaining and transmitting the desired information, namely, the azimuth angle to the personnel at the torpedo tubes with the least possible delay.

A further object is to provide a reliable and efficient mechanism of the above character having relatively few parts which may be inexpensively manufactured and installed.

A further object is to provide a mechanism of the last above mentioned character which will be substantially fool-proof in its operation and automatically transmit the desired information reliably and correctly.

A further object is to provide a mechanism of the above character with means whereby desired corrections may be incorporated in the problem involved for insuring proper spread in firing as well as corrections for the place of firing with respect to north and south latitude.

A further object is to provide an improved apparatus whereby torpedo firing problems may be accurately and almost instantly solved with the least possible loss of time and chance of error.

Other objects will be in part obvious and in part hereinafter pointed out in connection with the accompanying sheets of drawings illustrating one of various possible embodiments of the invention and wherein similar reference characters indicate corresponding parts throughout the several views.

In these drawings:

Figure 1 is a vertical sectional elevational view taken on the line 1—1 of Figure 2 showing such parts of the complete apparatus as is necessary to thoroughly understand the invention.

Figure 2 is an elevational view of the complete mechanism shown in Figure 1 and taken at substantially right angles thereto.

Figure 3 is a plan view of the torpedo director in setup position for a predetermined problem.

Figure 4 is a diagrammatic view showing the problem for which the instrument is set as shown in Figure 3.

Figure 5 is a detail view of a portion of the

mechanism at the lower right hand part of Figure 1.

Figure 6 is a detail sectional view taken substantially on the line 6—6, Figure 2.

Referring now to the drawings in detail and more particularly to Figure 1, there is indicated at 1 a central pedestal or pivot fixed with respect to the ship upon which it is mounted and about which the mechanism hereinafter described is assembled. This pedestal 1 rotatably supports a casing 2 movable about the axis of the pedestal. Supported upon the casing 2 is a plate 3 having channel-forming ribs $3'$, 3^2 and also carrying channel members 4 and 5, the top surface of all of the channels thus defined being substantially aligned to support transparent or translucent scale plates 6, 7 and 8, the plate 7 being movable relatively to the others thereby constituting a circular slide rule. As shown in Figure 3, an adjusting means or control knob 9 located at what might be called the front of the instrument is provided with a pinion 10 meshing with a rack 11 on the under side of the movable dial plate 7 whereby this plate may be moved to the right or left as desired. At each side and near the rear of the instrument are two adjusting knobs 12 provided with a worm gear 13 for moving a segmental rack 14 rigidly connected with a plate 15 whereby as the knobs 12 are turned the plate 15 is moved relatively to the scale 8. Carried by the plate 15 is an independently and freely movable cover 16 having the raised image of a ship mounted thereon which is set by hand corresponding to the estimated bearing of the target ship. This is merely set in an approximate position to either right or left and has for its purpose to expose the index 17 at one side and to conceal the index 18 shown in dotted lines at the other or vice versa, thus rendering the instrument substantially fool-proof so far as mistaking the side upon which the settings for the given problem are to be made is concerned.

In other words, the index 17 reads only upon those scales at the right in Figure 3 while the index 18 correspondingly cooperates with the markings at the left and when the target image is set in the same general direction as the bearing angle of the target ship then the indexes 17 or 18 are obscured according to this obvious setting. Carried at the top of the central pedestal or pivot 1 is a sighting instrumentality or telescope 20 mounted upon a support 21. This telescope is connected with the plate 15 whereby the indexes 17 and 18 are moved to register with the markings upon the scale 8 as will be more fully hereinafter described. Beneath the dial plates **6**, **7** and **8** and mounted in the casing **2** are transmitter and correction mechanisms. The transmitter casing **22** rotates bodily with casing **2** and is also rotatable about its own axis, casing **22** being provided with a segmental rack on its periphery adapted to be engaged by a bevel gear **23** mounted on shaft **35** passing through casing **24** which is provided on its front face with a dial **25**. The shaft is adapted to have a small rotary movement, for a purpose to be described later. Knob **26**, fixed to shaft **35**, as clearly shown in Figures 1 and 2, has a plate **36** made integral therewith on which there is an index mark coacting with dial **25** to indicate the position of the knob with respect thereto. As the knob is turned, bevel gear **23** is caused to rotate inducing relative movement of the transmitter casing **22** about its own axis through the rack on its periphery. The moving of the casing is in turn communicated to the torpedo firing station by suitable means of known character, which may include electrical components within the casing. The information communicated to the torpedo firing station by such rotation of the casing indicates the angle of spread of the torpedoes when making salvo fire and/or the latitude correction if any. There are preferably two of these spread indicators, and each is corrected for latitude by a mechanism now to be described.

An ear **37** depends from each of the spread indicators. A bar, **28**, extends between the ears **37** and is pivotally connected to them at its ends. This bar is provided with a scale **40** calibrated in degrees. The forward portion of the body **2** is provided with spaced lugs **38**, as may be seen in Figure 2. A shaft **39**, rotatably mounted through the bar, is provided on its inner end with an eccentrically mounted stud **30** operating between the lugs, and which when turned contacts with one or the other of them causing the bar to move in that particular direction. The movement of the bar is transmitted to the dial through the pivotal connections between the bar and the ears. A pointer **31** is operable over the scale **40**, and is fixed or made integral with the shaft **39** controlled by the knob **29**, as may be seen in Figure 6.

The correction for latitude is computed in any well known manner, and the pointer moved to the degree mark on the scale **40** corresponding to the result obtained by the computation. As the knob is turned to set the pointer, the eccentric stud is moved into contact with one of the lugs moving it in the path of the stud, which, as above explained, causes the correction for latitude to be communicated to the dial of the spread indicator. After the dial has been moved for correction for latitude, knob **26** can be operated to indicate the angle of spread, as before said, or to reset the pointer on zero spread, and thus indicate only the required latitude correction.

There is also provided an adjusting device **32** for obtaining general train of the entire mechanism after the problem has been set up whereby the sight is kept on the target regardless of the position in course of the firing ship.

As a check upon the information sent out by the transmitter and indicated by known means to the torpedo tube personnel, there is provided on the lower part of the apparatus a movable cover plate **33**, Figure 5, and fixed dial scale **34** exposing a series of numbers indicating the true firing angle.

The operation of this device can probably be best understood by reference to Figures 3 and 4

showing the instrument as actually set up for solving the problem graphically indicated in Figure 4.

This torpedo firing problem is based on the fact that a target maintaining a certain course and speed will be intercepted by a torpedo having a certain speed when the torpedo course is properly selected and the distance is within the torpedo range.

Referring to Figure 4 which represents the general problem and the setting of Figure 3, let Es=target speed, *ts*=torpedo speed, A=target angle, B=sight angle, *t*=time of travel.

In all torpedo problems the time of travel of the torpedo is equal to the time of travel of the target from the instant of firing to the time of hit and from the law of sines (see Fig. 4).

$$a \sin B = b \sin A \qquad (1)$$

but

$$a = ts \times t$$

and

$$b = Es \times t$$

substituting we get

$$tst \sin B = Est \sin A$$

or

$$\sin B = \frac{Est \sin A}{tst}$$

from which the time t will cancel, and we get that

$$B = \sin^{-1} \frac{Es \sin A}{ts}$$

From the above it is seen that if the target angle and target speed are estimated and the torpedo speed known, the angle that the torpedo course should make with the sight line (sight angle) can be solved by a simple proportion as by the use of a slide rule.

The usual practice is to construct an instrument embodying a set of arms which solve graphically for the angle B. In these graphic instruments, however, the arms are worked by sliding and swivel joints which in time become worn and introduce errors due to lost motion. The graphic instrument also gets into positions in which the joints tend to bend or stick.

In the improved instrument hereinbefore described and referred to as an improved torpedo director, there are no joints, gearing or bearings entering into the oblique triangle solution which may introduce errors. And, further, the triangle as set up remains the same as the course of the firing ship changes.

In the improved torpedo director the oblique triangle is solved by a circular slide rule comprising dials **6**, **7** and **8**, from which the sight angle in degrees is directly derived, automatically set, and automatically transmitted to the torpedo tubes in response to operation of the director. For convenience the slide rule arrangement is termed hereinafter the calculator.

On the calculator, top view, Figure 3, logarithmic values of *ts* and sin A are marked upon ring **7** which is free to turn between connected rings **6** and **8**, logarithmic values of Es and sin B are marked upon rings **6** and **8** respectively which bear a fixed relation to the torpedo course as transmitted to the firing station, except insofar as such course may be varied by the imposition of latitude or other arbitrary correction.

A conversion scale of lines on ring **8** converging from the inner logarithmic scale of ring **7** to a degree scale on the inner edge of ring **8** permits direct setting of the sight angle in degrees from the logarithmic scale. The arrangement permits of one setting of *ts* to E*s* for setting of sight angle for any value of target angle at that ratio of *ts* to E*s*.

As shown in Figure 3, two sets of scales are arranged on the calculator, one for course of target to the right, the other for course of target to the left.

In other words as herein shown in Figure 3 the target speed is estimated at 20 knots, the torpedo speed at 40 knots and the scale 7 is moved with respect to the scale 6 to bring the 20 and 40 into alignment. The target angle (A in Fig. 4) of the target ship is estimated at 30° with respect to the sighting line; then by moving the telescope by a wheel 12 so that the indicator 17 will coincide with the line running from the target angle mark (in this case 30°) across the plate 8, it will be found that this line represents an angle of 14½°, which for the problem stated is the true sight angle at which the torpedo must be fired to intercept the target ship at the estimated speeds and course. The setup of the given problem is now complete for the instantaneous conditions of target speed and target angle existing at the time of setting up the problem. Owing to the worm and wheel construction of all moving parts, no clamping or locking devices are needed and the settings will remain unchanged until hand wheels are again moved.

Having completed the set-up of the problem, hand wheel 32 is now used to bring to bear and keep the telescope directed at the target. If the firing point were stationary, the turning of handwheel 32 to bring the sight, which had been offset by the angle B back to bear on the target would transmit angle B to the personnel at the torpedo tubes. Any additional movement of the sight while keeping on the target due to movement of either ship would also be transmitted to such personnel, so that if for this or other reason the target angle changes, correction should be effected by appropriate adjustment of the knob 12. The movement of this handwheel by suitable gearing, etc. rotates the instrument as a unit around its pedestal and transmits to the personnel at the torpedo tube by actuation of the transmitter contained in casing 22, the actual torpedo bearing or angle with the center line of the firing ship that the tube must make to maintain the proper sight angle at 14½° between the axis of the torpedo tube and the line of sight to the target. The gearing above referred to consists of a worm gear 41 that is engaged by worm 42 mounted on the shaft of the hand wheel 32, and that is fixed in any suitable manner to the pedestal 1. Gear 43, that may form an integral part of the worm gear, as illustrated in Figure 1, or may be independently fixed to the pedestal, engages with spur gear 44 that is mounted on and through which the transmitter unit receives motion. It will thus be seen that as hand wheel 32 is operated casing 2 is rotated about the pedestal by virtue of the fixed gear 41. This motion is transmitted to the spur gear 44 and thence to the transmitter unit by the gear 43. A collar 45 is fixed to the pedestal below the gear 43 as an additional means to maintain the gears in proper position.

It is further pointed out that the "firing angle" is not the "sight angle" described above. The "firing angle" is the angle with respect to the ship's axis at which the torpedo is to be fired, whereas the "sight angle" is the angle of the firing direction with respect to the line of sight of the target from the ship, as distinguished from the ship's axis.

Were the target ship coming from the opposite direction and at substantially the same relative angle the image of the ship as shown in Figure 3 would be turned through substantially 60° thereby carrying the cover plate 16 around to cover the index 17 and expose the index 18 thus making it impossible for the operator to incorrectly read the firing angles.

To compute the sight angle for targets where the target angle is greater than 90°, it will be necessary to change the markings of dial 7 as follows: Target angle to be indicated by a double set of numbers from 0°–360°; the numbers on the right-hand side would run from 0°–180° and as the sine of an angle equals the sine of the supplement of that angle, 100 would be alongside 80, 110 alongside 70, etc.; the numbers on the left-hand side would run from 180° to 360°, 270° to 360° on the inner row and 270° to 180 on the outer row, for the inner row 270 would be substituted for 90, 280 for 80, 290 for 70, etc., for the outer row 260 would be alongside 280 and 250 would be alongside 290, etc. In order that index marks 17 and 18 will not be covered when plate 16 carrying the target model is set for target angles between 90°—180° and 180°—270° it will be necessary to reduce the diameter of plate 16. No confusion as to which index mark 17 or 18 to be used will result.

What I claim is:

1. In a torpedo director having a pedestal, a telescope supporting body mounted for rotation upon the pedestal, and a telescope mounted on said body, a computing mechanism comprising three concentric indicia bearing rings, the outer ring being normally stationary and having logarithmically spaced indications representing target speed, the middle ring being rotatable within the outer ring and having lines representing torpedo speed on its outer edge for registry with the indications on the outer ring and having logarithmically spaced lines along its inner edge representing target angle, and an inner ring having lines extending thereacross at various angles interconnecting logarithmically spaced indicia on its outer edge with arithmetically spaced indicia on its inner edge to convert the logarithmical values of the target angle to arithmetic values of telescope rotation, and a pointer positioned by the telescope supporting body to sweep along the arithmetic portion of said lines.

2. In a torpedo director having a pedestal, a telescope supporting body mounted for rotation upon the pedestal, and a telescope mounted on said body, a computing mechanism comprising three concentric indicia bearing rings, the outer ring being normally stationary and having logarithmically spaced indications representing target speed, the middle ring being rotatable within the outer ring and having lines representing torpedo speed on its outer edge for registry with the indications on the outer ring and having logarithmically spaced lines along its inner edge representing target angle, and an inner ring having lines extending thereacross at various angles interconnecting logarithmically spaced indicia on its outer edge with arithmetically spaced indicia on its inner edge to convert the logarithmical values of the target angle to arithmetic values of telescope rotation, a pointer positioned by the telescope supporting body to sweep along the arithmetic portion of said lines, and means for training the director and all of said rings and

the telescope as a unit to retain the telescope upon the target.

3. In a torpedo director having a pedestal, a telescope supporting body mounted for rotation upon the pedestal, and a telescope mounted on said body, a computing mechanism comprising three concentric indicia bearing rings thereabout, the outer ring being normally stationary and having logarithmically spaced indications representing target speed, the middle ring being rotatable within the outer ring and having lines representing torpedo speed on its outer edge for registry with the indications on the outer ring and having logarithmically spaced lines along its inner edge representing target angle, and an inner ring having lines extending thereacross at various angles interconnecting logarithmically spaced indicia on its outer edge with arithmetically spaced indicia on its inner edge to convert the logarithmical values of the target angle to arithmetic values of telescope rotation, a pointer positioned by the telescope supporting

body to sweep along the arithmetic portion of said lines, and means for transmitting the bearing of the telescope supporting body to a remote station.

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