Sept. 4, 1945. W. B. KLEMPERER 2,384,098

RANGING DEVICE

Filed Feb. 8, 1943 3 Sheets-Sheet 1

FIG. 1.

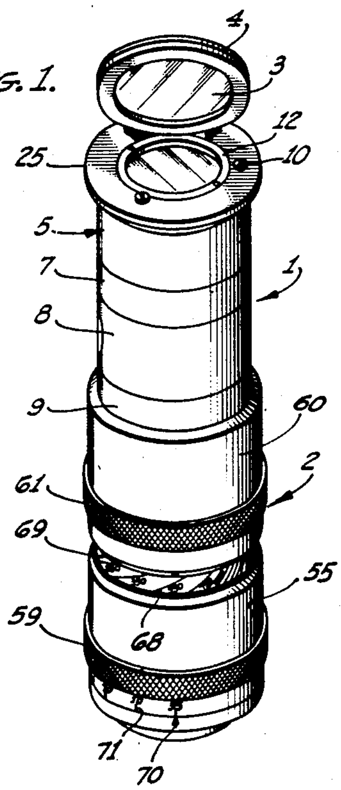
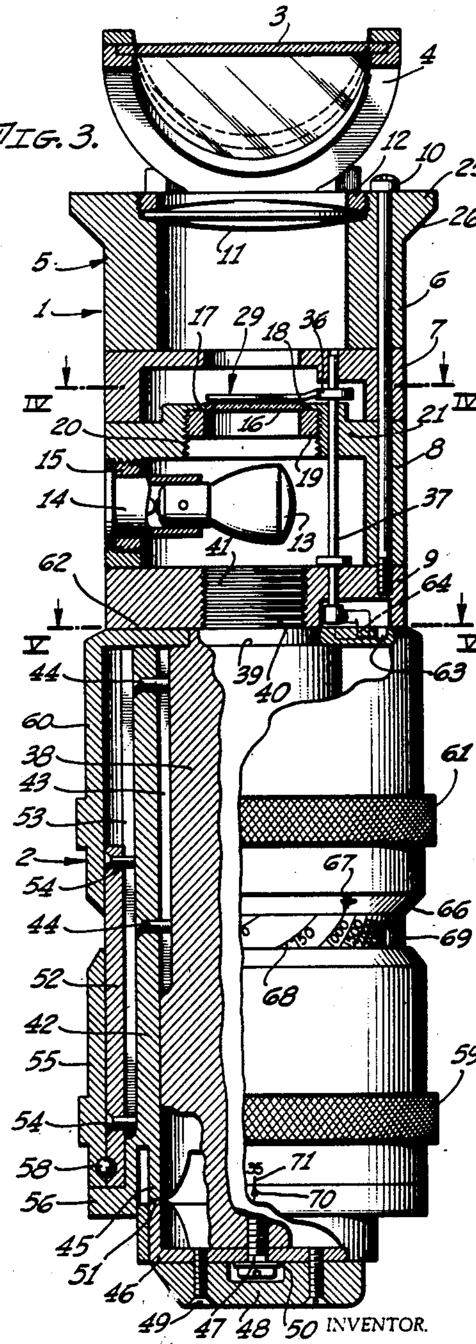


FIG. 3.



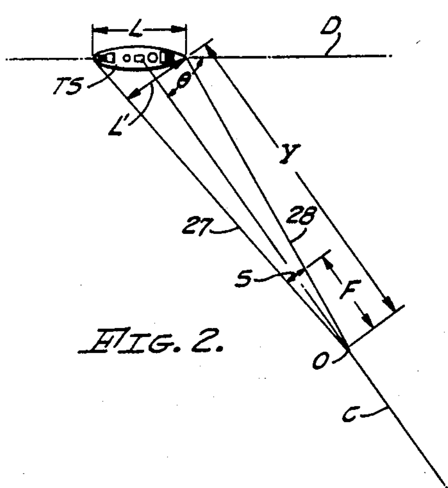


FIG. 2.

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RANGING DEVICE

Filed Feb. 8, 1943 3 Sheets-Sheet 2

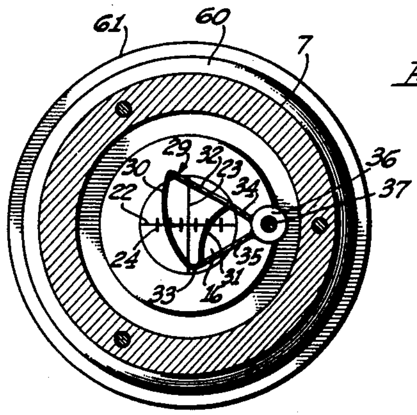

FIG. 4.

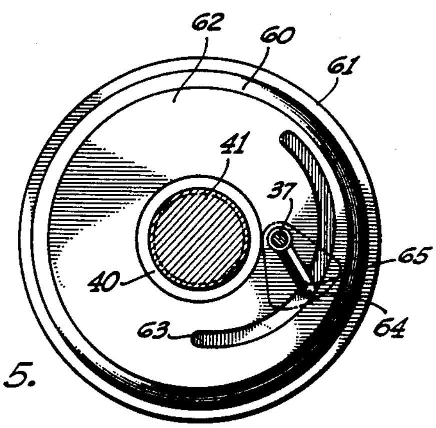

FIG. 5.

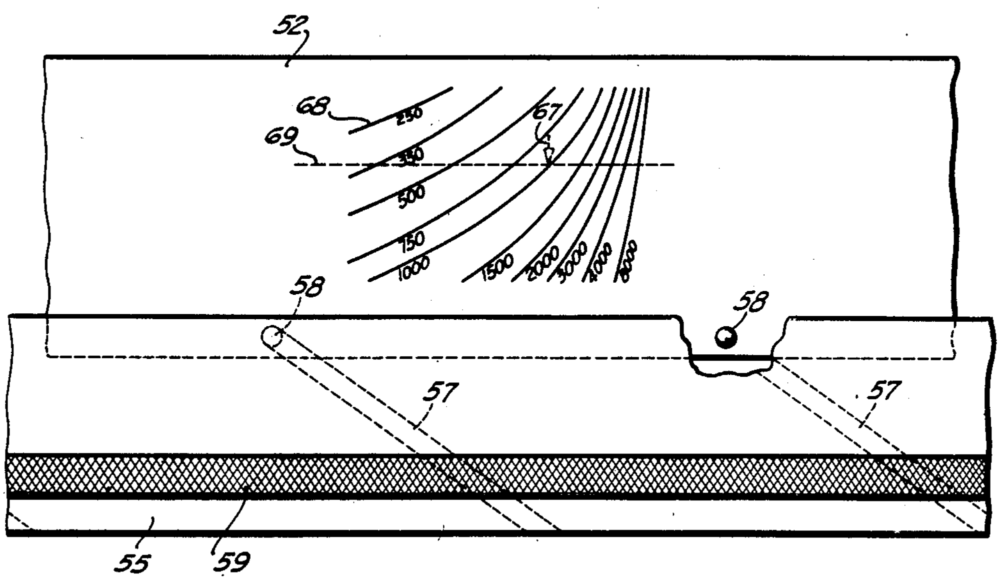

FIG. 6.

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Search Room

Sept. 4, 1945. W. B. KLEMPERER 2,384,098

RANGING DEVICE

Filed Feb. 8, 1943 3 Sheets-Sheet 3

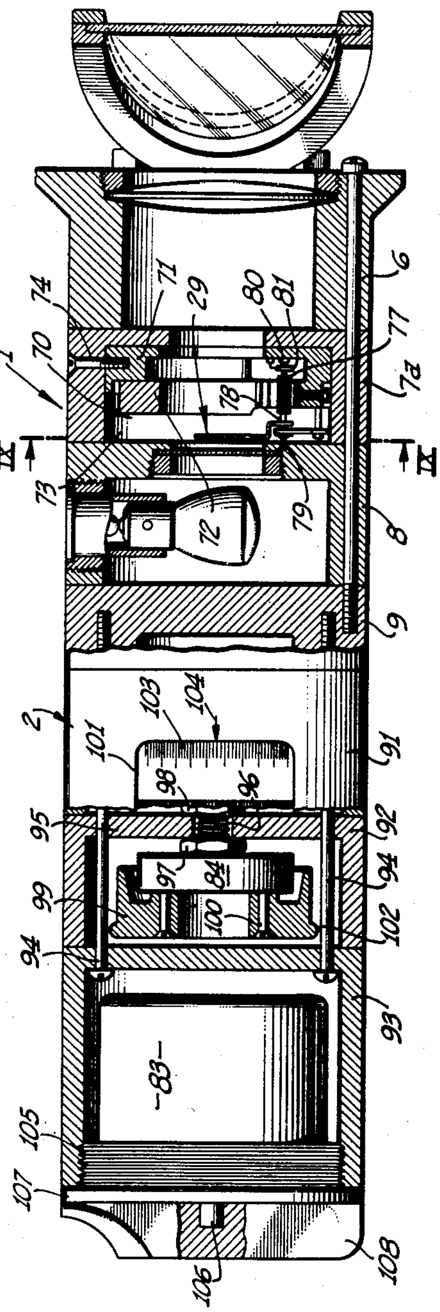

FIG. 8.

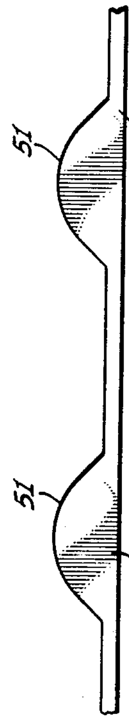

FIG. 7.

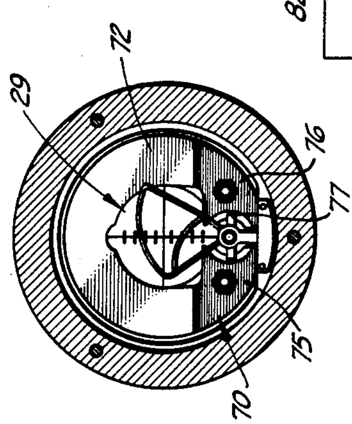

FIG. 9.

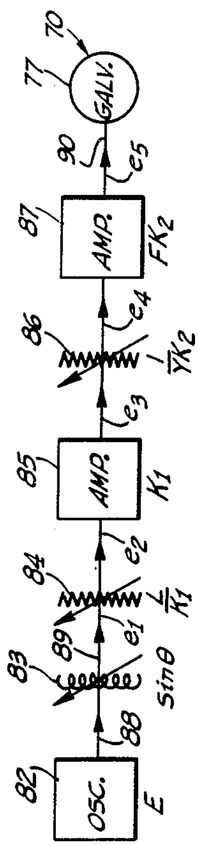

FIG. 10

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Patented Sept. 4, 1945 2,384,098

UNITED STATES PATENT OFFICE

2,384,098

RANGING DEVICE

Wolfgang B. Klemperer, West Los Angeles, Calif.

Application February 8, 1943, Serial No. 475,222

5 Claims. (Cl. 88—2.3)

My invention relates to a ranging device and has particular reference to a device for determining when a target and a projectile dropping, launching or firing device have reached positions relative to each other equal to the range of the particular projectile.

In the dropping of bombs or launching of torpedoes from aircraft or in the firing of relatively high caliber guns from aircraft against targets, it is essential that the pilot of the aircraft or person who is to drop, launch or fire such projectiles know when the aircraft has arrived at that distance away from the target at which, if the projectile is loosed, the target is at or within the range of the particular projectile employed.

For example, in the launching of torpedoes from aircraft or surface vessels observation of the target, particularly a moving target, may be made and the necessary lead angle and course of the torpedo may be computed so as to be sure of the intersection of the path of the torpedo and the target. The next problem is to determine the point along such path at which the torpedo should be launched so that its rate of travel through the distance between that point and the target will be such as to ensure collision between the torpedo and the target.

If the torpedo is to be directed at a moving vessel or target ship, the lead angle may be computed by known means and the travel speed of the torpedo after launching is a fixed or known quantity. As the attacking craft approaches the target ship, the pilot or operator can be apprised of the arrival of his craft at the range point or range distance of the torpedo and he can be substantially assured of a collision between the torpedo and the target ship.

It is, therefore, an object of my invention to provide a relatively small and compact device which, prior to the arrival of the attacking craft at the range point, will define such range point and apprise the pilot of the arrival of the craft at that point.

Another object of my invention is to provide a ranging device of the character described in which the definition of the range point is combined with a sighting device that the pilot may continuously observe the target in the sighting device and will be apprised of the arrival of his craft at the defined range point by the apparent size of the sighted target.

Another object of my invention is to provide a ranging device of the character described in which the device computes from the known length or other dimension of the target craft, the observed angle of approach of the attacking craft to the course of the target craft, the triangle formed by the sighting point (the attacking craft), and the fore and aft ends of the target ship which will exist when the attacking craft arrives at a predetermined distance away from the target craft, and sets up on the sighting portion of the ranging device a triangle having a base at right angles to the sighting line defined by spaced points on an image of a reticule superimposed on the target ship, the distance between said points being equal to the apparent length the target ship will assume in the sighting device when the attacking ship arrives at the range point.

It is also an object of my invention to provide a ranging device of the character set forth in the preceding paragraph which includes a computing means for correctly evaluating the relation between the range, the actual length of the sighted object and the angular disposition of said length relative to the sighting line.

It is an additional object of my invention to provide a ranging device of the character set forth in the preceding paragraph which includes also means for indicating the relation between the range and the apparent length of the sighted object.

It is also an object of my invention to provide a ranging device which includes a sighting means and an electromagnetic instrument so arranged in the field of view of the sighting means as to indicate therein an apparent length proportional to the electrical potential applied to said instrument.

It is a still further object of my invention to provide a ranging device of the character set forth in the preceding paragraph which includes additionally an electrical computer for producing an electrical potential proportional to the apparent length of the sighted object in terms of computer input values including a preselected sighting range, the actual length of the object and the angular disposition of said length relative to the line of sight.

Other objects and advantages of my invention will be apparent from a study of the following specifications, read in connection with the accompanying drawings, wherein:

Fig. 1 is a perspective view illustrating the general form and appearance of a ranging device construction in accordance with one embodiment of my invention;

Fig. 2 is a geometrical diagram illustrating the geometry involved in the solution of a typical ranging problem;

Fig. 3 is an enlarged view of the device shown in Fig. 1 with parts broken away to show a part of the device in longitudinal section and a part of the device in elevation;

Fig. 4 is a cross sectional view taken substantially along the line IV—IV of Fig. 3;

Fig. 5 is a cross sectional view taken substantially along the line V—V of Fig. 3;

Fig. 6 is a development indicating the cooperative relation between a setting and indicating member forming a part of the device illustrated in Fig. 1 and illustrating the manner in which the indicating element is calibrated;

Fig. 7 is a development illustrating the form of a cylindrical cam member employed in the device illustrated in Fig. 3;

Fig. 8 is a view similar to Fig. 3 showing parts in longitudinal section and parts in elevation of another embodiment of my invention adapted particularly to electrical calculation of the ranging problem;

Fig. 9 is a cross sectional view taken substantially along the line IX—IX of Fig. 8; and

Fig. 10 is a schematic block diagram illustrating the arrangement and mode of operation of an electrical calculating device which is used with the form of the invention which is illustrated in Fig. 8.

Referring to the drawings, I have illustrated in Fig. 1 the general form and appearance of one embodiment of my invention. As is shown in Fig. 1 the ranging device of my invention comprises a sighting means indicated generally by the reference character 1 to which is attached a computer or calculating device indicated generally by the reference character 2.

As is clearly shown in Fig. 3, the sighting means comprises a collimating sight or pelorus of substantially conventional construction including an inclined partially reflecting mirror 3 supported by means of a suitable supporting bracket 4 upon the upper end of a hollow cylindrical housing 5. The housing 5 may, as is shown in Fig. 3, comprise four separate cylindrical parts 6, 7, 8 and 9 assembled in axial alignment with each other and held in such position as by means of longitudinally extending clamping screws 10 passing through each of the four devices and threadedly engaging the lower element 9. The upper element 6 serves as a support for the longitudinal supporting bracket 4 and a lens 11 secured within a suitable counterbore in the upper portion of the device 6 as by means of a lock ring 12.

Each of the elements 6, 7 and 8 are hollow and the lower element 9 serves as a closure for the lower end of the assembly. The element 8 comprises a lamp housing and serves to enclose an incandescent electric lamp 13 which is suitably mounted in an appropriate socket construction 14 which may be removably secured to the housing 8 as by mounting the same upon a plug member 15 threaded into a suitably threaded opening formed in the side of the housing 8. The element 8 also supports a reticule 16 which may be held in a fixed position against a shoulder 17 as by means of a mounting ring 19 threaded into a threaded aperture 20 extended upwardly through a transversely extending partition 21 forming the upper part of the element 8.

The reticule 16 is positioned a distance below the lens 11 equal to the focal length of the lens and is, in the preferred embodiment of my invention, arranged as an opaque member defining transparent reticule lines. These lines may be provided by cutting appropriate slots in a solid member or may, if desired, be provided by employing glass or a transparent plastic material as the reticule 16, coating the same with an opaque substance and then engraving the lines through the opaque coating material.

In either event the reticule lines are preferably arranged as is indicated in Fig. 4 and include a horizontal or lateral diametrical line 22 and a similar diametrical line 23 disposed at right angles to the line 22. The reticule is preferably so aligned that the intersection of the lines 22 and 23 falls on the optical axis of the lens 11. The reticule line 22 may also be intersected by a plurality of short cross lines 24 spaced apart uniform distances on opposite sides of the vertical center reticule line 23.

With the construction such as has just been described, light emanating from the lamp 13 will pass through the transparent reticule lines 22—24 and upwardly through the hollow interior of the cylindrical housing 5 and through the lens 11 to be reflected rearwardly from the inclined face of the partially reflecting mirror 3 in a substantially horizontal plane, considering the optical axis of the lens 11 to be disposed vertically.

Thus, if a user of the device looks horizontally into the partially reflecting mirror 3, he will see apparently before him an image of the reticule 16. By virtue of the fact that the reticule 16 is positioned in the focal plane of the lens 11, the image seen by the user of the device will appear to be located a great distance away. Also because the mirror 3 is only partially reflecting, the user of the device is permitted to see into the mirror and see objects located within the angle of the observer's vision. The enlarged and distinct image of the reticule 16 thus appears to be superimposed or projected upon the objects directly seen by the observer and independent of the exact position of the observer's eye. The intersection of the main reticule lines 22 and 23 serve to define a line of sight and the apparent position of this intersection with respect to the object seen through the partially reflecting mirror 3 indicates the relative disposition of the line of sight and the object sighted.

It is intended and anticipated that the device of my invention will be mounted upon a mobile vehicle such as, for example, an aircraft. When the device is so mounted, it may readily be arranged to align the line of sight defined by the pelorus with the axis or course of the vehicle or aircraft, and it may similarly be arranged so that the line of sight can be swung in a horizontal plane through a measurable angle relative to the course of the aircraft. For this reason the housing element 6 preferably includes also some provision for such mounting in the aircraft.

In the form of the invention illustrated herein, the housing element 6 may include a radial flangelike portion 25 provided with a conical undersurface 26 which may serve as a bearing surface to coact with a similarly disposed surface provided upon a suitable mounting bracket secured to the structure of the aircraft. With such an arrangement it is possible to either align the sighting line defined by the pelorus with the axis of the aircraft or dispose such sighting line at any desired angle relative to the axis of the aircraft.

The device of my invention includes also means for evaluating the relation between the distance of the sighting means from an object sighted and the known length of such object. In order to facilitate the understanding of the computing and indicating means employed in my invention, attention will first be directed to a typical sighting problem and to the geometry and mathematics involved in the solution thereof.

For this purpose reference may be had to Fig. 2 wherein I have illustrated a surface vessel or target ship TS having a length L and travelling along a course D when observed by the pilot of an aircraft flying along a course C.

The target approach angle θ is either determined by the relative positions and courses of the aircraft and target ship at the initial sighting of the target ship or the aircraft may be maneuvered to select another approach angle as the tactical situation shall indicate is more desirable. Then from his knowledge of the type of projectile he proposes to use against the target and computation by any known means of the proper lead angle such projectile should have at the time it is loosed, the pilot or operator of the ranging device selects the range point or distance which should be between the aircraft and the target at the time the projectile is to be launched, dropped or fired from the aircraft. Now the problem is to determine when, as the aircraft approaches the target, it has reached that range point.

From previously compiled data as to the type, character, length and speeds of enemy vessels, the observer will be apprised of the approximate actual length of the target ship TS and this length, as observed through the sighting portion of my ranging device, will be foreshortened into an apparent length L'. Thus, at the time the aircraft reaches the range point O, a triangle will be formed between the range point O and the fore and aft ends of the target ship TS, the diverging sides **27** and **28** of which subtend at the target ship the apparent length L', the angle between the line **27** and the direction or course D of the target ship being represented by the angle θ and the distance across the mirror **3** which would then be occupied by the apparent length of the target ship being S. The range distance Y from the point O will bear the same ratio to the distance F (focal length of the lens **11**) as the apparent length L' bears to the measured distance S on the mirror.

From an inspection of Fig. 2 it may be seen that

$$S/F = L'/Y \qquad (1)$$

and

$$L' = L \sin \theta \qquad (2)$$

From Equations 1 and 2, the relation between S, L, Y and θ may be expressed as

$$S = (FL \sin \theta)/Y \qquad (3a)$$

or

$$Y = (FL \sin \theta)/S \qquad (3b)$$

Equation 3*a* indicates the mode of determining the distance S when the factors F, L, θ and Y are known. This is the condition which is ordinarily encountered in aircraft torpedoing practice wherein during the initial approach to the target the pilot of the aircraft, through his familiarity with the sizes, types and styles of enemy ships, is able to recognize the particular size of ship comprising the target ship TS so that he, therefore, knows its length L.

The device of my invention includes a means for directly indicating in the field of view of the sighting means the distance S as computed from Equation 3*a* and for indicating this distance S as the prospective apparent target ship length; that is, a distance representing what the apparent length of the target ship TS will be when the aircraft has so approached the target ship TS as to arrive at the point O.

This means may comprise a light intercepting member **29** (see Figs. 3 and 4) which is positioned between the reticule **16** and the lens **11** and closely adjacent to the reticule **16**. The member **29** includes a pair of curved arm members or horns **30** and **31** arranged in the form of a bent V and intertied at their upper and lower ends, respectively, by cross members **32** and **33**. The horn assembly **30—33** is preferably secured as by radial supporting members **34** and **35** to a collar **36** which may in turn be secured to a pivot shaft **37** so that the horn assembly may be pivotally moved about the axis of the pivot shaft **37**. The horns **30** and **31** are so positioned relative to each other that regardless of the angular disposition of the assembly with respect to the pivot shaft **37**, the horns **30** and **31** will cross the horizontal reticule line **22** at equal distances on either side of the vertical reticule line **23**.

It will be seen that with this arrangement, pivotal movement of the horn assembly in a clockwise direction as viewed in Fig. 4 will reduce the distance between the horns **30** and **31** as measured along the reticule line **22**, whereas rotation of the device in a counter-clockwise direction will correspondingly increase the distance along the reticule line **22** which is intercepted by the horns **30** and **31**.

The horns **30** and **31**, as previously stated, are opaque and so serve to block the light transmitted through the transparent reticule line **22** at the points where the horns **30** and **31** intersect this reticule line. Thus, to an observer using the device, the luminous reticule line **22** which is apparently projected upon the object sighted through the sighting device is broken or interrupted at points disposed equal distances on opposite sides of the vertical luminous reticule line **23**, the points corresponding to the intersection of the horns **30** and **31** with the reticule line **22**.

If the pivot shaft **37** is so turned as to make the distance between the horns **30** and **31** measured along the reticule line **22** equal to the value of S computed from Equation 3*a* when the term F of that equation is used to represent the focal length of the lens **11**, the pilot using the device will be apprised of the fact of his arrival at the point O by the equality between the apparent length of the target ship L' and the distance between the breaks or interruptions in the horizontal luminous reticule line **22**.

When the horn assembly is set as described and the aircraft is situated a distance greater than the preselected range Y from the target ship TS, the apparent length of the target ship will be less than the distance between the breaks in the reticule line. As the approach to the target ship TS is continued, the apparent length of the target ship TS will gradually expand as the distance between the aircraft and the target ship progressively reduces. When the apparent length of the target ship has so expanded as to precisely fill the space between the breaks in the horizontal luminous reticule line **22**, the pilot will be thereby apprised of his arrival at the point O situated the preselected range Y from the target ship TS.

I have illustrated in Figs. 3 through 7 a mechanical computer or calculating device arranged to permit the factors L, Y and θ to be introduced as input values and arranged to so control the position of the horn assembly **31—33** as to make the distance between the horns 30 and 31 as measured along the reticule line 22 precisely equal to the distance S as computed from Equation 3*a*, supra.

The computer just referred to is that portion of the device which is indicated in Fig. 1 generally by the reference character 2. This mechanism is supported from the sighting device 1 as by means of a central vertical supporting member 38. The member 38 is preferably twice reduced in diameter at its upper end to provide radial shoulders 39 and 40 and an upper pin portion 41 which is threaded to permit it to be screwed into a threaded aperture provided in the lower closure member 9 of the sighting device. The member 38 may be screwed into the threaded aperture to bring the shoulder 40 into engagement with the undersurface of the member 9 and thus lock the supporting member 38 to the sighting device 1.

The member 38 is of cylindrical form and is surrounded by a tubular carrier 42. The carrier 42 is preferably mounted upon the support 38 for non-rotating longitudinal sliding movement relative thereto as by providing in the member 38 one or more keyways 43 adapted to be engaged by inwardly extending projections or keys 44 mounted upon the carrier 42. The carrier 42 is provided with one or more downwardly extending fingers or projections 45 adapted to engage and rest upon the upper surface of a cam member 46. The cam member 46 is pivotally secured to the lower end of the support 38 as by means of a pivot screw 47 and a bar-like handle 48 is secured as by means of screws 49 to the cam member 46 to be manually turned. In order that the cam member 46 will not be inadvertently displaced from any position in which it may be placed by manually turning the bar 48, friction material 50 may be interposed between the head of the pivot screw 47 and the cam member 46.

The cam member 46 defines a cam surface such as that illustrated by the development in Fig. 7. Fig. 7 illustrates the type of cam surface which is employed when the carrier 42 is provided with two of the projections 45 disposed diametrically opposite to each other. As is shown in Fig. 7, the cam surface defined by the member 46 comprises two humps 51 disposed diametrically opposite to each other. The curved surface of these humps is a sine curve so that rotation of the cam member 46 may impart vertical sliding movement of the carrier 42 and so that the extent of the movement of the carrier 42 will be proportional to the sine of the angle through which the bar 48 is rotated.

The carrier 42 is preferably surrounded by an indicating member 52 which is mounted upon the carrier 42 for non-rotating longitudinal sliding movement relative thereto as by providing in the carrier 42 one or more longitudinally extending keyways 53 which are engaged by inwardly projecting keys or pins 54 secured to the indicating member 52.

The vertical positioning of the indicating member 52 relative to the carrier 42 is arranged to be controlled by a setting ring 55 which surrounds the indicating member 52 and rests upon a radially extending flange 56 formed upon the carrier 42.

As is shown in Fig. 6 which comprises a development of the indicating member 52 and the setting member 55, the setting member 55 includes one or more helical grooves or channels 57 cut into the inner surface of the setting member 55 and adapted to receive ball members 58 interposed between the setting member 55 and the indicating member 52 and received within suitable hemispherical depressions formed in the outer surface of the indicating member 52.

It will be noted that by this construction the members 52 and 55 are in effect threadedly interengaged with a thread of extreme pitch so that a considerable longitudinal displacement of the member 52 may be effected by a partial rotation of the setting member 55. Turning of the setting member 55 may be facilitated by providing a knurled ring 59 which is adapted to be grasped by the hand of a person using the device.

Also surrounding the indicating member 52 is a driving member 60. This member is of tubular form and includes a knurled ring 61 by means of which the member 60 may be rotated and an inwardly extending radial flange 62 which is received within the space between the underside of the closure member 9 and the shoulder 39 on the supporting member 38 to be thereby supported and journaled for rotation.

The upper surface of the flange 62 is provided with a groove 63 which preferably constitutes a portion of a spiral about the axis of rotation of the driving member 60. This groove is adapted to receive the downwardly projecting end 64 of a crank member 65 which is secured to the lower end of the pivot shaft 37. The pivot shaft 37 is journaled within suitably aligned apertures formed in the members 7, 8 and 9.

The indicating member 52 is adapted to coact with the driving member 60 to provide for the indication or the setting of the sighting range Y. For this purpose the lower end of the driving member 60 is chamfered or beveled as indicated at 66 and upon the surface so produced there is inscribed, engraved or otherwise affixed an index or witness point 67. The exterior surface of the indicating member 52 is likewise inscribed with suitable indicia or graduations adapted and intended to be read with reference to the witness point 67.

The form and shape of the graduations on the indicating member 52 is indicated in the development Fig. 6. As is shown therein the calibrations on the outer surface of the indicating member 52 comprise a family of curves 68, each of which represents an arbitrarily chosen sighting range Y. When developed on a plane surface as in Fig. 6, the curves 68 are plotted with the product of L and sin θ or ordinates and with the distance S as abscissa.

The manner in which the above described calibration is arranged and the manner in which this calibration may be used to obtain the desired results will be apparent from the ensuing description of the operation of the device. To operate the computing means just described, the entire structure including the sighting device 1 is turned to such position as to direct the sighting line defined by the sighting device on to the target ship TS. The setting bar 48 is then manually turned to a position which is in the best judgment of the pilot of the aircraft aligned with the length L of the target ship TS. The cam surface defined by the cam member 46 is so positioned with reference to the bar 48 that when the bar 48 is turned to a position extending at right angles to the line of sight, the carrier projections 45 will rest upon the uppermost point of the cam surface humps 51. This corresponds to the target approach situation in which the angle θ is equal to 90°.

It will be noted that turning the bar 47 to another position representing an angle θ of less than 90° will allow the carrier 42 to descend a distance such that its position with reference to its lowermost position is proportional to sin θ. Since the indicating member 52, through the setting member 55, is supported upon the carrier 42, this vertical positioning of the carrier in terms of the angular position of the setting bar 48 similarly introduces the factor sin θ into the vertical positioning of the indicating member 52 with reference to the unchanging location of the extreme lower edge 69 of the driving member 60.

It will be noted that when the line of sight is brought to bear upon the target ship TS and the setting bar 48 is then turned to a position paralleling the length of the target ship TS, a determination of the angle θ is thereby made and the vertical position of the indicating member 52 is adjusted in terms of sin θ.

The setting member 55 is intended to be used to introduce the factor L into the calculation and for this purpose the peripheral edge of the flange 56 may be provided with an index or witness point 70 adapted to coact with suitably marked graduations 71 provided on the lower portion of the outer cylindrical surface of the setting member 55. By means of the knurled ring 59, the setting member 55 may be rotated to a position such that the witness point 70 will indicate on the graduations 71 the known length L of the target ship TS.

Such movement of the setting ring 55 serves to further adjust the vertical position of the indicating member 52 so as to introduce into the longitudinal positioning of the indicating member 52 with reference to the surface 69 the additional factor L so that after the adjustment of the setting member 55 is made, the vertical position of the indicating member 52 with reference to the surface 69 corresponds to the introduced values of L and sin θ.

The undersurface 69 of the drive member 60 thus serves to, in effect, draw a horizontal line across the chart or graph comprising the graduations marked on the indicating member 42 somewhat in the manner illustrated by the dotted line in Fig. 6. This horizontal "reading" line represents the ordinate on the graph or chart corresponding to the mathematical operation FL sin θ when F is known and the values of L and θ are introduced as hereinbefore described.

Movement of the witness point 67 along this "reading" line by rotating the drive member 60 permits the range Y to be introduced. For example, as is illustrated in Figs. 3 and 6, the drive member 60 may be turned to a position corresponding to a value of Y equals 1,000 yards. This is accomplished by so turning the drive member 60 as to position the witness point 67 at the intersection of the "reading" line 69 with that one of the family of curves 68 which corresponds to a value of 1,000 for the factor Y.

It will be noted from the previous description that this turning of the drive member 60 will, through the engagement of the crank member 65 with the spiral groove 63, rotate the pivot shaft 37 and so change the position of the horn assembly 30—33 relative to the reticule 16. The parts employed in this drive connection are so proportioned that the actual distance between the horns 30 and 31 as measured along the reticule line 22 will be precisely equal to the value of S calculated from Equation 3*a*, supra, when there is substituted in that equation values of F, L, θ and Y equal to the known focal length of the lens 11 and the magnitudes of the factors L, θ and Y which have been introduced into the calculation by the setting of the members 48, 55 and 60.

To summarize the operation of the device, the pilot of the aircraft first brings the sight to bear upon the target ship TS. The bar is then set to parallelism with the length of the target ship TS and the setting member 55 is turned to a position representative of the length L of the target vessel. The drive member 60 is then set to a position representative of the chosen sighting range Y, whereupon the horns 30 and 31 will be so positioned as to define the distance S along the reticule line 22. Thereafter the pilot continues his approach to the target ship and observes the apparent expansion of the image of the target ship in the field of view of the sighting device.

When this apparent expansion of the image has proceeded to the point where the apparent length of the target ship TS precisely expands the distance between the breaks in the horizontal luminous reticule line 22, the pilot will be apprised of the fact that he has arrived at the point O situated the chosen sighting range Y from the target ship TS.

Instead of being used as a device for indicating arrival at the point O, the mechanism just described may alternatively be used as a device for determining and indicating the distance from the sighting device to the target ship. To so use the device the operation is the same as above described except that the drive member 60 instead of being set to some chosen value of Y is so turned as to just exactly embrace within the distance between the breaks in the luminous reticule line 22 the image of the target ship TS. The distance from the sighting device to the target ship may then be determined by reading the value of Y represented by the position of the witness point 67 along the reading line 69 with reference to the calibration curves 68 provided on the indicating member 52.

I have illustrated in Figs. 8, 9 and 10 an alternative embodiment of my invention wherein the calculations above described and the movement of the light intercepting member 29 is effected by electrical means. Referring particularly to Fig. 8, it will be observed that the modified form of the device, like the form first described, comprises a sighting device 1 and a calculating mechanism 2.

The sighting device 1 is substantially identical to that described in connection with Fig. 3 with the exception that the housing element 7 of Fig. 3 is replaced by a similar but somewhat different housing element 7*a*. The housing element 7*a* serves as a support for an electromagnetic instrument or galvanometer 70 which is preferably of the permanent magnet moving coil type and may comprise a substantially conventional construction such as is employed in voltmeters and milliammeters. The galvanometer 70 may include a base or supporting structure 71 upon which is mounted a permanent magnet 72 of the horseshoe type. The supporting structure 71 may be received within an interior cavity 73 defined by the housing 7*a* and may be secured therein as by means of screws 74.

As is shown in Fig. 9, the magnet 72 defines a pair of pole-pieces 75 and 76 between which is mounted a moving coil 77, the coil 77 being supported by a longitudinally extending shaft 78 pivoted as in jeweled pivots 79 and 80. A restoring spring 81 tends to return the coil to an initial position, whereas the passage of an electric current through the coil 77 tends to pivotally move the coil against the restoring force of the spring 81.

In conventional galvanometer constructions the coil 77 or the pivot shaft 78 supports a needle or hand adapted to be moved over an indicating dial. According to my invention this needle or hand is removed and in its place is substituted the light intercepting member 29 hereinbefore described.

With this construction it will be apparent that by applying to the moving coil 77 a voltage which is properly proportional to a given value of the distance S, the resulting movement of the coil 77 may be caused to move the light intercepting member 29 to a position such that the distance along the horizontal reticule line 22 between the intersections of that line with the horns 30 and 31 may be precisely equal to the chosen value of S.

From this, it will likewise be seen that in order to position the light intercepting member 29 in accordance with a value of S as calculated from Equation 3*a*, supra, it is only necessary to apply to the moving coil 77 a voltage which is proportional to the value of S as calculated from Equation 3*a*.

I have illustrated in Fig. 10 by diagrammatic means an electrical circuit by means of which such a proportional voltage may be developed. The circuit may be briefly described as including a source of alternating electrical potential 82, the output of which is fed to a transformer 83 and from there to a potentiometer 84. A portion of the voltage thus applied across the full length of the potentiometer circuit is taken between the tap of the potentiometer circuit and one end and applied to an amplifier 85. The output of the amplifier 85 is applied to a potentiometer 86 and a fractional part of the voltage applied to the entire potentiometer circuit 86 is applied to an amplifier 87. The output of the amplifier 87 is applied to the coil 77 of the galvanometer 70.

It will be noted that I have, in Fig. 10, used the variable resistance symbol to diagrammatically indicate the potentiometers. These potentiometers are arranged for manual control and by these the factors L and Y may be introduced into the computation. The variable inductance symbol previously referred to as comprising the transformer 83 is intended to represent a variable ratio transformer including input and output windings arranged for rotary movement with respect to each other in such manner that the transformation ratio between input and output windings is proportional to the angular displacement of one of the windings relative to the other.

The source 82 may comprise any suitable source of alternating electrical potential, although it is preferred to use the vacuum tube oscillator arranged to produce an alternating potential of fixed voltage and unchanging frequency of the order of one thousand cycles. The magnitude of the electrical potential generated by the oscillator 82 will be referred to as E. This voltage is applied as indicated at 88 to the input windings of the transformer 83. If the angular position of the input and output windings of the transformer 83 is adjusted to correspondence with the angle θ, then the transformation ratio of the transformer 83 will be proportional to $\sin\theta$.

Since the voltage E is applied to the input winding of the transformer 83, the voltage developed across the output winding will be

$$e_1 = E \sin\theta \qquad (4)$$

This voltage is applied as indicated at 89 across the full resistance strip portion of the potentiometer 84.

As will be hereinafter described, the potentiometer 84 includes also a movable contact movable along the length of the resistance strip. It is intended that the movement of this contact be controlled by a manually movable dial or pointer and that this dial or pointer be calibrated in terms of L. The calibration is so arranged that when the dial is set to a selected value of L, the voltage between the movable contact and one end of the resistance strip of the potentiometer 84 will be

$$e_2 = e_1(L/K_1) \qquad (5)$$

where K_1 represents the constant of proportionality included in the above described calibration of the dial.

The voltage e_2 is fed to the amplifier 85 and for simplicity of understanding, it is preferred to consider the amplifier 85 as having an overall gain equal to K_1. If this be the case, then the output voltage of the amplifier 85 will be

$$e_3 = EL \sin\theta \qquad (6)$$

The amplifier 85 like the amplifier 87 may be of any suitable construction and preferably comprises an electronic or vacuum tube amplifier of which any known types may be suitable. If desired, the overall gain of the amplifier 85 may be made different than the K_1 previously mentioned, it being only necessary that the factor K_1 be introduced into the circuit as an amplification either in the amplifier 85 or in the amplifier 87 or, in both.

The output voltage e_3 of the amplifier 85 is applied across the entire resistance strip portion of the potentiometer 86. The potentiometer 86 like the potentiometer 84 is, as will be hereinafter described, provided with an indicating dial arranged for manually controlling the position of the movable contact. This dial is calibrated in terms of Y in such manner that when the dial is set to a chosen value of Y, the voltage developed between the movable contact and one end of the resistance strip portion of the potentiometer 86 will be

$$e_4 = e_3(YK_2) \qquad (7)$$

The voltage e_4 is applied to the amplifier 87 and the gain of this amplifier is indicated as being made equal to FK_2.

As previously noted, the real requirement is that the total combined gain of the amplifiers 85 and 87 be FK_1, K_2. When the gains are so arranged, the output voltage of the amplifier 87 will be

$$e_5 = E(FL \sin\theta)/Y \qquad (8)$$

Comparing equation (8) with equation (3*a*), supra, it will noted that

$$e_5 = ES \qquad (9)$$

and from this it may be said that the voltage output e_5 of the amplifier 87 is proportional to the value of S as computed from Equation 3*a* in terms of the variable factors θ, L and Y according to the settings of the potentiometers 84 and 86 and the setting or the rotary transformer 83.

The voltage e_5 is, as indicated at 90, applied to the coil 77 of the galvanometer 70 so that the light intercepting member **29** will thereby be moved to a position such that the intersection of the horns **30** and **31** with the horizontal reticule line **22** will measure off and define a distance precisely equal to the distance S as calculated from Equation 3*a*. In short, it is seen that by this means the light intercepting member **29** is positioned according to the computed value of S is precisely the same manner as was previously described in connection with the mechanical modification of the device illustrated in Fig. 3.

Preferably the rotary transformer **83** and the potentiometers **84** and **86** are mounted in the calculating portion **2** attached to the sighting device **1**. The electronic equipment comprising the oscillator **82** and the amplifiers **85** and **87** may be mounted in any convenient location and connected to the ranging device by means of suitable cables.

As is shown in Fig. 8, the lower portion **2** of the ranging device comprises three cup-like cylindrical members **91**, **92** and **93**, these members being secured to each other and to the lower member **9** of the sighting device as by means of longitudinally extending bolts **94**. The members **91** and **92** may be identical and serve to respectively support the potentiometers **86** and **84**.

As is shown in Fig. 8, each of the members **91** and **92** includes a transversely extending web member **95** which is bored to receive the threaded sleeve portions **96** of the potentiometers **84** and **86**, it being understood that the potentiometers **84** and **86** are in themselves of conventional construction and of the character which may ordinarily be purchased in the open market.

By means of clamping nuts **97** and **98** threaded on to the sleeve **96** and positioned on opposite sides of the web member **95**, the potentiometers **84** and **86** may be secured within their respective housings **92** and **91**. To the support for the movable arm portion of the potentiometer **84** is secured a driving member or dial **99**, this attachment being effected as by means of rivets or screws **100**. The potentiometers **84** and **86** are mounted eccentrically with respect to their housings **91** and **92** and one side of the housings are cut away as indicated at **101** to permit the cylindrical dial member **99** to protrude through the opening. Each of the dial members **99** is preferably provided with a raised and knurled ring **102** to facilitate manual rotation of the dial members.

The outer cylindrical surface of the dial members may be provided with graduations **103** adapted to coact with an index or witness point **104** inscribed on the outer surface of the housings **91** and **92** so as to permit the dials **99** to be manually set to selected values of L and Y, respectively. The lower cup member **93** serves to enclose and support the rotary transformer **83**, the same being mounted within the housing **93** as by providing a threaded engagement **105** between the transformer **83** and the housing **93**. This serves to fix the output winding of the transformer **83** with respect to the ranging device. The input winding of the transformer **83** is, on the other hand, secured to a shaft **106** which is extended through and below a lower closure member **107** and a bar knob **108** is secured to the shaft **106**.

The positions of the bar **108** and the input winding secured to the shaft **106** are so adjusted that when the bar **108** is turned to a position disposing its length at right angles to the horizontal line of sight defined by the pelorus portion of the device, the transformation ratio of the transformer **83** will be a maximum.

The manner of use of the electrical modification of my invention is precisely the same as has been described in connection with the mechanical form shown in Fig. 3. This manner of use may be said to comprise first turning the sighting device to such position as will bring the line of sight to bear upon the target ship TS. The bar **108** is then turned to estimated parallelism with the length of the target ship TS. The actual known value of this length is introduced into the computation by turning the dial **99** of the potentiometer **84** to a position such that the witness point **104** will indicate on the graduations **103** the known value of L.

A similar setting is made on the potentiometer **86** in terms of the chosen sighting range. The light intercepting member **29** will thus be automatically positioned to produce breaks or interruptions in the luminous horizontal reticule line **22** conforming to the apparent length of the target ship TS at the time the sighting device has been moved to the point O situated the chosen sighting range Y from the target ship.

Like the mechanical form of the device, the electrical mechanism just described is susceptible to use for directly determining the distance between the sighting device and the target ship TS. To so use the device the bar **108** is set to parallelism with the length of the target ship and the value or magnitude of this length is set on the dial of the potentiometer **84**. The dial of the potentiometer **86** is then turned until the breaks in the horizontal luminous reticule line just exactly embrace the observed length of the target ship. The distance between the target ship and the sighting device may then be read from the dial of the potentiometer **86** through use of the witness point **104** and graduations **103**.

From the foregoing it will be observed that I have provided a ranging device which is small and compact and which provides a ready and accurate means for determining the relation between the length of a sighted target or object and the distance between that object and the sighting device.

It is also desired to call attention to the fact that by employing as a sighting means a collimating type of sight, it is possible and advantageous to use the device as a gun sight, torpedo director or other projectile directing means concurrently with its use as a ranging device.

While I have shown and described the preferred embodiment of my invention, I do not desire to be limited to any of the details of construction shown or described herein, except as defined in the appended claims.

I claim:

1. In a ranging device, a collimating sight defining a sighting line and including a reticule defining a reference line in the field of view of said sight and extending transversely of said sighting line, a light intercepting member positioned closely adjacent to said reticule, means mounting said member for movement from a rest position in a plane substantially parallel to the plane of said reticule, said member including means for indicating in the field of view of said sight a distance along said reference line proportional to the extent of movement of said member from said rest position, control means for moving said member to a position defining a distance in said field of view equal to the apparent length of an object of known length situated in said field of view, computing means for computing the range of said object relative to said

sight from input values comprising the known length of said object, the angular disposition of said length relative to said sighting line and the extent of movement of said member, and indicating means coacting with said computing means to indicate the value of the range corresponding to said input values.

2. In a ranging device, a collimating sight defining a sighting line and including a reticule defining a reference line in the field of view of said sight and extending transversely of said sighting line, a light intercepting member positioned closely adjacent to said reticule, means mounting said member for movement from a rest position in a plane substantially parallel to the plane of said reticule, said member including means for indicating in the field of view of said sight a distance along said reference line proportional to the extent of movement of said member from said rest position, computing means for computing the relation between the range of an object of known length situated in the field of view of said sight and the apparent length of said object in said field of view from input values comprising said known length and the angular disposition of said length relative to said sighting line and according to the formula

$$Y(S/F)=L \sin \theta$$

wherein Y represents said range, L represents said known length, θ represents said angular disposition, F represents an optical constant of said sight, and S represents said apparent length, control means for introducing into said computer said input values comprising the quantities Y, L and θ, means coacting with said computing means for moving said light intercepting member to a position defining a distance in said field of view corresponding to the relation determined by said computing means, and indicating means associated with said control means for indicating the value of the range Y introduced as input into said computing means, whereby so adjusting the value of Y as to make the distance defined by said light intercepting member equal to the apparent length of said object causes said indicating means to indicate the true range.

3. In a ranging device including a collimating sight for directing a sighting line toward an object of known length, computing means for computing from input values relating to the relative locations and positions of said object and said sight the prospective apparent length of said object in the field of view of said sight and as it should appear from a point situated a chosen distance from said object, associated means for introducing into said computing means input values comprising said known length of said object, the angular disposition of said length relative to said sighting line, and said chosen distance, indicating means on said sight movable to a position indicating in the field of view of said sight said prospective apparent length, and means coacting with said computing means for moving said indicating means to said position.

4. In a ranging device including a collimating sight for directing a sighting line toward an object of known length, computing means for computing from input values relating to the relative locations and positions of said object and said sight the prosepctive apparent length of said object in the field of view of said sight and as it should appear from a point situated a chosen distance from said object according to the formula

$$S/F=(L \sin \theta)/Y$$

wherein F represents an optical constant of said sight, S represents said prospective apparent length, L represents said known length, θ represents the angular disposition of said known length relative to said sighting line, and Y represents said chosen distance, associated means for introducing into said computing means input values comprising the quantities L, θ and Y, indicating means on said sight movable to a position indicating in the field of view of said sight said prospective apparent length, and means coacting with said computing means for moving said indicating means to said position.

5. In a ranging device including a collimating sight for directing a sighting line toward an object of known length, electrical computing means for computing from input values relating to the relative locations and positions of said object and said sight the prospective apparent length of said object in the field of view of said sight and as it should appear from a point situated a chosen distance from said object according to the formula

$$S/F=(L \sin \theta)/Y$$

wherein F represents an optical constant of said sight, S represents said prospective apparent length, L represents said known length, θ represents the angular disposition of said known length relative to said sighting line, and Y represents said chosen distance, associated means for introducing into the circuits of said computing means input values comprising the quantities L, θ and Y, indicating means on said sight movable to a position indicating in the field of view of said sight said prospective apparent length, and means coacting with said computing means for moving said indicating means to said position.

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