April 18, 1950 P. R. WHEELER 2,504,168

GUNSIGHT SUPERELEVATION CONTROL DEVICE

Filed Dec. 19, 1945 2 Sheets-Sheet 1

FIG. 1

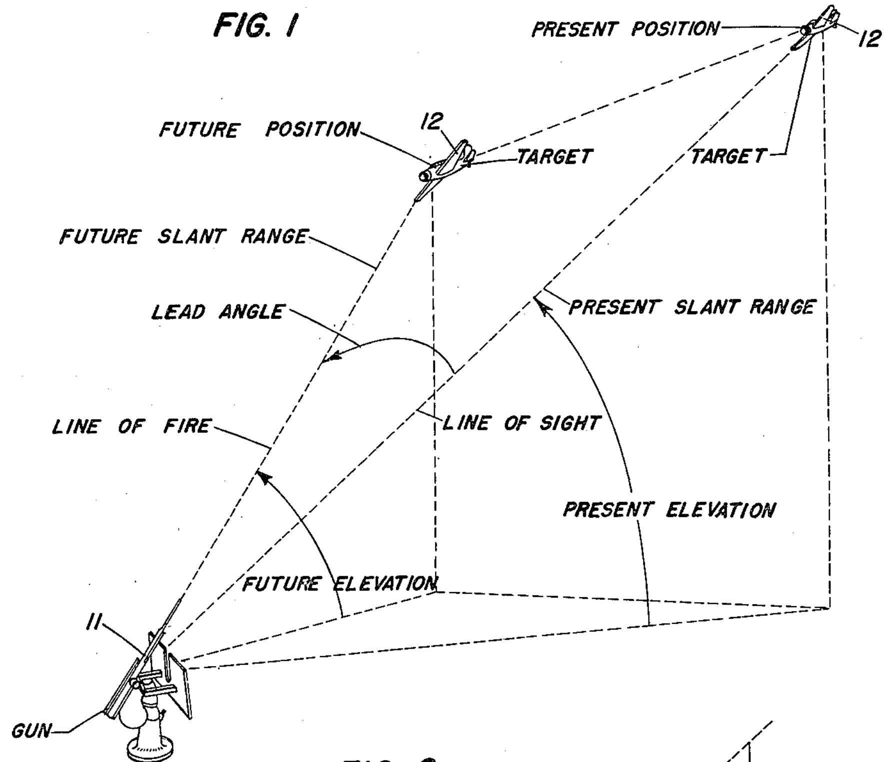
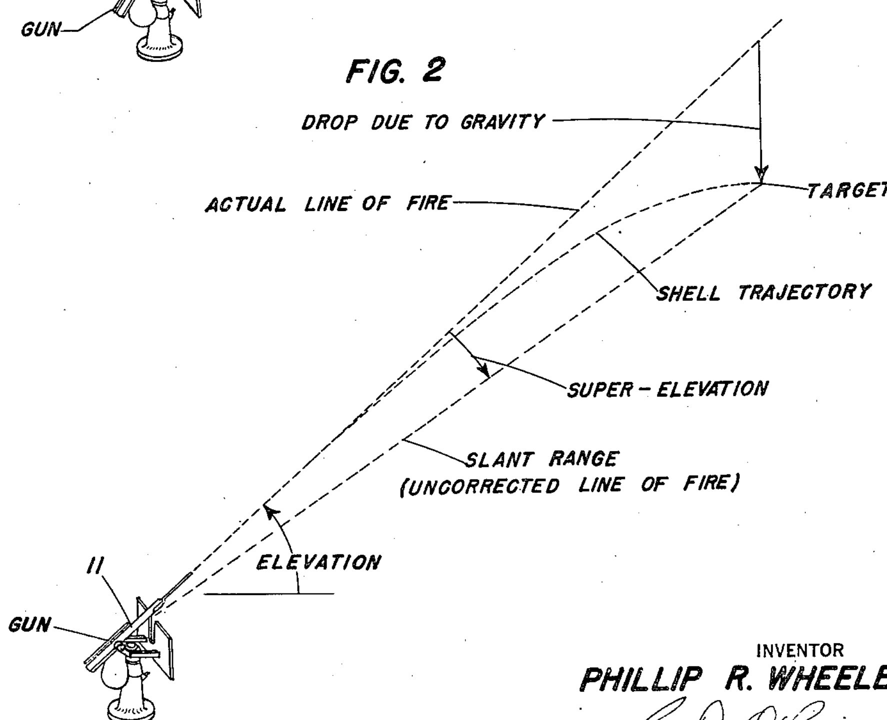


FIG. 2



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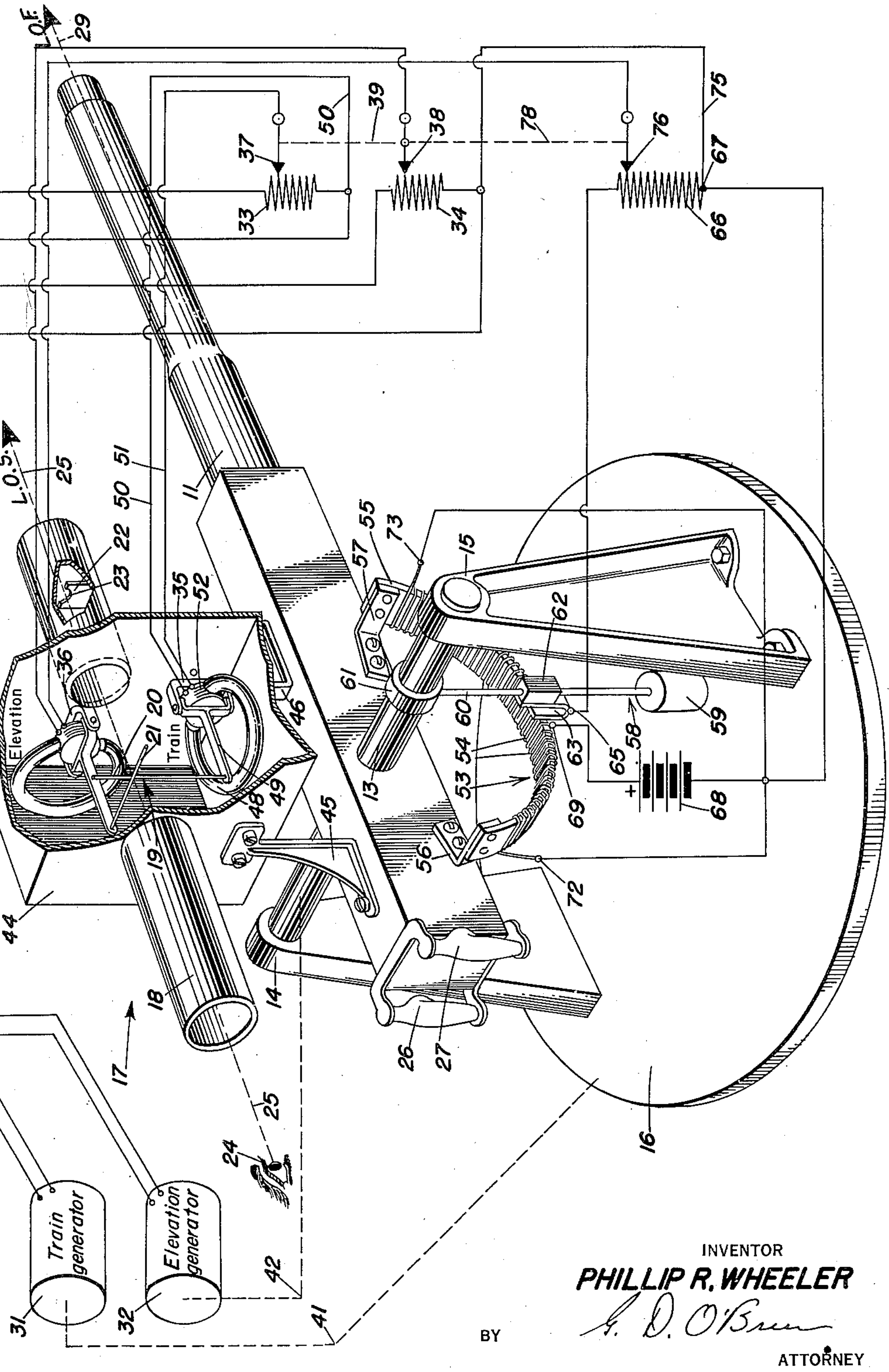

FIG. 3

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GUNSIGHT SUPERELEVATION CONTROL DEVICE

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1 Claim. (Cl. 33—49)

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The present invention relates to gun sights and particularly to gun-sight superelevation control devices of the type employed in sights operating on the disturbed-line-of-sight principle. Sights of this general character are described in the following United States patents: No. 1,322,153, J. S. Wilson and W. E. Dalby, issued November 18, 1919; No. 2,183,530, Robert Alkan, issued December 19, 1939; and 1,724,093, Robert Kauch and Charles L. Paulus, issued August 13, 1929.

This application is a continuation-in-part of my copending abandoned patent application Serial No. 510,403, entitled "Cathode ray gun sight" and filed in the U. S. Patent Office on November 15, 1943.

When a gunner establishes a line of sight on a moving target, he must "lead" the target by a suitable angle. That is, the weapon must be so pointed that the line of fire leads the line of sight. Otherwise the projectile would fall behind the target. The lead angle depends on the target velocity and the time of flight of the projectile. This "leading" is accomplished by the "target velocity" corrections of the sight setting. The gunner must allow also for the effect of gravity on the projectile. In other words, he must elevate the gun above the direct line of sight to the target to allow for the drop of the projectile after it leaves the gun muzzle. This is accomplished by the superelevation corrections of the sight setting. Superelevation is functionally related to range and it varies as the cosine of elevation. In gun sights which operate on the disturbed-line-of-sight principle the gunner maintains the line of sight on a target by tracking the target and he manually positions the gun and sight. The required lead angle and superelevation corrections furnish a basis for angularly so disturbing the line of sight with respect to the line of fire that when the line of sight is maintained on the target the line of fire is appropriate to score a hit.

It is an object of the present invention to provide an improved and simple electrical arrangement for automatically applying superelevation corrections to a gun sight of the type having a displaceable reference mark.

For a better understanding of the present invention, together with other and further objects thereof, reference is made to the following specification, to the claim appended thereto, and to the accompanying drawings in which:

Fig. 1 comprises a geometrical presentation of the lead angle computation;

Fig. 2 comprises a geometrical presentation of the superelevation computation; and

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Fig. 3 comprises a gun and sight including a superelevation control device in accordance with my invention.

Fig. 1 shows the essential features of the short-range fire control problem. A gun 11 is fired at an airplane 12. At the instant of fire the airplane is at a position called the "present position." The gun should be pointed at some later position of the target called the "future position," such that the projectile will reach the future position at the same time as the target. The angle between the line from the gun to the present target position (or line of sight) and the line from the gun to the future position (or line of fire) is the lead angle.

The angular velocity of the target as observed from the gun is the angular movement of the target about the gun per second of time. The time of flight is the time taken by the projectile to reach the target. The total angular motion of the target (or lead angle) during the time of flight is equal approximately to the angular velocity of the target at the present position multiplied by the time of flight in seconds. Other quantities involved in the lead-computing fire control problem, such as present and future slant range are appropriately labeled in Fig. 1.

If the gun bore is pointed at the future position of the target without further correction the projectile would then fall below the target because of the downward force of gravity. To compensate for this undesired effect of gravity the gun elevation is increased by an additional angle called the superelevation angle, as illustrated in Fig. 2. The superelevation angle required is dependent upon (a) the ballistics of the gun and projectiles, (b) the time of flight of the projectile to the target, and (c) the cosine of the angle of gun elevation. The ballistics data of the gun can be considered constant over short ranges and therefore the superelevation angle is calculated with reasonable approximation according to the following equation:

$$\text{Superelevation} = \text{Constant} \times \text{Time of flight} \times \text{Cosine of gun elevation}$$

The present invention is primarily concerned with the superelevation factor of the fire control problem.

In Fig. 3 there is illustrated, in combination with a universal gun mount carrying a gun for movement in elevation and in azimuth, a novel sighting arrangement. This arrangement comprises means for establishing a line of sight, electrical means actuated by an input signal for angularly disturbing the line of sight with reference to the gun bore axis or line of fire by an amount functionally related to the input signal, and means for applying to the disturbing means an electrical signal having a magnitude trigonometrically functionally related to the angle of elevation of the gun, thereby to actuate the disturbing means to disturb the line of sight by an amount trigonometrically functionally related to the angle of elevation, whereby maintenance of the line of sight on a target by the gunner causes the line of fire of the gun to be angularly elevated with respect to the line of sight by a proper amount to introduce the superelevation correction. A gun 11 is mounted for turning in elevation on trunnions (one of which has the reference numeral 13) journaled in bearings on suitable supports 14, 15. The gun is suitably mounted for movement in train (or azimuth) by reason of the fact that the supports 14, 15 are secured to a turnable platform 16. The Fig. 3 embodiment also includes an automatic compensating sighting apparatus for use in combination with the gun, this apparatus being generally designated by the numeral 17. The sighting apparatus comprises a telescope casing 18, a back sight member 19 comprising movable cross hairs 20 and 21, a front sight 22, and other desired optical elements (not shown). The reference mark provided by the intersection of the cross hairs 20 and 21 is centered in the peep or arcuate notch 23 on the front sight 22, as viewed by the eye 24 of the gunner and a line of sight 25 is in this manner defined from the operator's eye to the target. In placing the line of sight on a target the operator grasps the handles 26, 27 and swings the gun in elevation and in train while keeping the line of sight defined by the reference mark and by peep 23 on the target, the reference mark being superimposed on the target.

It will be noted that the gun defines a line of fire 29. The lead angle and superelevation corrections are developed in the sighting apparatus in such a manner as to govern the position of the reference mark provided by the intersection of cross hairs 20, 21 and thus to disturb the line of sight with reference to the line of fire. By keeping the disturbed line of sight on the target the operator automatically manually maintains the line of fire in a correct position. The gun 11, trunnions 13, supports 14, 15, turntable 16, telescope casing 18, cross hairs 20, 21 and front sight 22 are individually of the prior art and schematically shown. Any suitable arrangement for performing the same functions may be substituted for them.

The Fig. 3 embodiment also includes prior-art means responsive to dynamic movement of the gun in elevation and in azimuth for moving the reference mark in elevation and in azimuth for the purpose of introducing the lead angle (which is functionally related to target velocity). This means comprises a conventional reversible generator 31 for generating a direct current electrical signal voltage representative of the rate of tracking of the target in train (i. e., the component of target velocity in the plane of train or slant plane) and a similar generator 32 for generating an electrical signal voltage representative of the elevational component of the target velocity (i. e., the tracking rate in elevation). The output circuits of these generators are individually coupled to variable voltage dividers 33 and 34. The output of voltage divider 33 is coupled to a galvanometer 35 and the output of divider 34 is coupled to a galvanometer 36. The sliding contacts 37, 38 of potentiometers 33 and 34 are ganged by any suitable expedient indicated by the dashed line 39 for purposes of range correction. Galvanometer 35 positions cross hair 20 and galvanometer 36 positions cross hair 21. The operation of elements 31, 32, 33, 34, 35, 36, 37, 38, and 39 is such as to cause the reference mark to be positioned in elevation and in azimuth in coordination with the movements of the gun in elevation and in azimuth and thus to introduce the proper lead angle by causing the reference mark to be so positioned that the line of fire leads the line of sight. Elements 31 to 39, inclusive, are of the prior art and further description thereof is deemed unnecessary. Suitable generators corresponding to generators 31, 32 are shown in the above-mentioned U. S. Patent No. 1,322,153. Suitable galvanometers and cross-hair arrangements corresponding to elements 20, 21, 35 and 36 are shown in the above-mentioned U. S. Patent 1,724,093. The rotor of train generator 31 is coupled to turntable 16 by any suitable mechanical expedient indicated by the dashed line 41 so as to cause rotation thereof by movement of turntable 16 in train. The elevational generator 32 is coupled to the trunnions 13 by any suitable expedient indicated by the dashed line 42 in such manner as to cause the generator rotor to move in coordination with the movements of the gun in elevation. The generators may be secured by any suitable supports, such as brackets (not shown). The elements of my sighting system so far described in detail and numbered, taken in the aggregate, essentially constitute a sight as shown in the above-mentioned U. S. Patent No. 1,724,093, as modified by the substitution of the generators of the above-mentioned U. S. Patent No. 1,322,153, for the hydraulic rate control system in U. S. Patent No. 1,724,093.

Formed about the casing 18 is a suitable housing 44. The assembly of housing 44 and casing 18 is rigidly secured to the gun by suitable brackets 45, 46. Galvanometer 35 comprises a circular fixed magnet 48. This magnet influences lever 49, at the extremity of which is mounted cross hair 20. The current flowing in conductors 50 and 51 passes through the coil 52 mounted near the fulcrum point of the lever 49. This arrangement causes the lever which controls cross hair 20 to move from the central position shown by an amount directly proportional to the amount of current flowing through the circuit and thus by an amount functionally related to the input signal applied thereto by train generator 31. The movement is in a direction dependent on the polarity of this signal. The polarity of the signal in turn depends on direction of train. Galvanometer 36 is similar in construction and operation and its relationship to elevation generator 32 is substantially the same as that of galvanometer 35 to train generator 31.

The operation of that part of the sighting arrangement so far described is briefly as follows: As an ascending target is tracked by the operator the signals from generator 32 cause cross hair 21 to be elevated, though at a slower rate than the target, with the ultimate result that the line of fire has a greater elevation than the line of sight; conversely, as a descending target is tracked, cross hair 21 is downwardly displaced at a slower rate than the target and the lead angle correction tends to depress the line of fire with respect to the line of sight; similarly, as a target moving to the left is tracked cross hair 20 is moved to the left and as a target moving to the right is tracked cross hair 20 is moved to the right. Thus the problem posed by Fig. 1 is effectively solved. The range factor is introduced by elements 37, 38 and 39 in a manner taught in the above-mentioned U. S. Patent No. 1,322,153. For a given rate of target velocity, the deflection of the reference mark should be relatively small at short ranges and relatively greater at longer ranges, as is well known by those skilled in the fire control art.

The sighting arrangement includes my improved superelevation control for solving the problem posed by Fig. 2. For purposes of describing the construction and operation of the superelevation control arrangement which has been included in the Fig. 3 embodiment in accordance with my invention, it will be assumed that turntable 16 is at a stop and on the true horizontal and that the trunnions 13, 13 are parallel to turntable 16. It will further be assumed that the line of fire provided by gun 11 is normal to the axis of the trunnions. The line of sight has been disturbed in such a manner as to introduce corrections for target velocity. However, the solution of the problem posed in Fig. 2 requires a superelevation control for applying to the disturbing means 36 an electrical signal having a magnitude trigonometrically functionally related to the angle of elevation of the gun, thereby to actuate the galvanometer 36 to disturb the reference mark and the line of sight by an amount trigonometrically functionally related (as the cosine) to the angle of elevation. When such a control is provided maintenance of the line of sight on a target causes the line of fire to be angularly elevated with respect to the line of sight by the amount of the desired superelevation correction. The control for supplying the superelevation signal comprises a voltage-control arrangement of potentiometer 53, having a resistor 54 wound on an arcuate insulating and supporting form 55. The form is secured to the gun by suitable brackets 56, 57. The potentiometer also includes a pendulous contactor assembly indicated generally at 58 and comprising a weight 59 rigidly secured to a rod 60, the rod in turn being pivotally secured to one of the trunnions 13 by a suitable expedient indicated at 61. Secured to rod 60 is an insulating block 62 on which is mounted a metallic contact element 63. Weight 59 maintains rod 60 on the vertical and fixes contact 63 in a plane parallel to the plane of elevation.

A closed circuit is formed from contact 63, terminal 65, resistor 66, terminal 67, battery 68, terminal 69 and that portion of resistor 54 between contact 63 and terminal 69. When the line of fire is parallel to the horizontal plane and contact 63 is at the mid point on resistor 54 the full potential of battery 68 is impressed across resistor 66. This potential is here shown as of positive polarity. When the line of fire is elevated by 80°, for example, resistors 66 and 54 are so proportioned that the potential appearing across resistor 66 is equal to the product of 0.1736 and the full potential of battery 68. This potential is also of positive polarity. When the line of fire is depressed from the horizontal by 10° the potential of positive polarity then appearing across resistor 66 is equal to the product of 0.9848 and the full potential of battery 68. The two halves of resistor 54 are therefore not uniformly distributed and resistor 54 is so wound that the variation of resistance as contact 63 moves from terminal 69 to terminal 72 is not linear, but varies in accordance with a cosine function of the angle of elevation. The angle of elevation is the angle between the line of fire and the horizontal plane as measured in a plane perpendicular to trunnions 13 and to turntable 16. Additionally, the resistor winding portion between terminals 69 and 73 is also so shaped that the potential impressed across resistor 66 varies in accordance with a cosine function of that angle of elevation of the line of fire 29.

The output portion of voltage divider 34 and the output portion of resistor 66 are connected in series by conductor 75 and the terminals 38, 76 of this series combination are coupled to galvanometer 36. The output potential of voltage divider 34 causes the behavior of cross hair 21 to be determined in part by the elevational component of the velocity of the target, as explained hereinabove. The output potential appearing in resistor 66 causes the behavior of galvanometer 36 and of cross hair 21 also to be determined in part by the elevation of the target. Therefore, the position of cross hair 21 is a function of two arguments, the first of these arguments being a rate of dynamic condition and the second being a position or static condition.

As described above, the ganging of contacts 37 and 38 by expedient 39 provides a range adjustment. Since superelevation correction is also functionally related to range there is provided a sliding contact 76 on the potentiometer which includes resistor 66. This sliding contact is ganged with sliding contacts 37 and 38 by any suitable expedient indicated by the dashed line 78 to the end that the range adjustment for target velocity and for superelevation may be made by one operation.

In explaining the operation of the above-described superelevation control arrangement, it will be assumed that the interior and exterior ballistics have been determined, that range tables are available, that the characteristics of the gun and the projectile are known, and that a selected stationary target is depressed from the horizontal plane of turntable 16 and located on a line normal to trunnions 13. For purposes of simplicity it will be assumed that the target position is such that a hit is mathematically predictable if the line of fire 29 is horizontal. Under that assumed condition, gravity is exercising its maximum effect on the projectile. The sight is therefore so adjusted that contact 63 is at terminal 69 and the full potential of battery 68 appears across resistor 66. Cross hair 20 is then centered within tube 18 and cross hair 21 is moved from center by adjustment of galvanometer 36, while the gun is held stationary, in order to align the eye of the operator 24, the reference mark formed by the intersection of the cross hairs, the peep 23 of the front sight 22 and the target. The line of sight is then on the target and a hit should be scored when the gun is fired. The line of sight is disturbed to a maximum extent, for any given range, under this condition. Now let it be assumed that fire should be directed to another target which is stationary and located immediately above and at 90° of elevation from the gun. Under that condition the potential appearing across resistor 66 is zero, contact 63 is at terminal 72, and the reference mark provided by cross hairs 20 and 21 is centered in tube 18, so that the line of sight is not disturbed. The distance from the gun to the target may be regarded as infinite with respect to the distance between casing 18 and the gun. Between these two terminal conditions (i. e., when firing on targets between 0° and 90° of elevation) the voltage appearing across resistor 66 is trigonometrically functionally related to and varies as the cosine of the angle of elevation. The range adjustment is provided by the ganging expedient 78, which adjusts the position of sliding contact 76.

In practice, the ballistics of the gun and the projectile are obtained from range tables. The fire control problem is capable of mathematical solution and the characteristics of the train and elevation generators 31 and 32, resistor 54, resistor 66, and voltage dividers 33 and 34, as well as those of galvanometers 35 and 36 are mathematically determinable, so that specific circuit parameters are a matter of specific engineering design and depend upon the individual requirements of the system to be used, as will be clearly understood by those skilled in the art.

While there has been shown what is at present considered to be the preferred embodiment of the present invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the true scope thereof, and it is, accordingly, intended in the appended claim to cover all such changes and modifications as fall within the true scope of the invention and without the proper scope of the prior art.

The invention herein described may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

I claim:

In a lead-computing sight adapted for use on a gun mount and including electrical reference-mark-displacing-means for disturbing a line of sight, a superelevation correcting arrangement comprising a signal source, and potentiometer means for coupling said source to said reference-mark-displacing means, said potentiometer means comprising a resistor portion movable with said gun and a pendulous contactor portion pivoted on said mount and slideable on said resistor portion, whereby the signal applied to said displacing means varies in magnitude in accordance with the elevational position of said gun with respect to the true horizon.

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