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PARALLAX CORRECTOR FOR USE IN GUN CONTROL

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2 SHEETS—SHEET 1

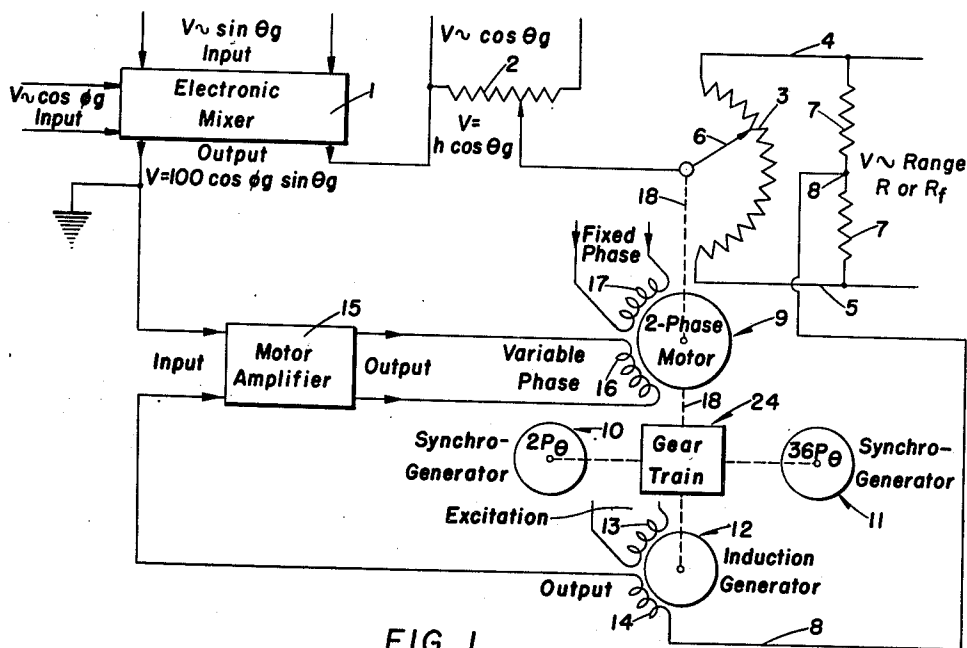


FIG. 1

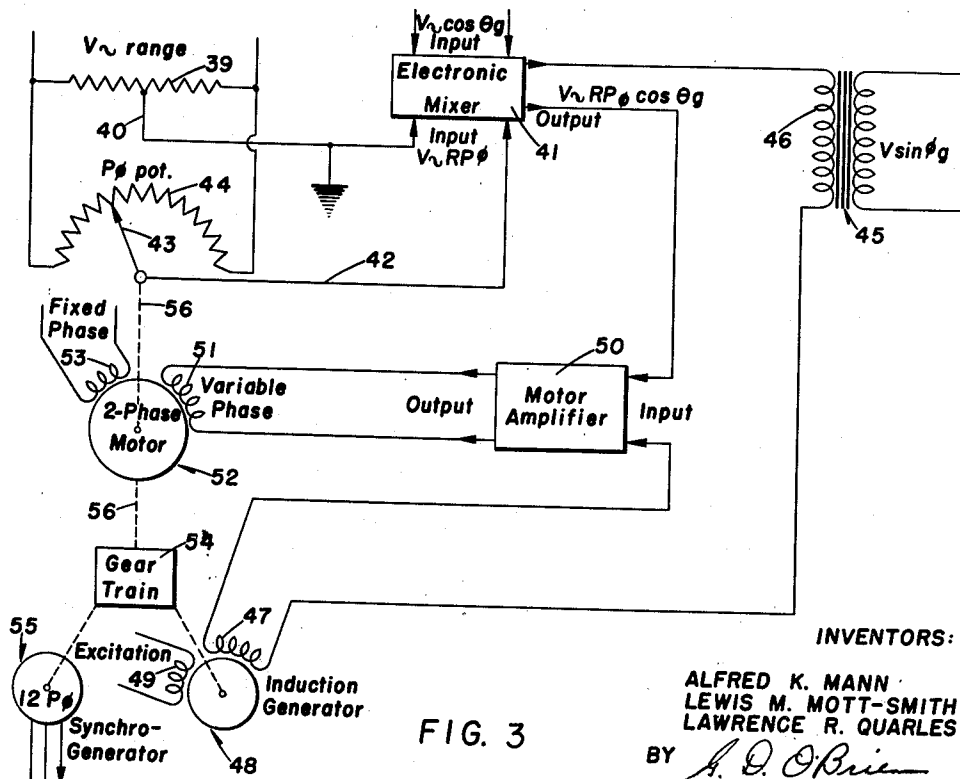


FIG. 3

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PARALLAX CORRECTOR FOR USE IN GUN CONTROL

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1 Claim. (Cl. 235—61.5)

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The present invention relates to a parallax corrector for use in gun control.

More specifically, it relates to a process and apparatus for correcting the parallactic errors in gun control, arising unavoidably from the obvious impossibility of locating both a gun and its director simultaneously at a single geometrical point.

When a gun is to be "pointed" or directed at a target, it is well-known practise to provide a gun-director, which receives electrical inputs from various devices, including computers and radar apparatus, for example. As a matter of convenience or necessity, it is usually found desirable to locate the gun and its director at a considerable horizontal distance from one another, such as several hundred feet, and moreover there may be differences in level also, for instance, when a gun and its director are mounted on different decks of a vessel.

Consequently, the direction of a target as seen from the director may be appreciably different from that as seen from the gun, and the error increases with the nearness of the target as well as its angular position relative to a line joining gun and director, being greatest when the target is in the plane perpendicularly bisecting said line.

It is the chief purpose of the present invention to provide automatic correcting means for such parallactic error, thus saving the delay and effort, as well as the chance of error, involved in computing the errors and manually correcting them.

An object of the invention therefore is to provide a process and apparatus for automatically correcting electrically and mechanically the parallactic errors that arise when there are differences of horizontal and/or vertical positions of a director and the gun controlled thereby, for example when the director is at a given horizontal distance from the gun on a ship or elsewhere, and usually also at a different level. Broadly, the invention contemplates electrically and mechanically combining certain signals derived from various sources, in the proper way to produce the necessary correction of the gun direction.

Other objects and many of the attendant advantages of this invention will be appreciated readily as the said invention becomes understood by reference to the following detailed description, when considered in connection with the accompanying drawings, wherein:

Figure 1 is a block diagram showing the elevation parallax computer and corrector;

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Figure 2 is a diagram showing the characteristic electrical circuits thereof; and

Figure 3 is a block diagram showing the train parallax computer and corrector.

In order to disclose the structure and operation of the invention clearly, it is convenient to assume a definite set-up, and therefore it will be assumed arbitrarily herein that the distance between the gun and its director is 100 yards and that there is a difference in height of h yards between them. On this assumption, the formula for the parallax error angle P_e in elevation, expressed in degrees, is:

$$P_e = 57.3 \frac{100 \sin \theta_g \cos \phi_g + h \cos \theta_g}{R_t} \quad (1)$$

In order to take advantage of this relationship, there are used component signals representing R_t , $\sin \theta_g$, $\cos \theta_g$, and $\cos \phi_g$, where theta represents angles of elevation, and phi angles of train, both in degrees, R_t being the future range of the target in yards, that is, the predicted range at the time the missile would reach the target.

Referring to Figure 1, it will be seen that voltages, proportional to $\sin \theta_g$ and $\cos \phi_g$ respectively, are fed into an electronic mixer 1. These voltages already exist in, or readily may be derived from, certain suitable conventional sources, such as the Scott phase-transformers in computers, etc. The electronic mixer 1, in the specific form shown in Fig. 2, comprises two pentagrid thermionic tubes V_1 and V_2 , which are here assumed to be of type 6L7, or any other tubes of similar characteristics.

The output of the electronic mixer 1, by virtue of the characteristics and connections of the tubes used, will be another voltage, whose magnitude is proportional to the product of the voltages fed into the said mixer, that is, the resultant, with proper adjustments, now represents $100 \cos \phi_g \sin \theta_g$. To this must be added another voltage, proportional to $h \cos \theta_g$, on the same scale. This is provided by the potentiometer 2, connected to give its output in series with that of the mixer 1, as shown in Figure 1.

The whole is then combined with a function of R_t , or specifically R_t , by means of potentiometer 3, across which exists a voltage proportional to R_t or R_t respectively, supplied by leads 4 and 5, across which are two equal resistors 7, that provide a center tap 8. These outputs are fed to the motor amplifier 15 in series with the output winding of the "Kollsman" generator 12. This may be defined as an induction generator, wherein a metal cylinder is rotated adjacent a

two-phase-wound stator, one of whose windings 13 is excited by an alternating current output, of suitable voltage, derived from the supply mains, whereupon the other winding 14 produces an output proportional to the said input and also proportional to the speed of rotation. The motor amplifier 15 yields an alternating current output, which energizes the "variable phase" winding 16 of the small two-phase motor 9, whose remaining or "fixed phase" winding 17 receives alternating current directly, or through a suitable transformer, from the mains.

The purpose of this motor 9 is to adjust the arm 6 of potentiometer 3 to balanced position and at the same time to provide mechanical power to the two synchro-generators 10 and 11 and the Kollsman generator 12, through suitable gearing in gear train 24 in each case, of course. The balancing referred to is accomplished by making use of the fact that when the potentiometer 3 is balanced, the input voltage of the motor amplifier 15 is reduced to zero, and hence the motor 9 stops, as the variable phase 16 is also reduced to zero. These synchro-generators add their outputs to those of the existing synchro-generators in the gun director, and thus provide parallax correction.

The Kollsman generator 12 produces an anti-hunt signal which, when fed as one component into the motor amplifier input circuit, as already mentioned, prevents over-running by reducing the amplifier input to zero at the proper instants. The dashed line 18 represents mechanical connections between the motor 9 and the potentiometer 3, for balancing the same.

Referring now to Figure 2, certain details of the circuits are given. The voltage derived from any suitable computer or the like, and representing $\cos \phi_g$, is fed to the wires 19 and 20. It is thus impressed across the two 0.25 megohm resistors 21 and 22, and also impressed on the 10,000 ohm potentiometer 23 in series with the 0.5 mfd. capacitor 24. A suitable adjustment of slider 25 of said potentiometer is made to provide a correctly-phased output to wire 26 with its 100,000 ohm potentiometer 27, through which in turn the third grid of each tube V_1 and V_2 is supplied by the wire 28.

An input proportional to $\sin \theta_g$ is supplied to the first grid of each of these tubes from the rectifier tube V_3 , which may conveniently be of type 6HG. A desired portion of the voltage fed to the 10,000 ohm potentiometer 29 connected to and between wires 30 and 31 is placed in series with a suitable 60 cycle voltage derived from a secondary winding of the transformer 32. The sum or difference of these voltages is impressed across the anodes of V_3 .

This second alternating voltage serves to provide a proper "zero" or reference voltage in the rectified output of V_3 so that said output may have either positive or negative values with respect thereto. This is requisite, as $\sin \theta_g$ may be either positive or negative.

The transformer 33 is provided to introduce into the circuit a proper-valued component proportional to the product $\sin \theta_g \cos \phi_g$, such that the mixer output to the balancing circuit will become zero when the value of $\sin \theta_g$ is zero, which otherwise would not occur.

The power supply, of which transformer 32 forms a part, will now be described briefly. It comprises a full wave rectifier tube V_4 , here indicated as of type 5U4G. This is connected in the conventional way to the high voltage terminals

of transformer 32, two smoothing capacitors and a choke being provided, and finally a bleeder 34, here shown as a 10,000 ohm resistor with a slider to adjust the voltages delivered to the work circuits.

One of said work circuits comprises the shield grids of the tubes V_1 and V_2 and is supplied with a voltage controlled by the voltage regulator tube V_6 , here shown as of type VR 105-30. An anode resistor of 7,500 ohms is provided for this tube, as shown. The other circuit supplies anode voltage for the tubes V_1 and V_2 , as well as for other uses. This circuit includes the voltage regulator tube V_5 , here of type VR 150-30, with a 4,500 ohm resistor in its anode circuit. The voltage regulation serves to make the system insensitive to fluctuations in alternating supply voltages derived from the mains.

The anode voltage is fed to tubes V_1 and V_2 through the center-tapped primary winding of transformer 35, whose single secondary has the 10,000 ohm resistor 36 bridged across it, as shown. This resistor 36 is thus traversed by currents proportional to the desired product $\sin \theta_g \cos \phi_g$.

Another power supply, likewise of conventional type, utilizes the transformer 37 and rectifier tube V_8 , shown as type 5V4G. Through the capacitors and choke illustrated, this feeds its output to the terminals of the 15,000 ohm bleeder 38 which supplies power to the tube V_7 , here a pentode of type 6SJ7 connected as indicated. It will be noted that neither end of the bleeder 38 is grounded. The purpose is to provide voltage stabilization of the computer with respect to line-voltage variations.

Referring now to Figure 3, it will be noted that the train computer is in a general way similar to the elevation computer of Figure 1, already described. Here a voltage proportional to the range R is fed across the center tapped resistor 39. This voltage may be derived, for example, from the range potentiometer in the radar range finder, or any other available ranging installation. The center tap 40, which preferably is grounded, forms one side of one input to the electronic mixer 41, the other side 42 of said input being connected to the movable contact 43 of potentiometer resistor 44, of the P_g potentiometer. Since the voltage across resistor 44 is proportional to the range R , and the deflection of the contact 43 represents the angle P_g , the input voltage between conductors 40 and 42 is therefore proportional to RP_g .

A second input voltage which is fed into the electronic mixer 41 represents $\cos \theta_g$ and is obtainable from certain suitable conventional sources, for example, the same source that provides the corresponding sine in Fig. 1. The mixer 41 combines these two inputs into a single output proportional to their product, $RP_g \cos \theta_g$.

The said output voltage of mixer 41 has added thereto, in series, a voltage proportional to $\sin \phi_g$, which is done by transformer 45. The secondary winding 46 of this transformer has the proper number of turns to obtain the desired ratio. Also in series with the two voltages already mentioned, is a further voltage delivered by the output winding 47 of the Kollsman generator 48, whose exciting winding 49 is energized with alternating current at a suitable fixed voltage, which may be derived from the supply mains.

All three voltages thus contribute, in series relation, to provide the input of the motor amplifier 50. This provides suitable amplification, so that the amplifier output may energize the variable phase winding 51 of the two-phase motor

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52. The fixed phase winding 53 of said motor is supplied with alternating current from the supply mains, at a suitable voltage.

The motor 52, through its shaft 56 and the gear train 54, actuates the Kollsman generator 48 as well as the synchro-generator 55, which provides the final output 12 P_o.

While the operation of the invention presumably will be readily deducible from the mechanism and circuits disclosed, it may be desirable to summarize it briefly, as follows:

Referring first to the elevation parallax corrector, Fig. 1 in particular, the electronic mixer 1 combines the voltages representing $\cos \phi_g$ and $\sin \theta_g$, to provide a resultant voltage proportional to 100 times their product. An additional voltage proportional to h times $\cos \theta_g$, on the same scale, is added to this resultant voltage by the potentiometer 2, thus yielding the numerator of the fraction that represents P_o , Equation 1.

This must, however, be divided by R_r , the denominator, which is accomplished by the potentiometer 3. In order to understand how it is done, let it be assumed that Equation 1 is transformed into an equivalent Equation 2 by multiplying both sides by R_r :

$$P_o \cdot R_r = 57.3 (100 \sin \theta_g \cos \phi_g + h \cos \theta_g) \quad (2)$$

Neglecting, for the present discussion, the voltage added by the Kollsman generator 12, which contributes only to damping and not to actual balancing of the potentiometer 3, and which vanishes at the instant of balance, it will be seen that Equation 2 says substantially that R_r is proportional to the expression in parentheses, $(100 \sin \theta_g \cos \phi_g + h \cos \theta_g)$.

This means that the angular deflection of the sliding contact 6 of potentiometer 3 will be such that the proportional part of the voltage representing R_r that exists between this contact 6 and the center tap 8 will be proportional also to the quantity $(100 \sin \theta_g \cos \phi_g + h \cos \theta_g)$ when the state of balance exists and hence at such time the division has, in effect, been performed, as shown by the fact that Equation 2 is then satisfied.

The net result is that, through operation of the amplifier 15 and motor 9, the shaft 18 carrying the contact arm 6 will have been turned through the angle P_o when balance is attained and the two synchro-generators 10 and 11 will have been rotated through $2 P_o$ and $36 P_o$ respectively, and will have introduced the corresponding elevation parallax correction into the gun director.

The train parallax correction is provided by the circuit shown in Fig. 3, but a different function is involved, wherein the range R_r appears as a multiplier instead of a divisor. In this circuit, a voltage proportional to R is introduced into the electronic mixer 41, where it is multiplied by a voltage proportional to $\cos \theta_g$. To this is then added another voltage proportional to $\sin \phi_g$ producing the final voltage representing $R \cdot P_o \cdot \cos \theta_g + \sin \phi_g$ which is fed into the amplifier 50 as an input. Here again the voltage derived from the Kollsman generator 48 is used merely for damping and does not enter into the expressions used in balancing, since it becomes zero at the instant of balance.

The motor 52 will turn the potentiometer arm 43 into such position that the expression $R \cdot P_o \cdot \cos \theta_g + \sin \phi_g$ becomes zero, and in so doing will

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have turned the rotor of synchro-generator 55 the appropriate amount to give the output $12 P_o$, the train parallax correction, which is fed into the gun's director.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. Therefore it is to be understood that within the scope of the appended claim the invention may be practiced otherwise than as specifically described.

We claim:

Electrical apparatus for correcting parallax errors in pointing a gun at a target, due to differences of location of a director and the gun controlled thereby, said apparatus being designed to receive an electrical input comprising two electrical signal voltages which are proportional respectively to the sine and the cosine of the angle of elevation of the gun, another signal voltage proportional to the cosine of the angle of train of the gun, and a further signal voltage proportional to the future range of the target, said apparatus including means for combining all these signal voltages electrically to provide the desired correction, said last-named means comprising an electronic mixer which includes two multi-grid thermionic tubes, means for applying said input voltage, proportional to the sine of the said angle of elevation, to one pair of corresponding grids, means for applying said input voltage proportional to the cosine of the said angle of train of the gun, to another pair of corresponding grids, said mixer providing an output voltage from the anode circuits of said thermionic tubes proportional to the product of its said input voltages, a voltage divider connected to the output of said mixer and across which is applied the voltage proportional to the cosine of the angle of elevation of the gun, whereby a portion of said last-named voltage is added in series with the output voltage of the electronic mixer, a second voltage divider connected to said first-mentioned voltage divider and across which is applied the voltage proportional to the range of the target, said second voltage divider having its output connected in series opposition with respect to the output of said first voltage divider, and means for adjusting said second voltage divider to cause its output voltage to exactly neutralize said two series-connected voltages.

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