

Sept. 7, 1948.

P. J. McLAREN

2,448,612

AIDED TRACKING AIMING MECHANISM

Filed Oct. 30, 1943

4 Sheets-Sheet 1

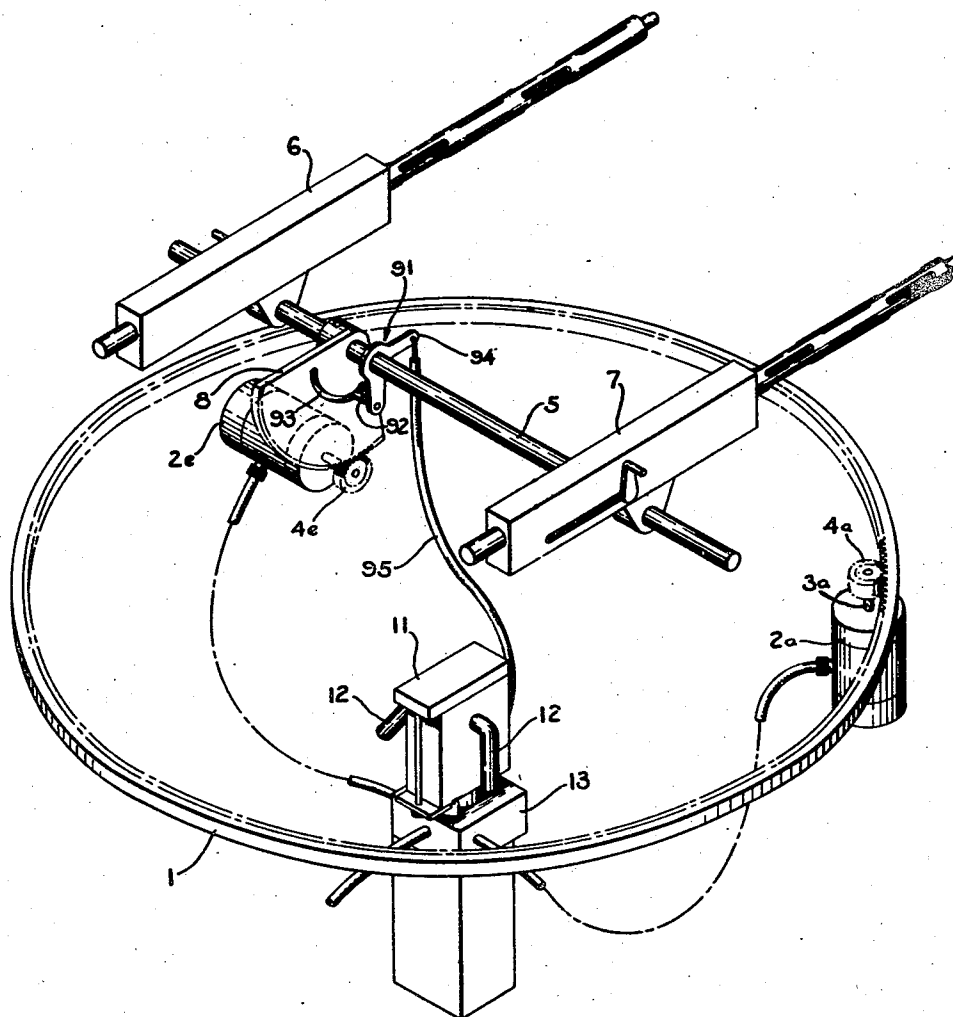


Fig. 1

INVENTOR.
Peter J. McLaren
BY
Horse & Holts
attorneys

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P. J. McLAREN

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4 Sheets-Sheet 2

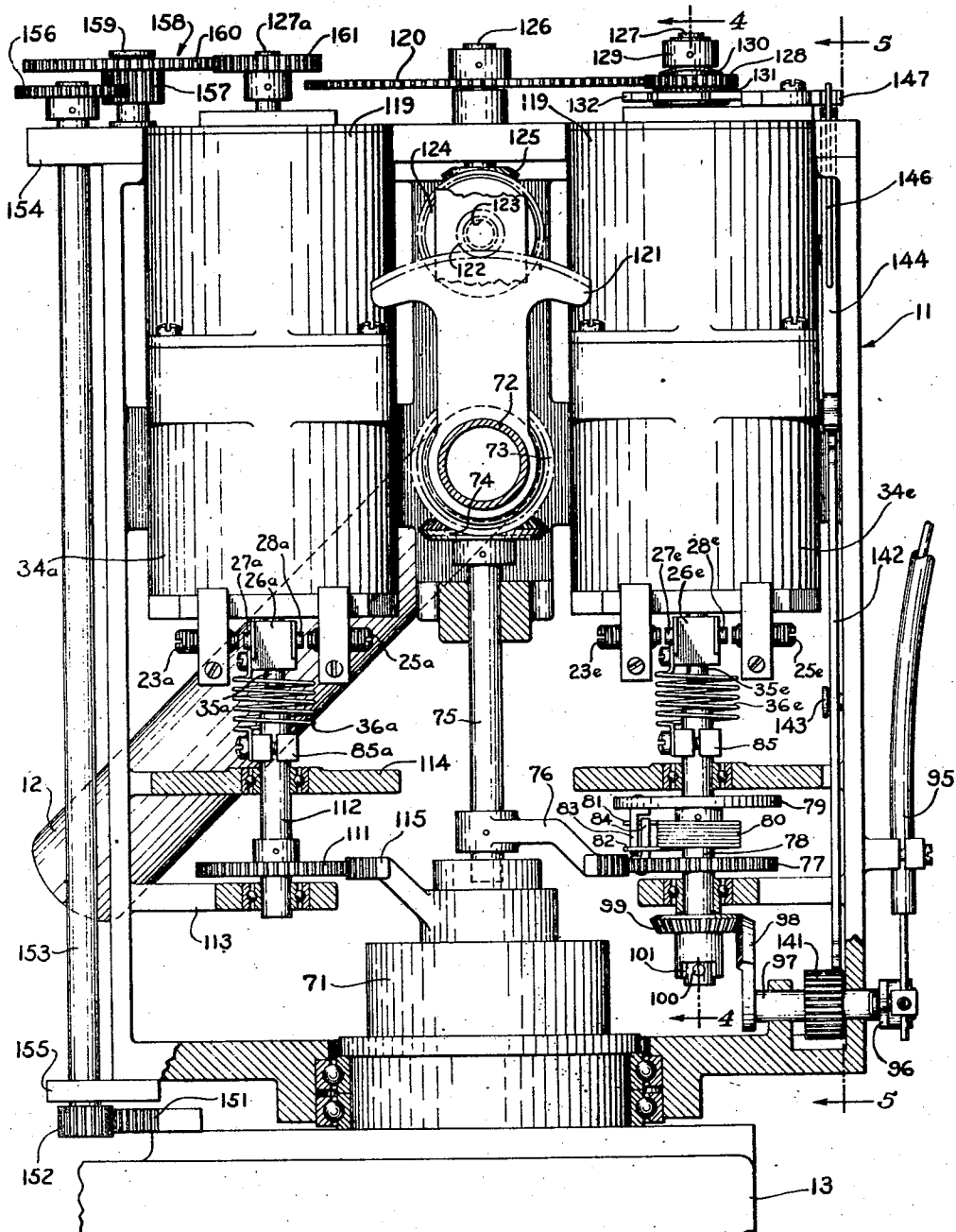


Fig. 2

INVENTOR.
Peter J. McLaren
BY *Moses & Nolte*
attorneys

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P. J. McLAREN

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4 Sheets-Sheet 3

Fig. 3

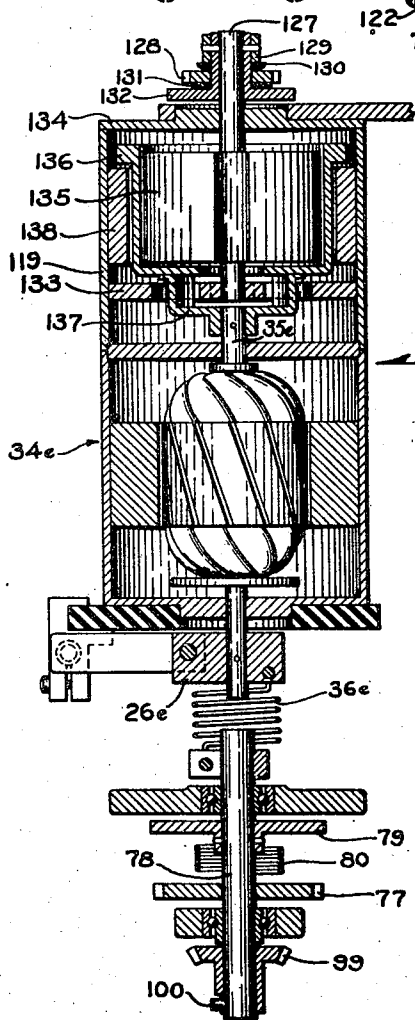
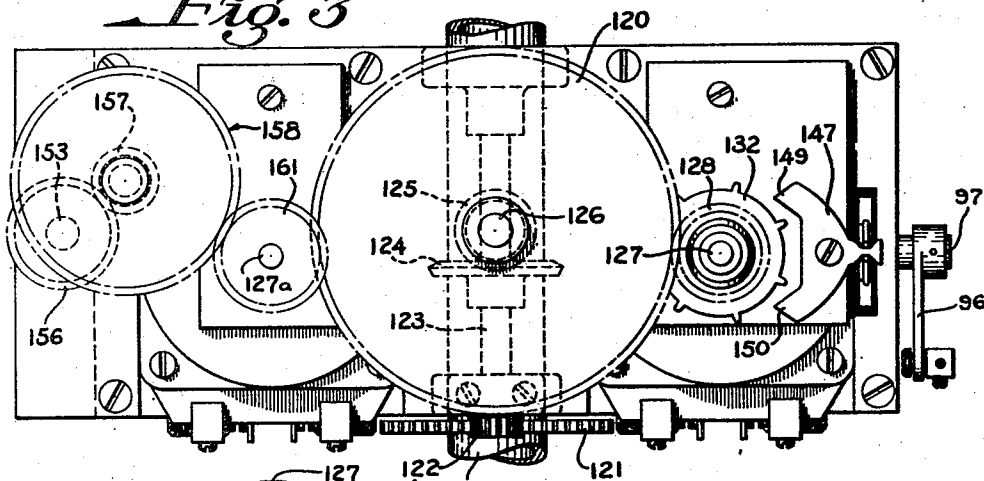


Fig. 4

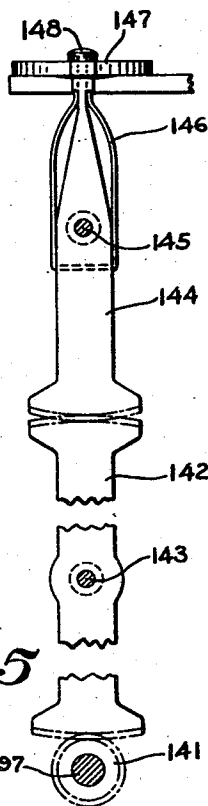


Fig. 5

INVENTOR.
Peter J. McLaren
BY *Moss & Holte*
attorneys

Sept. 7, 1948.

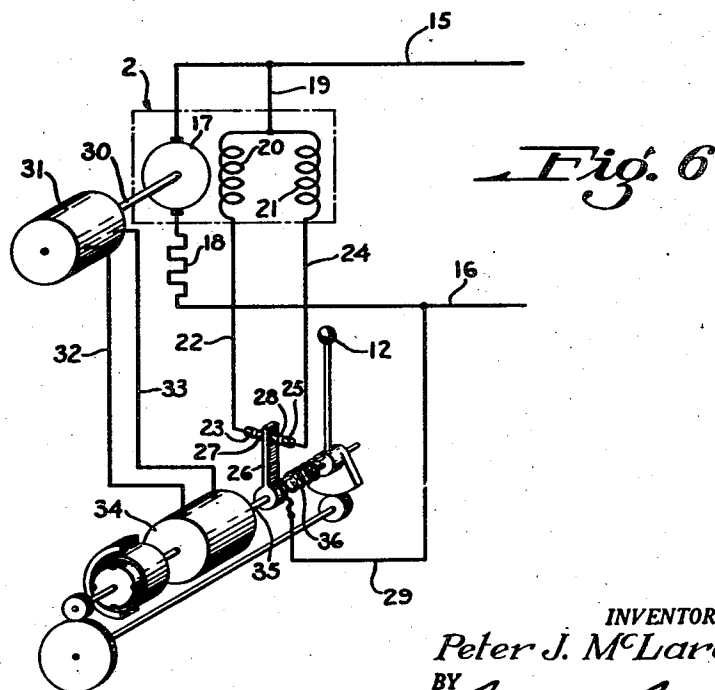
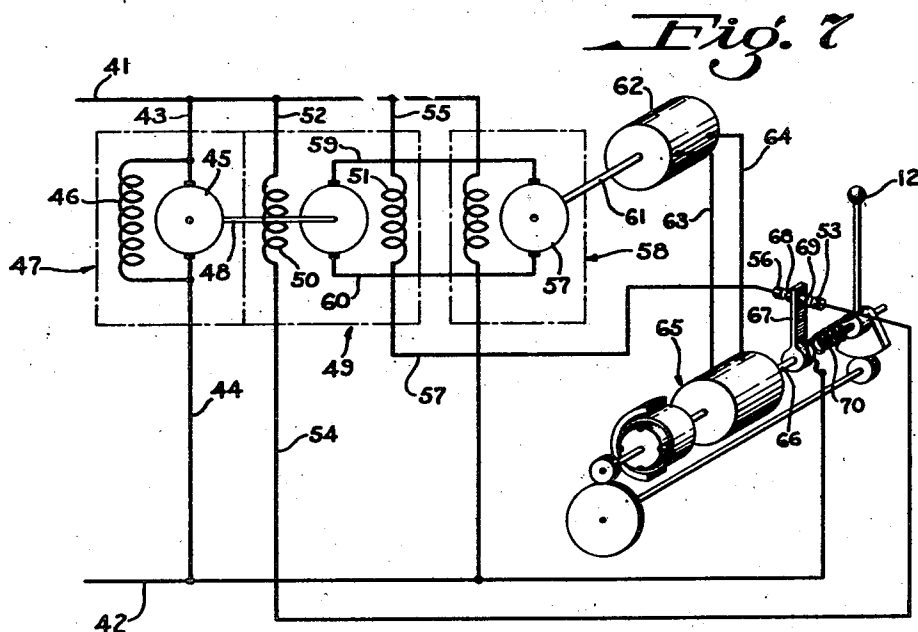
P. J. McLAREN

2,448,612

AIDED TRACKING AIMING MECHANISM

Filed Oct. 30, 1943

4 Sheets-Sheet 4



INVENTOR.
Peter J. McLaren
BY *Wm + Holtz*
attorneys

UNITED STATES PATENT OFFICE

2,448,612

AIDED TRACKING AIMING MECHANISM

Peter J. McLaren, New York, N. Y., assignor, by mesne assignments, to The W. L. Maxson Corporation, New York, N. Y., a corporation of New York

Application October 30, 1943, Serial No. 508,435

9 Claims. (Cl. 318-257)

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This invention relates to aided tracking in power operated aiming mechanism, and more particularly in power operated gun carrying turrets. By aided tracking is meant the automatic temporary introduction of a supplementary speed control factor when a change of speed of the turret is sought, which, for the time being augments the effect on the speed of the turret normally to be expected from the mere change of position of a speed control member effected by the operator.

Aided tracking is very advantageous in enabling an operator quickly to pick up a moving target in the turret sight and to track the target without excessive over-running and hunting. When an operator brings the turret sight to bear on a moving target he has necessarily done so by causing the speed of the turret in the direction in which it is operated to exceed the angular rate of target traverse in that direction. In order to produce tracking he must bring about an alteration of the speed of the turret to make the speed of the turret coincide with the angular speed of traverse of the target, and this with the turret sight bearing on the target. This is apt to involve either a cautious and delayed picking up of the target or a picking up of the target at an over-running speed of the turret.

As an over-running gap begins to appear the speed of the turret must be retarded, not only to prevent increase of the over-running, but to correct the over-running which has already been observed. If the speed of the turret were dependent exclusively upon the position of the control member, the control member would have to be moved in making such a correction to a setting which produces a turret speed substantially different from that of coincidence with the angular traverse of the target.

If, however, a temporary augmentation factor is introduced by the movement of the control member for effecting such change of speed, the sight may be returned to bear upon the target more quickly and without so great a change of position of the control member as would be necessary if change of speed of the turret depended solely upon change of position of the control member. Thus, the new settling of the control member, when the sight has again been brought to bear on the target will differ less from the speed of coincidence by reason of the fact that the temporary augmentation of speed change has been introduced and utilized. The same principle applies to subsequent corrective steps, and tracking can be maintained with much less deviation of the control member from the average position thereof corresponding to the speed of coincidence by virtue of the aided tracking feature.

It is a primary object of the present invention

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to provide, in combination with a normal turret speed control mechanism, which makes the speed of turret operation a pure function of the position of a speed control member, of auxiliary speed control mechanism for automatically introducing a supplemental speed control factor in response to movement of the control member, to augment temporarily the change of speed which would normally be brought about by the mere change of position of the control member resulting from such movement.

Other objects and advantages will hereinafter appear.

The invention is illustratively disclosed herein as an improvement upon the invention disclosed in the pending application of Peter J. McLaren, John A. Vaughan and Macon Fry, Serial No. 27,807, filed May 18, 1948, a continuation of Serial No. 473,800, filed January 28, 1943, now abandoned, for Continuously adjustable speed electric drive, and the pending application of Donald S. Kellogg, Serial No. 481,681, filed April 3, 1943, now Patent No. 2,395,000, issued February 19, 1946, for Electric drive, although it is to be understood that such disclosure is intended to be illustrative, and that the invention in its broader aspects is susceptible of other applications.

In the drawing forming part of this specification

Fig. 1 is a fragmentary perspective view illustrating a turret and turret operating mechanism embodying the present invention;

Fig. 2 is a view in right side elevation, partly broken away, of a control box and control mechanism associated therewith;

Fig. 3 is a top plan view of the control box of Fig. 2 together with associated mechanism;

Fig. 4 is a sectional view taken upon the line 4-4 of Fig. 2 looking in the direction of the arrows;

Fig. 5 is a view in sectional elevation taken along the line 5-5 of Fig. 2 looking in the direction of the arrows;

Fig. 6 is a schematic diagram of turret control mechanism including the aided tracking device as applied to a resistor type electric drive; and

Fig. 7 is a schematic diagram of turret control mechanism including the aided tracking device as applied to a motor generator type electric drive.

In Fig. 1 all of the parts illustrated are mounted upon and form parts of a rotary turret structure, with the exception of a stationary internal ring gear 1.

The turret is caused to rotate about a vertical axis which coincides with the center ring gear 1 by means of a turret carried azimuth drive motor 2a whose output shaft 3a has fast upon it a gear 4a in mesh with the internal teeth of the stationary ring gear 1. A horizontal shaft 5 is

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revolvably mounted in fixed bearings of the turret (not shown) and has fast upon it a pair of guns 6 and 7. A gear segment 8, pinned to the shaft 5, meshes with an output gear 4e of an elevation drive motor 2e for raising and lowering the guns.

The azimuth drive motor 2a and the elevation drive motor 2e are both controlled in their operations from a common control box 11 which is equipped with handles 12. The control box 11 and a supporting box 13 therefor are carried by the turret, but the supporting box 13 is made fast with the turret, while the control box 11 is mounted for limited manual rotation relative to the turret about a vertical axis.

The control mechanism which is mounted within and associated with the control box 11 is designed to operate the azimuth and elevation motors through the control of the respective motor operating circuits. Suitable circuits are illustrated in Figs. 6 and 7, respectively, and will be described presently.

When the handles 12 are operated to swing the control box about its vertical axis in one direction from azimuth neutral, the azimuth motor 2a is driven in one direction and at a speed proportional to the extent of displacement of the control box from its azimuth neutral position, and when the handles are operated to swing the control box about its vertical axis in the opposite direction from azimuth neutral, the azimuth motor 2a is driven in the opposite direction and at a speed proportional to the extent of displacement of the control box 11 from its azimuth neutral position.

When the handles 12 are depressed, the elevation motor 2e is operated in a direction to raise the guns and at a speed proportional to the extent of displacement of the handles from their elevation neutral attitude, and when the handles 12 are raised, the elevation motor 2e is operated in the direction to depress the guns and at a speed proportional to the extent of displacement of the handles from their elevation neutral attitude.

The motor control illustrated in Fig. 6 is like that disclosed in Serial No. 473,800 and will be briefly described and explained.

Line conductors 15 and 16 are constantly connected through the armature 17 of motor 2 and through a resistor 18. Current may flow from conductor 15 through conductor 19 and thence alternatively through opposed field windings 20 and 21 of the motor 17. Winding 20 is connected through conductor 22 to a stationary contact 23, while winding 21 is connected through a conductor 24 with a stationary contact 25.

A contact arm 26 is interposed between the contacts 23 and 25 and is provided with contacts 27 and 28 for cooperating, respectively, with the contacts 23 and 25. The contact arm 26 is connected through a conductor 29 with line conductor 16.

When contacts 23 and 27 are closed, current flows through field winding 20 to drive the motor 2 in one direction, and when contacts 25 and 28 are closed, current flows through field winding 21 to drive the motor 2 in the opposite direction. Output shaft 30 of motor 2 drives a D. C. generator 31 which is connected through conductors 32 and 33 with a torque motor or galvanometer 34. Contact arm 26 is fast upon the output shaft 35 of galvanometer 34. A control arm 12, which is diagrammatically representative of the handles 12 of Fig. 1 and mechanical connections operated thereby, is connected through a coil spring 36 with the arm 26.

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When the arm 12 is swung in either direction from the neutral attitude in which it is illustrated in Fig. 6 it exerts through the spring 36 a contact closing bias upon the arm 26. This energizes either field 20 or field 21 of motor 2, depending upon the direction the arm 26 is moved from neutral, and sets the motor 2 into operation in the direction characteristic of the energized field winding. The voltage generated by generator 31 is a function of the speed and direction of rotation of the motor 2, and the torque developed by the galvanometer 34 is a function of the voltage generated by generator 31, and hence of the speed and direction of rotation of the motor 2.

As the speed of the motor 2 increases the torque of the galvanometer 34 increases until it is sufficient to overcome the bias exerted by the spring 36 upon the effective pair of contacts and to cause disengagement thereof. The motor thereupon loses speed and the torque applied by the galvanometer 34 is correspondingly diminished, so that if the position of the arm 12 is unchanged, the force exerted by the spring 36 will cause the previously engaged contacts to become reengaged. This alternate make and break action will continue, maintaining the speed of the motor 2 at a definite value corresponding to the extent of displacement of the arm 12 from the neutral position. The same explanation holds good regardless of the direction of displacement of the handle 12 from neutral position, the only difference being that the rotation of the motor 2 will be in one direction for one direction of displacement of the handle 12, and in the opposite direction for the opposite direction of displacement of the handle 12. The description thus far given has nothing to do with aided tracking, but is in accordance with the normal law of operation of the illustrative mechanism if no aided tracking provision were made.

In the alternative form of control circuit illustrated in Fig. 7, line conductors 41 and 42 are constantly connected through conductors 43 and 44 with the armature 45 and the field winding 46 of a self-shunt motor 47. The output shaft 48 of the motor 47 drives a generator 49. The generator 49 is provided with opposed field windings 50 and 51, the former being connected to conductor 41 through conductor 52 and to a fixed contact 53 through a conductor 54, and the latter being connected to the conductor 41 through a conductor 55 and to a fixed contact 56 through a conductor 57. The purpose of the generator 49 is to provide armature current for the armature 57 of a power motor 58. The current is delivered to the armature 57 from the motor 49 through conductors 59 and 60. The direction of current flow through the armature 57 depends upon which one of the fields 50 and 51 of the generator 49 is effective, and the voltage generated by the generator 49 depends upon the position of control handle 12 through which the circuits of field windings 50 and 51 are controlled.

Output shaft 61 of motor 58 drives a D. C. generator 62 which is connected through conductors 63 and 64 with a galvanometer or torque motor 65. The output shaft 66 of galvanometer 65 is connected through a contact arm 67 having contacts 68 and 69 for cooperating, respectively, with the contacts 56 and 53. As in the case of Figure 6, the arm 12 is connected to contact arm 67 through a coil spring 70. The contact closing bias of the spring 70 is determined by the extent

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of displacement of the arm 12 from neutral position. The motor 58 is set into operation either by closing contact 68 upon contact 56, or by closing contact 69 upon contact 53. The motor thereupon drives generator 62 developing a voltage which is a function of the speed and direction of rotation of the motor 58, and this voltage in turn is applied to the galvanometer 65, developing a torque which is a function of the voltage and hence of the speed and direction of rotation of the motor 58.

When the motor 58 has attained the speed characteristic of the position in which the handle 12 is held, the galvanometer torque overcomes the torque of spring 70 and opens the engaged pair of contacts. The energized one of field windings 50 and 51 is thereupon deenergized, the armature current supplied to the motor 58 is diminished, and the motor loses speed. Again an alternate make and break action is set up as the motor 58 alternately rises above and falls below the speed characteristic of the position in which the handle 12 is held. This description has nothing to do with aided tracking, but is in accordance with the normal law of operation of the illustrative mechanism if no aided tracking provision were made.

In Fig. 2 the control box 11 is shown as revolvably mounted upon a stationary base member 71 which is affixed to the stationary supporting box 13. Raising or lowering of the handles 12 does not involve rotation of the control box 11, but serves only to effect control of the elevation drive. The control handles 12 are interconnected through a horizontal shaft 72 which, through bevel gears 73 and 74, drives a vertical shaft 75. The shaft 75 has pinned to it a segment 76 which meshes with a gear 77 loose on a vertical shaft 78. The shaft 78 has pinned to it a disc 79.

Motion of the gear 77 is yieldingly transmitted to the disc 79 and the shaft 78 through a coil spring 80 which surrounds the shaft. The opposite ends 81 and 82 of the spring 80 extend outward and receive between them a downwardly extending pin 83 which is fast upon the disc 79, and an upwardly extending pin 84 which is fast on the gear 77. This provision for the yielding transmission of motion is made for the purpose of enabling limit mechanism to override the effect of the manual control normally asserted by the handles 12, as will presently be explained. Normally the disc 79 turns in unison with the gear 77.

A clamping collar 85 which is clamped upon the shaft 78 has affixed to it one end of spring 36e. The opposite end of the spring 36e is affixed to contact arm 26e which is fast upon output shaft 35e of galvanometer 34e. The arm 26e carries the contacts 27e and 28e for cooperating with fixed contacts 23e and 25e, respectively.

The limit stop control mechanism, previously referred to, comprises a bellcrank 91 mounted on the shaft 5 (see Fig. 1) with provision for relative rotation of the bellcrank and the shaft. A stop pin 92, fast on the bellcrank at the lower extremity thereof, rides in a slot 93 formed in the operating segment 8 of the shaft 5. The bellcrank 91 includes a horizontally extending arm 94 to which is connected one end of a flexible push-pull cable 95, the other end of which is applied (see Figs. 2 and 3) to a crank 96 fast on a shaft 97. The shaft 97 has fast upon it a segment 98 which is in mesh with a bevel gear 99 mounted on shaft 78 with provision for lost motion relative to the shaft. The lost motion is provided by

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causing a pin 100 affixed to the shaft 78 to extend outward into a notch 101 formed in the lower end of the hub of the bevel gear 99.

As the guns approach an upper or lower limit because of the maintenance of the control handles 12 in a displaced position, a limit stop impulse will be transmitted through bellcrank 91, cable 95 and crank 96, causing displacement of shaft 97 and, through gears 98 and 99 and the removal of the remaining lost motion between gear 99 and shaft 78, restoration of disc 79 to its neutral position against the torsion of spring 80. Restoration of disc 16 to neutral removes the torque from spring 36e, causing the arm 26e to assume its neutral attitude.

Subsequent movement of the control handles to neutral permits the primary control elements to return to neutral and results in the normal realignment of pins 83 and 84.

When the control handles 12 are operated to turn the control box 11 about its vertical axis, controlled operation of the azimuth motor 2a is brought about.

A gear 111 is affixed to a vertical shaft 112 supported by bearings in inwardly reaching arms 113 and 114 of the control box 11. The gear 111 meshes with a stationary segment 115 which is carried by the stationary base 71 and travels planetwise about said segment. Thus, rotation of the control box produces rotation of the gear 111 and the shaft 112 about the common axis of the gear 111 and the shaft 112. The shaft 112 has affixed to it a clamp 85a to which one end of coil spring 36a is affixed. The opposite end of spring 36a is affixed to contact arm 26a which is fast on output shaft 35a of galvanometer 34a. The arm 26a carries contacts 27a and 28a for cooperating respectively with stationary contacts 23a and 25a.

The control is the same as that already described for the elevation motor. The transmission from gear 111 to shaft 112 is not yieldingly effected as in the case of transmission from gear 77 to shaft 78, for the reason that no azimuth limit stops are provided, the upper and lower limits being assumed to be planes.

In accordance with the description of the elevation and azimuth mechanisms as thus far given, the direction and speed of the elevation motor would be a pure function of the elevation attitude of the handles 12, and the direction of the speed of the azimuth motor would be a pure function of the azimuth attitude of the handles 12.

The present invention, however, is designed to introduce a temporary supplemental speed control which is a function of movement of the handles 12, as distinguished from the mere position thereof. This is done by operating eddy current drag cups from the handles 12 to apply a temporary supplemental torque to the galvanometer shaft 35a, 35e in augmentation of the change of contact closing torque which is mechanically effected through the springs 36a, 36e by the change of position of the handles 12. This supplemental torque comes into being and persists only so long as the handles are in motion.

In the case of the elevation mechanism, the shaft 72 has fast upon it a gear segment 121 which drives a small pinion 122 fast on a horizontal shaft 123. The shaft 123 through bevel gears 124 and 125 drives a vertical shaft 126. A large gear 120, pinned to the shaft 126, drives a gear 128 which is revolvably mounted upon a vertical shaft 127.

The gear 128 frictionally transmits rotation to shaft 127 so that a slip drive is provided. The

purpose of the slip drive, as will be more fully explained, is to enable the shaft 127 to be held stationary notwithstanding rotation of gear 128 when a limit of movement of the guns in elevation or depression is reached. A collar 129 pinned to the shaft 127 presses a spring washer 130 against the gear 128, and causes the gear 128 to press a friction disc 131 against a toothed wheel 132 fast on shaft 127. Normally shaft 127 turns in unison with gear 128, the turning being very extensive and very rapid as compared with the turning of shaft 72, because the entire train from shaft 72 to shaft 127 is designed to produce a large multiplication of motion.

The shaft 127 extends into an extension housing 119 (see Fig. 4) of galvanometer 34e, being revolvably supported in a partition plate 133 and end plate 134 of the extension housing 119. The shaft 127 has fast upon it a permanent magnet 135 whose opposite poles extend into proximity with an eddy current cup 136 of highly conductive metal such as copper.

The eddy current cup is carried by a supporting yoke or spider 137. The yoke or spider 137 is pinned to the output shaft 35e of galvanometer 34e, so that the cup is constrained to move in unison with the shaft. The arms of spider 137 extend through openings in the partition plate 133, and since the mechanical range of movement of the shaft 35e from neutral position may be approximately plus or minus 10°, the openings in partition plate 133 may readily be made wide enough to accommodate movement of the spider 137 and the eddy current cup 136 with the shaft 35e.

The eddy current cup 136 is surrounded by a ring 138 of highly permeable metal such as iron, so as to promote the passage of the lines of force from one pole of the magnet 135 through the eddy current cup and thence through the ring 138 back through the eddy current cup to the opposite pole of the magnet 135.

As the magnet 135 revolves, it tends to drag the eddy current cup around with it. The eddy current cup is not free to follow, but the drag upon it is applied as a torque to shaft 35e of galvanometer 34e.

If the handles 12 are displaced from neutral in a direction tending to apply clockwise torque to the shaft 35e through the spring 36e, the galvanometer torque applied to the shaft will be counterclockwise and the eddy current torque will be clockwise, opposing the galvanometer torque and aiding the torque applied through spring 36e. While this condition prevails the motor speed will be higher than that which is characteristic of the position of the handles 12. The eddy current torque will disappear as soon as the handles are brought to rest and the contact breaking speed will then be dependent exclusively upon the position of the handles 12.

If, now, the shaft 78 is rotated in a direction to increase the clockwise torque exerted by the spring 36e, the supplemental torque applied by the eddy current cup will be in the same direction as the torque applied by the spring 36e and in the same direction as the change of torque applied by the spring 36e, will augment opposition to the counterclockwise galvanometer generated torque, and hence will maintain the effective control contacts engaged until a higher speed of the motor 2e is attained than that which would result from the unaided change of torque introduced by the spring 36e as a result of the change of position of the shaft 78.

If, on the other hand, the shaft 78 is set to apply clockwise torque through the spring 36e, and the handles 12 are moved in a direction back toward neutral, not only will the torque of spring 36e be reduced by virtue of the change of position of shaft 78, but the torque exerted by the eddy current cup will be in counterclockwise direction to assist the counterclockwise torque generated by the galvanometer 34e. Now the effective contacts will be opened at a lower motor speed than that at which such opening would be brought about by the effect of spring 36e alone. Hence, an enhanced retarding effect will be introduced in this instance by the eddy current cup, which, however, will be maintained only so long as the control handles 12 are actually in motion.

The principle of operation is precisely the same, whether the motor 2e is operated in one direction or the other.

If, when the guns have been moved in elevation to a limit of movement, so that the cable 95 has superseded the handles 12 for preventing further operation of the guns toward that limit, the handles 12 should be moved in a direction normally designed to carry the guns toward or through that limit, the eddy current torque thus generated would cause reengagement of the contacts, and, therefore, an attempted resumption or continuation of movement of the guns toward the interference. To obviate this objection, there is provided means whereby the aided tracking device will be prevented from rotating in a direction to engage the contacts for carrying the guns toward the interference.

To this end, as previously mentioned, the gear 128 is connected frictionally to drive a toothed wheel 132 which is fast with the shaft 127 of permanent magnet 135. Means are further provided responsive to the cable 95 for blocking rotation of the wheel 132 and the connected magnet shaft 127.

When the limit stop impulse is transmitted through cable 95 and shaft 97 is rotated, a gear 141, fast on the shaft, is displaced. The gear 141 has driving engagement with a segment lever 142 which is pivotally mounted upon a stud 143. The upper end of the segment lever 142 has driving engagement with a segment lever 144 which is pivotally mounted on a stud 145. The segment lever 145 carries a hair pin spring 146, the free ends of which embrace the tail portion of a two toothed pawl 147. The pawl 147 is mounted on a pivot screw 148 on top of the control box 11 in position to cooperate with the spaced teeth of wheel 132.

Displacement of Hair pin spring 146 from the neutral position in which it is illustrated in Fig. 5, rocks pawl 147 interposing one of the teeth 149, 150 in the path of the teeth of wheel 132. Further displacement of the control handles, therefore, will cause gear 128 to rotate against the friction disc 131 without driving the wheel 132, and hence without driving the permanent magnet 135.

Movement of the control handles in the opposite direction, however, that is, in a direction tending to carry the guns away from the interference, is nevertheless effective to drive the magnet 135 through the gear 128 and wheel 132. The contour of the fingers 149, 150 is such that the teeth of wheel 132 may click past the engaged finger of pawl 147.

The supplemental speed control means for the azimuth motor 2a is essentially the same as that for the elevation motor 2e, the principal differ-

ence being that in the illustrative apparatus there are no azimuth limits, and hence there is no need for effecting a yielding drive to the supplemental speed control means nor for disabling the supplemental speed control means in response to limit mechanism.

The stationary supporting box 13 has fixed upon it a gear segment 151. A pinion 152, in mesh with the segment 151, is fast upon a vertical shaft 153 which is mounted in upper and lower bearing arms 154 and 155 of the control box 11.

When the control box 11 is turned about its vertical axis, the pinion 152 travels planetwise in mesh with the segment 151, and hence produces rotation of the shaft 153 about the shaft axis. The shaft 153 has fast upon it a gear 156 which drives the smaller member 157 of a compound gear 158 which is rotatably mounted upon a stud 159. The larger member 160 of the compound gear 158 drives a gear 161 which is fast upon the upper end of a shaft 127a. The shaft 127a corresponds to the shaft 127 of the supplemental speed control mechanism for the elevation motor.

Since this supplemental speed control mechanism is the same for the azimuth motor as for the elevation motor, it has not been separately illustrated, nor will it be described, but the showing of the mechanism in Fig. 4, and the description of it which has been given, may be taken as fully applicable to the corresponding part of the supplemental speed control mechanism for the azimuth motor.

I have described what I believe to be the best embodiments of my invention. I do not wish, however, to be confined to the embodiments shown, but what I desire to cover by Letters Patent is set forth in the appended claims.

What I claim is:

1. In an aiming mechanism including an aimed member, in combination, a control member movable in either of two opposite directions from a neutral or at rest position, a reversible electric driving motor for the aimed member, electrical means including pairs of opposed contacts alternatively engageable for operating the motor in either of two opposite directions dependent upon the direction of displacement of the control member from neutral, means for yieldingly applying a closing bias to the engaged contacts whose value depends upon the extent of displacement of the control member from neutral, motor operated speed responsive means for applying a contact opening bias to the engaged contacts whose value depends upon the speed of the motor, whereby the direction of operation of the motor is determined and controlled by the direction of displacement of the control member from neutral and the speed of the motor is normally determined and controlled by the extent of displacement of the control member from neutral, and supplementary speed responsive control means energized by movement of the control member away from neutral to apply an additional component of contact closing bias to bring about an abnormally high speed of motor operation and by movement of the control member toward neutral to apply an additional component of contact opening bias to bring about an abnormally low speed of motor operation.

2. In an aiming mechanism including an aimed member, in combination, a control member movable in either of two opposite directions from a neutral or at rest position, a reversible electric driving motor for the aimed member, electrical means including pairs of opposed contacts alter-

natively engageable for operating the motor in either of two opposite directions dependent upon the direction of displacement of the control member from neutral, means for yieldingly applying a closing bias to the engaged contacts whose value depends upon the extent of displacement of the control member from neutral, a speed responsive generator driven by the motor, a torque motor energized by the generator and having its output shaft connected to operate one of the contacts of each pair to apply a contact opening bias to the engaged one of said contacts when the motor is in operation, whereby the direction of operation of the motor is determined and controlled by the direction of displacement of the control member from neutral, and the speed of operation of the motor is normally determined and controlled by the extent of displacement of the control member from neutral, and supplementary speed responsive control means energized by movement of the control member away from neutral to apply an additional component of contact controlling bias to the output shaft of the torque motor depending in direction upon the direction of movement of the control member and in value upon the speed of movement of the control member, the construction and arrangement being such that the supplementary bias generated by movement of the control member away from neutral opposes the contact opening bias of the torque motor and the supplementary torque generated by movement of the control member toward neutral aids the contact opening bias of the torque motor.

3. In an aiming mechanism including an aimed member, in combination, a control member movable in either of two opposite directions from a neutral or at rest position, a reversible electric driving motor for the aimed member, electrical means including pairs of opposed contacts alternatively engageable for operating the motor in either of two opposite directions dependent upon the direction of displacement of the control member from neutral, means for yieldingly applying a closing bias to the engaged contacts whose value depends upon the extent of displacement of the control member from neutral, a speed responsive generator driven by the motor, a torque motor energized by the generator and having its output shaft connected to operate one of the contacts of each pair to apply a contact opening bias to the engaged one of said contacts when the motor is in operation, whereby the direction of operation of the motor is determined and controlled by the direction of displacement of the control member from neutral, and the speed of operation of the motor is normally determined and controlled by the extent of displacement of the control member from neutral, and supplementary speed responsive control means energized by movement of the control member, said supplementary means comprising a pair of inductively coupled rotors, the first being mounted for limited rotation in unison with the output shaft of the torque rotor, and the second being mounted for rotation coaxially with the first, and transmission mechanism for driving said second rotor from the control member.

4. In an aiming mechanism including an aimed member, in combination, a reversible electric driving motor for the aimed member, electrical control means for the driving motor comprising two pairs of alternatively engageable contacts, a movable support carrying one contact of each pair, a control member movable in either of two

opposite directions from neutral position for selectively closing said pairs of contacts, a spring for applying to said movable member a contact closing bias whose magnitude is determined by the extent of displacement of the control member from the neutral position, a speed responsive generator driven by the power motor, a torque motor energized by the generator and having an output shaft connected to actuate said movable contact support, a pair of coaxially mounted inductively coupled rotors, means operatively connecting the first rotor with the output shaft of the torque motor, and transmission mechanism for driving the second rotor from the control member at a speed dependent upon the speed of operation of the control member.

5. In an aiming mechanism including an aimed member, in combination, a reversible electric driving motor for the aimed member, electrical control means for the driving motor comprising two pairs of alternatively engageable contacts, a movable support carrying one contact of each pair, a control member movable in either of two opposite directions from neutral position for selectively closing said pairs of contacts, a spring for applying to said movable member a contact closing bias whose magnitude is determined by the extent of displacement of the control member from the neutral position, a speed responsive generator driven by the power motor, a torque motor energized by the generator and having an output shaft connected to actuate said movable contact support, and electrical drag means comprising a pair of relatively rotatable inductively coupled members for acting upon the output shaft of the torque motor, and transmission mechanism for driving one of said relatively rotatable members from the control member at a speed dependent upon the speed of operation of the control member.

6. In an aiming mechanism including an aimed member, in combination, a reversible electric driving motor for the aimed member, electrical control means for the driving motor comprising two pairs of alternatively engageable contacts, a movable support carrying one contact of each pair, a control member movable in either of two opposite directions from neutral position for selectively closing said pairs of contacts, a spring for applying to said movable member a contact closing bias whose magnitude is determined by the extent of displacement of the control member from the neutral position, a speed responsive generator driven by the power motor, a torque motor energized by the generator and having an output shaft connected to actuate said movable contact support, and electrical drag means acting upon the output shaft of the torque motor comprising a highly conductive eddy current cup, means connecting the eddy current cup for operation in synchronism with the output shaft of the torque motor, a permeable ring surrounding the eddy current cup, an inductive rotor within the eddy current cup, and transmission mechanism for driving said rotor from the control member at a speed dependent upon the speed of operation of the control member.

7. In an aiming mechanism including an aimed member, in combination, a driving motor for the aimed member, a control member, biasing mechanism responsive to the position of the control member, speed responsive biasing mechanism energized by the driving motor in accordance with the speed thereof, speed responsive biasing mechanism energized by the control member in accord-

ance with the speed thereof, means controlled jointly by said three biasing mechanisms for determining the speed of operation of the driving motor, limit mechanism for rendering the control member inoperative to influence the motor to drive the aimed member beyond a prescribed limit of movement, and mechanism operated by said limit mechanism to render the speed responsive biasing mechanism which is energized by the control member inoperative to influence the motor to drive the aimed member beyond said limit.

8. In an aiming mechanism including an aimed member, in combination, a control member, power driving mechanism responsive to the control member for normally operating the aimed member at a speed determined by the position of the control member, aided tracking mechanism responsive to the movement of the control member for introducing and applying to the aimed member an additional speed component in augmentation of the change of speed which would normally result from the mere change of position of the control member, and limit mechanism including means for rendering the control member ineffective to influence the driving mechanism to drive the aimed member beyond a prescribed limit of movement, and means concomitantly to render the control member ineffective to operate the aided tracking mechanism in a direction to influence the driving mechanism to drive the aimed member beyond said limit.

9. In an aiming mechanism including an aimed member, in combination, a reversible electric driving motor for the aimed member, operating circuit means for the driving motor comprising alternatively engageable pairs of contacts for operating the motor in opposite directions, a speed responsive generator operated by the motor, a torque motor energized by the generator and having an output shaft, a contact support carried by said output shaft upon which one contact of each pair is carried, an input shaft, a torque transmitting spring interposed between and connected to said shafts, a control member, operating transmission mechanism connecting the control member yieldingly to the input shaft, an electrical slip drag device acting upon the output shaft, slip drive transmission means connecting the control member to the slip drag device, and limit mechanism for preventing operation of the input shaft by the control member and operation of the slip drag device by the control member in a direction to cause the motor to drive the aimed member beyond a prescribed limit of movement.

PETER J. McLAREN.

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