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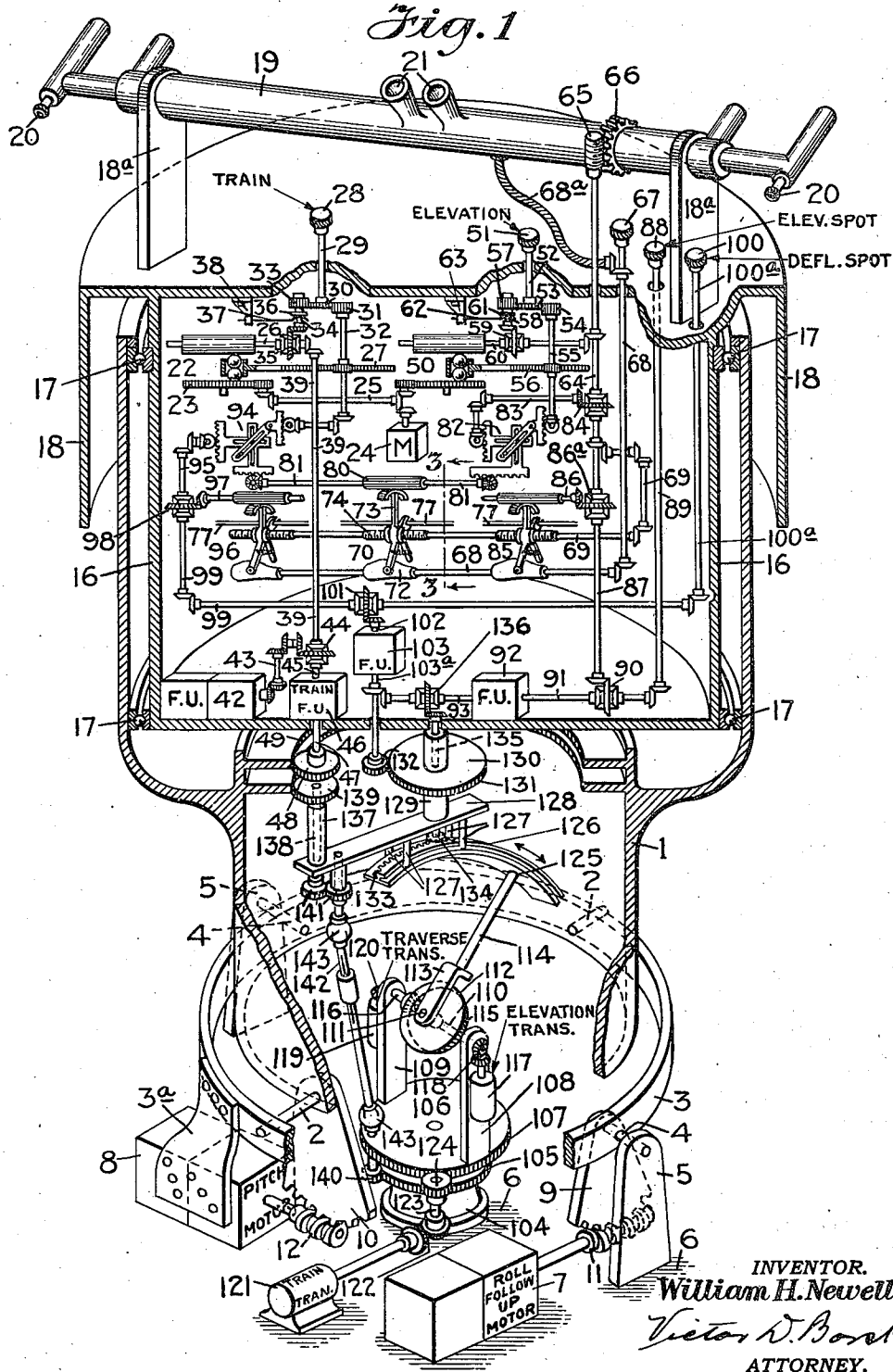
W. H. NEWELL

2,339,508

FIRE CONTROL SYSTEM

Filed June 25, 1940

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Fig. 2

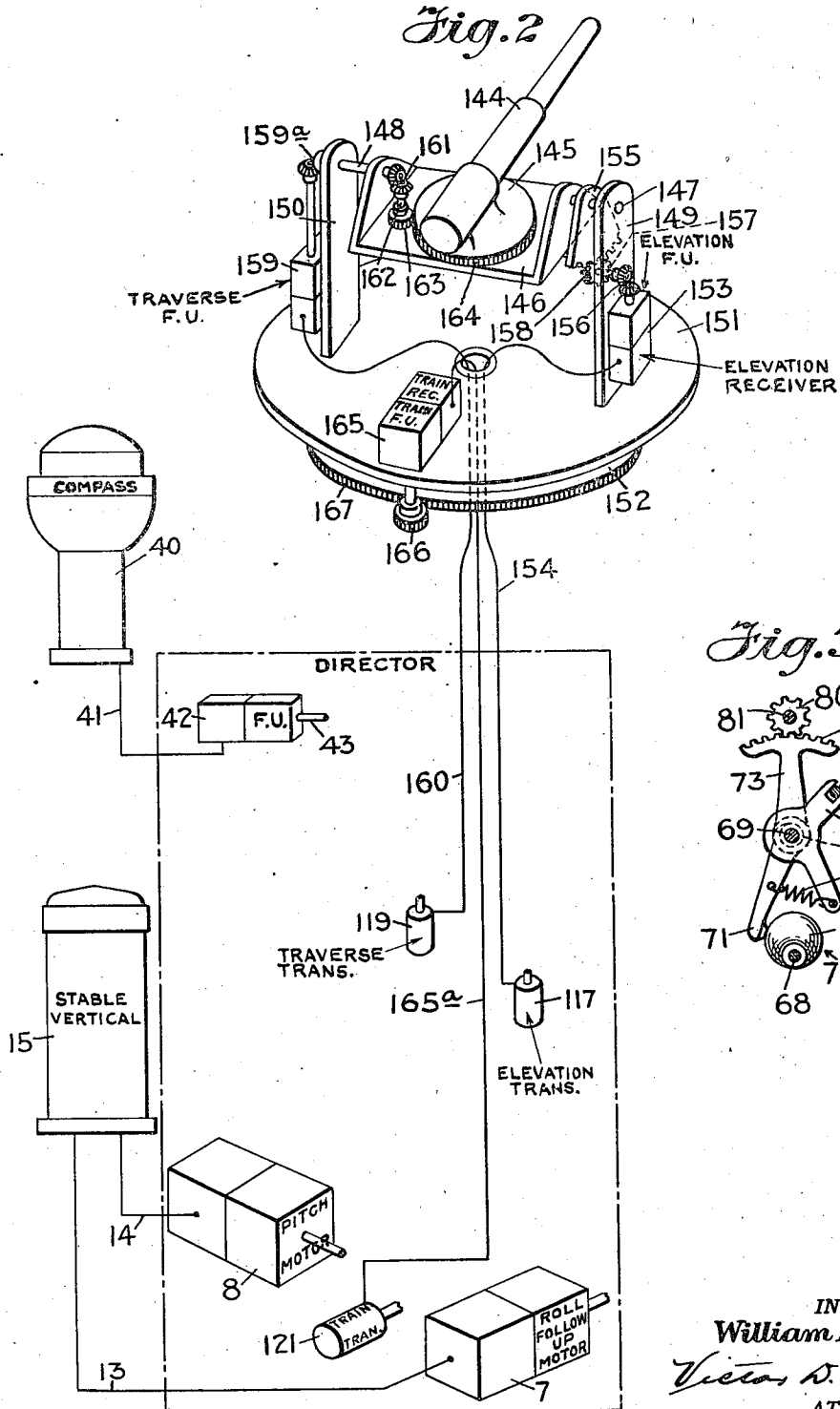
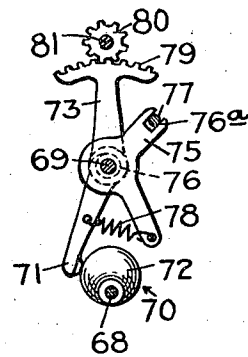


Fig. 3



INVENTOR,
William H. Newell
Victor D. Borst
ATTORNEY.

UNITED STATES PATENT OFFICE

2,339,508

FIRE CONTROL SYSTEM

William H. Newell, New York, N. Y., assignor to
Ford Instrument Company, Inc., Long Island
City, N. Y., a corporation of New York

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3 Claims. (Cl. 33—49)

This invention relates to a fire control system and more particularly to a fire control system for a gun mounted for universal movement including traverse, that is, about an axis perpendicular to the plane of elevation.

The principal object of the invention is to provide a director and a prediction computer particularly adapted to control the fire of universally mounted guns.

Another object of the invention is to provide a fire control system for a universally mounted gun that is mounted on a ship or a vehicle subject to rocking movements.

A further object of the invention is to provide a universally mounted sight on a ship or vehicle subjected to rocking movements, adapted, with other associated mechanisms, to control the fire of guns similarly mounted.

A further object of the invention is to provide a fire control system in which the sight and part of the mechanism of the director are stabilized whereby the reactions between the stabilized parts and the parts not stabilized automatically apply corrections within the system as a whole.

Other objects of the invention will become apparent from a consideration of the specification and drawings forming a part of this application and in which:

Fig. 1 is a perspective view of a director and computer embodying the invention;

Fig. 2 is a perspective view of a gun controlled by the director of Fig. 1, with associated mechanisms; and

Fig. 3 is a cross-section of a portion of the director on line 3—3 of Fig. 1, showing a three-dimensional cam.

The standard type of gun mounts developed for land and ship firing at surface targets have been used at a disadvantage when firing at aerial targets and especially when these targets are at high angles of elevation. The difficulties arose from the fact that the guns were mounted for movement on only two axes, viz., train and elevation. As the movements of aerial targets are along three axes, corrections for elevation had to be made for changes in train, which were complicated in their computations especially with high rates of change in range and bearing usually involved in the firing at such targets. Also it was practically impossible to follow a target at high elevation as the training rate becomes very high as the target passes near the zenith.

To overcome these defects a third movement

was provided as illustrated in the well known Scarff ring, which was mounted on a base movable in train and which carried a ball on which was mounted the gun. The gun was capable of movement in elevation and train relative to the ball.

Another form of so-called universal gun mount was devised and was disclosed in Henderson Patent No. 1,693,712 in which a third or cross level movement was provided between the train and elevation movements. However, the setting of the sights in this system was difficult and complicated as the changes in the settings for train disturbed the setting for elevation and vice versa. It was also difficult to provide a remote sight or director control for mounts of this type.

There have been remote sights that were universally mounted, such as described in Willard patent No. 1,936,442, but in that arrangement the transmissions to the gun were in terms of the conventional train and elevation, whereas the transmissions in the present invention are in terms of train, elevation and traverse. Traverse is defined as the angular position about an axis perpendicular to the plane of elevation, that is, the plane including the bore of the gun and the axis of the gun elevation trunnions.

The present invention contemplates mounting the sight and part of the director on a frame stabilized for pitch and roll so that the train axis of the sight is continuously maintained vertical and the elevation axis is continuously maintained horizontal. As the mount of the gun must necessarily be secured to the deck of the ship, the train and elevation values generated by the director must be corrected for roll and pitch. This is accomplished by mounting on the deck below the central axis of the stabilized part of the director a dummy gun whose muzzle end is moved in accordance with the generated train, elevation and stabilizing values and whose associated transmitters transmit the generated values corrected for pitch and roll. It is evident that the gimbal system of converting generated values to corrected values, as disclosed herein, could be replaced by a converter of the computer type.

The upper part of the director contains the range finder, sights, train and elevation variable speed devices, and prediction devices operated in part by the rates of the variable speed devices and in part in accordance with the range, converted to time of flight. A ballistic computer is also provided in this section in which the range is converted to time of flight, super-elevation and drift by three-dimensional cams con-

trolled by the predicted elevation of the line of sight above the horizontal and the range. Conventional power follow-ups are provided for the outputs of train, elevation and deflection.

The lower part of the director consists of a dummy gun by which transmitters are driven for controlling the actual gun. The center of the dummy gun system coincides with the center of the stabilized gimbal system of the director. The muzzle end of the dummy gun is located in space by fitting its upper end into a hole in a sector member controlled by the outputs of the computer or stabilized section. This hole is positioned in space with reference to the pivoting point of the dummy gun in accordance with the direction of the line of sight modified for predictions, spots, and ballistic corrections so that the line from the center of the dummy gun, which is in the vertical axis of the stabilizing gimbal system, to the hole in the sector member represents the direction of the gun in space. As the dummy gun is mounted directly on the ship on a base parallel with the reference plane of the guns, it is continuously positioned to transmit the proper values of train, elevation and traverse to the real gun.

With reference to Fig. 1, the frame 1 of the director is mounted on trunnions 2, 2 to ring 3 which is supported on the trunnions 4, 4 by standards 5, 5 secured to the deck 6. The director frame 1 is maintained in a horizontal plane with its main axis vertical by roll follow-up motor 7 secured to the deck 6 and pitch follow-up motor 8 secured to the ring 3 by bracket 3a, whose shafts are connected to segments 9 and 10 secured to the ring 3 and frame 1 respectively by worms 11 and 12 respectively. Control of the motors 7 and 8 is had through cables 13 and 14 from a suitable stable vertical, well known in the art, and indicated at 15 (see Fig. 2).

Within the frame 1 and coaxial therewith is mounted the director head 16 which is free to rotate with reference to frame 1 about its vertical axis. The head 16 is held in position by ball bearings 17. An apron 18 extends downward from the director head 16 for protection of the mechanisms within it from the weather and the blasts of the guns.

On the top of director head 16 is mounted by standards 18a a conventional combined range finder and sight 19. The optical system of the sight terminates in eyepieces 20 and the optical system of the range finder terminates in the eyepieces 21.

Train values are generated by variable speed device 22 whose disk 23 is driven by constant speed motor 24 through shaft 25. The output of variable speed device 22, represented by the rotation of shaft 26, is controlled by the position of control element 27 which is positioned by the knob 28 through shaft 29, gears 30 and 31, and shaft 32. Corrections to the generated values are applied by knob 28 through shaft 29, gears 30 and 33, shaft 34, and differential 35, one side of which is connected to the output of the variable speed device 22. A disk 36 is secured to shaft 34 and cooperates with spring 37 secured to the director head 16 by lug 38 to prevent the output of the variable speed device 22 from moving gear 33 rather than moving shaft 39, which is the output of differential 35. The retarding force between the disk 36 and the spring 37 is such that it may be overcome by a force applied to knob 28 but is not overcome by the force necessary to move shaft 39.

In the position shown, gear 30 engages gears 31

and 33 and the movement of shaft 29 applies corrections to both the rate and the output of variable speed device 22. Gear 30 may be shifted upward and engage gear 33 only in which case corrections would be applied only to the output of variable speed device 22. If gear 30 is moved downward it engages gear 31 only, in which case knob 28 applies corrections only to the position of the rate member of variable speed device 22.

The rotation of shaft 39, representing train, is combined with the compass course of the ship supplied by compass 40 through cables 41 to follow-up 42 to give relative bearings in train. This is accomplished by combining the output of the compass course follow-up 42, represented by the rotation of shaft 43, with the rotation of shaft 39 in differential 44, the output of which, shaft 45, is connected to the input of train follow-up 46. The output of follow-up 46, shaft 47, is connected to gear 48, which meshes with an internal gear formed by teeth 49 in frame 1. In this manner the sights 20 are kept continuously on the target in train.

Elevation values are generated by variable speed device 50, driven by motor 24, and controlled by knob 51, shaft 52, gears 53 and 54, shaft 55, control element 56, as previously described for variable speed device 22. Likewise corrections to the generated values of the variable speed device 50 are applied through gear 57, shaft 58, and differential 59, which is connected to the output of the variable speed device 50, by shaft 60. On shaft 58 is disk 61 which cooperates with spring 62 secured to the frame 1 by lug 63 to prevent the output of the variable speed device 50 from moving gear 57. Corrections to the rate of generation or the generated values may be applied simultaneously or individually by shifting the position of gear 53, as previously described for gear 30. The generated values of elevation, represented by the motion of shaft 64, is applied to the range finder-sight 19 by worm 65 which meshes with gear 66 secured to the range finder-sight 19.

The range is set up in the mechanism mechanically by knob 67, connected to shaft 68, which is connected by a flexible shaft 68a to a mechanism in the range finder which converts the movements of shafts 68 and 68a, directly representing range, to the corresponding variable movements required of the range finder optical system.

The advance elevation is the algebraic sum of the elevation of the sight and the elevation prediction factor. The elevation prediction factor is the product of the rate of change of elevation multiplied by the time of flight. The time of flight is a function of the advance elevation and the range. A closed or regenerative system is therefore provided to obtain the advance elevation as follows: The range, represented by the rotation of shaft 68, and the advance elevation represented by the rotation of shaft 69, are fed into the three-dimensional cam mechanism 70 by shaft 68'. Cam mechanism 70 is shown in detail in Fig. 3. The surface of cam 72 is determined by calculations and experiments. The movement of cam lever 73 about its axis is determined by the rotation of shaft 68' and the particular part of the surface of cam 72 which cam follower 71 engages. The latter factor is determined by the movement of cam lever 73 along the shaft 69. This is accomplished by mounting cam lever 73 to rotate relative to lever 75, which is internally threaded at 76 to engage the threaded portion 74 of shaft 69. To prevent

rotation of lever 75 a slot 76a is cut in the end of one of its arms which engages shaft 77 secured to some solid part of the director head 16. At the end of the other arm of lever 75 is attached a spring 78 which is connected to the cam lever 73. In the upper end of cam lever 73 are cut teeth 79 that mesh with gear 80, secured to shaft 81. It will thus be seen that cam lever 73 is translated along shaft 69 in proportion to the advanced elevation and is rotated about its axis in accordance with the surface of cam 72 with which it is held in contact by spring 78 and its rotational movement is in proportion to the time of flight of the projectile.

The time of flight, represented by the motion of shaft 81, is multiplied by the rate of change of elevation, represented by the rotation of shaft 55, by a conventional multiplying mechanism 82, the output of which, represented by the rotation of shaft 83, is the elevation prediction factor. This is combined with the elevation of the target, represented by the rotation of shaft 64, in differential 84 to obtain the advanced elevation, represented by the rotation of shaft 69. The construction and operation of a conventional multiplying mechanism are described in Patent 1,937,336.

The super-elevation correction is a function of range and advanced elevation and is generated by a three-dimensional cam mechanism designated generally as 85 which operates similarly to cam mechanism 70, previously described. The output of this mechanism, represented by the rotation of shaft 86, is combined with the advance elevation, represented by the rotation of shaft 69, by differential 86a, the output of which, shaft 87, represents the elevation of the gun above the horizon.

Elevation spots are added by turning knob 88 connected to shaft 89, whose movement is combined with that of shaft 87 by differential 90. The output of differential 90, shaft 91, is connected to a conventional follow-up 92, the output of which is shaft 93.

The deflection correction is made up of two factors: (1) the rate of change of train multiplied by the time of flight, and (2) a drift which is proportional to the advance elevation and range. The mechanism to generate the first factor (1) of this correction consists of the conventional multiplier 94 whose inputs are shafts 32 and 81, previously described, and whose output is shaft 95. The factor of drift is generated by a three-dimensional cam mechanism, shown generally at 96, and which is similar in all respects in construction and operation with the three-dimensional cam mechanism 70, previously described. The output of cam mechanism 96 is shaft 97, whose motion is combined with that of shaft 95 in differential 98, the output of which is shaft 99 whose motion represents the combined generated deflection correction.

Spots in deflection are set up in the mechanism by knob 100 connected to shaft 100a whose movement is combined with that of shaft 99 in differential 101 whose output, shaft 102, is connected to a conventional follow-up 103, whose output is shaft 103a, the rotation of which represents the desired total deflection in azimuth.

Secured to the deck and coaxial with the ring 3 is base 104 on the side of which are cut teeth 105. On the top of base 104 is mounted plate 106 which is mounted to rotate about the axis of base 104. Teeth 107 are cut in the edge of plate 106. On top of plate 106 are mounted two

standards 108 and 109. Journaled in the upper end of standard 108 is shaft 110 which supports pin 111 on which rotates together arm 113 and plate 112. On the end of arm 113 is secured dummy gun 114, such that the axis of the dummy gun 114 intersects the axis of shaft 110. In the edge of plate 112 are cut teeth 115 which mesh with a gear on shaft 116 which is journaled in the upper end of standard 109. Elevation transmitter 117 is connected to shaft 110 by gears 118. Traverse transmitter 119 is connected to shaft 116 by gears 120. Train transmitter 121 is connected to plate 106 by gears 122, shaft 123, gear 124 and teeth 107.

The manner in which dummy gun 114 receives its motion, and thereby moves the elevation transmitter 117, traverse transmitter 119, and train transmitter 121 is as follows: The upper end of the dummy gun 114 fits into a hole 125 on sector strip 126 which is adapted to slide in grooves formed of braces 127. Braces 127 are connected to bracket 128 which is secured at one end to hollow shaft or sleeve 129 which in turn is secured to plate 130. Plate 130 is connected to shaft 103a by teeth 131 and gear 132.

Strip 126 is moved between the braces 127 by rack 133, secured to strip 126, and engaging gear 134 secured to shaft 135 which rotates within sleeve 129. Shaft 135 is connected to shaft 93 and to shaft 103a through the conventional differential 136.

The outer end of bracket 128 carries sleeve 137 in which rotates shaft 138 connected at its upper end by gear 139 to a second internal gear formed by teeth 140a of frame 1. Shaft 138 transmits its rotation to gear 140, which meshes with teeth 105, through gears 141 and telescoping shaft 142 including universal joints 143. Shaft 142 passes through a journal in plate 106. In this manner it will be seen the axis of plate 106, at right angles to the axis passing through the center of the standards 108 and 109, is kept substantially parallel to the longitudinal axis of bracket 128.

The gun 144 is mounted for universal movement by securing it to a plate 145 rotatively secured to frame 146. Frame 146 is supported by shafts 147 and 148 journaled in the upper ends of standards 149 and 150 respectively, which are secured to the plate 151. Plate 151 is rotatively mounted on base 152 secured to the deck of the ship.

Motion of the gun in elevation is had by connecting elevation transmitter 117 to elevation receiver and follow-up 153 by cable 154. The output of this follow-up is transmitted to segment 155, which is secured to shaft 147, by gears 156, shaft 157, and gear 158.

Motion of the gun in traverse is had by connecting traverse transmitter 119 to traverse receiver and follow-up 159 by cable 160. The output of this follow-up is transmitted to plate 145 through gears 159a, shaft 148, gears 161, shaft 162, and gear 163 which meshes with teeth 164 on the edge of plate 145.

Motion of the gun in train is had by connecting train transmitter 121 to train receiver and follow-up 165 by cable 165a. The output of this follow-up is journaled in plate 151 and is connected to gear 166 which meshes with teeth of a gear rack 167 secured to the side of the base 152.

It is obvious that various changes may be made by those skilled in the art in the details of the embodiment of the invention disclosed in the

drawings and described above within the principle and scope of the invention as expressed in the appended claims.

I claim:

1. In a system for directing anti-aircraft guns, in combination with an angularly movable platform, a director frame mounted on the platform for universal angular movement relative thereto, stabilizing means for maintaining an axis of the frame vertical, a director head on the director frame adapted for rotation about said vertical axis, a directing device on the director head adapted for rotation about a horizontal axis and for rotation with the director head about the vertical axis, a dummy gun mounted on the platform and movable in train about an axis perpendicular to the platform and in line with the said vertical axis when the platform is horizontal, and in elevation about an axis parallel with the platform and in traverse about an axis perpendicular to the elevation axis and to the plane of elevation, means for transmitting the train of the directing device to the dummy gun to rotate the dummy gun substantially in synchronism with the train of the directing device, and constraining means for the dummy gun automatically controlled in elevation by the elevation setting of the directing device and operative to control the position of the dummy gun about its traverse axis in response to relative angular movement between the platform and the directing device.

2. In a system for directing anti-aircraft guns, in combination with an angularly movable platform, a director frame mounted on the platform for universal angular movement relative thereto about intersecting axes, stabilizing means for maintaining an axis of the frame vertical, a director head on the director frame adapted for rotation in train about said vertical axis, a directing device on the director head adapted for rotation in elevation about an axis perpendicular to the vertical axis and for rotation in train with the director head about the vertical axis, a dummy gun mounted on the platform and movable in train about an axis perpendicular to the platform and in elevation about an axis parallel

with the platform and in traverse about an axis perpendicular to the elevation axis and to the plane of elevation, each of said dummy gun axes being arranged to intersect the frame mounting axes, a sector mounted on the director head for angular displacement relative thereto about vertical and horizontal axes also intersecting the frame mounting axes, adjustable variable speed power means adapted for moving said director head and said sector in train about their vertical axes, means for displacing the sector in train relative to the directing device in proportion to the adjustment of the variable speed power means, means to position the dummy gun in train by and in accordance with the train of the director head and the displacement of the sector about their vertical axes relative to the director frame, means to position the sector about its horizontal axis in accordance with the elevation of the directing device relative to the director head, and constraining means interconnecting the sector and the dummy gun whereby to cause the dummy gun to move about its traverse and elevation axes.

3. In a system for directing anti-aircraft guns, in combination with an angularly movable platform, a director frame mounted on said platform and adapted for angular movement relative thereto, stabilizing means for maintaining an axis of the frame vertical, a directing device mounted on said frame for train about said vertical axis and for elevation about an axis perpendicular to said vertical axis, a dummy gun mounted on the platform for movement relative thereto about three axes of rotation, one of said axes being perpendicular to the platform and in line with the said vertical axis when the platform is horizontal, means for transmitting the train of the directing device to position the dummy gun about the axis perpendicular to the platform, and constraining means for the dummy gun responsive to the elevation setting of the directing device and operative to cause the dummy gun to move about its second and third mounting axes as the platform moves relatively to the horizontal.

WILLIAM H. NEWELL.