Dec. 26, 1944. P. T. TUCKER ET AL 2,366,072

GUN CONTROL MECHANISM

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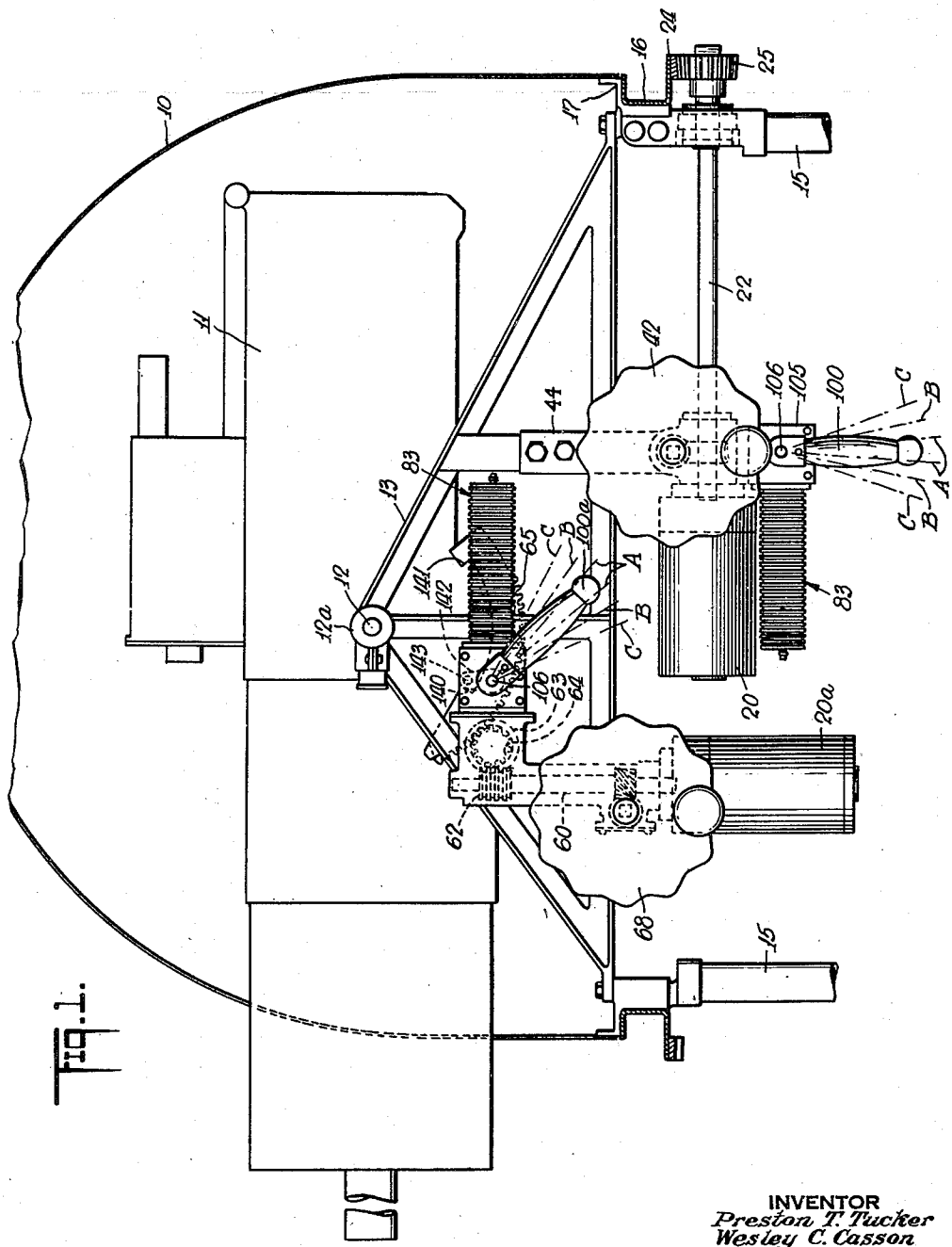

Fig. 1.

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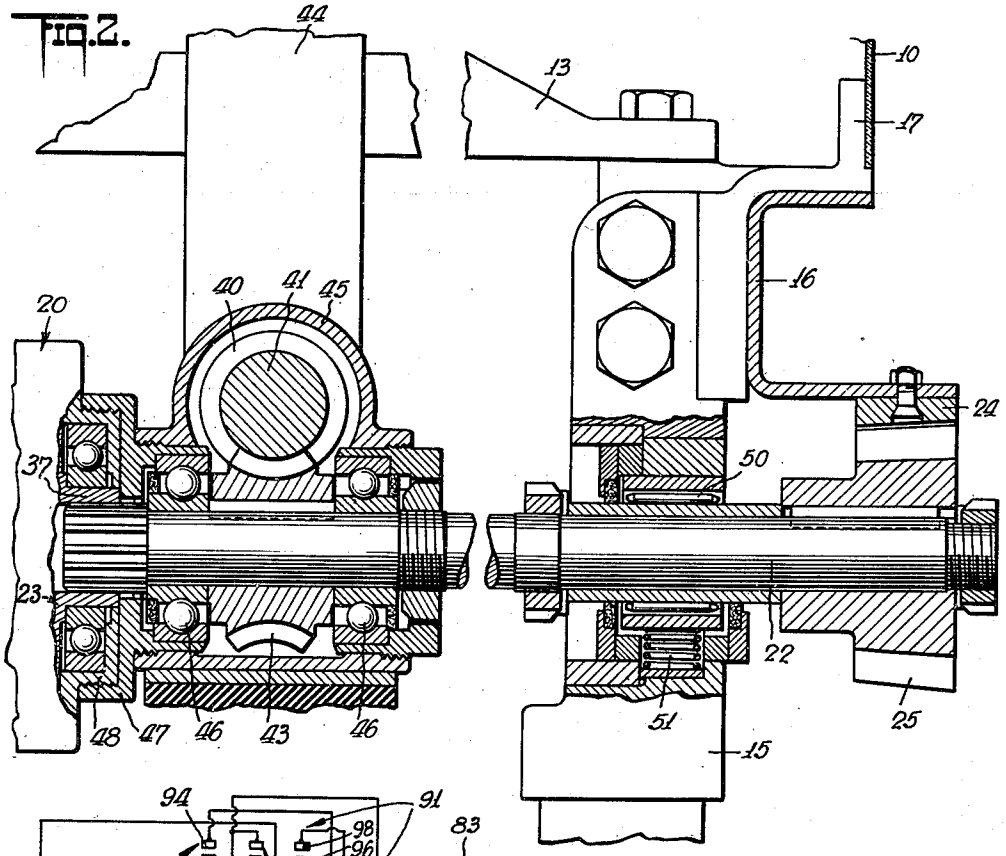
Fig. 2.



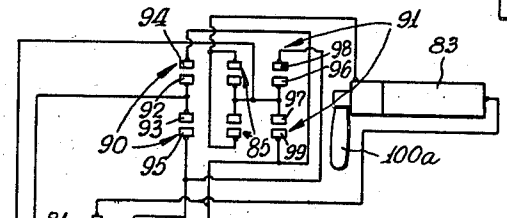
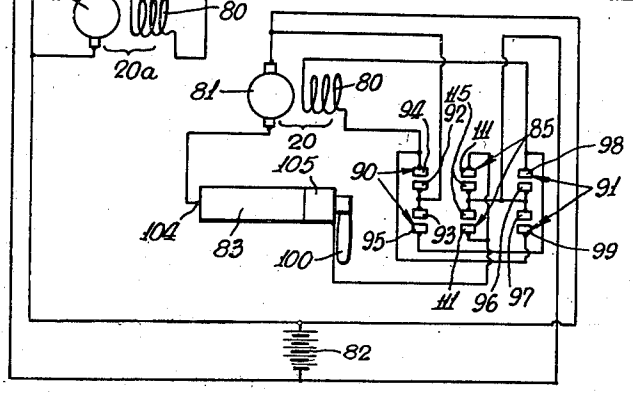


Fig. 13.



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GUN CONTROL MECHANISM

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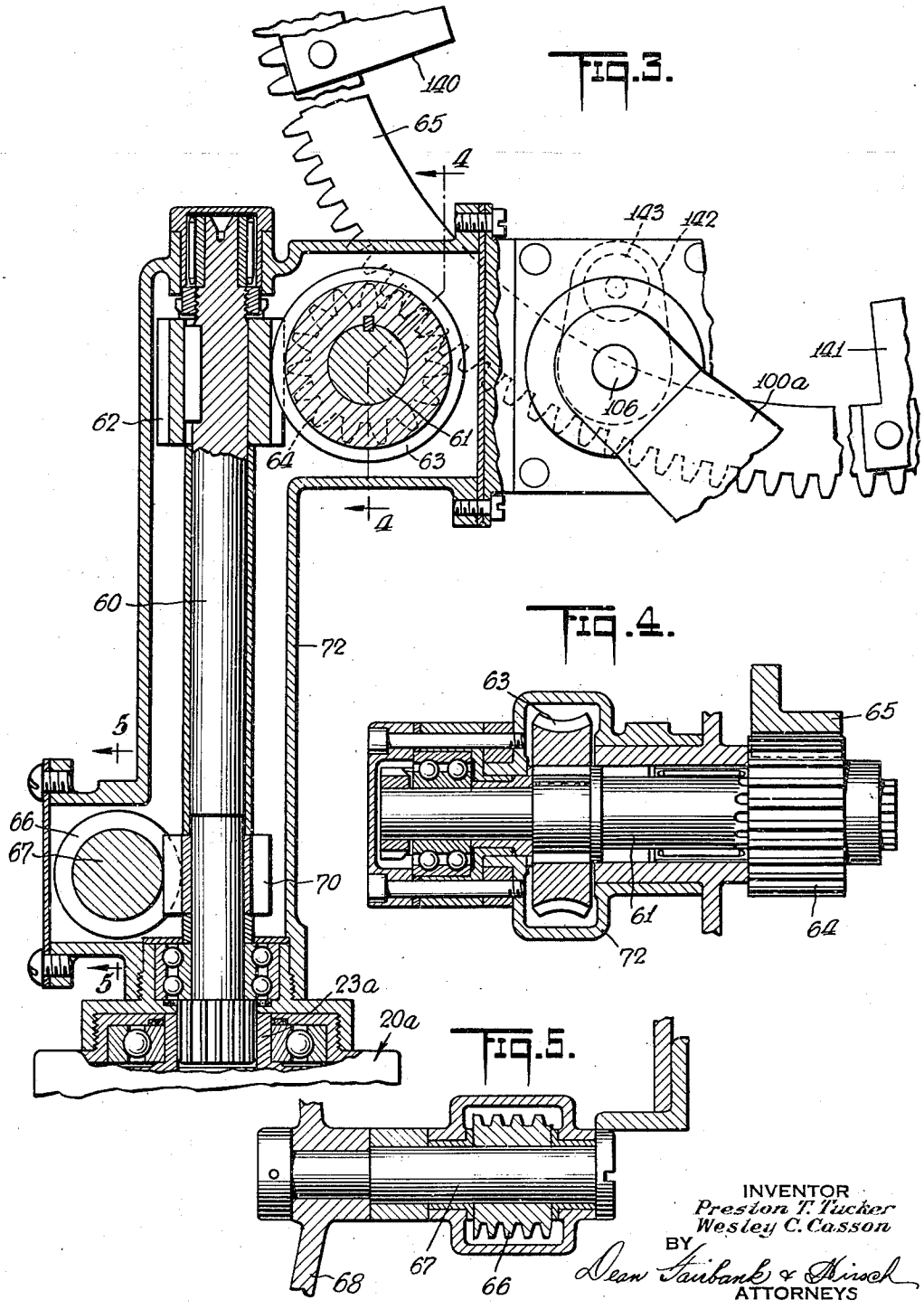

FIG. 3.

FIG. 4.

FIG. 5.

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GUN CONTROL MECHANISM

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FIG. 6.

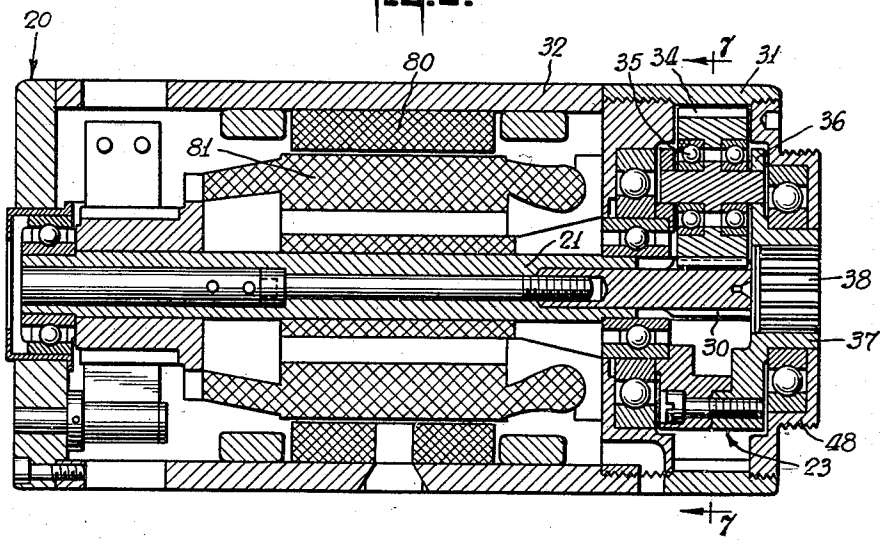
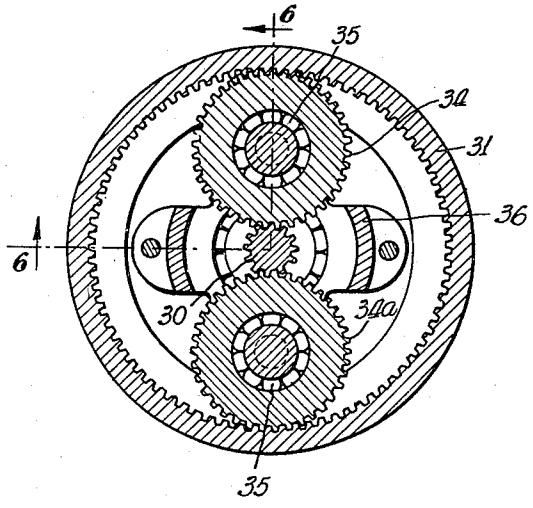


FIG. 7.



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GUN CONTROL MECHANISM

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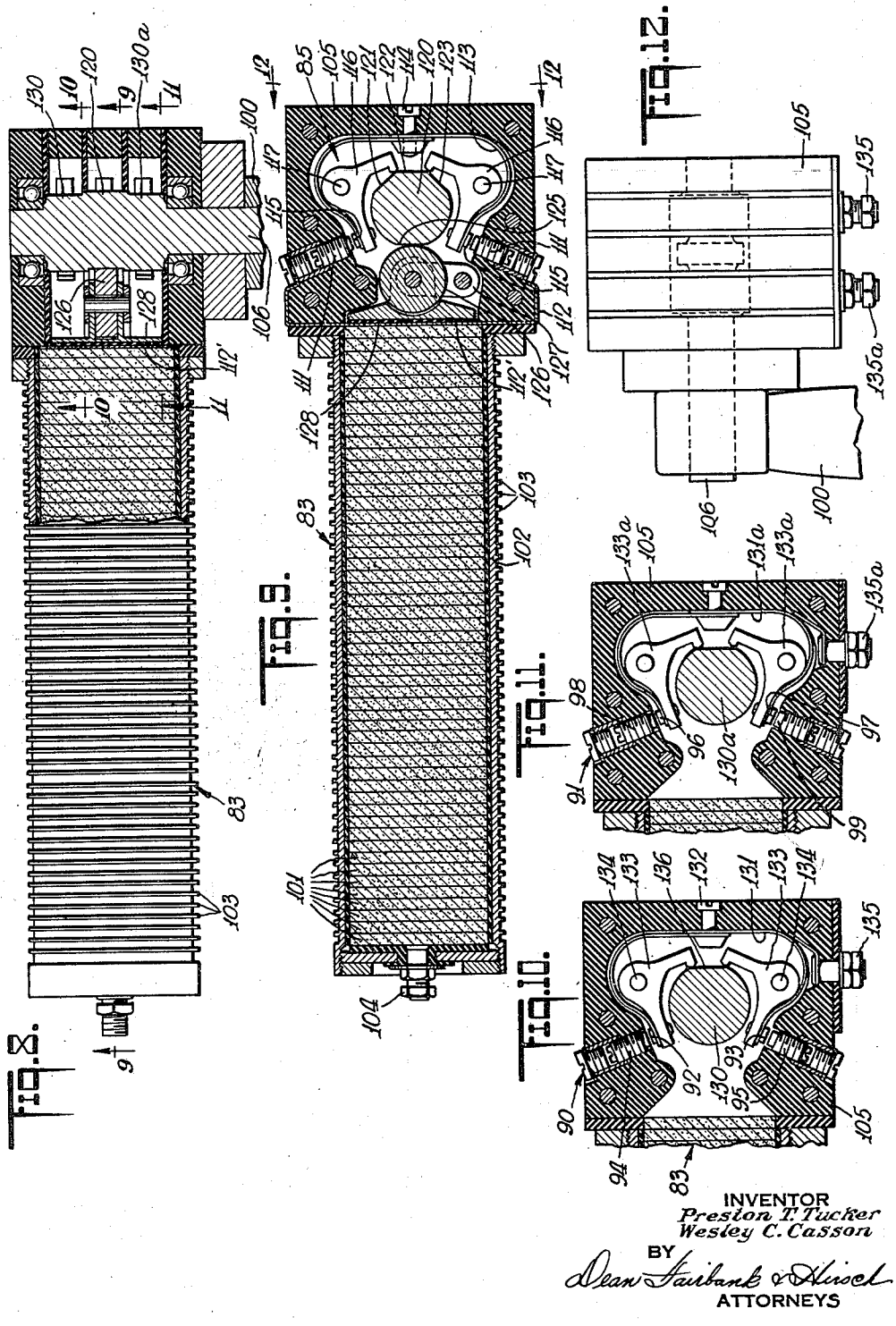

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2,366,072

UNITED STATES PATENT OFFICE

2,366,072

GUN CONTROL MECHANISM

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Application July 18, 1939, Serial No. 285,064

3 Claims. (Cl. 89—41)

In that type of warfare in which the relative positions of a carriage mounted gun and its target change very rapidly, as in the case of air combat, it is necessary to maneuver the gun very quickly to aim or keep it trained on the rapidly moving target. Hand driven aiming or training maneuvers of the gun, especially of that type having traversing and elevating mechanisms, at best are relatively slow in operation, and fatigue the operator under conditions where alertness is vital.

One object of the present invention is to provide new and improved gun traversing and elevating mechanisms, by which rapid universal maneuvering of a gun into desired shooting position can be effected without physical strain upon the operator.

Another object is to provide power driven traversing and elevating mechanism, by which maneuvering of the gun into desired shooting position can be effected at selected speed ranging from creeping to very rapid movement.

Another object is to provide a gun control mechannism, which is comparatively simple, rugged, and durable, which is reliable in operation, and which will not easily get out of order.

Various other objects and advantages of the invention will be apparent from the following particular description, and from an inspection of the accompanying drawings, in which

Fig. 1 is a side elevation of an aircraft machine gun, somewhat diagrammatic, and showing traversing and elevating mechanisms therefor embodying the present invention,

Fig. 2 shows details of a portion of the traversing mechanism on a larger scale, parts being in vertical section and others in side elevation.

Fig. 3 shows details of a portion of the elevating mechanism on a larger scale, parts being shown in vertical section and others in side elevation,

Figs. 4 and 5 are sections taken on lines 4—4 and 5—5 respectively of Fig. 3,

Fig. 6 is a longitudinal section through different radial planes of the motor of the traversing mechanism, taken on line 6—6 of Fig. 7,

Fig. 7 is a transverse section of the reduction gearing in the motor, taken on line 7—7 of Fig. 6,

Fig. 8 is a detail on a larger scale of the motor control, parts being shown in longitudinal section and others in side elevation,

Figs. 9, 10 and 11 are sections taken on lines 9—9, 10—10 and 11—11 respectively of Fig. 8,

Fig. 12 is an end view of the motor control, taken on line 12—12 of Fig. 9, and

Fig. 13 is a wiring diagram of the electric circuit of the gun traversing and elevating mechanisms.

The gun, aside from the mechanisms for maneuvering it in the desired diretcion, forms per se no part of the present invention, and may be of the usual machine gun type, mounted in the nacelle or other suitable location in an aircraft. In the specific form shown, this gun is partially enclosed in a gunner's bullet-proof shield dome 10, and includes the usual barrel 11, having its muzzle projecting through an opening of said dome, and pivotally supported by trunnions 12 in bearings 12a at the apexes of a pair of opposed trusses 13, which form a turret frame as shown in Fig. 1. These trusses 13 have their radially outer ends secured to respective stanchions 15 of a gun mount, guided for rotation in a fixed ring 16, and form a rotatable unit with the dome 10, desirably through the instrumentality of brackets 17, interconnecting said stanchions and said dome.

As a feature of the present invention, the means for maneuvering the gun universally into the desired shooting direction comprises electrically operated and controlled traversing and elevating mechanisms. The traversing mechanism is supported from the turret frame 13 for rotation therewith as will be hereinafter described, and includes an electric motor 20, and a shaft 22, extending horizontally and radially of the guide ring 16, and driven from the motor shaft 21 through a reduction gearing 23. Between the shaft 22 and ring 16 is an epicyclic gear train, comprising a bevelled crown or face gear 24, fixed to the underside of the guide ring 16, and a bevelled gear 25, secured to the radially outer end of the shaft 22, and meshing with said face gear for rolling action therealong upon operation of said motor.

The reduction gearing 23 between the motor shaft 21 and the shaft 22 is shown in Figs. 6 and 7 in the form of a planetary gear train casing unit, mountable upon the end of the motor 20, and comprising a sun gear 30, affixed to said motor shaft, an annular internal gear 31, threaded or otherwise secured to the motor housing 32 against rotation, and a pair of intermediate idler spur gears 34 and 34a, meshing with said sun gear and with said annular gear 31, and carried by respective anti-friction bearings 35 on a rotatable cage 36. Cage 36 terminates at one end in an axial sleeve 37, having a socket 38 therein with a series of keyways to form a spline connec-

tion with the inner end of the shaft 22 as shown in Fig. 2.

Hand driven means for use should electric power fail desirably comprises a worm 40, affixed to the shaft 41 of a handwheel 42, and meshing with a gear wheel 43 on the shaft 22. The pitch of the threads of the helical gears 40 and 43 is steep enough, so that these are reversible in operation, thereby permitting either hand or motor operations without the use of a clutch.

For supporting the motor 20 and shaft 22 from the turret frame, there is secured to one of the turret trusses 13 a bracket 44, to which is connected a housing 45 for the gearing 40, 43. This housing 45 carries suitable anti-friction bearings 46 for the shaft 22, and has affixed to one end thereof a collar 47, having an internal threaded engagement with a hub 48, affixed to the outer end of the annular gear 31 of the planetary gear train 23. By this construction, the motor unit, including the planetary gear train 23, is supported from the turret frame 13, and is easily coupled to the shaft 22 by merely threading the hub 48 into the collar 47 to establish the necessary spline connection between the sleeve 37 and said shaft.

Another anti-friction bearing 50 for the shaft 22 is carried at the upper end of one of the stanchions 15, and is pressed upwardly by a spring 51, to assure proper meshing contact between the two gears 24 and 25.

Rotation of motor 20 causes rotation of the gear 25, which thereby rolls over the gear 24, to cause transverse rotation of the turret frame 13, and resultant rotation of the gun barrel 11 and the dome 10.

The elevating mechanism, also supported on the turret frame 13 as shown in Figs. 1, and 3 to 5, includes an electric motor 20*a*, similar to traverse motor 20 but with its axis vertically disposed, a vertical shaft 60, driven from the motor shaft through a reduction gearing 23*a* similar to planetary gearing 23, a horizontal shaft 61, a gear transmission between shafts 60 and 61, comprising a worm 62 and a wheel 63 on shafts 60 and 61 respectively, and a spur gear 64 on shaft 61, meshing with a segmental gear 65, affixed to the gun barrel 11, and concentric with trunnions 12. Rotation of the motor 20*a* causes rotation of the gear 64, and resultant rotation of the segmental gear 65 about bearings 12*a* to cause elevational movement of the gun barrel 11. The gears 62 and 63 are desirably irreversible, so that the gun is effectively locked against elevational movement when the motor 20*a* is not running.

Hand driven means for the shaft 60, available in case electric power fails, desirably comprises a worm 66, affixed to the shaft 67 of a handwheel 68, and meshing with a gear wheel 70 on said shaft 60. The pitch of these gears 66 and 70 is steep enough to render these gears reversible in operation.

The power transmission mechanism between the motor 20*a* and the segmental gear 65 is enclosed in a housing 72, affixed to the turrent frame 13, and connected to the output side of the planetary gear unit 23*a* by a detachable connection similar to that between the planetary gear unit 23 and the shaft 22 of the traversing mechanism.

The motors 20 and 20*a* are controlled for right or left traverse and for raising and depressing elevation at selective speeds. For that purpose, each motor in the specific form shown is of the shunt wound direct current type, with a saturated field 80, shunted across the series connected armature 81 and rheostat 83 and energized from a voltage line leading from an electric battery 82, to which the two motor circuits are connected in parallel as shown in Fig. 13. The rheostat 83 in each of the armature circuits serves not only for starting but also to vary the speed of its respective motors. Also in each of the armature circuits is a switch 85, which serves selectively to open or close its respective armature circuit to start the corresponding motor when the rheostat is sufficiently compressed.

In each of the field circuits are two switches 90 and 91, for changing the direction of current in said circuit in accordance with the desired direction of turning of the respective motor. In the specific form shown, switch 90 has two branch feed contacts 92 and 93 on one side of the battery 82, and two contacts 94 and 95, connected to opposite sides of the field 80, and adapted to make and break with feed contacts 92 and 93 respectively, and switch 91 similarly has a pair of branch feed contacts 96 and 97, but on the other side of the battery 82, and two contacts 98 and 99 on opposite sides of the field 80 for make and break co-operation with feed contacts 96 and 97 respectively.

As a feature of the present invention, the various controls of motors 20 and 20*a* are effected from control members 100 and 100*a* respectively, which are desirably in the form of handles pivoted at convenient location on the gun mounting, and which stop or start their respective motors through the operation of their respective armature switches 85, control their direction through operation of their respective reversing switches 90 and 91, and control their speed through operation of their respective armature rheostats 83, as shown in Figs. 8 to 13, and as will be hereinafter described. For that purpose, each armature rheostat 83 is of the carbon pile type, and comprises a series of carbon discs 101, held in a casing 102 insulated from said plates, and desirably provided with cooling fins 103 on its outer periphery to prevent overheating. At one end of the rheostat casing 102 is a terminal 104, in electrical contact with the end disc 101, and to its other end is connected a switch housing 105 made of suitable insulating material, and desirably forming a unit with said casing 102. Journalled desirably by anti-friction bearings in this switch housing 105 is a shaft 106 having one end thereof extending beyond said housing to rigidly receive its respective control handle 100 or 100*a*.

The armature control switch 85 as shown in Fig. 9 is mounted in the switch housing 105 for operation by the handle 100, and is desirably of the tumbler type with a pair of contacts in the form of screws 111, threaded for adjustment in the respective holes in opposite side walls of said housing. These screws 111 are in electrical contact with the ends of a jumper 112, having its intermediate portion extending across the end of the rheostat casing 102 in electrical contact with the end carbon disc 101. A metal contact leaf spring 113 is fixed at its middle section to the end wall of the switch housing 105 by a terminal screw 114 to which the main lead-in is connected. This spring 113 is shown made of two parts with their inner ends held in overlapping relationship by the terminal screw 114. The outer ends 115 of spring 113 are affixed to one end respectively of a pair of angular or bell

crank levers 116, pivotally supported at 117, and are disposed opposite the respective inner ends of the contact screws 111 for circuit make and break co-operation therewith. The spring 113, due to its inherent resiliency, tends to straighten out from the position shown in Fig. 9 to urge the contact ends thereof into electrical contact with the screws 111 to close the switch 85.

Cam means are provided for holding switch 85 in open position shown in Fig. 9 against the resiliency of the spring 113, and for controlling the movement of the ends of said spring into or out of contact with the screws 111. In the specific form shown, this cam means comprises a cam section 120, formed on the shaft 106, the levers 116 being rotatably urged about their pivotal supports by the spring 113 to bring the right hand extremities of said levers as shown in Fig. 9 in follower engagement with said cam section. This cam 120 has three adjoining substantially flat or slightly concave chordal surfaces 121, 122 and 123 in angular relationship, the end portions of which surfaces form the high sections of the cam, and the middle portions, the low sections. When the cam 120 is in the open switch position shown in Fig. 9, the follower ends of the levers 116 are at the high ends of the middle cam surface 122, so that the contact ends 115 of the spring 113 are held spaced from their respective contact screws 111 to hold the motor armature circuit open. When the cam 120 is rotated clockwise by the rotation of the shaft 106 through the manipulation of the control handle 100, from neutral position shown in Fig. 1, cam surface 121 will ride past the follower end of the upper lever 116, while cam surface 122 will ride past the follower end of the other lever 116, thereby causing said follower ends to move inwardly with respect to cam 120 under the action of the spring 113. This will move the ends 115 of the spring 113 into electrical contact with the respective contact screws 111 to close the motor armature circuit.

Similarly, counter-clockwise rotation of cam 120 from neutral position will cause the cam surfaces 122 and 123 to ride past the upper and lower follower ends of levers 116 respectively, to close both pairs of contacts 111 and 115, and thereby close the motor armature circuit.

The upper pair of contacts 111 and 115, and the lower pair 111 and 115 are connected in parallel in the armature circuit as shown in Fig. 13, and both pairs are simultaneously closed when the control handle 100 is moved in either direction from the neutral position shown in Fig. 1. The two pairs of contacts 111 and 115 therefore share the comparatively heavy armature current between them, so that the same size contacts as for the field reversing switches 90 and 91 may be used as will hereinafter be made apparent. Furthermore, double contacts in the armature circuit affords greater reliability in the operation of the switch 85.

The manipulation of the control handle 100 or 100*a*, by which the armature switch 85 is opened or closed to start or stop the corresponding motor also varies the pressure between the carbon plates 101 of the rheostat 83, to vary the resistance of said rheostat, and in turn the speed of said motor. For that purpose, the cam 120 has a substantially flat chordal cam surface 125, diametrically opposite the cam surface 122. In follower engagement with this cam surface 125 is a roller 126, rotatably carried at one end of a pivotally supported arm 127, to which is connected a floating shoe 128 coacting with the intermediate portion of the jumper 112, which has limited transverse flexibility. Shaft 106, and floating shoe 128 are preferably of steel, and the latter is insulated from the jumper 112 by an interposed sheet of insulation 112', preferably of mica.

In open position of the armature switch 85 shown in Fig. 9, roller 126 in engagement with the low portion of the cam surface 125 will exert little or no pressure on the carbon pile, so that the resistance through the rheostat 83 is at its maximum. Upon rotation of the control handle 100 in either direction from a neutral position, the corresponding rotation of the cam 120 moves the roller 126 to the left to exert pressure on the rheostat carbon pile through the shoe 128, the extent of this pressure depending upon the angular position of said handle. The curvature of the cam 125 is so designed, that the resistance of the rheostat 83 will vary in a substantially linear relation inversely with the angular displacement of the handle from neutral position. The reduction in resistance through the rheostat 83 correspondingly increases the speed of the armature, since current therethrough increases without change in the field flux, which remains substantially constant by virtue of the saturation of the field poles. In other words, the speed of the motor is directly proportional to the armature current, since the field flux remains constant at all times.

The handle 100 also controls the field reversing switches 90 and 91. For that purpose, the reversing switch 90 is of the tumbler type, and is operated from a cam section 130 desirably formed on the shaft 106. A contact leaf spring 131, similar to contact spring 113, and similarly secured to the inner side wall of the switch housing 105 by a screw 132, has its contact ends 92 and 93 affixed to the respective arms of angular levers 133. These levers 133 are pivotally supported at 134 desirably on the same pivot pins that support the levers 116, and have cam follower extremities urged into contact with the cam by the inherent tendency of the spring 131 to straighten out. A screw terminal 135 to which a main lead-in is connected is mounted in a wall of the switch housing 105, and has electrical contact with an intermediate portion of the contact spring 131, which connects contact ends 92 and 93.

The contacts 94 and 95, electrically co-operating with the spring contact ends 92 and 93 respectively, are in the form of screws adjustably threaded into the opposite side walls, as in the case of the screws 111 of the switch 85, and have wire connections thereto from the field circuit as shown in Fig. 13.

The cam 130 has a substantially flat or slightly concave chordal surface 136, centrally disposed with respect to the follower ends of the lever 130 in neutral position of the handle 100, with said ends engaging the high ends of said cam surface 136 as shown in Fig. 10. The remainder of the periphery of the cam 130 is of circular contour.

With the handle 100 in neutral position, contacts 92 and 93 will be spaced from the respective contacts 94 and 95 as shown in Figs. 10 and 13. Upon rotation of the shaft 106 as for instance in clockwise direction (Fig. 10) by operation of the handle 100, the corresponding clockwise rotation of the cam 130 causes the circular high portion thereof to ride past the follower end of the upper lever 133, so that said lever will re-

main almost stationary with the spring contact end 92 spaced from the opposed contact screw 94, while the cam surface 136 will ride past the follower end of the lower lever 133. Since the distance from the cam surface 136 to the axis of rotation of the cam 130 decreases progressively from the ends towards the center of said surface, this clockwise rotation of the cam 130 from the position shown in Fig. 10 causes the lower lever 133 to rotate counterclockwise under the resilient action of leaf spring 131, until the contact end 93 of said spring is in electrical contact with the contact screw 95. This will cause the field current to travel through the contacts 93 and 95 to one side of the field 80 for rotation of the motor in one predetermined direction. Similarly, rotation of the shaft 106 in the opposite counterclockwise direction from the neutral position shown in Fig. 10 will cause contacts 92 and 94 to close, while contacts 93 and 95 remain open, so that the field current traveling through the contacts 92 and 94 to the other side of the field 80 will cause rotation of the motor in the other direction.

The field reversing switch 91 shown in Fig. 11 is similar in construction to that of the switch 90, with the contacts 96 and 97 at the ends of the leaf spring 131*a*, co-operating with the screw contacts 98 and 99 respectively, a terminal screw 135*a*, mounted for lead-in connection to said spring, and the cam section 130*a* on the shaft 106, controlling operation of said spring contacts 96 and 97 through the instrumentality of the angular levers 133*a*, as already described with reference to the switch 90. This switch 91 is operated through the handle 100 in the manner already described to open contacts 96 and 98 and close contacts 97 and 99 or vice versa, in accordance with the desired direction of rotation of the corresponding motor.

In order to limit the travel of the gun during elevational maneuvering thereof, said gear 65 has secured near the opposite ends thereof by bolting or the like cams 140 and 141, and the shaft 106 of the elevating mechanism has affixed thereto a lever 142 with a roller 143 at its outer end in the path of circular travel of said cams. When the segmental gear 65 reaches one of its extreme positions, one of the cams 140 or 141 engaging the roller 143 will rotate the lever 142, and thereby force the handle 100*a* into neutral position or even into reverse position if the gun is moving fast enough. This lever and cam action is powerful enough to overcome any amount of hand pressure which may still be applied to the control handle.

Although the operation of the gun control mechanism has been suggested in the foregoing description, such operation will now be summarized.

When the gun control is inactive, the handles 100 and 100*a* will be in the neutral position shown in Fig. 1, and the armature and field circuits of the corresponding motors will be open as shown in Fig. 13. If it is desired to elevationally maneuver the gun, the handle 100*a* is moved angularly in one or the other direction from neutral position, according to whether it is desired to angularly depress or raise the gun. For instance, gun raising operations may be effected by clockwise rotation (Fig. 1) of the handle 100*a* from neutral position, and depressing operation, by counterclockwise rotation. This manipulation of the handle 100*a* closes the armature circuit through switch 85, and closes contacts 92 and 94 of switch 90, and contacts 96 and 98 of switch 91, while contacts 93, 95 and 97, 99 remain open, when the control handle 100*a* is moved to one side of its neutral position, and closes contacts 93, 95 of switch 90 and contacts 97, 99 of switch 91, while contacts 92, 94 and 96, 98 remain open, when the control handle is moved to the other side of its neutral position. The field circuit is thus closed and current flows therethrough in selective direction corresponding to the desired direction of rotation of the armature. The angular position of the handle 100*a* from its neutral position determines the pressure between the carbon piles of the rheostat 83, and correspondingly controls the speed of the motor. For instance, in the positions A of the handle as shown in dotted lines in Fig. 1, the motor 20*a* may be travelling at a speed which will cause just creeping elevational movement of the gun. In positions B of the handle, the gun may be moving at a slow speed, but nevertheless faster than the creeping speed indicated at A, and when the handle is at C, the gun may be travelling fast. When it is desired to reverse the direction of elevational maneuvering of the gun, the handle 100*a* is turned to the other side of its neutral position. This causes the reversal of the switches 90 and 91, so that the field current is reversed in the field 80, to cause the reversal of the motor 20*a*.

Selective traverse maneuvering is effected in the manner already indicated with respect to the elevation of the gun by manipulation of the handle 100. For instance, angular movement of the handle counter-clockwise (Fig. 1) from neutral position will cause left traverse operations of the gun, and clockwise will cause right traverse operations.

Both of the handles 100 and 100*a* are so positioned on one side of the gun mount, that they can be simultaneously manipulated conveniently by one person to effect simultaneous elevational and traverse movement of the gun. This gun movement is effected at selective rates from creeping to fast speed, so that a gun may be quickly and accurately aimed into desired shooting position, while the aircraft carrying it is moving at high speed, and while the target which may be another aircraft is also moving at high speed, and may rapidly without fatiguing manipulation be kept trained on this target by proper control of the handles 100 and 100*a*.

Although the present invention has particular adaptation to the control of machine guns on aircrafts, as far as certain aspects are concerned, it is adaptable for use in other types of guns in which the relative positions of the gun and the target change rapidly. For instance, certain aspects of the invention may be used in anti-aircraft or anti-tank guns.

As many changes could be made in the above construction, and many apparently widely different embodiments of this invention could be made without departing from the scope of the claims, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In combination with a gun mounting means for maneuvering the gun carried thereby to the desired shooting position including, a motor unit mounted on the mounting means on a horizontal axis, a gun mount traversing pinion directly con-

nected on said horizontal axis to said motor unit, and a reversible electric motor, a fixed crown gear in meshed relation with said traversing pinion, said unit further including a pivoted control handle on said gun mounting for controlling the operation of the electric motor in both directions of gun traverse, a second motor control unit on said gun mounting including a second reversible electric motor mounted with its axis vertical, elevating mechanism for the gun, gearing connecting said second motor to said elevating mechanism, said second unit including a second pivoted control handle on said gun mounting for controlling the operation of the said second electric motor in both directions, and electric means operated by each control handle for controlling the direction of rotation and the speed of each motor by its control handle.

2. In combination with a gun mounting, means for maneuvering the gun carried thereby to the desired shooting position including, a motor unit mounted on the mounting means on a horizontal axis, a gun mount traversing pinion directly connected on said horizotal axis to said motor unit, a reversible electric motor, a fixed crown gear in meshed relation with said traversing pinion, said unit further including a control handle on said gun mounting for controlling the operation of the electric motor in both directions, of gun traverse, a second motor control unit on said gun mounting including a second reversible electric motor mounted with its axis vertical, elevating mechanism for the gun, gearing connecting said second motor to said elevating mechanism, said second unit including a second control handle on said gun mounting for controlling the operatio of the said second electric motor in both directions, and electric means operated by each control handle for controlling the direction of rotation and the speed of each motor by its control handle.

3. In combination with a gun mounting, means for maneuvering the gun carried thereby to the desired shooting position including, a motor unit mounted on the mounting means on a horizontal axis, a gun mount traversing pinion directly connected on said horizontal axis to said motor unit, and a reversible electric motor, a fixed crown gear in meshed relation with said traversing pinion, said unit further including a manual control means on said gun mounting for controlling the operation of the electric motor in both directions of gun traverse, a second motor control unit on said gun mounting including a second reversible electric motor mounted with its axis vertical, elevating mechanism for the gun, gearing connecting said second motor to said elevating mechanism, said second unit including a second manual control means on said gun mounting for controlling the operation of said second electric motor in both directions, and electric means operated by each control means for controlling the direction of rotation and the speed of each motor by its control means.

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