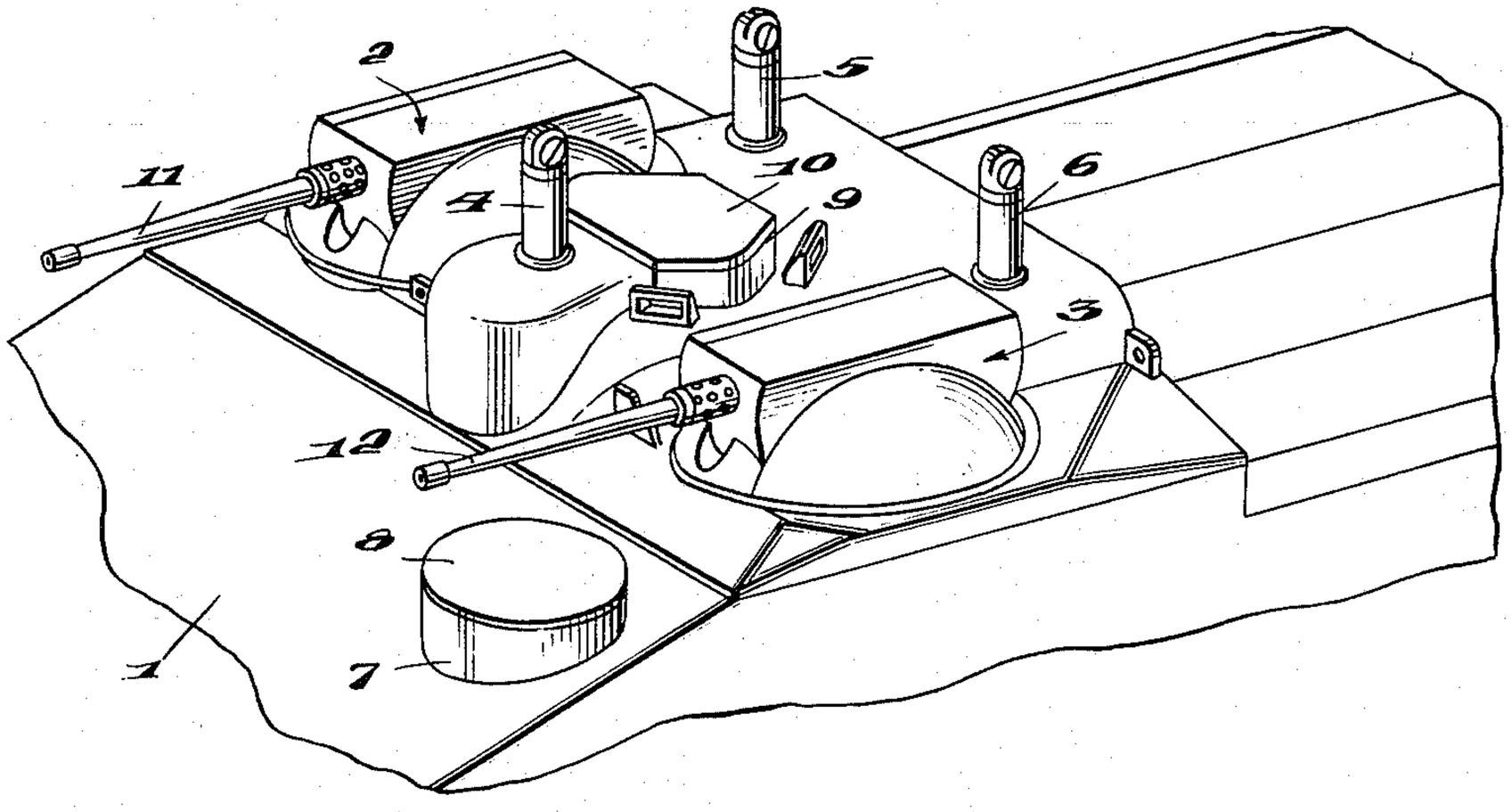
Feb. 17, 1953 D. D. TERWILLIGER ET AL 2,628,535

GUN CONTROL SYSTEM

Filed Nov. 15, 1949 3 Sheets-Sheet 1

Fig. 1.



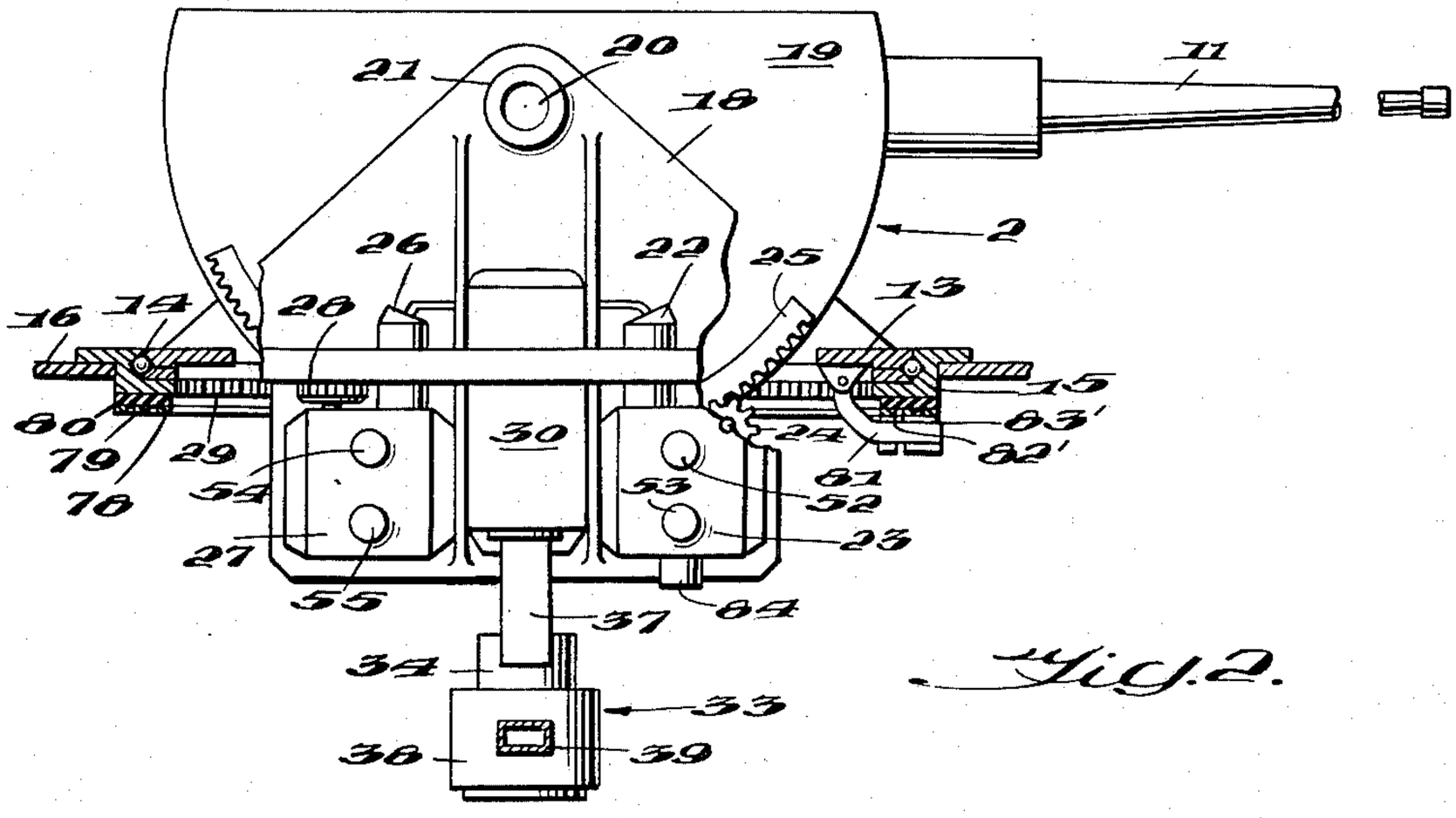


Fig. 2.

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Fig. 4.

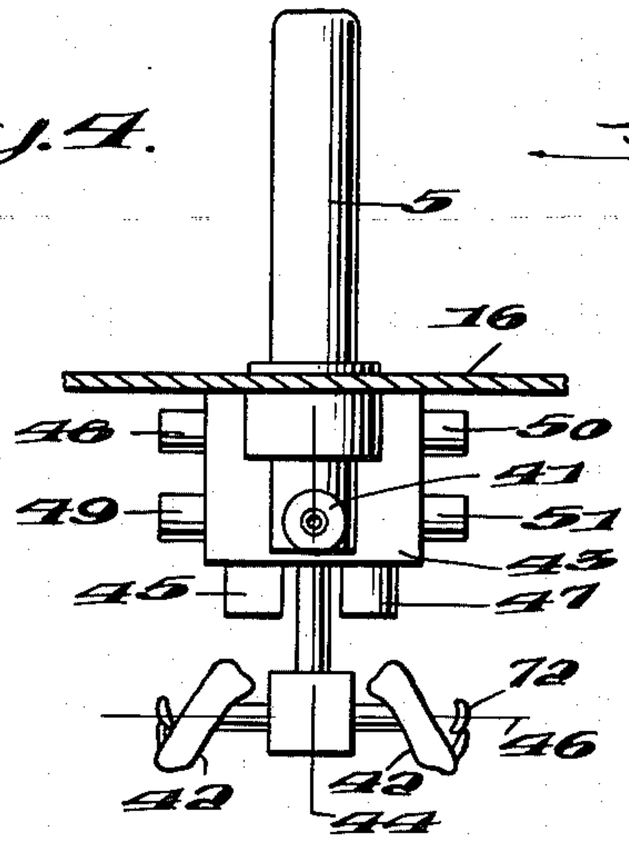
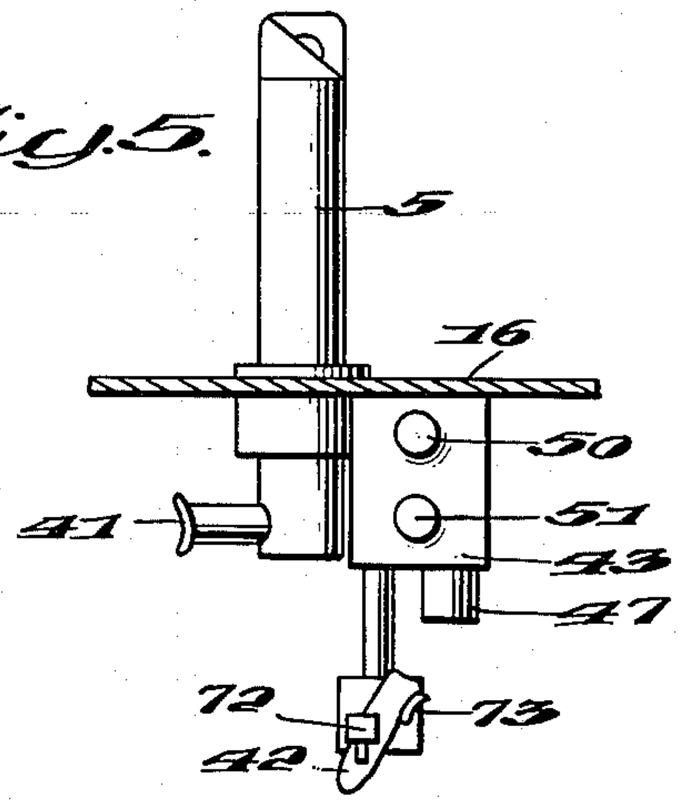


Fig. 5.



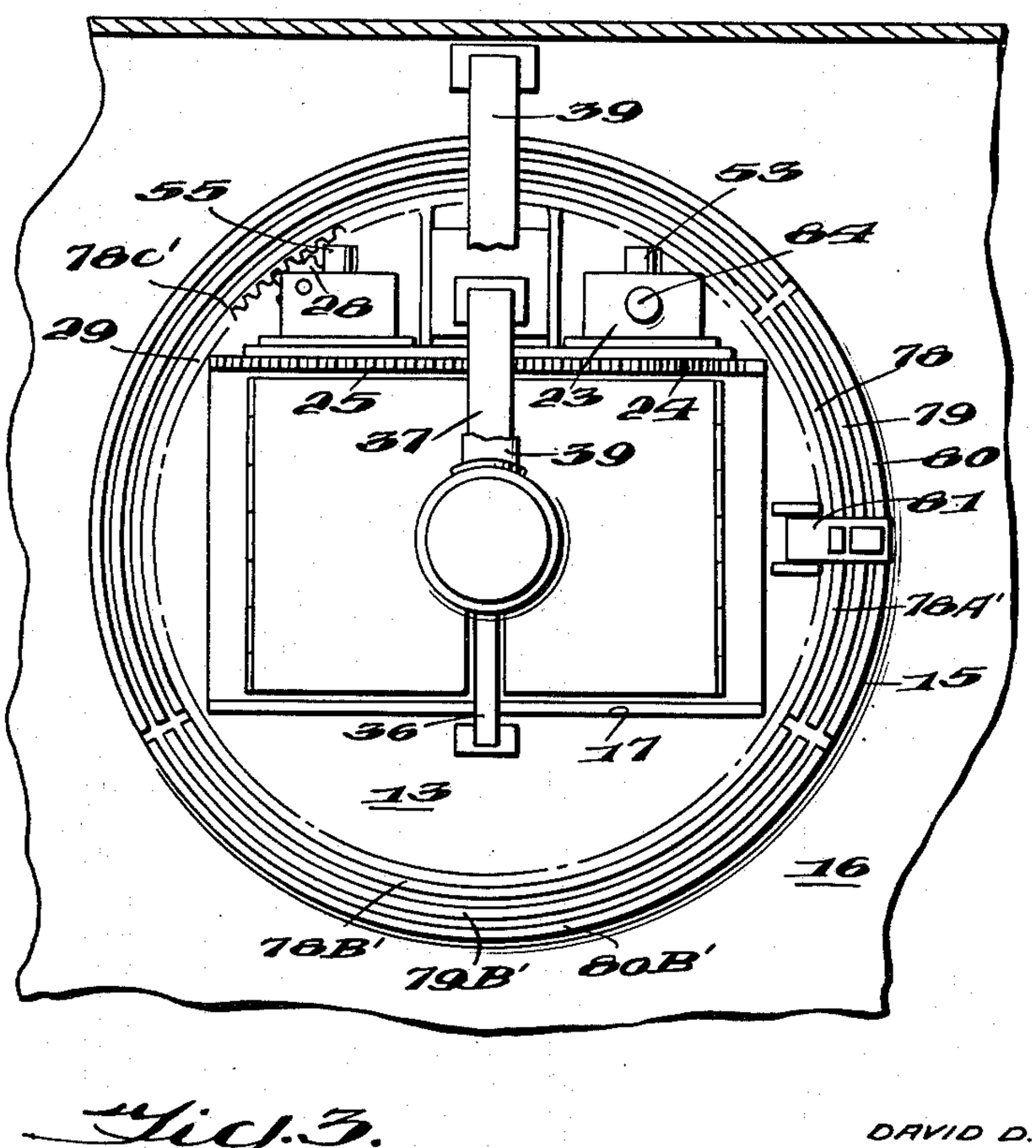


Fig. 3.

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GUN CONTROL SYSTEM

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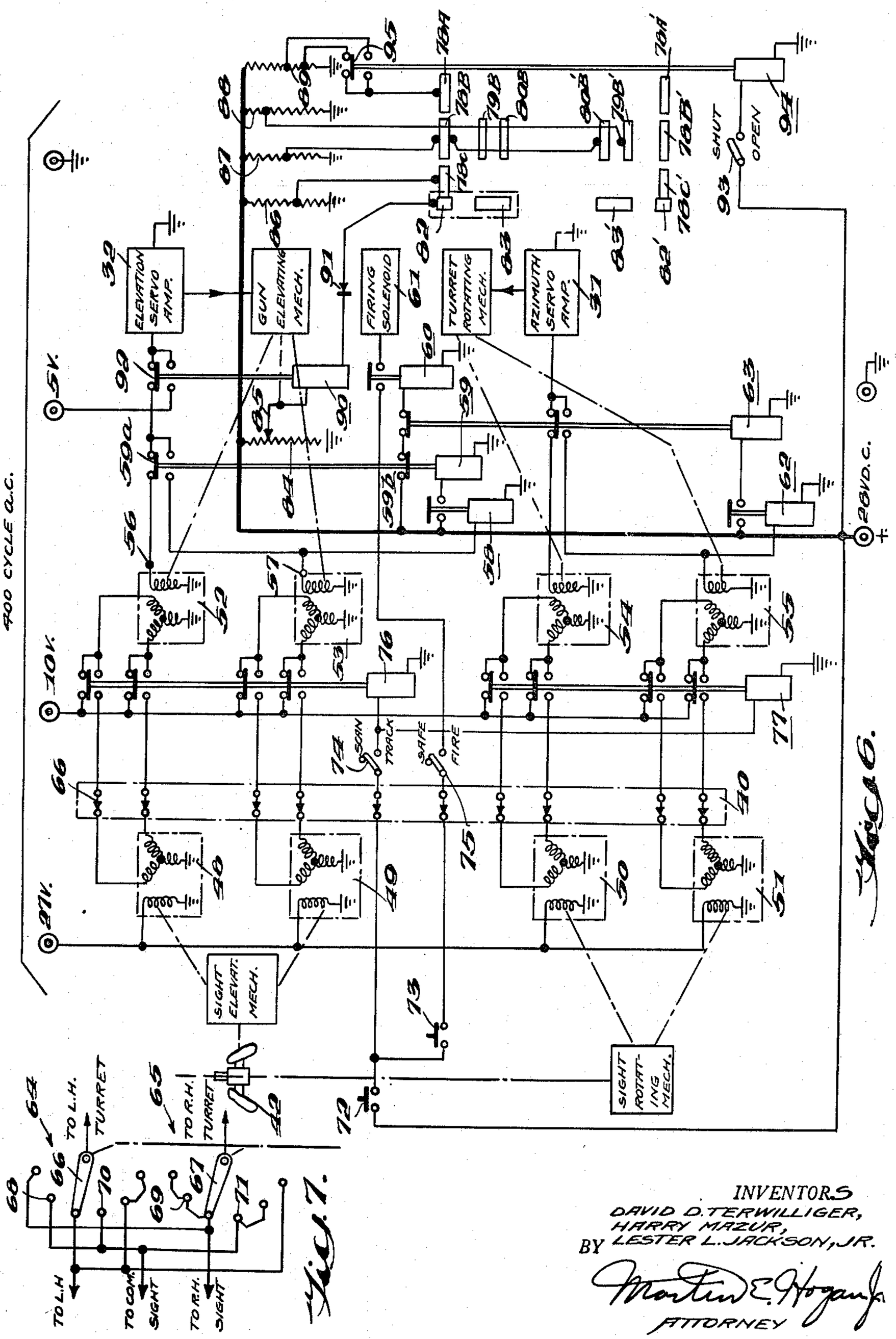

Fig. 6.

Fig. 7.

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2,628,535

GUN CONTROL SYSTEM

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Application November 15, 1949, Serial No. 127,382

14 Claims. (Cl. 89—41)

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This invention relates to an improved gun control system for controlling the direction and sighting of a flexibly mounted gun.

An object of this invention is to provide a gun control system wherein a sighting station is provided remotely from the gun mounting, and in which the gun may be made to follow closely movements of the sighting means.

Another object is to provide, in such a control system, for operation of the sighting means, independently of the gun, with the latter remaining in stowed position until desired, but wherein, at any time desired, the gun may be quickly moved to a position corresponding to that of the sight.

A further object is to provide an improved structural interrupter for preventing interference between the structure adjacent the gun mount and the gun itself.

A further object is to provide such a structural interrupter wherein relatively small and light electrical elements perform the necessary interruption functions.

A further object is to provide a structural interrupter readily changeable to accommodate a particular mounting.

A further object is to provide a gun control system wherein the gun will automatically return to a fixed stowage position whenever it is released from control by its associated sighting station.

A still further object is to provide a gun control system wherein the gun is able to be fired only so long as it is following closely movements of the sighting means.

Other and further objects will become apparent upon a reading of the following description and claims, especially when taken in view of the accompanying drawings.

In the drawings:

Figure 1 is a fragmentary perspective view of an armored vehicle provided with the gun control system of this invention;

Figure 2 is a fragmentary side view showing the arrangement of one of the gun turrets;

Figure 3 is a bottom plan view of said turret;

Figure 4 is a view looking forwardly at one of the sighting stations;

Figure 5 is a side view of the sighting station;

Figure 6 is a schematic diagram of the electrical control system; and

Figure 7 is a diagram of a portion of one of the switches shown in Figure 6.

Turning first to Figure 1, there is shown the upper portion of a military vehicle 1 provided with a pair of gun turrets 2, 3 and three sighting periscopes 4, 5 and 6. Just ahead of the left hand turret the upper surface of the vehicle is provided with a hatch 7 having a hatch cover 8 hinged thereto along its rear edge. Midway between the turrets a second hatch 9 is shown also having a cover 10 hinged thereto. Each of the turrets is provided with a gun 11, 12, each turret being rotatable about its vertical axis to position its gun in azimuth, and each gun being mounted in its turret for swinging about a horizontal axis transverse of the gun for positioning the gun in elevation.

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Figures 2 and 3 show the construction of one of the turrets, the other being substantially identical, except reversely arranged. The turret 2 includes a circular base plate 13 supported for rotation about its vertical axis by suitable anti-friction bearings 14 carried by a stationary supporting ring 15 rigidly connected to the top plate 16 of the vehicle.

The plate 13 is provided with a generally rectangular, centrally located opening 17 and along opposite sides of this opening are a pair of upstanding plates 18 of generally triangular shape. Pivotally supported between these plates 18 is a gun cradle assembly 19 of generally semi-cylindrical form, having trunnions 20 carried by suitable bearings 21 in the upper portion of plates 18. Gun 11 is rigidly carried by the cradle assembly, projecting outwardly as shown through the curved end wall thereof.

To elevate the gun about its transverse trunnion axis, a rotary hydraulic motor 22 is provided, which, through suitable gearing (not shown) within the housing 23, drives a pinion 24 meshing with an arcuate rack 25 on one side wall of the cradle assembly.

To rotate the gun and turret about the vertical turret axis, a second rotary hydraulic motor 26 is provided, which, through suitable gearing (not shown) within the housing 27, drives a pinion 28 meshing with a ring gear 29 formed on the supporting ring 15.

Motors 22 and 26 are adapted to be rotated in either direction and at any desired speed, and may be operated individually or simultaneously as the circumstances demand. Hydraulic fluid is supplied to the motors by an electrically controlled hydraulic transmission unit 30 carried, as shown, on the turret between the housings 23 and 27.

This transmission unit 30 is of the type well known in the art and no detailed description is deemed necessary. Suffice it to say that the unit is arranged to control the direction and rate of flow of hydraulic fluid to either motor in substan-

tially direct proportion to the phase relationship and potential of a control voltage applied thereto. The control voltage for controlling fluid flow to the turret rotating motor **26** is obtained from the azimuth servo-amplifier **31** shown in the electrical diagram, Figure 6. That for controlling fluid flow to the gun elevating motor **22** is obtained from the elevation servo-amplifier **32** also shown in the electrical diagram.

Electrical connections between the turret and the associated control and generating apparatus carried within the vehicle include a slip ring assembly **33** arranged below and coaxial with the turret. The slip ring assembly includes an inner contact ring assembly **34** rigidly supported from the turret by suitable bracket arms **36** and **37**. The slip ring assembly further includes an outer brush holder **38** having brushes (not shown) therein for electrically contacting the individual contact rings of assembly **34**. Holder **38** is fixedly supported from the interior of the vehicle by a bracket arm **39**. The various electrical leads to the brushes may be housed within this arm **39** while those to the slip rings may be housed within arm **37**.

Figures 4 and 5 show, somewhat diagrammatically, one of the periscope sighting and control stations. The periscope **5** is arranged to project upwardly through the top wall **16** of the vehicle and is of the known type wherein the eyepiece **41** remains stationary as the optical system rotates to vary the line of sight. A pair of hand grips **42** is mounted from the periscope drive and control housing **43** so that they may be moved about a vertical axis **44** to energize the periscope azimuth drive motor **45** to shift the line of sight in azimuth, and may be rocked about horizontal axis **46** to energize the periscope elevation drive motor **47** to shift the line of sight in elevation. The details of this sight control system are quite conventional and well known in the gun control art and form no part of the present invention.

A selsyn system is provided for causing the gun to follow the movements of the particular sight then in control thereof. Mounted on the sight drive housing **43** are four selsyn generators **48, 49, 50** and **51**. Selsyn **48** has its rotor geared to the sight elevating mechanism so that it rotates at a rate 27 times as fast as the sight elevates. Selsyn **49** is also geared to the sight elevating mechanism, but at a 1:1 ratio. Selsyns **50** and **51** are similarly geared to the sight rotating mechanism at 27:1 and 1:1 ratios, respectively.

Mounted on the gun elevation drive housing **23** are a pair of selsyns **52** and **53** having their rotors geared to the gun elevating mechanism in 27:1 and 1:1 ratios, respectively, and on the turret rotating drive housing **27**, a pair of selsyns **54** and **55** are mounted, also driven in 27:1 and 1:1 ratio with the turret. The various related pairs of selsyns are electrically connected through a master selector switch **40**, as shown in Figure 6, so that whenever the gun is out of step with its sight, in elevation, for example, control voltages of phase and magnitude corresponding to the relative direction and amount of mis-alignment will appear at the output terminals **56** and **57** of the selsyns **54** and **55**. Normally the control voltages from the 27:1 selsyns will be applied to the elevation and azimuth servo-amplifiers to cause the latter to so control the transmission **30** as to actuate the elevation and azimuth motors **22** and **23** in such a direction and at such a speed as to correct the mis-alignment.

If, however, the mis-alignment exceeds some predetermined amount, means is provided for switching the control to the 1:1 selsyn system to insure against losing control of the gun. At the same time the gun firing circuit is made inoperative. To obtain these results, a sensitive error-detecting relay **58** is connected to the control voltage output terminal **57** of the 1:1 selsyn **55**, and is adapted to be energized whenever this voltage reaches a value corresponding to an error of the predetermined magnitude. Energization of relay **58** causes energization of selsyn selector relay **59** which breaks the control connection **59***a* between the 27:1 selsyn **54** and the elevation servo-amplifier **32** and makes connection between the 1:1 selsyn **55** and the servo-amplifier. At the same time contacts **59***b* on relay **59** open the circuit to firing control relay **60**, preventing operation of the firing solenoid **61** until such time as control is returned to the 27:1 selsyn system.

A similar error-detecting relay **62** and selsyn selector relay **63** are provided in the azimuth control system for the same purposes.

Turrets **2** and **3** are adapted to be controlled, either individually or collectively from any of the periscope sighting stations. Master switch **40**, as shown in Figures 6 and 7, is provided to select which of the control and sighting stations is to control which turret. No attempt is made to show this switch in detail in Figure 6 since it would unnecessarily complicate the wiring diagram. Suffice it to say that the switch comprises a plurality of 6-position, single-pole sections adapted to be actuated simultaneously. Two sections, one for each turret, are used for each of the control circuits. Thus the uppermost portion of switch **40** shown in Figure 6 would actually comprise two sections **64** and **65** connected to the sighting stations and to the turrets as shown in Figure 7. With the switch arms **66** and **67** set as shown in Figure 7 the left hand turret **3** would be under the control of the left hand periscope sighting station **6** while the right hand turret **2** would be under the control of the right hand sighting station **5**. This is the switch position assumed in Figure 6, wherein only those switch sections and contacts actually used to connect the left hand turret **3** to the left hand periscope station **6** have been illustrated.

Note that, if the switch arms **66** and **67** are moved to the position wherein they engage with contacts **68** and **69** respectively the control of left hand gun **3** will be switched to the commander's sighting station **4** while gun **2** will remain under the control of the right hand sighting station **5**. If the switch arms are moved to contacts **70** and **71** the control of both guns will be from the comander's sighting station, etc.

Each of the grips on the sighting device is provided with an acquisition switch **72** and a trigger switch **73**. Adjacent the master switch **40** at the master control station are provided a Scan-Track switch **74** and a Safe-Fire switch **75** for each turret.

As shown in Figure 6, acquisition switch **72** and Scan-Tract switch **74** are arranged in series relation to control a pair of stowage relays **76** and **77**. Stowage relays **76** and **77** are adapted, when deenergized (as shown in Figure 6) to disconnect the sight and turret selsyns from one another so that actuation of the sight will not cause movement of the gun. Moreover in this deenergized condition, the stowage relays **76** and **77** apply an

A.-C. potential of fixed value (10 v.) to two of the stator windings of the turret selsyns. Under these conditions there will be a single, definite position of each of the turret selysn rotors where no voltage will appear at its output terminal. The turret selsyns are so oriented with the turret drive mechanism that these positions of the various rotors correspond to the desired stowage position of the gun shown in Figure 1 for example. Thus, whenever the operator releases the acquisition switch 72 or the commander throws the switch 74 from Track to Scan, the gun will automatically and quickly return from whatever position it may be in at the time, to its stowed position.

If, while scanning, the operator sights a target (assuming that switch 74 is in Track position) he need merely press switch 64 to energize relays 76 and 77 to restore the selsyn circuits between the sight and the turret, whereupon the gun will quickly swing into step with the sight. This arrangement is especially desirable as it permits continuous scanning without requiring the relatively large drain on the electrical system that is involved when the turret is being operated. Yet at the mere pressing of a switch, the gun will swing to the desired firing position.

Trigger switch 73 and Safe-Fire switch 75 are connected in series relation between acquisition switch 72 and the firing solenoid 61, so that the gun can be fired only when all three switches are closed at the same time.

As is obvious from Figure 1, the minimum elevation angle at which either gun may be safely fired will vary with its position in azimuth, and also will be affected by the position of other movable structure on the vehicle. For example, with hatch cover 8 closed, the gun 12, when directed forwardly, can be depressed below the horizontal position and still clear the vehicle, while with the hatch cover open, the gun cannot be lowered even to the horizontal position without interference. There is, therefore, for each sector of space about a turret, a particular limiting clearance angle below which the gun may not be safely fired, and, if there is movable structure within a particular zone, another limiting angle, at times effective, depending on the position of the movable structure.

A structural interrupter system is therefore incorporated in the control system to automatically prevent lowering of a gun to a position which might cause interference. The interrupter of this invention operates electrically and includes a commutator assembly including a plurality of comutator rings 78, 79 and 80 suitably attached to and insulated from the under side of the stationary supporting ring 15 as shown in Figures 2 and 3. Each commutator ring is formed from a plurality of commutator segments, insulated from one another, and each corresponding to a particular zone of space about the turret. The space may be thus divided into as many zones as is deemed desirable; obviously the more segments that are employed, the more closely can the guns be made to follow the structural profile of the vehicle. To avoid unnecessary confusion, however, each commutator ring is shown in the drawing as being formed of but three segments 78A, 78B, 78C, etc., dividing the space about the turret into a forward zone, a gun-to-gun zone (wherein the gun of one turret is aimed generally across the vehicle and over the other turret) and a remaining zone, to the rear and adjacent side of the vehicle.

Carried by the base plate 13 of the turret is a brush holder 81 carrying a contact brush 82, adapted to contact the inner commutator ring 78, and a brush 83 adapted to bridge across commutator rings 79 and 80 as clearly shown in Figure 2. Suitable springs, not shown, bias the brushes into continuous contact with the associated rings.

Turning to Figure 6, the commutator segments 78A, 78B, 78C, etc. for turret 3 are shown associated with the remaining elements of the interrupter system for that turret.

The corresponding segments for the other turret are also shown, being identified by similar numbers primed.

The commutator system is basically a resistance bridge network, so arranged that whenever the gun starts to move below a critical angle for any particular sector, the bridge will be thrown out of balance in such a sense as to energize an interrupter relay, which, in turn will remove the gun elevating mechanism from control by the sight and apply a voltage of proper phase to make the gun immediately move upwardly into a safe firing position. More specifically, the bridge network includes a potentiometer 84, mounted on and geared to the gun elevating mechanism (see Figures 2 and 3), so that its movable contact will move in synchronism with the gun. This potentiometer is connected directly between the 28 v. D. C. line and ground so that the potential of its movable contact 85 will always correspond to the angular position of the gun in elevation.

Also connected between the 28 v. D. C. line and ground is a plurality of tapped resistors 86, 87, 88, 89, the number of which will vary with the number of zones and the number of different limiting angles desired for a particular installation. The taps from these resistors are electrically connected to the various commutator segments as shown in Figure 6. Connected between brush 82 and movable contact 85 of the elevation potentiometer is an interrupter relay 90, in series with a rectifier 91 so polarized that whenever the potential of brush 82 is greater than that of contact 85, interrupter relay 90 will be energized. The tap on resistor 86 is so positioned that its potential corresponds to the minimum elevation angle for the gun to clear all structure within the rear and side zone corresponding to segment 78C.

Thus with the gun positioned in this particular zone, as long as the gun is aimed above this minimum clearance angle, relay 90 will be deenergized, but as soon as the gun is moved to a position below this clearance angle, the relay will be energized to open the normal elevation control circuit at 92 and to connect the elevation servo-amplifier to an A.-C. voltage of proper phase and magnitude to cause the servo-amplifier to control the gun elevating mechanism to elevate the gun.

Where movable structure on the vehicle is located within a particular zone, automatic selection of two or more different clearance angles may be desired, depending upon the position of the movable structure at that particular time.

Thus when the gun is aimed across the vehicle, not only must safe gun fire clearance be provided, but physical interference with the other turret or gun must also be avoided. The latter problem is most severe when both guns are aimed across the vehicle, or in other words, when both guns are in their gun-to-gun sectors corresponding to segments B, B′ of their commutators. Tapped

resistor 87 is connected to segment 78B to act, just as does resistor 86, to determine the limiting fire clearance angle for gun 12 of turret 3, while in its gun-to-gun sector, at all times except when the other gun 11 is also in its gun-to-gun zone. When this latter condition prevails, a higher clearance angle is obviously necessary and the following apparatus is provided to apply a correspondingly higher voltage to segment 78B.

As shown in Figure 6, the gun-to-gun segment 80B' for turret 2 is electrically connected to segment 78B of turret 3. Segment 79B' is connected to a relatively high potential tap on resistor 88. Thus whenever turret 2 is in its gun-to-gun zone its brush 83' will bridge contacts 79B' and 80B' and the potential of segment 78B will be raised to some value intermediate that corresponding to the taps on resistors 87 and 88. Thus brush 82 will be at a higher potential than if turret 2 were in some other zone, and the interrupter relay 90 will be energized at a correspondingly higher elevation angle of the gun.

When the gun is in its forward zone its safe clearance angle will vary with the position of hatch cover 6. In this case a hatch switch 93 is provided, being arranged for actuation by the hatch cover, for energizing or deenergizing a hatch relay 94, which in turn selects which of two taps on resistor 89 will be electrically connected to front segment 78A. When the hatch cover is shut, the switch 93 will be open and the relay 94 will be deenergized as shown in Figure 6 so that the low-voltage tap corresponding to a low clearance angle of the gun will be effective. When the hatch cover is opened, relay 94 will be energized, switching its contacts 95 to the high voltage tap on resistor 89, corresponding to a higher clearance angle.

Operation

While the operation of the above described Control System is believed to be fairly obvious, typical operation under certain assumed conditions may be as follows:

For example, assume that the armored vehicle is traveling along with no enemy target in sight, any or all of the periscope sighting stations will be available for scanning purposes, while the guns will be in their stowed position. Under such conditions, the Track-Scan switches for the two turrets will be set in their Scan positions. If an enemy is sighted, say to the left of the vehicle, the commander will set the selector switch 40 to whatever position appears desirable for most effective counter action—in this case, probably to the position giving the left hand sighting station 6 control over both guns. He will also set the Track-Scan switches for both turrets to their Track position. The operator of the left hand sighting station may then, by appropriate manipulation of his control grips, follow the movements of the target and, as it approaches firing range, will depress the acquisition switch on the control grips. This will energize the stowage relays 76 and 77 for both guns, and the guns will quickly swing into a position corresponding to the line of sight of the periscope and will thereafter continue to track with the sight. Firing of both guns may be obtained by merely pressing the trigger switch on the grips whenever the operator deems it desirable.

Meanwhile, the right hand gunner, and possibly the commander, will continue to operate their sighting periscopes to scan about the vehicle. If another enemy is sighted in a different zone, the commander will set the selector switch 40 to the position giving himself, or the right hand gunner, control over the right hand turret, while leaving the left hand gun under the control of the left hand gunner. Under these conditions each gun will track its respective sighting station entirely independently of the other.

If the target for a particular turret moves into a position wherein the gun could not be safely fired without danger of striking part of the vehicle structure, the interrupter relay 90 for that particular turret will be energized as previously described to maintain the gun above the critical elevation angle for that particular zone. The operator, however, may continue to follow the target both in azimuth and elevation with his sight. However, as soon as the sight is depressed below the critical angle, a misalignment between the gun and the sight will obtain, causing a voltage of sufficient potential to appear at the output of the 1:1 elevation selsyn 55, for that particular gun, to energize the elevation error-detecting relay 58. Relay 58 in turn will energize the selsyn selector relay 59 to open the firing circuit for that gun and to switch control from the 27:1 to the 1:1 selsyn system to prevent losing control of the gun in elevation. However the gun will remain under the control of the 27:1 azimuth selsyn system and will therefore continue to follow the movements of the sight in azimuth. As soon as the target has moved to a position wherein it is again above the critical angle, the gun will again swing into alignment with the sight and the error-detecting relay 58 will drop out, restoring control of the gun to the 27:1 system and again permitting firing of the gun.

In the event that the ammunition supply is exhausted for either gun, the operator need merely release the acquisition switch which will in turn deenergize the stowage relays, and the gun will immediately swing to stowage position wherein it can be readily serviced. The operator meanwhile can continue to track the target and as soon as the gun is reloaded will have merely to again press the acquisition switch to cause the gun to once more swing into line with the sight.

While in the disclosed device but three segments were shown in each commutator ring, it is obvious that any number of segments could be employed, depending upon how closely it was desired that the interrupter pattern follow the contour of the vehicle. Obviously, also, vacuum or gas "trigger" tubes could be used in place of certain of the relays, they being well known equivalents.

While the vehicle is shown as being provided with but three sighting stations and two turrets, the principles involved are clearly applicable to any desired number of sighting stations or turrets.

Many other modifications could obviously be made without departing from the spirit and scope of the appended claims.

We claim as our invention:

1. A gun control system for a vehicle having a turret mounted thereon for rotation in azimuth about a generally vertical axis and a gun pivotally carried by said turret for angular adjustment in elevation, power means for rotating said turret and for swinging said gun in elevation whereby said gun has a field of fire coverage over a predetermined sector of space about said turret, control means normally controlling the operation of said power means for pointing said gun in any desired direction within said sector, said vehicle including structure normally projecting into said

field of five coverage, means for effectively dividing the space about said turret axis into individual zones and comprising a commutator assembly including a plurality of commutator segments corresponding to said zones and contact means movable relative to said commutator segments in accordance with movement of said turret about its axis and adapted to electrically contact said individual segments, a source of electrical potential, means connecting each of said segments to said source whereby to apply a voltage to each segment proportional to the minimum angular position of elevation of said gun necessary to clear such of said structure as lies within the zone corresponding to that particular segment, means operatively connected to said gun and to said source and having a voltage output terminal the potential of which varies in accordance with the angle of elevation of said gun and means connected to said contact means and to said output terminal and responsive to a predetermined difference in potential therebetween to cause said control means to be made ineffective to cause movement of said gun beyond said clearance angle.

2. A gun control system for a vehicle having a turret mounted thereon for rotation in azimuth about a generally vertical axis and a gun pivotally carried by said turret for angular adjustment in elevation, power means for rotating said turret and for swinging said gun in elevation whereby said gun has a field of fire coverage over a predetermined sector of space about said turret, control means normally controlling the operation of said power means for pointing said gun in any desired direction within said sector, said vehicle including structure normally projecting into said field of fire coverage, means for effectively dividing the space about said turret axis into individual zones and comprising a commutator assembly including a plurality of commutator segments corresponding to said zones and contact means movable relative to said commutator segments in accordance with movement of said turret about its axis and adapted to electrically contact said individual segments, a source of electrical potential, means connecting each of said segments to said source whereby to apply a voltage to each segment proportional to the minimum angular position of elevation of said gun necessary to clear such of said structure as lies within the zone corresponding to that particular segment, means operatively connected to said gun and to said source and having a voltage output terminal the potential of which varies in accordance with the angle of elevation of said gun, and means connected to said contact means and to said output terminal and responsive to a predetermined difference in potential therebetween to cause said control means to be made ineffective to cause movement of said gun beyond said clearance angle, certain of said structure being movable relative to said vehicle between positions requiring different clearance angles, and means responsive to movement of said certain structure to said different positions to cause corresponding changes in the potential applied to the segment corresponding to that zone within which said certain structure lies.

3. A gun control system for a gun mounted for angular adjustment about substantially perpendicularly related axes, power means for swinging said gun about said axes whereby said gun has a field of fire coverage over a predetermined sector of space about said gun, control means

normally controlling the operation of said power means for pointing said gun in any desired direction within said sector, structure normally projecting into said field of fire coverage, means for effectively dividing the space about said gun into individual zones and comprising a commutator assembly carried by the unit and including a plurality of commutator segments corresponding to said zones and contact means movable relative to said segments in accordance with movement of said gun about a first of said axes and adapted to electrically contact said individual segments, a source of electrical potential, means connecting each of said segments to said source whereby to apply a voltage to each segment proportional to the minimum angular position of said gun about the other of said axes necessary to clear such of said structure as lies within the zone corresponding to that particular segment, means operatively connected to said gun and to said source and having a voltage output terminal the potential of which varies in accordance with the angular position of said gun about said other axis, and means connected to said contact means and to said output terminal and responsive to the difference in potential therebetween to render said control means ineffective to cause movement of said gun to an angular position about said second axis less than said minimum clearance angle.

4. A gun control system for a gun mounted for angular adjustment about substantially perpendicularly related axes, power means for swinging said gun about said axes whereby said gun has a field of fire coverage over a predetermined sector of space about said gun, control means normally controlling the operation of said power means for pointing said gun in any desired direction within said sector, structure normally projecting into said field of fire coverage, zoning means effectively dividing the space about said first axis into zones and responsive to the position of said gun in a particular zone to produce an output voltage substantially proportional to the minimum angular position of said gun about the second of said axes necessary to clear such of said structure as lies within that particular zone, gun position means connected to said gun and adapted to produce an output voltage proportional to the angular position of said gun about said second axis, and means connected to said zoning means and to said gun position means and responsive to the difference in potential between said output voltages to render said normal control means ineffective to cause movement of said gun below said clearance angle.

5. A gun control system for a gun mounted for angular adjustment about substantially perpendicularly related axes, power means for swinging said gun about said axes whereby said gun has a field of fire coverage over a predetermined sector of space about said gun, control means normally controlling the operation of said power means for pointing said gun in any desired direction within said sector, structure normally projecting into said field of fire coverage, zoning means effectively dividing the space about said first axis into zones and responsive to the position of said gun in a particular zone to produce an output voltage substantially proportional to the minimum angular position of said gun about the second of said axes necessary to clear such of said structure as lies within that particular zone, gun position means connected to said gun and adapted to produce an output voltage proportional to the angu-

lar position of said gun about said second axis, and means connected to said zoning means and to said gun position means and responsive to the difference in potential between said output voltages to render said normal control means ineffective to cause movement of said gun below said clearance angle, certain of said structure being movable relative to said gun between positions requiring different clearance angles, and means responsive to movement of said certain structure to said different positions to cause corresponding changes in the output voltage of said zoning means for that zone within which said certain structure lies.

6. A gun control system for a gun mounted for pivotal movement about perpendicularly related axes, power means for swinging said gun about said axes, control means normally controlling said power means for pointing said gun in any desired direction about said axes, means responsive to the position of said gun about a first of said axes for producing an output voltage substantially proportional to a desired clearance angle of said gun about the second of said axes, means responsive to the angular position of said gun about said second axis for producing an output voltage substantially proportional to the angular position of the gun about said second axis, and interrupter means responsive to said output voltages for rendering said normal control means ineffective to control movement of said gun about said second axis whenever a predetermined one of said output voltages exceeds the other.

7. A gun control system for a gun mounted for pivotal movement about perpendicularly related axes, power means for swinging said gun about said axes, control means normally controlling said power means for pointing said gun in any desired direction about said axes, means responsive to the position of said gun about a first of said axes for producing an output voltage substantially proportional to a desired clearance angle of said gun about the second of said axes, means responsive to the angular position of said gun about said second axis for producing an output voltage substantially proportional to the angular position of the gun about said second axis, interrupter means responsive to said output voltages for rendering said normal control means ineffective to control movement of said gun about said second axis whenever a predetermined one of said output voltages exceeds the other, and means responsive to operation of said interrupter means for causing said power means to move said gun about said second axis to a position wherein said output voltages are substantially equal.

8. In a gun control system for a gun mounted for movement about an axis, control means for said gun including a sighting mechanism having means for shifting the line of sight about a corresponding axis, means for causing said gun to follow movements of said sighting mechanism including a plurality of sets of selsyn mechanisms, each set including a pair of interconnected selsyns, having their rotors connected to said sighting mechanism and said gun respectively for movement at a predetermined low ratio relative thereto, and a second pair of interconnected selsyns having their rotors connected to the sighting mechanism and to the gun respectively for movement at a predetermined higher ratio relative thereto, servo-means normally responsive to the voltage across the rotor of said high-ratio gun selsyn for controlling movement of said gun,

selector means responsive to a predetermined voltage across the rotor of said low-ratio gun selsyn for switching control of said servo-means from said high-ratio to said low-ratio gun selsyn, means for causing firing of said gun and means responsive to such actuation of said selector means for rendering inoperative said firing means.

9. In a gun control system for a gun mounted for pivotal movement about an axis, control means for said gun including sighting means having means for shifting the line of sight about a corresponding axis, means for causing said gun to follow movements of said sighting means including high-ratio and low-ratio selsyn systems interconnecting said sighting means and said gun, and servo-mechanism normally responsive to the output of said high-ratio selsyn system for controlling movement of said gun, means responsive to a predetermined angular misalignment between said line of sight and said gun for switching control of said servo-mechanism from said high-ratio to said low-ratio selsyn system, means for firing said gun, and fire interrupting means responsive to operation of said switching means for rendering inoperative said firing means.

10. In a gun control system for a gun mounted for pivotal movement about an axis, control means for said gun, power means for moving said gun, a selsyn system normally responsive to said control means and connecting said control means to said power means, said power means being normally responsive to the output voltage of said selsyn system to cause said gun to follow the movements of said control means, a switch, and means responsive to actuation of said switch for breaking the connection between said power means and said control means through said selsyn system and for applying a predetermined voltage to said power means, whereby said gun moving means will cause said gun to move to a predetermined stowage position corresponding to said predetermined output voltage.

11. A gun control system for a gun mounted for pivotal movement about perpendicularly related axes, power means for swinging said gun about said axes, control means normally controlling said power means for pointing said gun in any desired direction about said axes, means responsive to the position of said gun about a first of said axes for producing an output voltage substantially proportional to a desired clearance angle of said gun about the second of said axes, means responsive to the angular position of said gun about said second axis for producing an output voltage substantially proportional to the angular position of the gun about said second axis, and interrupter means responsive to said output voltages for rendering said normal control means ineffective to control movement of said gun about said second axis whenever a predetermined one of said output voltage exceeds the other, said normal control means including a sighting mechanism having means for shifting the line of sight about corresponding axes, means for causing firing of said gun, and means responsive to operation of said sighting mechanism to shift the line of sight a predetermined amount beyond said clearance angle for rendering said firing means inoperative.

12. A gun control system for a gun mounted for movement about perpendicularly related axes comprising, sighting mechanism including means for shifting the line of sight about corresponding axes, control means responsive to said sighting

mechanism for normally causing said gun to follow movements of said sighting mechanism, means for rendering said control means ineffective to cause movement of said gun about either axis whereby said sight may be operated independently of the gun, structural interrupter means responsive to movement of the gun about one of said axes beyond a predetermined angle for also making said control means ineffective to cause movement of said gun about said one axis while retaining control of said gun about the other axis, means for causing firing of said guns, and means responsive to a predetermined degree of misalignment between said sighting means and said gun for rendering said firing means inoperative.

13. In combination with a vehicle, a turret mounted for rotation in azimuth about a generally vertical axis, a gun pivotally carried by said turret for angular adjustment in elevation, power means for rotating said turret and for swinging said gun in elevation whereby said gun has a field of fire coverage over a predetermined sector of space about said turret, control means normally controlling the operation of said power means for pointing said gun in any desired direction within said sector, said vehicle including structure normally projecting into said field of fire coverage, means for dividing said sector into zones including a commutator ring comprising a plurality of segments each corresponding to a zone of said sector, contact means rotatable with said turret, and means controlled by said segments and said contact means for making said control means inoperative to cause depression of said gun below a predetermined angle for any particular segment.

14. In combination with a vehicle, a turret mounted for rotation in azimuth about a generally vertical axis, a gun pivotally carried by said turret for angular adjustment in elevation, power means for rotating said turret and for swinging said gun in elevation whereby said gun has a field of fire coverage over a predetermined sector of space about said turret, control means normally controlling the operation of said power means for pointing said gun in any desired direction within said sector, said vehicle including structure normally projecting into said field of fire coverage, means for dividing said sector into zones including a commutator ring comprising a plurality of segments each corresponding to a zone of said sector, contact means rotatable with said turret, a source of voltage of predetermined potential connected to each individual segment, elevation-responsive means connected to the gun for producing a second voltage having a potential which varies in generally direct relation to the elevation of the gun, and means connected between said contact means and said elevation-responsive means and responsive to said voltages to limit further movement of the gun in one direction whenever a predetermined one of said voltages exceeds the other.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,408,070	Hull et al.	Sept. 24, 1946
2,415,967	Pontius	Feb. 18, 1947

FOREIGN PATENTS

Number	Country	Date
609,306	Great Britain	Sept. 29, 1948