Jan. 12, 1960 H. E. HELM 2,920,531

AUTOMATIC INDEXING DEVICE

Filed April 24, 1957 3 Sheets-Sheet 1

Fig. 1.

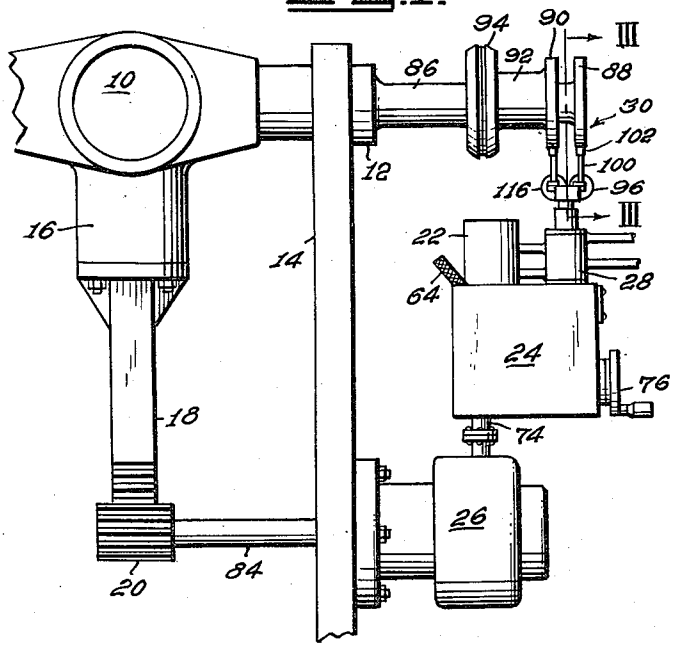
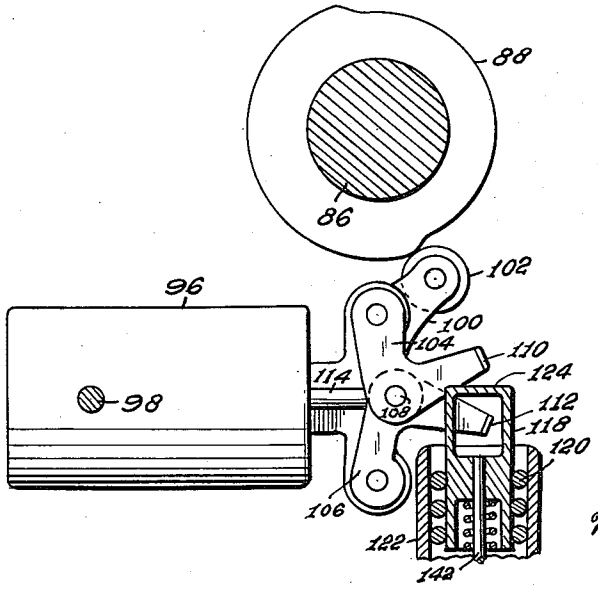


Fig. 3.



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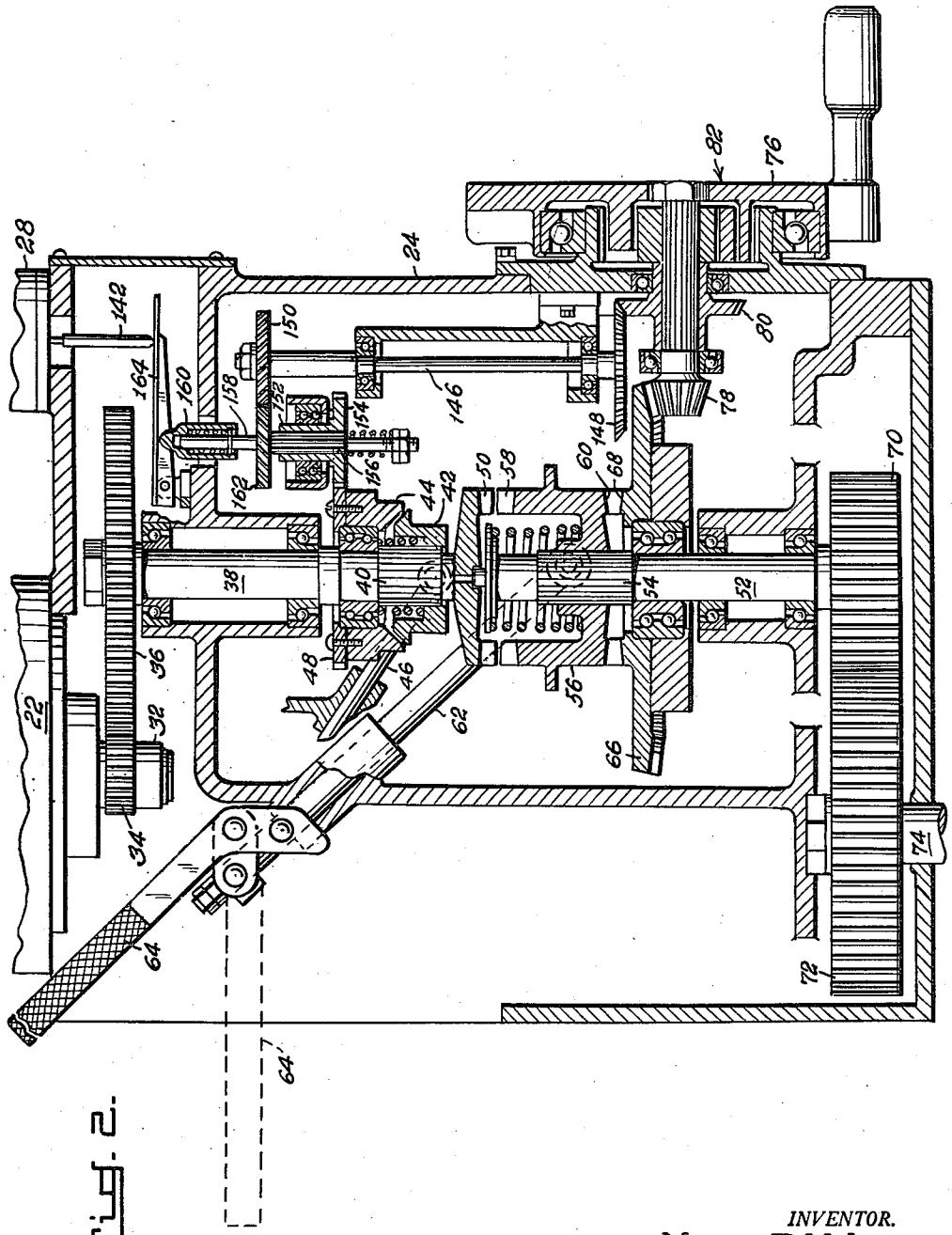


Fig. 2.

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AUTOMATIC INDEXING DEVICE

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Fig. 4.

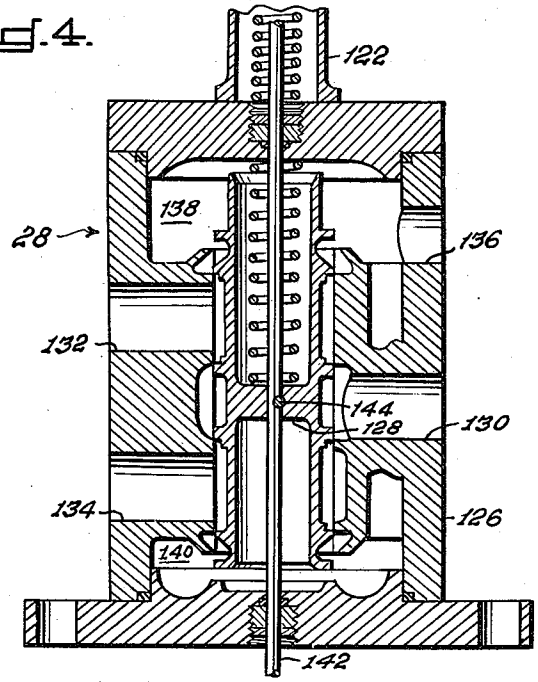
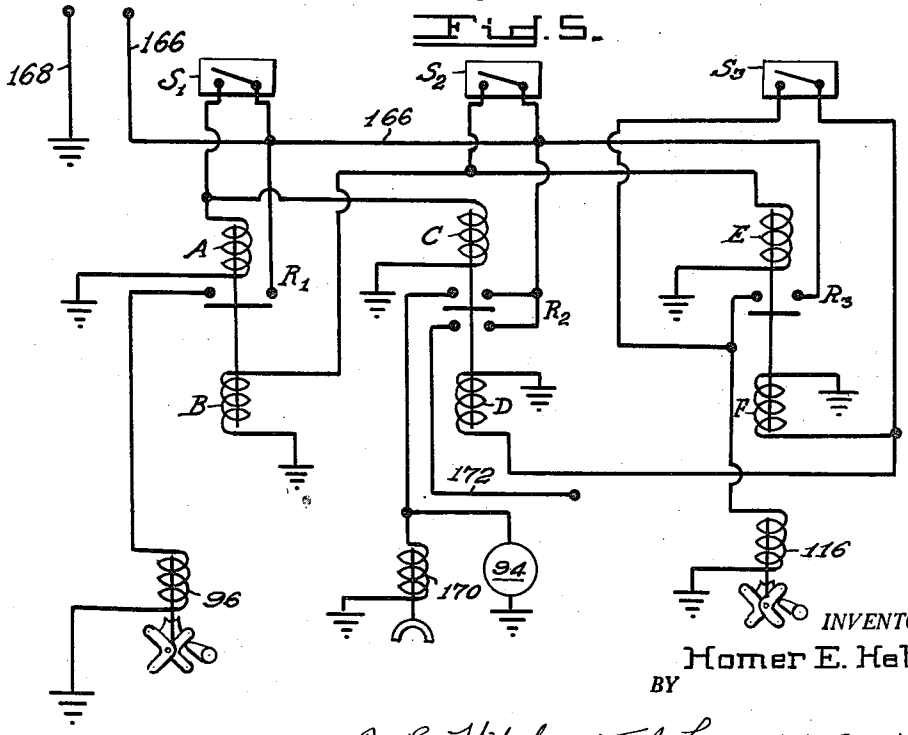


Fig. 5.



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AUTOMATIC INDEXING DEVICE

Homer E. Helm, Birmingham, Mich., assignor to the United States of America as represented by the Secretary of the Army

Application April 24, 1957, Serial No. 654,973

8 Claims. (Cl. 89—1)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States for governmental purposes without the payment to me of any royalties thereon.

The invention relates to an indexing device for ordnance, and particularly to an indexing device for a gun which automatically indexes the gun from the firing position to a loading position and back to the firing position.

Heavy guns, some of which are mounted on vehicles, are frequently reloaded by mechanical loading apparatus, and a design problem arises since the gun is fired in various elevational positions and a complicated loading mechanism is necessary to load the weapon at all possible elevations.

In installations where space restrictions make it difficult to use a self-aligning loader, a system has been developed whereby the gun is brought down to a fixed loading position and then returned to the firing position. The above system permits simplified loading apparatus to be employed, however, as the weapon must be depressed and elevated after each round, a time lapse occurs, and difficulty is encountered in returning the gun to the exact previous firing position should it be desired to fire a second round at the same elevation. The invention pertains to an automatic gun indexing device for use with the above type of fixed loading system.

It is thus an object of the invention to design a gun indexing device which will accurately and rapidly move the gun from the firing position to the loading position and back to the firing position. The indexing of the weapon to the various positions must be very accurate to insure effective fire control and in accordance with the invention is accomplished by means of an elevation control motor which is regulated by automatic control means sensitive to the position of the gun.

A further object of the invention is to design an indexing device for ordnance which will automatically position the weapon between a fixed loading position and a variable firing position returning the gun to the previous firing position.

Another object of the invention is to design a gun indexing device which may be either automatically actuated, power actuated under manual control, or manually operated in event of a power failure.

Yet another object of the invention is to design an automatic gun indexing device wherein the sequential operations are instigated by the normal functions of the gun.

These and other objects of the invention will become apparent when viewed in regard to the accompanying description and included drawings wherein:

Fig. 1 is an elevational view of the general arrangement of the invention.

Fig. 2 is a cross-section elevational view of the gear box and manual adjusting apparatus.

Fig. 3 is a cross-section elevational view of the loading position cam and solenoid taken along the line III—III of Fig. 1.

Fig. 4 is a cross-section elevational view of the valve body.

Fig. 5 is a schematic diagram of the electrical circuit employed with the invention.

Although the invention may be employed in any of the several types of servo systems used to operate gun elevational apparatus, the herein disclosed embodiment is used with a hydraulic servo system, and the description will be confined thereto.

The general arrangement of the various components of the invention is shown in Fig. 1 wherein a breech end view of a gun 10 is shown, which is supported by trunnion 12, which is in turn journaled in the trunnion support bracket 14. A boss 16 is attached beneath gun 10 and supports a gear sector 18 which meshes with the elevation control gear 20. The above structure is conventional and is therefore not shown in detail.

Basically, the indexing system of the invention consists of a hydraulic motor 22 which is connected to elevation gear 20 by means of gear box 24 and speed reducer 26. Motor 22 is controlled by valve 28 which in turn is operated by sensing means 30 responsive to the position of the gun, thus motor 22 may be made to automatically control the gun elevation.

As seen in Fig. 2, the power from motor 22 is delivered into gear box 24, via drive shaft 32. Power is transferred by means of gears 34 and 36 to the shaft 38 which is journaled in box 24 by conventional anti-friction bearings. The shaft 38 is splined at 40 thereby providing driving engagement with a cone clutch 42. A clutch plate 44 is journaled to shaft 38 and may be engaged by clutch 42 upon actuation of the operator shaft 46. An annular gear 48 is attached to clutch plate 44 for purposes later described, and an annular set of axial extending teeth 50 are located at the extreme end of shaft 38 for clutching purposes.

A shaft 52 is journaled within gear box 24 co-axially with shaft 38 and is splined at 54 whereby clutch dog 56 will constantly be in sliding driving engagement with shaft 52. Dog 56 is provided with teeth 58 and 60 at the ends and is reciprocated through a yoke operated by actuator 62 and control handle 64. An annular gear 66 is journaled to shaft 52 and is also provided with teeth 68, thus upward movement of clutch dog 56, as viewed in Fig. 2, will engage teeth 50 and 58, coupling shafts 38 and 52 or downward movement of dog 56 will engage gear 66 to shaft 52 through teeth 60 and 68.

A gear 70 is keyed to the lower end of shaft 52 which meshes with gear 72, affixed to shaft 74 of the speed reducer 26.

Manual means for rotating shaft 52 consists of a handwheel 76 and crank which are journaled in gear box 24 at right angles to shaft 52. Crank 76 is adapted to rotate gears 78 and 80 through a "no-back" device 82. The "no-back" device 82 is described in my co-pending application No. 621,484 filed November 9, 1956 and is not shown in detail. The device 82 functions to permit the handwheel 76 to manually rotate gears 78 and 80 in either direction, yet locks gears 78 and 80, preventing rotation when the handwheel is stationary. Thus, the gears will be rotated only when handwheel 76 is rotated and rotation is unidirectionally transmitted through the "no-back" device 82.

The gear 78 meshes with gear 66 thereby permitting handwheel 76 to rotate shaft 52 when teeth 60 and 68 are engaged.

As shown in Fig. 1, the speed reducer 26 is attached to bracket 14 and drives gear 20 through shaft 84. Thus, the gun 10 may be elevated or depressed by motor 22 through shafts 38, 52, 74 and 84 when control handle 64 engages teeth 50 and 58, or gun 14 may be manually

operated through handwheel **76** through gears **78** and **66**, shafts **52**, **74** and **84** when teeth **60** and **68** are interlocked.

The sensing means **30** for automatically controlling the gun indexing consists, in part, of a shaft **86** which is, in effect, an extension of the trunnion **12** and will therefore rotate as the gun **10** is elevated or depressed. A load positioning cam **88** is affixed to the end of shaft **86** for rotation therewith, and a fire positioning cam **90** is rotatably supported upon shaft **86** by means of sleeve **92** which is affixed to the driven element of the magnetically operated clutch **94**. The drive element of clutch **94** is attached to shaft **86**, thus the fire position cam **90** may be selectively locked and unlocked to shaft **86** under control of clutch **94**.

Connection between the cams and valve **28** is accomplished by a pair of similar solenoid actuated feelers, one of which is disclosed in Fig. 3. The feelers for cams **88** and **90** are identical, therefore only the loading position cam feeler will be described. The loading position cam feeler consists of a solenoid **96** pivotally mounted at **98**. An arm **100** is carried by solenoid **96** and supports a roller **102** which is constantly biased against cam **88** by a spring (not shown). A pair of toggle levers **104** and **106** are also supported upon arm **100** and are linked together at pin **108**. Levers **104** and **106** are formed with tips **110** and **112**, respectively, which are bent at right angles to the plane of the levers, thus forming pincers when the toggle levers **104** and **106** are actuated by the solenoid plunger rod **114** which connects to pin **108**. Thus, reciprocation of rod **114** will cause tips **110** and **112** to close together. A similar feeler arrangement is provided for the fire position cam **90** and is actuated by solenoid **116**.

The tips **110** and **112** are adapted to engage a hollow head **118** which is slidingly supported by roller bearings **120** within sleeve **122**. Thus, when actuator rod **114** is operated, the tips **110** and **112** will clamp upon the flange **124** of head **118**. The head **118** may also be engaged in a like manner by the toggle lever tips operated by the fire position solenoid **116**.

As disclosed in Fig. 4, the sleeve **122** is attached to the body of valve **28** which is in turn affixed to the gear box **24**. Valve **28** is of a standard design comprising a body **126** and a movable valve spool **128**. The pressurized fluid enters valve **28** through inlet port **130** and is transmitted to the motor **22** through either outlet port **132** or **134**, depending on the position of spool **128**. The exhaust port is located at **136** and communicates with chambers **138** and **140** whereby when one outlet port is introducing fluid to the motor **22**, the other outlet port is receiving the exhaust fluid from the motor and passing the same through exhaust port **136**. Suitable conduits connect the valve **28** to motor **22**, and conventional equipment may be used to provide valve **28** with a uniform source of hydraulic fluid under high pressure. Whether pressurized fluid is introduced into port **132** or **134** will determine the direction of rotation of motor **22** and shaft **32**.

The valve spool **128** is controlled by a rod **142** which axially extends through spool **128** and is fixed thereto by a pin **144**. As noted in Fig. 3, the upper end of rod **142** attaches to head **118**, while the lower end terminates within gear box **24**, see Fig. 2.

The follow-up means for manual control of hydraulic motor **22** consists of a shaft **146** journaled within gear box **24**. A bevel gear **148** is formed on the lower end of shaft **146** for engagement with gear **80**, while a gear **150** is affixed to the upper end. The gear **150** is of the helical type wherein the gear teeth are arcuate and are arranged at an angle to the gear axis.

A hollow bushing **152** is rotatably supported in gear box **24** and is exteriorly formed with a gear **154**, which will mesh with gear **48**, and interiorly provided with a splined bore **156**. A splined plunger **158** is supported within bore **156** for rotation with bushing **152** and is provided with a spring biased contact head **160** and a helical gear **162** which engages with gear **150**.

Contact head **160** abuts the lower side of a lever **164** which is pivoted at one end to the gear box **24**. As noted in Fig. 2, the lower end of rod **142** also contacts the lever **160** thereby transmitting operation of the follow-up system to the hydraulic valve **28** and motor **22** as will be explained later. Suitable springs are used with rod **142**, spool **128** and plunger **158** to obtain the proper balance of forces and eliminates interference between the automatic and manual control of motor **22**.

The automatic indexing device is controlled by an electric circuit shown in Fig. 5. The circuit is energized from the power lines **166** and **168**; the line **168** is grounded to the chassis of the gun thereby eliminating excessive wiring. The automatic control is actuated by three switches S_1, S_2 and S_3. S_1 is a normally closed switch which is held open by the gun in the battery position and will close during the recoiling action. S_2 is a normally open switch which is momentarily closed by the closing of the gun breech after reloading. S_3 is a normally open switch which is held open at all times except when the gun returns to the firing position, at which time switch S_3 will close. The above switches are wired to a set of relays R_1, R_2 and R_3 which are of the double coil latching type whereby energization of one coil will close the contacts, and energization of the other coil is necessary to open the contacts. As seen from Fig. 5, one side of switch S_1 is connected to the power line **166**, while the other side is connected to coils A and C. Switch S_2 is also supplied from line **166** and is adapted to energize coils B and E. The relay R_1, when closed, will actuate the loading position solenoid **96**, while the relay R_2 will actuate a feed back engaging solenoid **170** and magnetic clutch **94** when coil C is energized and energize the firing circuit feed line **172** when coil D is operated. Energization of coil E closes the circuit to the firing position solenoid **116** and also provides electrical energy to the switch S_3, thereafter closing of switch S_3 will energize coils D and F energizing firing circuit **172** and opening relay R_3.

The operation of the automatic indexing device is as follows:

Assuming the gun **10** to be loaded and in the firing position, the switches S_1 and S_2 will be open and switch S_3 will be closed thereby energizing the firing circuit feed line **172**, and the lever **64** is in the position wherein teeth **50** and **58** are engaged. The gun may now be fired. Once the gun **10** is discharged, the breech will move backwardly in the recoil action which will momentarily close switch S_1 energizing coils A and C of relays R_1 and R_2, respectively, actuating the load position index solenoid **96**, feed back solenoid **170** and magnetic clutch **94**. Energization of coil C also will disarm the ring circuit **172**.

Upon actuation of the load index solenoid **96**, the rod **114** (Fig. 3) will move to the left causing tips **110** and **112** to approach each other until flange **124** of head **118** is securely grasped between them. Thus rod **142** will be directly connected to roller **102** transmitting the motion produced by the irregular periphery of cam **88** to the valve spool **128**. The feed back solenoid **170** is connected to the operator shaft **46** and, upon energization, serves to disengage cone **42** from the clutch plate **44** and energization of clutch **94** will lock the fire position cam **90** to the shaft **86** for rotation therewith.

The configuration of load position index cam **88** will cause the valve spool **128** to be displaced while the gun is in an elevated position, thus upon actuation of solenoid **96** the spool **128** will be axially displaced actuating motor **22**. As the control handle **64** will be in the "power" position, teeth **50** and **58** are in engagement, transmitting the torque created by motor **22** to the speed reducer **26** and gear **20**, depressing gun **10**. As the gun **10** is lowered, the cam **88** will be rotating through a like degree and is shaped to return the valve spool **128** to the neutral loca-

tion within valve body 126 upon the gun reaching the loading position.

The gun 10 is now in the required loading position and may be easily loaded by mechanical loading means. After reloading is accomplished, the breech is closed which will close switch S_2 for sufficient time to energize coils B and E of relays R_1 and R_3. Coil B will open relay R_1 de-energizing solenoid 96 thereby releasing control of valve spool 128 from the loading position index cam 88. Energization of coil E energized the fire position index solenoid 116 which will cause apparatus similar to that shown in Fig. 3 to link the valve spool 128 to a roller traversing the periphery of cam 90. Cam 90 is shaped to displace spool 128 when the gun 10 is in the load position, thus, as soon as solenoid 116 is actuated, the valve spool 128 will be under the control of cam 90 which will begin elevating the gun. As the cam 90 is not clutched to shaft 86 until the gun is fired, the cam 90 will be oriented to the firing position of each preceding round, and thus the gun 10 will return to the prior firing position under the control of cam 90 acting on valve spool 128. When the proper elevation is achieved, the cam 90 will permit the spool 128 to return to a neutral position stopping the elevational movement.

Upon returning to firing position, the switch S_3 will be closed. As noted in Fig. 5, energization of the circuit controlling solenoid 116 also provides power to switch S_3 whereby the closing of the Switch S_3 will energize coils D and F of relays R_2 and R_3, respectively. Coil D will break the circuit to feed back solenoid 170, clutching cone 42 to clutch plate 44, and de-energize magnetic clutch 94 disengaging cam 90 from shaft 86. At the same time coil D will close the firing circuit 172 arming the weapon.

Coil F will open relay R_3, de-energizing fire position solenoid 116 and opening the circuit to switch S_3, thus, the control of valve 28 is released from the cams and the automatic indexing cycle is completed. The gun 10 may now be fired if it is desired to fire another shell at the same elevational position as the previous round.

To relocate the firing position, the gunner need only rotate handwheel 76 in the desired direction. For example, to elevate the gun a given degree above the previous firing position, the gunner will rotate handwheel 76 through a given arc. Rotation of handwheel 76 will rotate gears 80, 148, shaft 146 and helical gear 150. Inasmuch as cone 42 and clutch plate 44 are engaged, the gear 162 will not rotate due to the splined connection between plunger 158 and bushing 152, which drivingly meshes with clutch plate 44 through gears 154 and 48. Thus, upon rotation of gear 150, a force vector produced by the meshing helical gear teeth of gears 150 and 162 will cause plunger 158 to be axially reciprocated thereby pivoting lever 164 and causing an axial displacement of rod 142. Rod 142 will actuate valve spool 128 instigating the desired directional rotation of motor 22. As motor 22 is rotated, the cone 42, plate 44, gear 48, bushing 152, plunger 158 and gear 160 is such to counteract and reverse the tendency of gear 150 to impart axial reciprocation to plunger 158, thus rotation of handwheel 76 will control operation of motor 22 while clutch plate 44 and bushing 152 provide the "follow-up" connection between motor 22 and handwheel 76.

The gun may therefore be adjusted to any desired elevation by handwheel 76, yet since the fire position index cam 90 is not engaged to the shaft 86 until the gun is fired, the fire position index cam 90 will automatically be oriented to each firing position. It will be noted that the feed back solenoid 172 disengages cone 42 and clutch plate 44 as soon as the weapon is fired preventing damage to the feed back mechanism while the device is under control of cams 88 and 90.

It will therefore be understood that the automatic indexing cycle will begin when the gun 10 is fired, which locks the fire position cam 90 to shaft 86 and places the operation of motor 22 under control of the loading index position cam 88 depressing the gun to the loading position. Closing of the breech instigates the second phase by transferring control of motor 22 from the loading cam 88 to the fire position index cam 90 which elevates the weapon to the previous firing elevation. The final phase takes place upon return of the gun to the firing position when motor control by the fire position index cam 90 is released, the feed back clutch 42—44 is engaged, the fire position index cam 90 is unlocked from shaft 86 and the firing circuit 172 is energized. Thus, the motor 22 may now be controlled by handwheel 76 to correct or change the firing position.

Should an emergency arise wherein hydraulic fluid was not available to operate motor 22, the control handle 64 may be shifted to a "manual" position whereby teeth 60 and 68 are engaged, as shown in Fig. 2, permitting rotation of handwheel 76 to rotate shaft 52, and ultimately actuate gear 20 through speed reducer 26 elevating or depressing gun 10. Means are provided to manually disengage clutch 42—44 when control handle 64 is shifted to the "manual" position thereby disengaging the "follow-up" connection between motor 22 and handwheel 76. The "no back" device 82 will prevent the setting of handwheel 76 from changing due to vibration or the weight of the gun 10. It will thus be understood that the invention discloses an automatic gun indexing device which permits a gun to rapidly index from a firing position to a loading position and back to the firing position without special attention by the gunner. By using cams and hydraulic valve the indexing is very accurate and the gun will return to the exact prior firing position thereby obtaining accurate fire power once the target is "zeroed in." The incorporation of manual control of the elevting motor permits the firing position to be easily changed, yet the use of the magnetic clutch 94 orients the fire positioning index cam 90 to each fire position. The complete cycle between rounds takes place very rapidly increasing fire power of a given weapon and may enable a small gun crew to efficiently operate a heavy weapon.

The illustrated embodiments are not intended to limit the invention and it is understood that various modifications may be apparent to those in the art without departing from the spirit and scope of the invention.

I claim:

1. An indexing device for ordnance comprising a trunnion mounted gun, a gear sector attached to said gun, a speed reducer, an elevation gear operated by the output shaft of said speed reducer, and engaging said gear sector so as to depress and elevate said gun, a gear box, a toothed input and splined output shaft journaled in said gear box, a hydraulic motor in driving connection with said input shaft, said speed reducer being driven by said output shaft in said gear box, a valve regulating said motor, a handwheel journaled in said gear box, first and second gears driven by said handwheel, reciprocating means actuated by said first gear operatively connected to said valve, a toothed annular gear in engagement with said second gear, a toothed clutch dog splined to said output shaft, an actuator adapted to selectively engage said clutch dog with the teeth of said input shaft and said annular gear so that said output shaft can be selectively driven by said motor when said clutch dog engages said input shaft and by said handwheel when said clutch dog engages said toothed annular gear, and follow-up means operated by said input shaft counteracting movement of said reciprocating means thereby controlling operation of said motor through said valve.

2. An indexing device for ordnance comprising a trunnion mounted gun, gun elevation gearing in operable connection with said gun, a gear box including an output shaft for said gear box operably connected to said elevation gearing, an input shaft for said gear box, a hydraulic motor in driving connection with said input shaft,

a regulating valve connected to said motor for regulating the latter, manual control means carried by said gear box, first and second gears in driven connection with said manual control means, reciprocating means in actuatable connection with said first gear and operatively connected to said valve for actuation of the latter, a toothed clutch member axially slidable on said output shaft and rotatable therewith, an actuator manually operable to selectively operably engage said clutch member with said input shaft and with said second gear for respective selective rotation therewith, whereby said output shaft is selectively drivable by said motor when said clutch member operably engages said input shaft and by said manual control means when said clutch member operably engages said second gear, and follow-up means for said manual control means in operable connection with said input shaft and said valve providing counteracting movement of said reciprocating means.

3. An indexing device for ordinance comprising a motor adapted to elevate and depress a trunnion mounted gun having a breech, regulating means connectedly controlling operation of said motor, gun loading position indicating means and gun firing position indicating means adapted to be operably connected with said gun for fixed movement relative to elevational movement of the latter, disengageable clutch means interposed between said gun loading position and said gun firing position indicating means permitting relative positional variation thereof, electrically actuated connecting means responsively connecting each of said position indicating means and said disengageable clutch means respectively with said regulating means for responsive actuation thereof, and an electrical circuit connectable to a source of electrical energy and controlling operation of said disengageable clutch means and each of said electrically actuated connecting means whereby said gun through said regulating means is controllably indexed to loading and firing positions, said electrical circuit including a normally closed first switch, means responsive to movement of said gun holding said first switch open when said gun is in firing position, a normally open second switch, means responsive to movement of the breech of said gun closing said second switch when said breech is closed after reloading of said gun, a normally open third switch, means responsive to movement of said gun closing said third switch when said gun is in firing position, a first circuit establishing means between said first switch and said electrically actuated connecting means responsively connecting said gun loading position indicator means and between said first switch and said electrically actuated connecting means of said disengageable clutch means, a second circuit establishing means between said second switch and said electrically actuated connecting means of said disengageable clutch means, a third circuit establishing means between said third switch and said electrically actuated connecting means responsively connecting said gun firing position indicator means, and separate circuit closure means for each of said circuit establishing means respectively actuatable by closure of said first, second and third switches.

4. An indexing device for ordnance as set forth in claim 3 wherein each of said position indicating means comprises a cam responsive to gun elevation movement, and each of said electrically actuated connecting means comprises a follower member on each of said cams selectively linked to said regulating means by an electrically actuatable solenoid lever.

5. An indexing device for ordnance as set forth in claim 3, including selective manual operation means connected to said regulating means.

6. An indexing device for ordnance as set forth in claim 3, wherein said clutch means comprises an electrically actuated disengageable magnetic clutch.

7. An indexing device for ordnance comprising a hydraulic motor adapted to elevate and depress a trunnion mounted gun having a breech, a valve regulating said motor, a shaft on said trunnion coaxial therewith, a gun loading position indicating cam fixed to said shaft, a gun firing position indicating cam, an electrically actuated disengageable magnetic clutch engageably connecting said gun firing position indicating cam to said shaft, a pivotally mounted roller engaging the contour of said gun loading position indicating cam, a pivotally mounted roller engaging the contour of said gun firing position indicating cam, a respective electrically actuated solenoid lever selectively connecting each of said rollers to said valve, and an electrical circuit controlling energization of said magnetic clutch and each of said solenoid levers from a source of electrical energy, whereby said gun loading position indicating cam controls actuation of said valve for indexing said gun to a loading position after firing and said gun firing position indicating cam controls actuation of said valve for indexing said gun to prior firing position after loading, said electrical circuit including first, second and third switches closingly and openingly responsive in predetermined sequence to said gun positions, first, second and third circuit establishing means between ones of said switches and ones of said solenoid levers and said magnetic clutch, and separate circuit closure means for each said circuit establishing means respectively actuatable by closure of said switches.

8. An indexing device for ordnance as set forth in claim 7, including manually operable means connected to said valve permitting manual operation of the latter.

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