

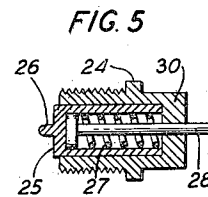
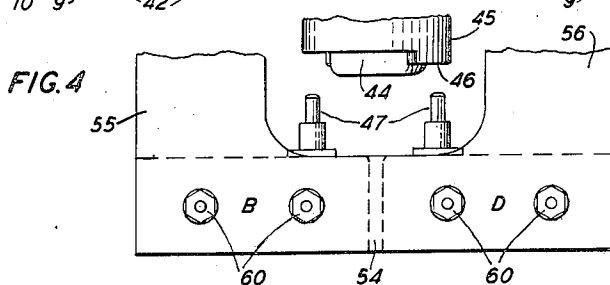
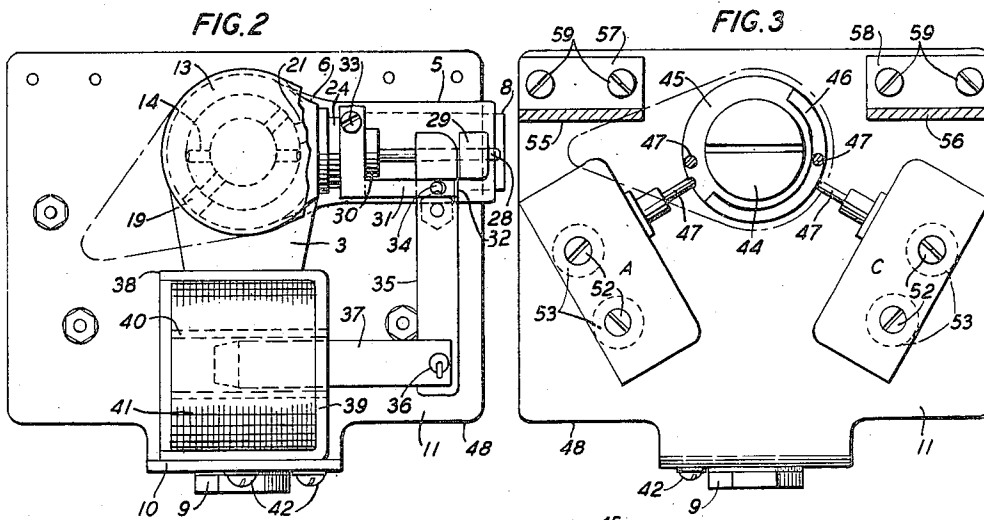
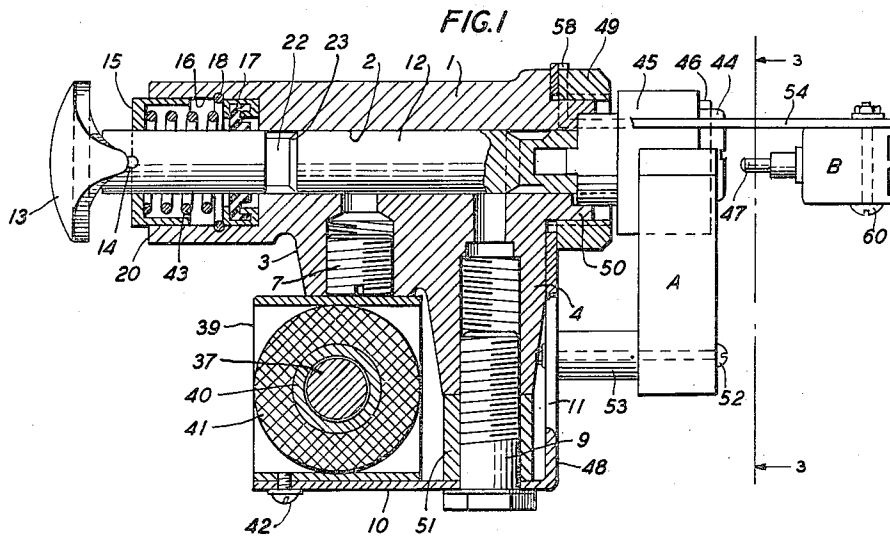
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R. B. BUCHANAN
GUNNERY TRAINING DEVICE

2,459,867

Filed Oct. 12, 1945

2 Sheets-Sheet 1



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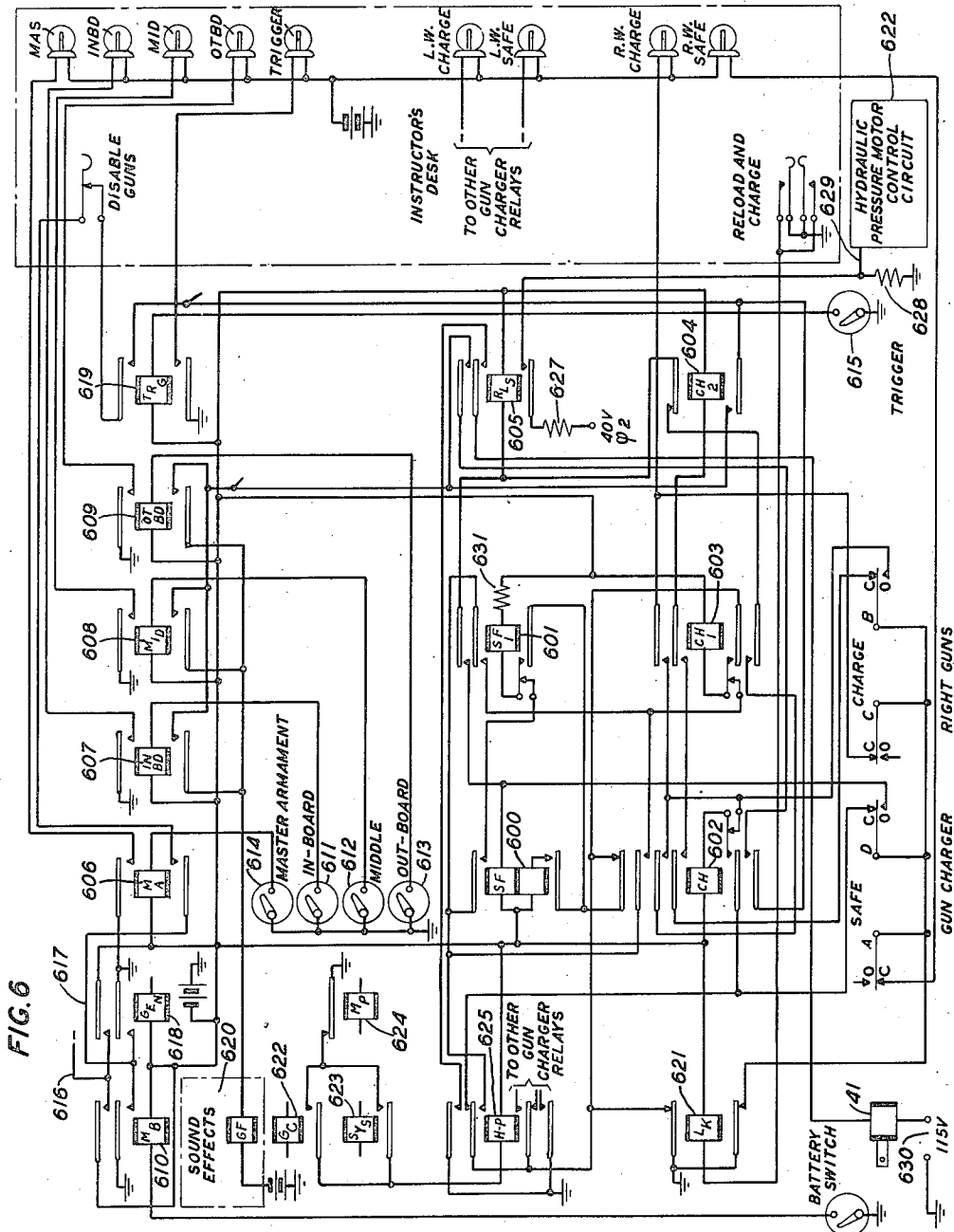
R. B. BUCHANAN

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GUNNERY TRAINING DEVICE

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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GUNNERY TRAINING DEVICE

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Application October 12, 1945, Serial No. 622,066

12 Claims. (Cl. 35-25)

1

This invention relates to an operational flight trainer and more particularly to circuits and apparatus for simulating the control of the guns of an airplane.

An airplane of the fighter type, which the trainer is designed to simulate, may be provided with a plurality of guns. For the sake of safety when the airplane is on the carrier deck, air field, or in formation flight but not in actual combat, the guns are not charged with shells. The charging mechanism of these guns is hydraulically operated by pressure supplied from the hydraulic system of the airplane under the control of gun chargers located on the pilot's pedestal in the cockpit and operable by the pilot. A plurality of these gun chargers may be provided, each capable of controlling the charging of one or more of the guns. In the airplane simulated by the trainer under consideration two such chargers are provided, one for charging the guns on the left wing and the other for charging the right guns.

To charge the guns under its control the gun charger knob is turned to the Charge position and then depressed. The turning of the knob opens a valve allowing oil in the hydraulic system to enter the gun charging system of the associated guns. The knob when depressed is locked in its depressed position. The application of pressure to the gun charging system causes the gun charging cylinders of the guns to pull out the bolts and allows the gun charging mechanisms of the guns to receive shells which will be forced into the breeches when the bolts are later released. When the hydraulic pressure in the gun charging valve builds up to about 800 pounds per square inch, the valve will open the release port thereof and the gun charging knob will snap out. This releases the pressure in the charging cylinders of the guns allowing the bolts to restore and forcing the shells into the breeches of the guns. The guns are then ready to be fired.

To safety the guns the gun charger knob is turned to the Safety position and then depressed. The turning of the knob opens the valve to allow oil in the hydraulic system to enter the gun charging system of the associated guns. The knob when depressed is locked in its depressed position. The application of pressure to the gun charging system causes the gun charging cylinders of the guns to pull out the bolts as they did for charging. When the hydraulic pressure in the gun charging valve builds up to about 800 pounds per square inch the gun charging knob

2

will snap out but the valve does not open the release port of the valve. Therefore the bolts will remain out and the breeches will remain open and the guns are safe.

Turning the gun charging knob to the Charge position after the guns have been safetied will open the release port of the valve thus releasing the pressure in the charging cylinders of the guns, allowing the bolts to restore and closing the breeches of the guns even though the knob is not depressed in the Charge position. Also after the guns are once charged or safetied, failure of the hydraulic system will not prevent charging the guns but will make it impossible to safety them.

It is the object of the present invention to simulate the charging and safetying of the guns of an airplane in a ground trainer for pilot training.

In a trainer it is not desirable to provide the expensive guns which would form the armament of an actual airplane or to provide the hydraulic system which would be required to furnish the hydraulic power necessary to charge and safety the guns, to extend and retract the landing gear, to operate the wing flaps, to operate the engine cowl flaps, to operate the inter-cooler and oil cooler shutters and to operate the wing locking pins. Therefore, simpler and less expensive electrical equipment is provided which simulates the production of the requisite hydraulic pressure, which simulates the pressure controls exercised by the gun charger valves and which simulates the responses of the gun mechanisms.

In order that in so far as the pilot under training is concerned, the gun chargers which are mounted on the pedestal in the cockpit of the trainer shall have the same appearance and shall appear to function in exactly the same manner as those installed in the cockpit of an actual airplane, each gun charger valve, used in the actual airplane which the trainer simulates, has been modified by the removal of all piping connections thereto, by the addition of a switch operable when the charging knob is turned to its Charge position, of a switch operable when the knob is depressed when turned to the Charge position, of a switch operable when the knob is turned to its Safety position, of a switch operable when the knob is depressed when turned to its Safety position, and by the addition of a solenoid release for the knob to replace the pressure-operated release.

For a better understanding of the invention reference may be had to the following detailed de-

scription when read in connection with the accompanying drawings in which:

Fig. 1 is a side elevational view of a gun charger valve shown partly in cross-section modified in accordance with the invention;

Fig. 2 is a front elevational view of the valve;

Fig. 3 is the rear elevational view of the valve taken along the section line 3—3 of Fig. 1;

Fig. 4 is a top plan view of the rear end of the valve showing the cam carried by the rear end of the valve stem and two of the switch assemblies operable thereby;

Fig. 5 is a detail view in cross-section of the solenoid operated detent for locking the knob and valve stem in their depressed position; and

Fig. 6 is a diagram of such circuits and apparatus of the trainer as are deemed essential to an understanding of the invention.

The gun charger valve disclosed in Figs. 1 to 5, inclusive, comprises a casing 1 having a valve stem bore 2 extending therethrough, two downwardly extending valve bosses 3 and 4 and two horizontally extending valve bosses 5 and 6. The bosses 3, 4 and 5 are provided with holes therethrough which connect with the valve stem bore 2. The outward portions of the holes are threaded to enable connection with pipes of the hydraulic system. Since, however, no piping is connected with the valve in the trainer, these threaded holes are closed by the screw-threaded plugs 7, 8 and 9. The plugs 7 and 8 are slotted so that they may be screwed into the holes in the bosses 3 and 5. The plug 9 which screws into the hole in the boss 4 is provided with a hexagonal head for the purpose of securing the horizontal arm 10 of the L-shaped bracket 11 to the end of the boss 4.

Slidably and rotatably supported in the bore 2 of the valve casing 1 is a valve stem 12 in the forward end of which the handle 13 is secured by the pin 14. Surrounding the forward end of the valve stem is a cup-shaped collar 15 the cylindrical portion of which is slidable within the chamber portion 16 of the bore 2. Positioned at the rear of the chamber 16 and surrounding the stem 12 is a sealing member 17 which is retained in the rear end of the chamber by the snap ring 18. Surrounding the stem 2 and positioned between the outer face of the member 17 and the inner face of the collar 15 is a return spring 43 which is tensioned to thrust the collar 15 outwardly against the pin 14 secured to the stem 12 to thereby move the stem to its normal or extended position.

The stem 12 also is provided near its outer end with a detent 19, shown in dotted lines in Fig. 2, the head of which normally rests against the outer face 20 of the casing 1 to prevent the valve stem from being pressed inwardly by the handle 13 unless the handle is turned into either the Safety position illustrated in Fig. 2 or into the Charge position indicated by the dotted position of the handle 13 shown in Fig. 2. In either of these positions the stud 19 will be aligned with slots in the casing extending parallel with the axis of the stem 12 and the handle 13 may then be depressed to move the stem longitudinally through the bore 2. The stud 19 is illustrated in Fig. 2 as aligned with one of the slots when the handle 13 is in the Safety position, and the other slot 21 with which the stud 19 becomes aligned when the handle is in the Charge position is indicated by dotted lines in Fig. 2.

The valve stem just back of the chamber 16 is provided with a reduced portion 22 having a shoulder 23. Mounted in the boss 6 is a detent

assembly shown more in detail in Fig. 5. This assembly comprises a chambered cap screw 24 threaded into the tapped hole in the boss 6 and having a detent 25 slidably supported in the chamber thereof. The detent has a detent stud 26 engageable against the shoulder 23 of the stem 12 by the spring 27. The spring 27 is positioned within the chambered portion of the detent 25 and bears against the outer end wall of the chambered portion of the screw 24 and against the lower end wall of the chambered portion of the detent.

Secured to the detent 25 is a rod 28 which extends outwardly through a hole in the end of the cap screw 24 and have a retainer 29 secured to the outer end thereof. Clamped to the cylindrical end 30 of the cap screw 24 is a bracket 31. The bracket is L-shaped, the short leg 32 thereof being provided with a hole therethrough to enable such leg to be slipped over the end 30 of the cap screw and having a saw cerf extending from such hole to one edge of the leg with a screw 33 extending through the two portions separated by the saw cerf to enable the bracket to be clamped to the cap screw. Pivoted to the long leg of the bracket by the pin 34 is a downwardly extending link 35, the upper end of which bears against the inner face of the retainer 29.

The lower end of the link 35 is pivoted by the pivot pin 36 to the outer end of the core 37 of a solenoid. The solenoid has a U-shaped heel-piece 38 of magnetic material to the base 39 of which is secured a cylindrical sleeve 40 of non-magnetic material which extends within the arms of the heel-piece and parallel thereto, and within which the core 37 is free to slide. Surrounding the sleeve 40 is the solenoid coil 41. The solenoid assembly is supported with the outside of its upper heel-piece arm against the outer end of the boss 3 by the horizontal arm 10 of the bracket 11, the lower arm of the heel-piece 39 being secured to the arm 10 by the screws 42.

When the knob 13 is turned to either its Charge or Safety position and then depressed, the detent 26 is forced by the spring 27 into engagement with the reduced portion of the valve stem 12 so that when pressure on the knob 13 is released the shoulder 23 of the stem engages the detent and the stem is thereby held in its depressed position. To permit the stem to be returned to its normal position by the return spring 43, the coil 41 of the solenoid is energized to attract its core 37 and through the pivoted link 35 to cause the detent 26 to be pulled out against the tension of the detent spring 27 to release the valve stem 12.

Secured by a screw 44 to the rear end of the valve stem 12 is a cam member 45. The end of the cam member is provided with a tubular cam extension 46 which extends through substantially 200 degrees of the circumference of the member 45. Positioned to be operated by the rotation of the cam extension 46 are two spring assemblies A and C and positioned to be operated by the cam extension 46 when the valve stem 12 is depressed are two other spring assemblies B and D. Each of these spring assemblies comprises three springs the two outer springs being fixed to serve as front and back contact springs and the middle spring being normally engaged with the back contact spring and having a stud 47 of insulating material extending therefrom by which such spring may be forced out of engagement with the back contact spring and into engagement with the front contact spring. These spring assemblies are illustrated schematically in the lower

portion of Fig. 6, the back contact position of each assembly being indicated by the letter c and the front contact position by the letter o.

For supporting the spring assemblies A and C the L-shaped bracket 11, hereinbefore referred to, is provided, which bracket has its horizontal arm 10 secured to the end of the boss 4 of the valve casing 1 by the cap screw 9 and has its vertical arm 48 clamped to the end of the casing 1 by the nut 49 which is threaded on to a threaded extension 50 of the casing. The arms 10 and 48 are provided with suitable holes through which the cap screw 9 and the threaded extension 50 extend. To space the arm 10 of the bracket properly to permit the solenoid assembly to be supported between the arm 10 and the end of the boss 3, a tubular spacer 51 is interposed between the end of boss 4 and the arm 10 of the bracket.

The spring assemblies A and C are secured to the vertical arm 48 of the bracket 11 by bolts 52 which extend through the assemblies and through tubular spacers 53 and through holes in the bracket.

For supporting the switch assemblies C and D a U-shaped horizontal bracket 54 is provided the ends of the arms 55 and 56 of which are bent at right angles to form feet 57 and 58 by which the arms are secured by screws 59 to the bracket 11 near the upper edge of the vertical arm 48 thereof. The spring assemblies are secured to the outer end of the bracket 54 by bolts 60.

When the knob 13 is in the Safety position as illustrated the cam extension 46 is moved into such a position that the switch assembly C is operated to its alternate or o position and the other switch assemblies A, B and D remain in their normal or c positions. If the knob 13 is now depressed while in the Safety position, the switch assembly C remains operated to the o position and in addition the engagement of the edge of the cam extension 46 with the stud 47 of the switch assembly D operates such assembly to its alternate or o position.

When the knob 13 is rotated to the Charge position the cam extension 46 is moved into such a position that the switch assembly C is permitted to release to its normal or c position and switch assembly A is operated to its alternate or o position and the other switch assemblies B, C and D remain in their normal or c positions. If the knob 13 is now depressed while in the Charge position, the switch assembly A remains operated to the o position and in addition the engagement of the end of the cam extension 46 with the stud 47 of the switch assembly B operates such assembly to its alternate or o position.

Referring now to Fig. 6 in which the circuits which embody the invention are disclosed, the switch assemblies A, B, C and D of the gun charging valve which in an airplane would control the guns mounted in the right wing, are disclosed schematically in the lower portion of the drawing. The SF, SF1, CH, CH1, CH2 and RLS relays 600 to 605, inclusive, operable by the spring assemblies are provided to simulate the charging and safetying of the right guns. Similar switch assemblies and relays would be provided for simulating the charging and safetying of the guns which would be mounted on the left wing of an actual airplane. All of these relays together with the other relays disclosed in the drawing are mounted in relay racks in the apparatus cabinets for the trainer which cabinets are connected to

the mock-up of the fuselage and with an instructor's desk by cables of conductors.

The group of relays including the INBD, MID and OTBD relays 607, 608 and 609 are selectively operable under the control of the Inboard, Middle and Outboard gun selector switches 611, 612 and 613 mounted on the electrical distribution panel in the cockpit, to enable the pilot to select the Inboard, Middle or Outboard guns for firing. The Master armament switch 614 also mounted on the electrical distribution panel controls the MA relay 606 to render the trigger 615 mounted on the control switch of the airplane effective to simulate the firing of any of the guns.

The apparatus enclosed within the dot-dash rectangle in the right portion of the figure shows such apparatus at an instructor's desk as concerns the supervision of the pilot in simulating the handling of the guns.

The apparatus which embodies the invention having now been discussed, consideration will now be given to the manner in which the apparatus functions under a pilot's control to simulate the operations of the guns of an airplane.

To prepare the trainer for a simulated flight the pilot closes the Battery switch located on the electrical distribution panel in the cockpit thereby establishing an obvious circuit for the MB relay 610 which, upon operating, connects battery and ground to the battery and ground bus bars 616 and 617. As soon as the simulated starting of the engine has been completed and the engine has assumed a simulated speed of 1,300 R. P. M., the GEN relay 618 operates and supplies battery and ground to the bus bars 616 and 617, in simulation of the supplying of direct current by the generator driven by the engine. In the operation of an actual airplane the guns are not charged with shells and prepared for firing until the airplane is in flight and is approaching an area where enemy action may be expected and therefore even though the pilot may have operated the Master armament switch 614 and may have operated one of the gun selection switches, the trigger switch 615 is ineffective. This is a safeguard against the infliction of casualties which might occur while the airplane is on the carrier or is flying in formation.

In the trainer should the pilot operate the master armament switch 614 thereby operating the MA relay 606, operate one of the gun selection switches, for example switch 611, thereby operating the INBD relay 607, and then operate the trigger switch 615 thereby operating the TRG relay 619, no circuit will be established for the GF relay in the sound effects circuit 620 to cause the production of sound effects representative of the firing of one or more of the guns.

It will now be assumed that during the simulated flight the pilot decides to simulate the preparation of the guns for firing. To charge the right guns he first rotates the knob 13 of the gun charger to the Charge position and then depresses the knob whereby it becomes locked in the Charge position. With the knob rotated to this position the switch assembly C is released to its c position thereby establishing a circuit from ground over the lower back contact of the locking ground supply (LK) relay 621, over the contacts of switch assembly C and through the RW Charge lamp at the instructor's desk to battery, to inform the instructor that the pilot has operated the gun charger for the right guns to its Charge position.

When the pilot depresses the knob 13, the

switch assembly B is operated to its alternate or o position, and the assembly C remains released. With the switch assembly B in its alternate position, a circuit is established from ground at the lower back contact of the LK relay 621, over the contacts of switch B, over the inner lower normal contacts and through the winding of the CH relay 602 to battery. Relay 602 thereupon operates and locks over its inner lower alternate contacts and over the normal or c contacts of the switch assembly D to ground at the lower back contact of relay 621. Relay 602 thus remains operated until the guns are safetied and the switch assembly has become operated to its alternate or o position.

Relay 602 upon operating establishes the circuit for operating the CH1 relay 603 if the hydraulic pressure simulated by the operation of the hydraulic pressure motor control circuit schematically illustrated by the rectangle 622 is not less than 800 pounds per square inch. If there is simulated hydraulic pressure in the hydraulic system, the SYS relay 623 will be operated and if the pressure is not less than 800 pounds per square inch, the medium pressure (relay 624) will be released and a circuit will be effective for the hydraulic pressure (H-P) relay 625 which may be traced from ground over the back contact of relay 624, over the contacts of relay 623 and through the winding of relay 625 to battery. The simulation of hydraulic pressure for the trainer involving the control of relays 623, 624, 625 and 626, and the hydraulic motor control circuit 622 are fully disclosed in the application of F. M. Pearsall, Serial No. 622,069 filed concurrently herewith, and a more complete description of such apparatus is deemed unnecessary herein. Thus with relay 625 operated the circuit of relay 603 may be traced from ground over the upper back contact of the LK relay 621, over the inner upper front contact of relay 625, over the upper front contact of relay 602, through the inner lower normal contacts and winding of relay 603 and to battery. Relay 603 thereupon operates and locks over its inner lower alternate contacts to ground at the upper back contact of relay 621. The operation of the CH1 relay 603 simulates the application of pressure to the cylinders of the guns to pull out the bolts and to permit the gun charging mechanism of each gun to receive a shell.

With relay 603 operated a circuit is now established for the RLS relay 605 which may be traced from battery through its winding, over the back contact of the CH2 relay 604, over the lower contacts of relay 603, over the next-to-inner upper contacts of relay 602, over the contacts of switch assembly B in the alternate or o position and to ground at the lower back contact of relay 621. Relay 605 upon operating connects potential from a 40-volt source of alternating current of phase ϕ_2 , through resistance 627 and over its lower contacts and through resistance 628 to ground from which potential divider potential is applied to control conductor 629 of the hydraulic pressure motor control circuit 622 which will cause such circuit to operate in a manner representative of a change in the simulated pressure in the hydraulic system of the trainer. Relay 605 also establishes a circuit for solenoid 41 of the gun charger which may be traced from the source 630 of alternating current, through the winding 41 of the solenoid, over the inner upper contacts of relay 605 and over the upper contacts of relay 625 to ground. The operation of the solenoid 41 to

release the charger knob 13 simulates the building up of pressure in the charger valve of an actual airplane to a point where the knob would be released and pressure in the gun charging cylinders would be released to allow the bolts to restore and shells to be forced into the breeches of the guns ready for firing.

With the switch assembly B now released, a circuit is effective for the CH2 relay 603 which may be traced from battery through the winding of such relay, over the inner upper contacts of relays 603 and 602 and over the normal or c contacts of switch B to ground at the lower back contact of relay 621. As soon as the RLS relay 605 operates, the trigger circuit is made effective over the upper contacts of such relay and is sustained over the lower contacts of the CH2 relay 604 after relay 604 operates and releases relay 605. Relay 605, upon releasing when the knob 13 restores, opens the circuit of solenoid 41 and removes the phase ϕ_2 hydraulic pressure drain potential from control conductor 629 of the hydraulic pressure motor control circuit 622.

It will be assumed, however, that the pilot does not yet wish to fire the guns but decides to safety them for the time being. To do this he turns the knob 13 out of the Charge position into the Safety position. Upon leaving the Charge position the switch assembly C is permitted to release thereby opening the previously traced circuit for the RW Charge lamp at the instructor's desk. When the switch reaches the Safety position, the switch assembly A is permitted to release into its c position thereby establishing a circuit from ground at the lower back contact of relay 621, over the contacts of switch A and through the RW Safe lamp at the instructor's desk to inform the instructor that the pilot has taken steps to render the right guns safe.

When the knob 13 is now depressed, the switch A remains in its released position and switch assembly D becomes operated to its alternate position. The locking circuit of the CH relay 602 is now opened at the c contacts of switch D and relay 602 releases, if the simulated hydraulic pressure has not fallen below 800 pounds per square inch to release relay 625 and thus open the alternative locking circuit for relay 602. The release of relay 602 is followed by the release of the CH2 relay 604. With the RLS relay 605 and the CH2 relay both released, the trigger circuit is rendered ineffective and the guns are thus safetied.

The depression of the knob also establishes a circuit from battery through the upper winding of the SF relay 600, over the o contacts of the switch assembly D to ground at the lower back contact of relay 621 and relay 600, upon operating, locks in a circuit from battery through its lower winding and over its lower contacts, over the upper back contact of the CH relay 602 and to ground at the upper back contact of relay 621. If the simulated hydraulic pressure is at least 800 pounds per square inch, which would be sufficient to cause the charger cylinders of actual guns to pull out the bolts to safety the guns and which would be sufficient to operate the detent mechanism of the charger valve, relay 625 will be operated and, following the operation of relay 603, the operating circuit of the SF1 relay 601 will be established from ground over the upper back contact of relay 621, over the inner upper front contact of relay 625, over

the upper contacts of relay 600, over the lower normal contacts and through the winding of relay 601 and through resistance 631 to battery. Relay 601, upon operating, locks over its lower alternate contacts and over the upper back contact of relay 602 to ground at the upper back contact of relay 621 so that it will remain operated until the CH relay 602 is again operated to charge the guns.

With relay 601 operated, a circuit for the RLS relay 605 is established which may be traced from ground at the lower back contact of relay 621, over switch D in its o position, over the upper contacts of relay 601 and through the winding of relay 605 to battery. Relay 605, upon operating, establishes the circuit of solenoid 41 to withdraw the detent of the gun charger to permit the knob 13 to restore, and reapplies phase ϕ_2 hydraulic drain potential to control conductor 629 of the hydraulic pressure motor control circuit 622 whereby such circuit functions in a manner representative of a reduction in pressure in the hydraulic system incident to safetizing the guns. When the knob 13 snaps out the switch D restores to its normal position thereby opening the initial operating circuit of relay 600 and opening the circuit of the RLS relay 605. Relay 605 now releases but relay 600 remains operated under the control of the CH relay 602. Relay 605, upon releasing, releases the solenoid 41 and removes the hydraulic drain potential of phase ϕ_2 from control conductor 629 of the hydraulic pressure motor control circuit 622 representative of the fact that the guns have become safetied and are no longer draining potential from the hydraulic system. When the RLS relay 605 was operated, the trigger circuit was not effective because the CH relay 602 was not at the time operated.

It will now be assumed that the pilot desires to simulate the placing of the guns in condition for firing. To do so he now turns the gun charger knob to the Charge position. The switch assembly A is now operated to the o position thereby extinguishing the RW Safe lamp at the instructor's desk and the switch assembly C is operated to the c position thereby establishing the circuit of the RW Charge lamp at the instructor's desk. With switch C in the c position and with the CH1 relay 602 still locked up, a circuit is established from ground at the lower back contact of relay 621, over the contacts of switch C, over the upper contacts of relay 603 and over the inner lower normal contacts and through the winding of relay 602 to battery.

Relay 602 now operates and locks over its inner lower alternate contacts, over the contacts of switch assembly D in its normal or c position and to ground at the lower back contact of relay 621. Relay 602, upon operating, opens at its upper back contact the locking circuits of the SF and SF1 relays 609 and 601 which now release. Relay 602 now establishes the circuit of the CH2 relay 604 which may be traced from battery through its winding, over the inner upper contacts of relays 603 and 602 and over the normal contacts of the switch assembly D to ground at the lower back contact of relay 621. The trigger circuit is now effective without pushing the knob 13 in.

If the knob 13 should be depressed thereby operating the switch assembly B to its alternate position, relay 604 would be released and the previously traced circuit for the RLS relay 605 would be established over its upper back con-

tact, whereupon the solenoid 41 would be operated to release the knob followed by the release of relay 605 and the reoperation of relay 604.

The operation of the gun charger for the left guns functions in the same manner, supervision of such charger being secured at the instructor's desk by the lighting of other lamps LW Charge and LW Safe.

To fire any of the guns the Master armament switch 614 must first be closed thereby causing the operation of the MA relay 606 which upon operating establishes a circuit from ground over its upper contacts and through the master armament switch lamp MAS at the instructor's desk to inform the instructor that the pilot has closed the Master armament switch. It will be assumed that the pilot now selects the outboard guns for firing by operating the Outboard gun selection switch 613 thereby establishing a circuit from ground over the contacts of such switch and through the winding of the OTBD relay 609 to battery. Relay 609, upon operating, now establishes a circuit from ground over its upper contacts and through the OTBD lamp at the instructor's desk to inform the instructor that the pilot has selected the outboard guns for firing.

When now the pilot closes the trigger switch 615 located on the upper end of the control stick and the TRG relay 619 operates over an obvious circuit, the closure of a trigger circuit for firing the outboard guns is simulated. This circuit may be traced from ground over the upper inner contacts of either relay 610 or relay 618, over the lower contacts of relay 606, over contacts of the Disable gun switch at the instructor's desk, over the upper contacts of the TRG relay 619, over the lower contacts of the CH2 relay 604, which it will be recalled operated to simulate the charged condition of the guns, over the lower contacts of the OTBD relay 609 and through the winding of the gun firing (GF) relay of the sound effects circuit 620 to battery. Relay GF thereupon operates and in the manner fully disclosed in the application of R. H. Gumley Serial No. 622,065 filed concurrently herewith, the sound effects circuit is rendered effective to produce sounds in the loudspeaker system of the trainer, simulating the noise of gun fire. The TRG relay 619 also closes over its lower contacts a circuit for the Trigger lamp at the instructor's desk to inform the instructor that the pilot is attempting to fire the outboard guns as indicated by the lighted OTBD lamp. The instructor will know if this attempt is successful if he hears gun fire noise in the loudspeaker system.

The pilot may select the inboard or middle guns for firing by operating either the Inboard or the Middle gun selection switches 611 or 612 thereby operating either the INBD or the MID relay 607 or 608 or he may fire any combination of the guns by operating different combinations of the switches 611, 612 or 613.

The pilot may safety the guns before charging them by operating each gun charger to its safety position whereupon the associated SF relay 600 is operated as previously described upon the operation of the switch assembly D to its alternate or o position. The relay 600 locks in a circuit over the upper back contact of the CH relay 602 and establishes the previously traced circuit for the SF1 relay 601 which also operates and locks in a circuit over the upper back contact of relay 602. A circuit at this time is established for the CH1 relay 603 if hydraulic pressure is at least 800 pounds per square inch as represented by the

operated condition of the H-P relay 625. The circuit of relay 603 may be traced from ground over the inner upper contacts of relay 625, over the inner upper contacts of relay 601 and through the inner lower normal contacts and through the winding of relay 603 to battery. Relay 603 now locks to ground at the upper back contact of relay 621. With relay 601 operated a circuit is established from battery through the RLS relay 605, over the upper contacts of relay 601 and over the alternate contacts of the switch assembly D to ground at the lower back contact of relay 621. Relay 601 thereupon operates to apply a hydraulic pressure drain potential to control conductor 629 of the hydraulic pressure motor control circuit 622 and to cause the energization of the solenoid 41 to release the knob 13 of the gun charger.

Should the simulated hydraulic pressure fail and the H-P relay 625 consequently release, when the SF, SF1 and CH1 600, 601 and 603 are operated to denote that the guns have been safetied such relays will remain operated since they are all locked over the upper back contact of the CH relay 603 and the guns will stay in their safety conditions. The guns can still be charged by turning the gun charger knob 13 to its Charge position in which the switch assembly C is released to its c position and the circuit of the CH relay 602 is established from ground at the lower back contact of relay 621, over the contacts of switch assembly C, over the upper contacts of operated relay 603 and through the inner lower normal contacts and winding of relay 602 to battery. Relay 602 operates, locks over its inner lower alternate contacts, over the inner upper back contact of relay 625 to ground at the upper back contact of relay 621, opens at its upper back contact the locking circuit of the SF and SF1 relays 600 and 601 which release, and establishes the circuit of the CH2 relay 604 which may be traced from battery through the winding of relay 604, over the inner upper contacts of relays 603 and 602, over the normal contacts of the switch assembly B and to ground at the lower back contact of relay 621. The guns are now charged and may be fired.

It is not necessary for the pilot to depress the gun charger knob 13 to charge the guns at this time but if he does the CH2 relay if operated will be released and the RLS relay 605 will be operated upon the movement of the switch assembly B to its alternate position. The solenoid 41 will be operated to release the gun charger knob and a drain potential will be added to the control conductor 629 of the hydraulic pressure motor control circuit 632 in the manner previously described. As soon as the knob is released, relay 605 will release and relay 604 will reoperate to signify that the guns are in a charged condition.

If the hydraulic pressure is below 800 pounds per square inch and the pilot attempts to initially safety the guns, he can not do so because the SF1 relay 601 will not operate following the operation of relay 600 when the gun charger is operated to its Safety position since the circuit of relay 601 is opened with relay 625 released. Also if the pilot attempts to initially charge the guns he can not do so because the CH1 relay 603 will not operate following the operation of relay 602 when the gun charger is operated to its Charge position, since the circuit of relay 603 is opened with relay 625 released. Since relay 603 can not operate the CH2 relay 604 can not operate to permit the pilot to close the trigger circuit. Since neither relay 601 nor 603 can be operated, the

RLS relay 605 can not operate and the knob if depressed will remain locked in its depressed condition and no drain potential is applied to the control conductor 629 of the hydraulic pressure motor control circuit 622. This simulates the condition when the hydraulic pressure is too low to operate the gun charging mechanisms to pull back the bolts to either charge or safety the guns.

If the guns are assumed to be in the charged condition at the time the hydraulic pressure fails, it will be impossible for the pilot to safety them since the CH relay 602 will remain locked over the upper back contact of relay 625 to ground and the upper back contact of relay 621 and when the SF relay 600 becomes operated when the gun charge knob is turned to the Safety position and depressed, the SF1 relay can not operate and as a consequence the RLS relay 605 can not be operated to release the knob from its depressed Safety position. With relay 602 operated the CH1 and CH2 relays 603 and 604 both remain operated and the trigger circuit remains effective. This simulates the condition when the hydraulic pressure is too low to pull back the bolts of the guns after they have been charged.

The instructor may disable the guns at any time by opening the Disable gun switch and may simulate the exhaustion of ammunition for the guns by operating the Reload and charge key thereby operating the LK relay 621 which releases all operated relays in the gun charging circuits thereby restoring such circuits to normal.

What is claimed is:

1. In apparatus in a trainer for simulating the operations incident to the operation of a gun charger control, a rotatable and depressible gun charger control, a relay operable in response to the rotation and depression of said control, means for locking said control in its depressed position, a magnet for releasing said locking means, a trigger switch, and a relay operable in response to the operation of said first relay to cause the operation of said release magnet and to render said trigger switch effective.

2. In apparatus in a trainer for simulating the hydraulic control of a gun charger by a gun charger control valve, means for simulating the production of a hydraulic pressure adequate to operate the charger of a gun, a rotatable and depressible gun charger control for simulating a gun charger control valve, a relay operable in response to the rotation and depression of said control, means for locking said control in its depressed condition, a magnet operable for releasing said locking means in simulation of the opening of the release port of a gun charger valve when a pressure is reached adequate to operate the gun charger, a trigger switch and a relay operable in response to the operation of said first relay if said hydraulic pressure simulating means is in a condition representative of said adequate pressure to cause the operation of said release magnet and to render said trigger switch effective.

3. In apparatus in a trainer for simulating the hydraulic control of a gun charger by a gun charger control valve, means for simulating the production of a hydraulic pressure adequate to operate the charger of the gun, a rotatable and depressible gun charger control for simulating the gun charger control valve, a relay operable in response to the rotation and depression of said control means for locking said control in its depressed condition, a magnet operable for releasing said locking means in simulation of the opening of the release port of a gun charger valve

when a pressure is reached adequate to operate the gun charger, a trigger switch, a relay operable in response to the operation of said first relay if said hydraulic pressure simulating means is in a condition representative of said adequate pressure to cause the operation of said release magnet and to render said trigger switch effective, and means controlled by said latter relay to simulate the reduction in hydraulic pressure incident to charging a gun.

4. In apparatus in a trainer for simulating the hydraulic control of a gun charger by a gun charger control valve, means for simulating the production of a hydraulic pressure adequate to operate the charging mechanism of a gun, a rotatable and depressible gun charger control for simulating a gun charger control valve, a relay operable in response to the rotation and depression of said control, means for locking said control in its depressed condition, a magnet operable for releasing said locking means in simulation of the opening of the release port of a gun charger valve when a pressure is reached adequate to operate the gun charger, a trigger switch, a relay operable in response to the operation of said first relay if said hydraulic pressure simulating means is in a condition representative of said adequate pressure to cause the operation of said release magnet, and a relay operable in response to the restoration of said control for rendering said trigger switch effective in simulation of the release of pressure in said gun charging mechanism which would render the gun ready for firing.

5. In apparatus in a trainer for simulating the operations incident to the operation of a gun charger control, a gun charger control rotatable to a gun safetying position and then depressible, a relay operable in response to the rotation and depression of said control, means for locking said control in its depressed condition, a magnet for releasing said locking means and a relay operable in response to the operation of said first relay to cause the operation of said release magnet in simulation of the completion of safetying of a gun.

6. In apparatus in a trainer for simulating the hydraulic control of a gun charger by a gun charger control valve, means for simulating the production of a hydraulic pressure adequate to pull back the bolt of the gun to safety the gun, a gun charger control rotatable to a gun safetying position and then depressible for simulating a gun charger control valve, a relay operable in response to the rotation and depression of said control, means for locking said control in its depressed position, a magnet operable for releasing said locking means in simulation of the increase in hydraulic pressure to a value adequate to pull out the bolt of a gun, a relay operable in response to the operation of said first relay if said hydraulic pressure simulating means is in a condition representative of said adequate pressure to cause the operation of said release magnet, and means controlled by said latter relay to simulate the reduction of hydraulic pressure incident to pulling back the bolt of a gun to safety the gun.

7. In apparatus in a trainer for simulating the hydraulic control of a gun charger by a gun charger control valve, means for simulating the production of a hydraulic pressure adequate to charge a gun or to safety it, a gun charger control rotatable to either a charge or to a safety position and then depressible, means for locking said control in its depressed position, a magnet operable for releasing said locking means in simula-

tion of the opening of the release port of a gun charger valve when a pressure is reached adequate to operate a gun charger to charge the gun, a relay operable when said control is rotated to its charge position and then depressed, a trigger switch, a second relay operable in response to the operation of said first relay if said hydraulic pressure simulating means is in a condition representative of said adequate pressure to cause the operation of said release magnet, a relay operable in response to the restoration of said control in simulation of the release of pressure in said gun charger for rendering said trigger switch effective, means for releasing said latter relay if said control is rotated to its safety position and then depressed to render said trigger switch ineffective, and a relay operable when said control is rotated to its safety position and then depressed for causing the reoperation of said second relay to release said control from its depressed position.

8. In apparatus in a trainer for simulating the hydraulic control of a gun charger by a gun charger control valve, means for simulating the production of a hydraulic pressure adequate to charge the gun or to safety it, a gun charging control rotatable to either a charge or to a safety position and then depressible, means for locking said control in its depressed condition, a magnet operable in simulation of the application of hydraulic pressure to a gun charger adequate to charge or to safety the gun for releasing said locking means, a first relay operable when said control is rotated to its charge position and then depressed, a second relay operable when said control is rotated to its safety position and then depressed, a relay operable in response to the operation of either said first or said second relay if said hydraulic pressure simulating means is in the condition representative of said adequate pressure to cause the operation of said release magnet, a trigger switch, and a relay responsive to the restoration of said control from its depressed charge position for rendering said trigger switch effective, said latter relay being released to render said trigger switch ineffective if said control is depressed in its safety position subsequent to being released from its charge position.

9. In apparatus in a trainer for simulating the hydraulic control of a gun charger by a gun charger control valve, means for simulating the production of a hydraulic pressure adequate to charge a gun or to safety it, a gun charger control rotatable to either a charge or to a safety position and then depressible, means for locking said control in its depressed position, a magnet operable in simulation of the application of hydraulic pressure to a gun charger adequate to charge or to safety the gun for releasing said locking means, a first relay operable when said control is rotated to its charge position and then depressed, a second relay operable when said control is rotated to its safety position and then depressed, a relay operable in response to the operation of either said first or said second relay if said hydraulic pressure simulating means is in a condition representative of said adequate pressure to cause the operation of said release magnet, a trigger switch, and a relay responsive to the operation of said first relay following the release of said control from its safety position and its rotation into its charge position for rendering said trigger switch effective.

10. In apparatus in a trainer for simulating the operations incident to the control of a plurality of guns, a master armament switch, a plurality of

gun selection switches, a gun charger control, means responsive to the operation of said control into a position simulating the charging of said guns, a trigger switch, means for simulating the sound of gun fire, and a circuit controlled jointly by said master armament switch, by the operated gun selector switches, by said trigger switch and by said gun charger simulating means for rendering said gun fire simulating means effective.

11. In apparatus in a trainer for simulating the operations incident to the control of a plurality of guns, a master armament switch, a plurality of gun selection switches, an instructor's desk, lamps at said desk responsive to the operation of said switches for informing the instructor as to which of said switches has been operated, a gun charger control, means responsive to the operation of said control into a position simulating the charging of said guns, a trigger switch, means for simulating the sound of gun fire, a circuit controlled jointly by said master armament switch, by the operated gun selection switches, by said trigger switch and by said gun charger simulating means for rendering said gun fire simulating means effective, and a switch at said instructor's desk for rendering said circuit ineffective in simulation of the failure of the guns to fire.

12. In apparatus in a trainer for simulating the operation incident to the control of a plurality of

guns, a master armament switch, a plurality of gun selector switches, an instructor's desk, lamps at said desk responsive to the operation of said switches for informing the instructor as to which of said switches has been operated, a gun charger control operable into a charge or into a safety position, lamps at said desk operable to inform the instructor as to the position to which said control has been operated, means responsive to the operation of said control into its charge position for simulating the charging of said guns, a trigger switch, means for simulating the sound of gun fire, and a circuit controlled jointly by said master armament switch, by the operated gun selector switches, by said trigger switch and by said gun charger simulating means for rendering said gun fire simulating means effective.

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