# United States Patent

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[72] Inventor Robert E. Nelson
Indianapolis, Indiana
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[73] Assignee General Motors Corporation
Detroit, Michigan
a corporation of Delaware

[54] CIRCUIT FOR AUTOMATICALLY OPERATING THE BREECH OF A LARGE CALIBER GUN
5 Claims, 6 Drawing Figs.

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[51] Int. Cl. .......... F41f 11/12
[50] Field of Search .......... 307/; 318/; 89/20.4, 28, 45, 47, 135

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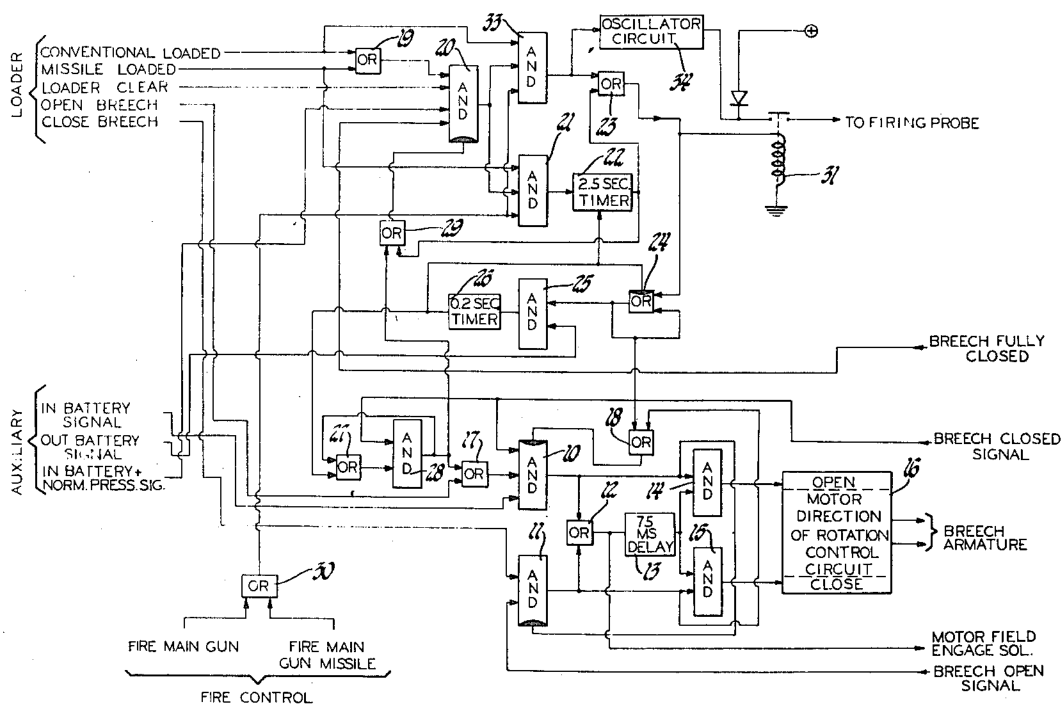
*Primary Examiner*—Benjamin A. Borchelt
*Assistant Examiner*—Stephen C. Bentley
*Attorney*—Richard G. Stahr and W. E. Finken

**ABSTRACT:** An electronic circuit for automatically operating the breech of a large caliber gun. The logic circuitry of this invention is responsive to predetermined combinations of externally generated electrical input signals which indicate the condition of the breech, the recoil mechanism and the automatic loader and other input signals from the automatic loader and the fire control system to provide for the following operations when the proper combination of signals are present:

a. delivers a properly timed firing pulse to a firing probe within the gun chamber, and

b. automatically opens the breech after the gun has fired or prevents the opening of the breech if the gun misfires.



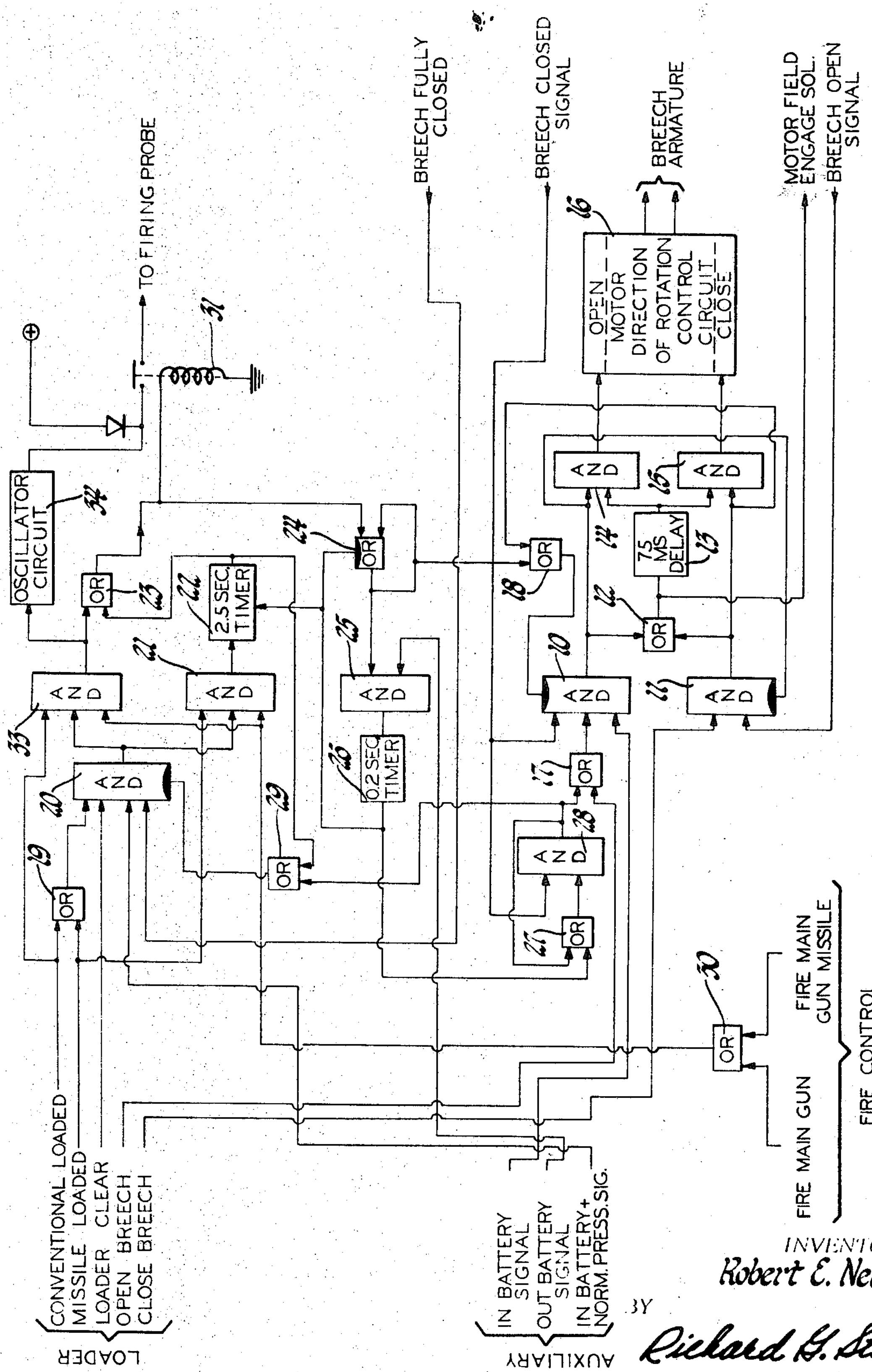



Fig.1

INVENTOR
Robert E. Nelson
BY
Richard G. Stahr
ATTORNEY

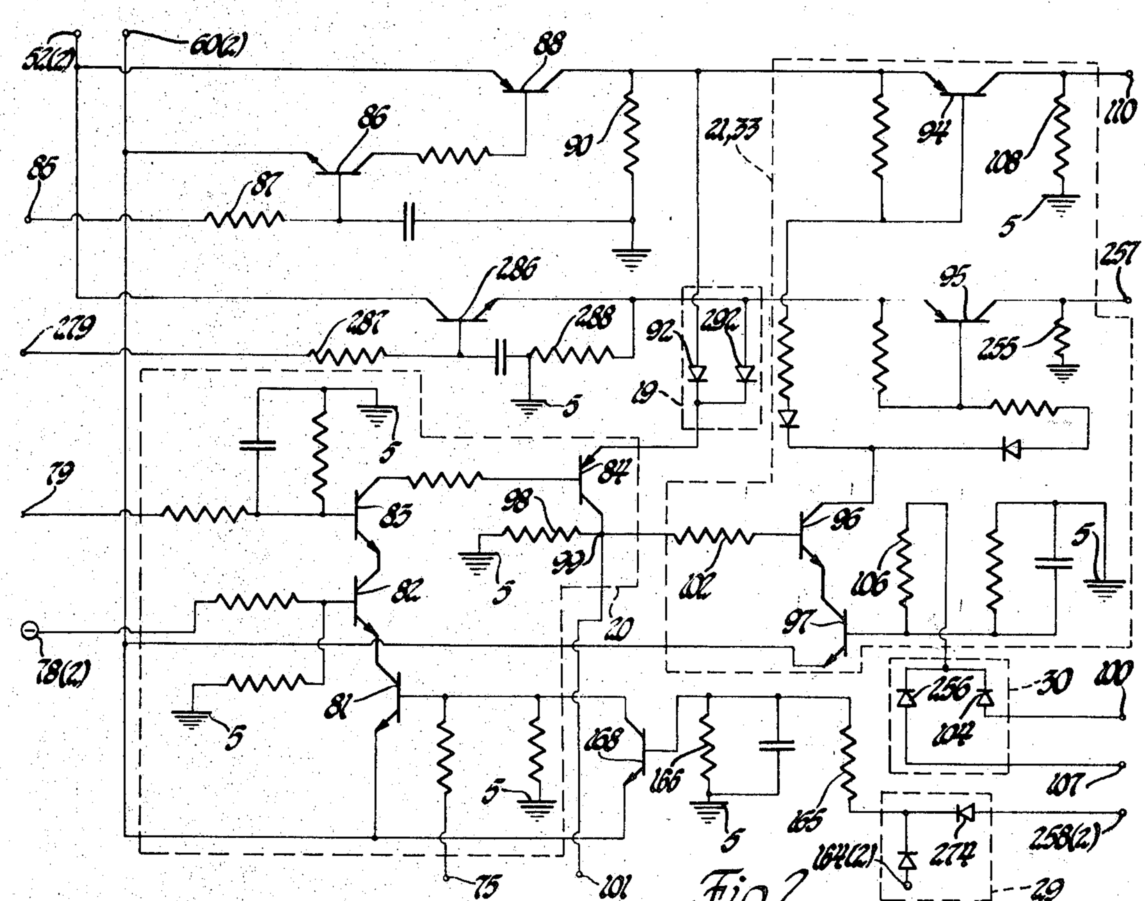


Fig. 2

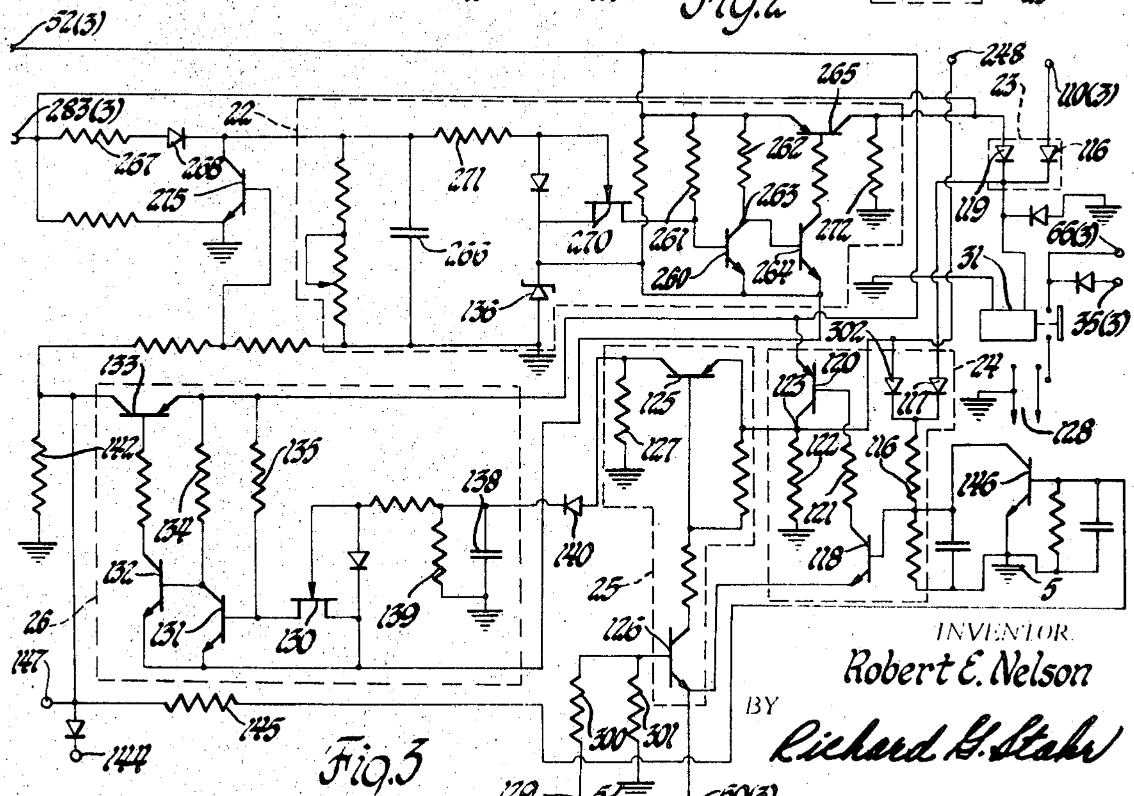


Fig. 3

INVENTOR
Robert E. Nelson

BY Richard G. Stahr

ATTORNEY

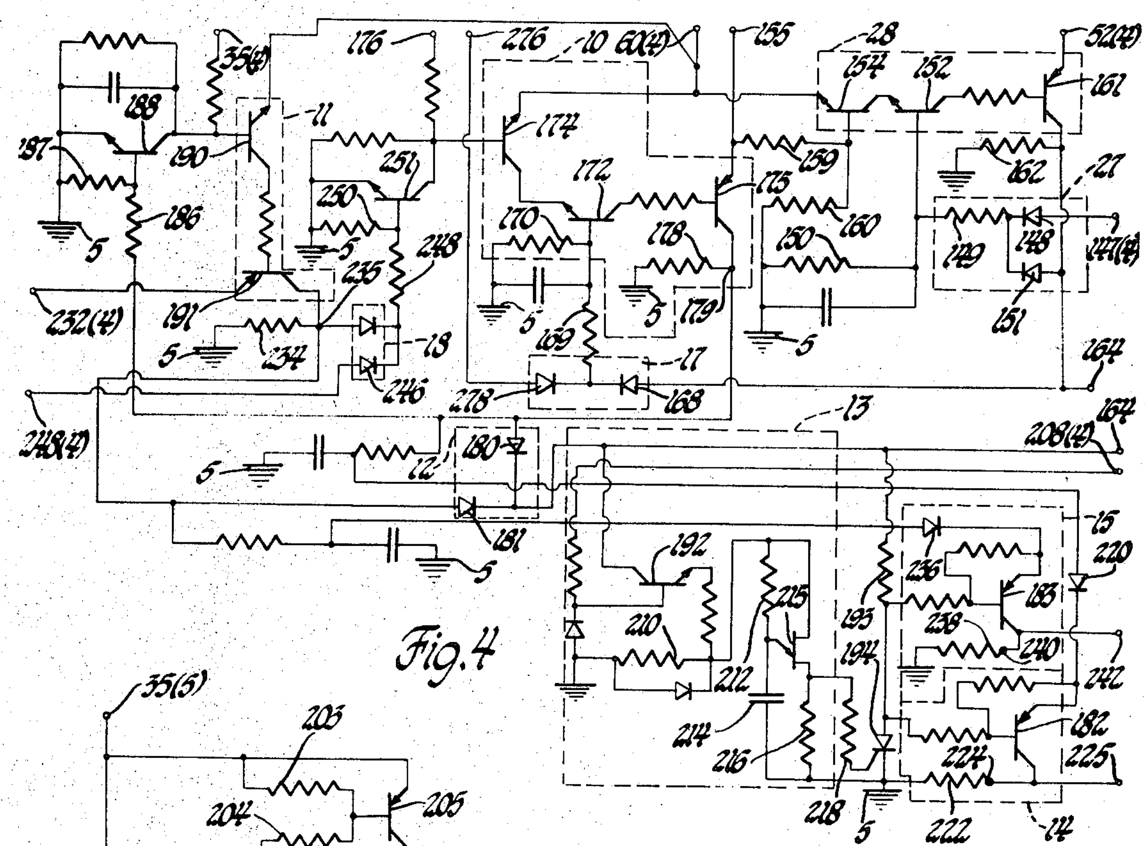


Fig. 4

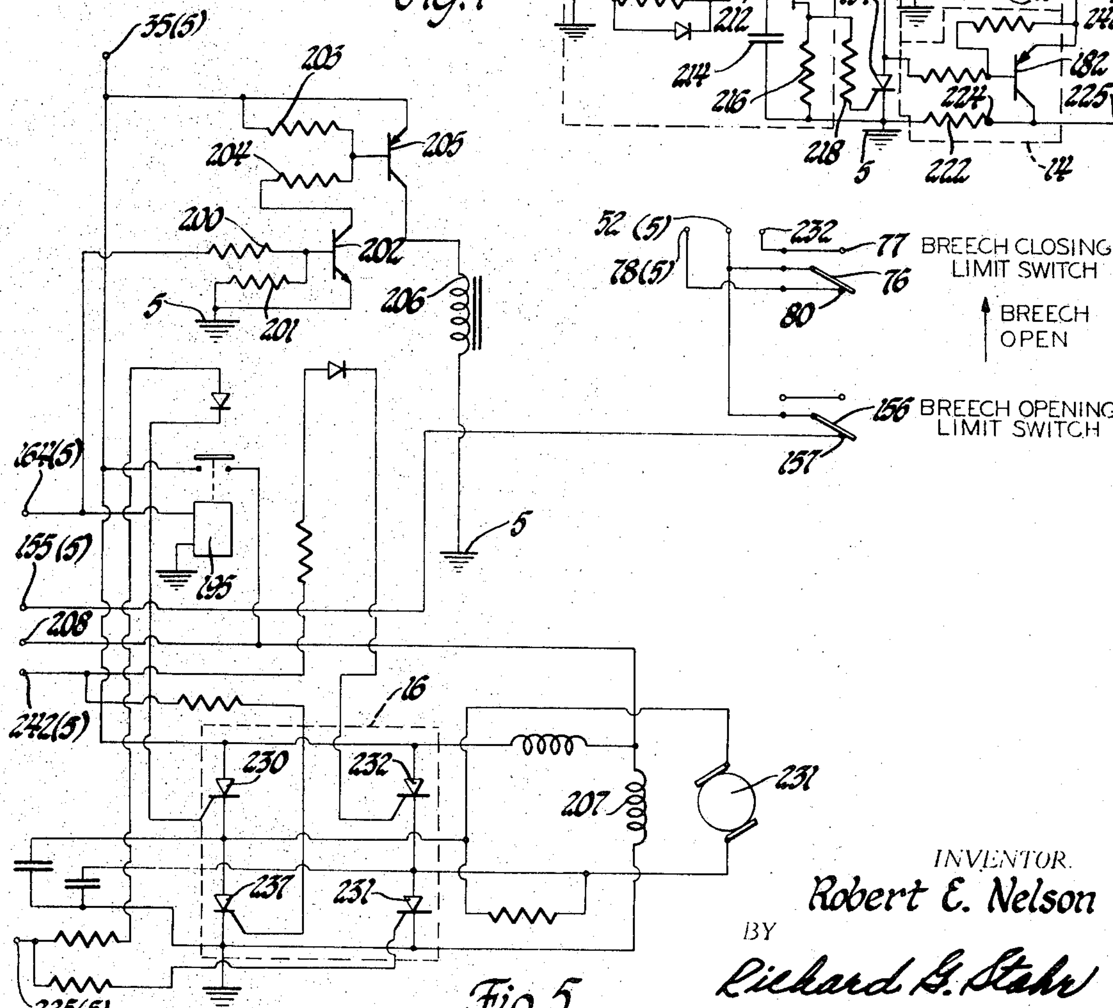



Fig. 5

INVENTOR.
Robert E. Nelson
BY
Richard G. Stahr
ATTORNEY

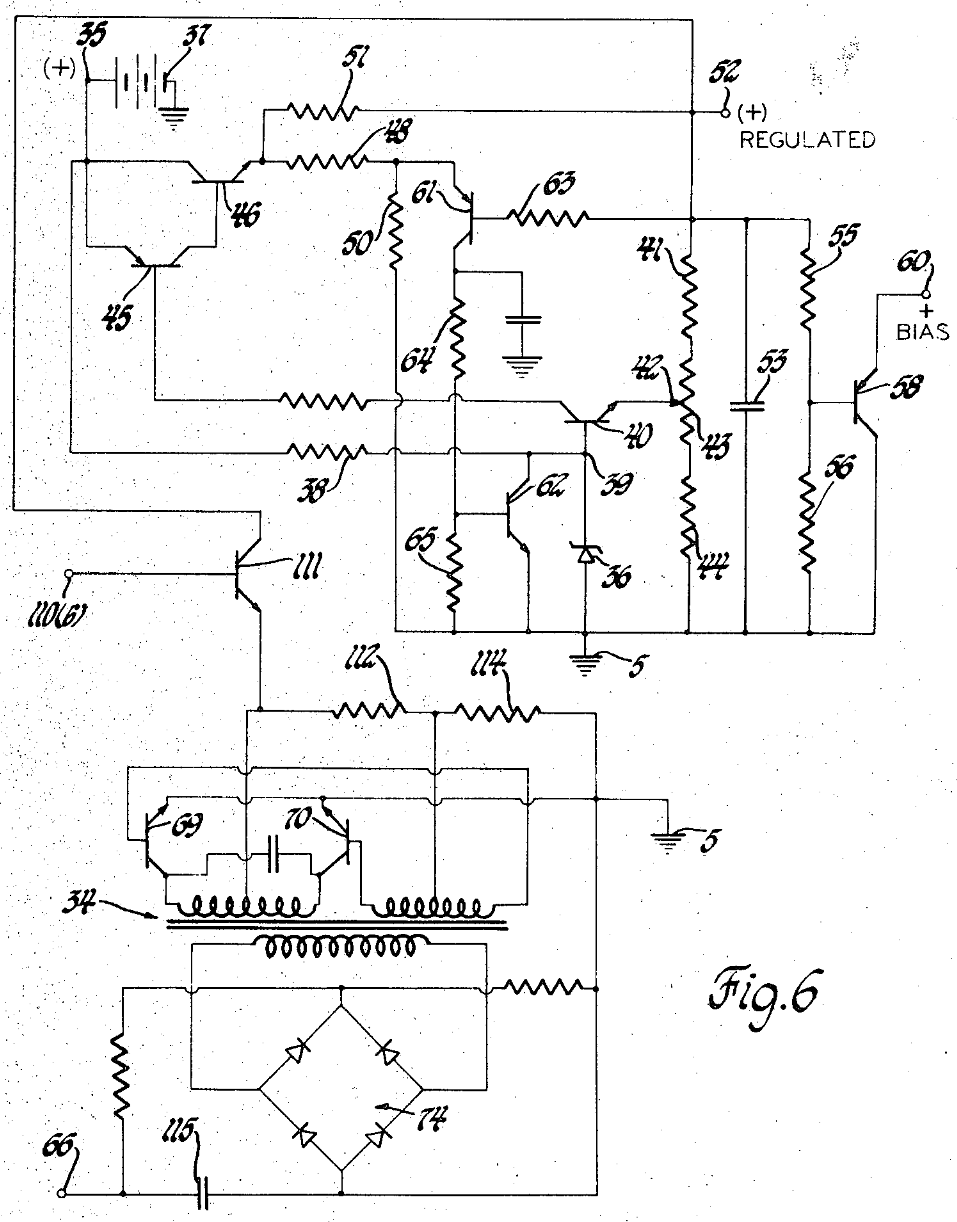



Fig. 6

INVENTOR
Robert E. Nelson
BY
Richard G. Stahr
ATTORNEY

## CIRCUIT FOR AUTOMATICALLY OPERATING THE BREECH OF A LARGE CALIBER GUN

This invention relates to a circuit for automatically operating the breech of a large caliber gun and, more specifically, to a circuit of this type made up of electronic components.

As substantially fail-safe control systems for automatically operating the breech mechanism of large caliber guns without operator assistance is desirable, it is an object of this invention to provide an improved circuit for automatically operating the breech of a large caliber gun.

It is another object of this invention to provide an improved circuit for automatically operating the breech of a large caliber gun in response to predetermined combinations of externally generated electrical input signals employing solid state logic circuitry.

In accordance with this invention a solid state logic circuit for automatically operating the breech of a large caliber gun in response to predetermined combinations of externally generated electrical input signals is provided.

For a better understanding of the present invention, together with additional objects, advantages and features thereof, reference is made to the following description and accompanying drawings in which:

FIG. 1 is a logic diagram of the circuit of this invention in block form;

FIG. 2 is a schematic diagram of the circuitry contained within blocks **19, 20, 21, 29, 30** and **33** of FIG. **1**;

FIG. 3 is a schematic diagram of the circuitry contained within blocks **22, 23 24, 25, 26** and **31** of FIG. 1;

FIG. 4 is a schematic diagram of the circuitry contained within blocks **10, 11, 12, 13, 14, 15, 17, 18, 27** and **28** of FIG. **1**;

FIG. **5** is a schematic diagram of the circuit components contained within block **16** of FIG. **1** and the operating motor energization circuitry; and

FIG. **6** is a schematic diagram of the power supplies employed with the circuit of this invention.

The automatic electronic breech control circuit of this invention is designed for use with a large caliber gun breech of the plug breech chamber-type which is operated by a single, reversible direct current electric motor. With the breech closed, the operating motor may be energized to rotate the breech chamber through approximately 30 percent angular travel on an interrupted thread to unlock the breech chamber, to linearly move the breech chamber in a direction along the axis of the gun bore until the chamber clears the gun breech and to swing the breech chamber out of the way to provide open access to the gun breech. Breech closing is accomplished by reversing the direction of rotation of the operating motor which operates the breech chamber in the reverse order of events just described. The breech control circuit accepts externally generated electrical input signals from the automatic loader and from the fire control system and combines these input signals with other electrical input signals which indicate the condition of the breech, the recoil mechanism and the loader to provide the following operations when the proper combination of signals are present:

a. delivers a properly timed firing pulse to fire the round;

b. automatically opens the breech after the round has fired or inhibits the opening of the breech if the round misfires; and,

c. returns signals back to the loader and fire control stations indicating what has happened and awaits the next instructions.

FIG. **1** of the drawings is a block form logic diagram of the control system of this invention. The specific electronic circuitry components contained within each block will be explained in detail later in this specification.

The breech open and close logic circuitry comprises breech open AND gate **10**, breech close AND gate **11**, breech operating OR gate **12**, a 75-millisecond delay circuit **13**, breech operating motor armature open AND gate **14** and breech operating motor armature close AND gate **15**.

Breech open AND gate **10** is a three input AND gate which requires a "breech closed" input signal, which indicates that the breech is closed, an "in battery" input signal which indicates that the recoil mechanism has placed the gun in the in battery position, and a manually supplied "open breech" input signal or an automatic "open breech" input signal produced by another portion of the circuitry, in a manner to be later explained, to produce an output signal.

Breech operating OR gate **12** is a two input OR gate which requires an input signal from either breech open AND gate **10** or breech close AND gate **11** to produce an output signal.

Breech operating motor armature open AND gate **14** is a two input AND gate which requires an input signal from the breech open AND gate **10** and an input signal from breech operating OR gate **12**, which is delayed for 75-milliseconds by the 75-millisecond delay circuit **13**, to produce an output signal.

Breech operating motor armature close AND gate **15** is a two input AND gate which requires an input signal from the breech close AND gate **11** and an input signal from breech operating OR gate **12**, which is delayed for **75**-milliseconds by the **75**-millisecond delay circuit **13**, to produce an output signal.

The operating motor direction of rotation control circuit **16** is responsive to an output signal from breech operating motor armature open AND gate **14** to energize the operating motor armature in a polarity relationship to produce rotation thereof in a direction to open the breech and to a signal from the breech motor armature close AND gate **15** to energize the operating motor armature in a polarity relationship to produce rotation thereof in a direction to close the breech, in a manner which will be explained in detail later in this specification.

In the following explanation of the logic circuit of the breech control of this invention, the various required controls will be assumed to be present or supplied without regard to the manner in which these signals are produced, which will be explained in detail later in this specification.

To manually open the breech, a "breech closed" signal and an "in battery" signal are present upon two of the input circuit terminals of breech open AND gate **10** and an "open breech" input signal is manually supplied through OR gate **17** to the other input circuit terminal thereof.

The resulting output signal from breech open AND gate **10** inhibits breech close AND gate **11**, to prevent the circuitry from attempting to simultaneously open and close the breech, and is applied as an input signal to each the breech operating OR gate **12** and breech operating motor armature open AND gate **14**.

The resulting output signal from breech operating OR gate **12** is applied to the 75-millisecond delay circuit **13** to one input terminal of breech operating motor armature AND gate **14** after a 75-millisecond delay, across the motor field relay operating coil, not shown, and to the motor solenoid control circuitry, also not shown.

The 75-millisecond delay circuit is provided for the purpose of delaying the application of electrical power to the breech operating motor armature and series field until the motor solenoid has had time to engage the gearing.

After a 75-millisecond delay in response to the output signal from breech operating OR gate **12**, the 75-millisecond delay circuit **13** permits the output signal from breech operating OR gate **12** to be applied as the other input signal to breech operating motor armature open AND gate **14**.

The operating motor direction of rotation control circuit **16** is responsive to the resulting output signal from breech operating motor armature open AND gate **14** to energize the operating motor armature in a polarity relationship to produce rotation thereof in a direction to open the breech.

To manually close the breech, a "breech open" signal is present upon one input circuit terminal of breech close AND gate **11** and a "close breech" input signal is manually supplied to the other input circuit terminal thereof.

The resulting output signal from breech close AND gate **11** inhibits the breech open AND gate **10** through an OR gate **18**, to prevent the circuitry from attempting to simultaneously open and close the breech, and is applied as an input signal to each the breech operating OR gate **12** and to breech operating motor armature close AND gate **15**.

After a 75-millisecond delay, as previously explained, the output signal from breech operating OR gate **12** is applied as the other input signal to breech operating motor armature close AND gate **15**.

The operating motor direction of rotation control circuit **16** is responsive to the resulting output signal from breech operating motor armature close AND gate **15** to energize the operating motor armature in a polarity relationship to produce rotation thereof in a direction to close the breech.

The gun for which the control circuit of this invention was specifically designed is capable of firing both missiles and conventional rounds. Therefore, the circuitry is designed to be responsive to both an externally supplied "missile loaded" signal or a "conventional loaded" signal. As these signals are employed separately in other portions of the circuitry in a manner to be later described, a two input gun loaded OR gate **19** is provided.

For missile firing, gun loaded OR gate **19**, ready to fire AND gate **20**, fire missile AND gate **21**, 2.5-second timer **22**, OR gate **23**, OR gate **24**, AND gate **25**, .2-second timer **26**, OR gate **27** and AND gate **28** are required in addition to the breech open logic circuitry previously described.

Ready to fire AND gate **20** is a four input AND gate which requires the presence of a "breech closed" input signal, which indicates that the breech is closed, an "in battery-pressure normal" input signal, which indicates that the gun is in the in battery position and the pressure is normal, a "loader clear" input signal which indicates that the loader is clear, and a "-missile loaded" input signal, which indicates that the missile is loaded in the gun, to produce an output signal.

Fire missile AND gate **21** is a three input AND gate which requires a "missile loaded" input signal, a ready to fire input signal from ready to fire AND gate **20**, and a "fire main gun-missile" input signal to produce an output signal.

The 2.5-second timer is responsive to an output signal from fire missile AND gate **21** to control the duration of the firing pulse, the 2.5 sequence providing the maximum time for the missile to fire.

OR gate **23** is a two input OR gate which, for missile firing, requires an input signal from the 2.5-second timer to produce an output signal which energizes the firing relay **31** to place an unregulated direct current potential across the firing probe within the gun chamber in a manner to be later explained.

OR gate **24** is a two input OR gate which requires an input signal from either the output of OR gate **23** on the output signal from itself, which is returned from the output circuit thereof to the other one of the input circuit terminals for the purpose of maintaining the gate in its "on" mode even though the output signal from OR gate **23** may be removed.

AND gate **25** is a two input AND gate which requires an input signal from the output of OR gate **24** and an "out of battery" input signal, which indicates that the round has fired to produce an output signal.

The .2-second timer is responsive to the output signal from AND gate **25** to produce an output signal which inhibits the 2.5-second timer, produces an external round fired signal, inhibits OR gate **24** and supplies one input signal for two input OR gate **27**.

AND gate **28** is a two input AND gate which requires a "-breech closed" input signal and an output signal from OR gate **27** to produce an output signal.

To fire a missile, a "breech closed" signal, an "in battery-pressure normal" signal and a "loader clear" signal are present upon each of three input circuit terminals of four input ready to fire AND gate **20** and a "missile loaded" signal is manually supplied through OR gate **19** to the fourth input circuit terminal thereof when the missile has been loaded.

The resulting output signal from ready to fire AND gate **20** is applied as another input signal to another input circuit terminal of fire missile AND gate **21**. At this time, the "missile loaded" signal and the signal from the output of ready to fire AND gate **20** are present upon two of the three input circuit terminals of fire missile AND gate **21**. A "fire main gun-missile" signal is applied to the other input circuit terminal thereof through OR gate **30** when it is desired to fire the gun.

The resulting output signal from fire missile AND gate **21** is applied to the 2.5-second timer **22**, which produces the firing pulse of a duration of 2.5 seconds to provide a maximum time for the missile to fire. Normally, missile firing would occur earlier than 2.5 seconds, in which case the .2-second timer would produce an output signal which inhibits or stops the operation of the 2.5-second timer. In the event the missile should not fire, the 2.5-second timer will repeat its cycle as long as the firing signal from fire missile AND gate **21** is present.

The output of the 2.5-second timer is supplied to one input circuit terminal of OR gate **23** and to one input circuit terminal of OR gate **29** and produces an external "missile fire" signal.

The resulting output signal from OR gate **23** energizes firing relay **31** to place an unregulated direct current potential across the firing probe within the gun chamber and is applied as an input signal to one of the input circuit terminals of OR gate **24**.

The resulting output from OR gate **29** is applied as an inhibiting signal to ready to fire AND gate **20** to place this gate in the "off" mode, a condition which removes one of the input signals from fire missile AND gate **21**. The removal of this signal from AND gate **21** places this device in its "off" mode to extinguish the firing signal.

The resulting output signal from OR gate **24** is returned to the other input circuit thereof to maintain OR gate **24** in its "on" mode, and is applied to one input circuit terminal of OR gate **18**, a condition which produces an output signal therefrom which serves to inhibit breech open AND gate **10** as a safety feature and is applied as an input signal to one of the input circuit terminals of AND gate **25**.

As OR gate **24** is not inhibited at this time and is maintained in its "on" mode even though the output signal from 2.5-second timer **22** is interrupted, the output signal therefrom inhibits open breech AND gate **10**. This prevents the opening of the breech through the control circuitry while the gun contains a misfired missile.

In the event the missile fires, the recoil mechanism permits the gun to go out of battery which produces an "out of battery signal". This "out of battery" signal is applied as the other input signal to the other input circuit terminal of AND gate **25**. The resulting output signal from AND gate **25** activates the .2-second timer **26**. Therefore, the .2-second timer produces the pulse of .2 seconds duration immediately after the firing pulse has occurred and the gun goes out of battery, indicating that the gun has fired.

The output of the .2-second timer **26** inhibits the 2.5-second second timer **22**, inhibits OR gate **24** which removes its output signal from OR gate **18** to enable breech open AND gate **10**, produces an external "round fired" signal and supplies an input signal to one of the input circuit terminals of OR gate **27**. The resulting output signal from OR gate **27** is applied as one input signal to one of the input circuit terminals of AND gate **28**.

As the "breech closed" signal is also present upon the other input circuit terminal of AND gate **28**, an output signal is produced thereby which is applied to OR gate **17**, to the other input circuit terminal of OR gate **27** to maintain this device in its "on" mode and to OR gate **29**.

The resulting output signal from OR gate **29** inhibits ready to fire AND gate **20** and the resulting output signal from OR gate **17** is applied as one input signal to one input circuit terminal of breech open AND gate **10**. Consequently, this gate has present upon two of its input circuit terminals a "breech closed" input signal and the output signal from OR gate 17. When the gun returns to the in battery position, the "in battery" signal thus produced is applied to the third input circuit terminal of breech open AND gate 10. The resulting output signal activates the open breech logic circuitry previously described to automatically open the gun breech and prepare the gun to receive the next round.

In the event the missile does not fire during the 2.5-second duration firing signal produced by the 2.5-second timer 22, the gun does not go out of battery, consequently, the "out of battery" signal is not supplied to the other input circuit terminal of AND gate 25 and, of course, there is no output signal therefrom. With no output signal from AND gate 25, the .2-second timer is not activated to inhibit the 2.5-second timer 22 and OR gate 24. Consequently, at the end of 2.5-seconds, the output signal from the 2.5-second timer 22 is removed from the input circuits of respective OR gates 23 and 29. The resulting absence of a signal from OR gate 29 removes the inhibit signal from ready to fire AND gate 20, a condition which permits this circuit to produce another out put signal. This output signal is supplied to the corresponding input circuit of fire missile AND gate 21. The resulting output signal therefrom produces the same sequence of events just described.

To fire a conventional round, a fire conventional AND gate 33 and a high direct current potential circuit 34 are required in addition to the missile firing circuitry just described and the 2.5-second timer 22 and AND gate 21 are not used.

Assuming that the "breech closed" the "in battery" and pressure normal and "loader clear" input signals are all present upon respective input circuit terminals of ready to fire AND gate 20, a "conventional loaded" signal is supplied through OR gate 19. As all of the input signals are present, ready to fire AND gate 20 produces an output signal which is applied to one of the input circuit terminals of fire conventional AND gate 33. As the "conventional loaded" signal is also present upon one of the input circuit terminals of fire conventional AND gate 33, the only signal required is a "fire main gun-conventional" signal which is supplied through OR gate 30. As all of the input signals are now present upon respective input circuit terminals of fire conventional AND gate 33, the output signal produced thereby is applied to one input circuit terminal of OR gate 23 and to the high direct current potential circuit 34.

High potential circuit 34 operates to produce a high direct current potential which serves to burn off any oxides which may be present upon the case of the conventional round to provide a good electrical contact with the firing probe. In a practical application, this circuit operates to generate 120 volts, direct current.

The resulting signal from OR gate 23 energizes firing relay 31 to place the potential produced by high potential circuit 34 and an unregulated direct current potential across the firing probe of the gun. The output of OR gate 23 is also applied as one of the input circuit terminals of OR gate 24.

The resulting output signal from OR gate 24 is applied back to its input circuit, to an input circuit terminal of OR gate 18 and to one of the input circuit terminals of two input AND gate 25. The resulting output signal from OR gate 18, of course, inhibits breech open AND gate 10 in the event the round does not fire and the gun does not go out of battery to prevent the opening of the breech with a misfired round in the chamber.

In the event the round fires, the gun goes out of battery to produce an "out of battery signal" which is applied to the other input signal circuit terminal of AND gate 25.

The resulting output signal from AND gate 25 operates the remainder of the logic circuitry to open the breech in a manner identical to that previously described in regard to the missile firing sequence.

The circuitry contained within each of the blocks of the logic diagram of FIG. 1 will now be explained in detail.

Referring to FIG. 6 of the drawing, a regulated direct current potential power supply and the high potential circuit 34 of FIG. 1 are set forth in schematic form. An unregulated direct current potential source, such as battery 37, is connected across input terminal 35 and a point of reference or ground potential which, since it is the same point electrically throughout the system, is indicated by the accepted symbol and referenced by the numeral 5. The direct current potential of unregulated source 37 is applied across Zener diode 36 in a reverse polarity relationship through resistor 38. Zener diode 36 is selected to have an inverse breakdown potential rating of a value less than the magnitude of unregulated source 37, consequently, this device breaks down and conducts in a reverse direction to maintain a substantially constant direct current potential upon the base electrode of type NPN control transistor 40, which is of a positive polarity at junction 39 with respect to ground 5. As the emitter electrode of type NPN control transistor 40 is connected to ground 5 through the movable contact 42 of potentiometer 43 and resistor 44, the proper base-emitter potential polarity relationship to produce base-emitter current flow through a type NPN transistor appears across the base-emitter electrodes of control transistor 40, consequently, base-emitter current flows therethrough to trigger this device conductive through the collector-emitter electrodes thereof.

With transistor 40 conducting through its collector-emitter electrodes, a circuit is established for emitter-base current flow through type PNP transistor 45. As the positive polarity potential of unregulated potential source 37 is applied across the emitter electrode of type PNP transistor 45 and ground 5, the resulting emitter-base current flow therethrough triggers this device conductive through the emitter-collector electrodes thereof. With transistor 45 conducting through the emitter-collector electrodes, a circuit is established for base-emitter current flow through type NPN regulator transistor 46. As the emitter electrode of type NPN regulator transistor 46 is connected to point of reference or ground potential 5 through series resistors 48 and 50, the positive polarity potential present upon the base electrode thereof, through the emitter-collector electrodes of transistor 45 produces base-emitter current flow therethrough to trigger this device conductive through the collector-emitter electrodes thereof. Conducting transistor 46 operates as a series type regulator transistor which regulates the output potential appearing across output terminal 52 and ground which is of a positive polarity upon terminal 52 with respect to ground.

The magnitude of the current through the base-emitter electrodes of transistor 46 is determined by the degree of conduction through transistor 45 and the degree of conduction through transistor 45 is determined by the degree of conduction through control transistor 40. To adjust the degree of conduction through the collector-emitter electrodes of control transistor 40, a voltage divider network consisting of the series combination of resistor 41, potentiometer 43 and resistor 44 is connected across regulated potential output terminal 52 and point of reference or ground potential 5. An adjustment of movable contact 42 of potentiometer 43 in a direction toward resistor 41 raises the magnitude of the positive polarity potential applied to the emitter electrode of control transistor 40, consequently, conduction through this device is decreased. An adjustment of movable contact 42 in the opposite direction, of course, reduces the magnitude of the positive polarity potential applied to the emitter electrode of control transistor 40, consequently, conduction through this device is increased. Therefore, movable contact 42 of potentiometer 43 may be adjusted to a position which will produce the required regulated direct current potential across capacitor 53 which also appears across regulated potential output terminal 52 and ground. This regulated direct current potential is employed as the logic circuit components supply potential throughout the system.

Also connected across capacitor 53 and output terminal 52 is another voltage divider network comprising series resistors

55 and 56. The base electrode of type PNP transistor 58 is connected to the junction between resistors 55 and 56. The elements of this combination are proportioned to provide a direct current potential of a magnitude of approximately two volts which is of a positive polarity at output terminal 60 with respect to ground 5 which is employed throughout the remainder of the system as a transistor reverse bias potential to prevent spontaneous low level noise from triggering the various circuits.

As an over-current safety feature, resistor 51 is connected in series between the emitter electrode of regulator transistor 46 and the regulated potential output terminal 52. The values of series resistors 48 and 50 are selected to provide approximately a two volt drop across resistor 48. Therefore, when the load current through series resistor 51 produces a potential drop of two volts, the potential present upon the base electrode of type PNP transistor 61 is of a polarity less positive than the potential present upon the emitter electrode thereof. This potential differential across the emitter-base electrodes of type PNP transistor 61 produces base-emitter current flow therethrough, which triggers this device conductive through the emitter-collector electrodes thereof. With transistor 61 conducting through the emitter-collector electrodes, a circuit is established for base-emitter current flow through type NPN transistor 62. The base-emitter current flow through transistor 62 triggers this device conductive through the collector-emitter electrodes thereof to provide a low resistance path in shunt around Zener diode 36, thereby reducing the potential present upon the base electrode of transistor 40 to essentially ground potential. This ground potential causes transistor 40 to go out of conduction, thereby disenabling the power supply. Resistors 63 and 64 are current limiting resistors and resistor 65 is a base-bias resistor for transistor 62.

Throughout the drawings, terminals of other FIGS. which are electrically connected to respective output terminal 52 and 60 of FIG. 6 are referenced by the corresponding reference numeral with the FIG. number of the drawing in parentheses. For example, output terminal 52 of FIG. 6 is electrically connected by a conductor to input terminal 52 (4) of FIG. 4 and output terminal 60 is electrically connected by a conductor to input terminal 60 (2) of FIG. 2, etc.

Also shown in FIG. 6 is the high direct current potential circuit 34 of FIG. 1 which operates from a direct current potential source to produce a high direct current potential output across output terminal 66 and point of reference or ground potential 5. Transistors 69 and 70 and the associated circuitry comprise a conventional push-pull type oscillator circuit which is designed to operate from a direct current potential source. As these circuits are conventional in design and form no part of this invention, per se, it will not be described in detail in this specification. The high frequency output of this oscillator circuit is inductively coupled to a full wave bridge-type rectifier 74 which full wave rectifies the oscillator output to produce a direct current potential across capacitor 115 and output terminal 66 and point of reference or ground potential 5 which is of a positive polarity with respect to ground 5.

The detailed description of the remainder of the circuitry will be initially described in regard to the firing of a conventional round.

Assuming that the gun is in the in battery position with the pressure normal, that the conventional round is loaded in the gun breech, that the loader is clear and that the breech is closed, a limit switch, not shown, on the gun recoil mechanism applies a direct current potential, which may be obtained from source 37 of FIG. 6, across input terminal 75 of ready to fire AND gate 20 of FIG. 2 and ground 5; movable contact 76 of the breech closing limit switch, FIG. 5, places the regulated potential across input terminal 78 (2) and ground 5 of FIG. 2 through stationary contact 80, FIG. 5, and output terminal 78 (5) which is electrically interconnected with input terminal 78 (2) of FIG. 2, and a limit switch, not shown, mounted upon the loader mechanism places a direct current potential, which may be obtained from source 37 of FIG. 6, across input terminal 79 of FIG. 2 and ground 5, all of a positive polarity with respect to point of reference or ground potential 5.

The "in battery-pressure normal" input signal appearing across input terminal 75 and ground 5 is of the proper base-emitter polarity relationship for base-emitter current flow through type NPN transistor 81, the "breech closed" input signal appearing across input terminal 78 (2) and ground 5 is of the proper base-emitter polarity relationship for base-emitter current flow through type NPN transistor 82 and the "loader clear" input signal appearing across input terminal 79 and ground 5 is of the proper base-emitter polarity relationship for base-emitter current flow through type NPN transistor 83. Therefore, transistors 81 and 82 are conducting through the collector-emitter electrodes thereof and transistor 83 is not conducting through the collector-emitter electrodes thereof as this circuit is interrupted by nonconducting type PNP transistor 84, consequently, there is no output from ready to fire AND gate 20.

By closing a switch, not shown, potential "conventional loaded" input signal, which may be obtained from source 37 of FIG. 6, is applied across input terminal 85 and ground 5 which is of a positive polarity with respect to ground 5. This positive polarity potential is applied to the base electrode of type NPN transistor 86 through resistor 87.

As the emitter electrode of transistor 86 is connected to the positive bias potential produced by the power supply of FIG. 6 through terminal 60 (2), which is electrically interconnected with output terminal 60 of FIG. 6, the proper base-emitter polarity relationship for base-emitter conduction through type NPN transistor 86 is provided. Consequently, this device conducts through the collector-emitter electrodes thereof. As transistor 86 conducts through the collector-emitter electrodes thereof, a circuit is established for emitter base current flow through type PNP transistor 88, the emitter electrode of which is connected to the positive polarity regulated supply potential through terminal 52 (2), which is electrically interconnected with terminal 52 of FIG. 6. The emitter-base current which flows through transistor 88 triggers this device to conduction through the emitter-collector electrodes thereof and an output signal appears across resistor 90. This output signal is applied to diode 92 of OR gate 19 and to the emitter electrode of type PNP transistor 94 of fire conventional AND gate 33. This signal is of the correct polarity to enable type PNP transistor 94 to conduct through the emitter-base electrodes thereof, however, this device does not conduct at this time as transistors 96 and 97 are nonconductive to interrupt the emitter-base circuit therefor.

It is pointed out that transistor 96 and 97 are common to both fire conventional AND gate 33 and fire missile AND gate 21. Transistor 94 produces the output signal from fire conventional AND gate 33 and transistor 95 produces the output signal from fire missile AND gate 21.

The signal appearing across resistor 90 is conducted through diode 92 of OR gate 19 and is applied across the emitter-base electrodes of type PNP transistor 84 of ready to fire AND gate 20 and is of the correct polarity relationship to produce emitter-base current flow through a type PNP transistor. As transistors 81 and 82 of ready to fire AND gate 20 are conducting through the respective collector-emitter electrodes thereof, as previously described, and transistor 83 is conducting through the base-emitter electrodes thereof, as previously described, the enabling of transistor 84 to conduct through the emitter-base electrodes thereof permits current flow through the emitter-collector electrodes of transistor 84 and the collector-emitter electrodes of respective transistors 83, 82 and 81. Therefore, transistor 84 conducts through emitter-collector electrodes thereof and an output signal from ready to fire AND gate 20 appears across resistor 98 which is of a positive polarity at junction 99 with respect to ground 5.

This signal may be taken from output terminal 101 and employed to energize an external "ready for firing" signal which may be, for example, a light. This is also applied across the base-emitter electrodes of type NPN transistor 96 of fire conventional AND gate 33 through resistor 102. As this is the correct baseeemitter polarity relationship for base-emitter conduction through a type NPN transistor, transistor 96 is enabled but does not conduct at this time as its base-emitter circuit to the two volt bias potential is interrupted by nonconducting transistor 97.

At this time, two input signals are being supplied to respective input circuit terminals of three input fire conventional AND gate 33. When it is desired to fire the gun, a "fire main gun-conventional" signal may be supplied to input terminal 100 by manually closing a switch, not shown, which places a direct current potential, which may be obtained from source 37 of FIG. 6, upon input terminal 100 which is of a positive polarity with respect to ground 5. This signal is conducted through diode 104 of OR gate 30 and is applied across the base-emitter electrodes of type NPN transistor 97 through resistor 106. As the emitter electrode of transistor 97 is returned to the 2 volt direct current bias potential through terminal 60 (2), the correct base emitter polarity relationship is established for base-emitter current flow through type NPN transistor 97. As transistor 97 conducts through its base-emitter electrodes, a circuit is completed for collector-emitter current flow through transistor 96 which, in turn, establishes a circuit for emitter-base current flow through transistor 94. Therefore, transistor 94 conducts through its emitter-collector electrodes and the output signal from fire conventional AND gate 33 appears across resistor 108 and may be taken from output terminal 110.

The output signal from fire conventional AND gate 33 is applied to the high direct current potential circuit of FIG. 6 through input terminal 110 (6) and to one of the input circuits of OR gate 23 through input terminal 110 (3) of FIG. 3, both of which are electrically connected to output terminal 110 of FIG. 2.

This signal, which is of a positive polarity with respect to ground upon input terminal 110 (6) of FIG. 6, is applied across the base-emitter electrodes of type NPN transistor 111, the emitter electrode of which is connected to point of reference or ground potential 5 through series resistors 112 and 114. As this is the correct base-emitter polarity relationship for base-emitter current flow through a type NPN transistor, this device conducts through the collector-emitter electrodes thereof and applies the regulated direct current potential across the oscillator circuit of FIG. 6 to render this device operative to produce a high direct current potential across output terminal 66 and point of reference or ground potential 5 to charge capacitor 115. This positive polarity output signal from fire conventional AND gate 33 is also conducted through diode 116 of OR gate 23 of FIG. 3 to diode 117 of OR gate 24 and across the operating coil of firing relay 31. Conducting diode 117 of OR gate 24 places this positive polarity signal across the base-emitter electrodes of type NPN transistor 118 through resistor 116. As the emitter electrode of transistor 118 is connected to the positive bias potential produced by the regulator circuit of FIG. 6 through terminal 60 (3), which is electrically connected to output terminal 60 of FIG. 6, the positive polarity signal applied across the base-emitter electrodes of type NPN transistor 118 produces base-emitter current flow therethrough. As the collector electrode of transistor 118 is connected to the base electrode of transistor 120 through resistor 121, conducting transistor 118 establishes a circuit for emitter-base current flow through transistor 120. As the emitter electrode of transistor 120 is connected to the source of regulated supply potential through terminal 52 (3), which is electrically connected to terminal 52 of the potential regulator circuit of FIG. 6, this device conducts through the emitter-base electrodes thereof and, consequently, through the emitter-collector electrodes thereof and an output signal from OR gate 24 appears across resistor 122 which is of a positive polarity at junction 123.

This positive polarity potential signal is applied across the emitter-base electrodes of type PNP transistor 125 of AND gate 25 and is of the proper emitter-base polarity relationship to produce emitter-base current flow through a type PNP transistor. However, transistor 125 does not conduct through the emitter-base circuit at this time as this circuit is interrupted by type PNP transistor 126 which is not conducting.

The signal applied across the operating coil of firing relay 31 energizes this device to close the normally open contacts thereof. Direct current potential source 37 of FIG. 6 is electrically connected to terminal 35 (3) of FIG. 3, through terminal 35 of FIG. 6, and the output terminal 66 of the high direct current potential source 34 is electrically connected to input terminal 66 (3) of FIG. 3. Consequently, upon the closure of the normally open contacts of firing relay 31, the high direct current potential of source 34 and the unregulated direct current potential of source 37 are simultaneously applied across firing probe 128 within the chamber of the gun. The combination of these potentials should fire the conventional round.

In the event the round should fire, the gun recoil mechanism permits the gun to go out of battery and a limit switch, not shown, mounted upon the recoil mechanism places a direct current potential, which may be obtained from source 37 of FIG. 6, across input terminal 129 and ground which is of a positive polarity with respect to ground. This positive polarity "out of battery" signal is applied across the base-emitter electrodes of type NPN transistor 126 through a voltage divider network comprising resistors 300 and 301. As the emitter electrode of type NPN transistor 126 is connected to the bias potential through terminal 60 (3), which is electrically connected to terminal 60 of FIG. 6, this is the correct base-emitter polarity relationship for base-emitter current flow through a type NPN transistor. Consequently, this device conducts through the base emitter electrodes thereof to trigger this device conductive through the collector-emitter electrodes thereof to establish a circuit for emitter-base current flow through type PNP transistor 125 which has been enabled by the output signal from OR gate 24 in a manner previously described. Consequently, transistor 125 conducts through the emitter-collector electrodes thereof and the output signal from AND gate 25 appears across resistor 127.

The output signal from OR gate 24 which appears across resistor 122 is also applied to diode 302 thereof to maintain OR gate 24 in its conducting mode after the signal from fire conventional AND gate 33 is removed.

The output signal from AND gate 25 is applied to the .2-second timer 26 which produces a pulse of .2-second duration immediately after the firing pulse has occurred and the gun has gone out of battery for the purpose of providing an indication that the round has fired.

The .2-second timer circuit comprises a field effect transistor 130, type NPN transistors 131 and 132 and type PNP transistor 133 and the associated circuitry. The regulated supply potential produced by the regulator circuit of FIG. 6 is applied across the collector-emitter electrodes and base-emitter electrodes of type NPN transistor 131 through input terminal 52 (3), electrically connected to output terminal 52 of FIG. 6, and respective resistors 134 and 135. As the emitter electrode of type NPN transistor 131 is connected to point of reference or ground potential 5 through Zener diode 136, the correct base-emitter polarity relationship is provided for base-emitter current flow through this type NPN transistor, consequently, transistor 131 is normally conducting through the collector-emitter electrodes thereof. With transistor 131 conducting, the base and emitter electrodes of transistor 132 are at substantially the same potential maintaining this device nonconductive. With transistor 132 not conducting, the emitter-base circuit for transistor 133 is interrupted, consequently this device is also nonconducting. Field effect transistor 130 is maintained in the nonconducting state by Zener diode 136.

Upon the occurrence of an output signal from AND gate 25, capacitor 138 charges through diode 140 to render field effect transistor 130 conductive. Conducting field effect transistor 130 places the base-emitter electrodes of conducting transistor 131 at substantially the same potential, consequently, this device goes not conductive, a condition which places the regulated potential across the base-emitter electrodes of type NPN transistor 132 through resistor 134. As this is the correct polarity relationship for base-emitter current flow through a type NPN transistor, this device conducts through the base-emitter electrodes thereof and establishes a circuit for emitter-base current flow through type PNP transistor 133 through the collector-emitter electrodes of transistor 132. As the emitter electrode of transistor 133 is connected to the regulated potential through terminal 52 (3), emitter-base current flows through this device, consequently, transistor 133 conducts through the collector-emitter electrodes thereof and an output signal therefrom appears across resistor 142. The length of the output pulse is determined by the value of resistor 139.

For conventional round firing, the output signal from the .2-second timer 26 may be taken from output circuit terminal 144 to energize an external signal indicating that the round has been fired and is applied through resistor 145 across the base-emitter electrodes of type NPN transistor 146, the emitter electrode of which is connected to point of reference or ground potential 5. As this positive polarity signal provides the correct base-emitter polarity relationship to produce base-emitter conduction through a type NPN transistor, base-emitter current flows there through, consequently, this device conducts through its collector-emitter electrodes. Conducting transistor 146 removes the base drive from conducting transistor 118 of OR gate 24, consequently, this OR gate is inhibited to its nonconducting mode and the output signal therefrom which appears across resistor 122 is removed. The output signal from the .2-second timer is also taken from output terminal 147 and impressed upon diode 148 of OR gate 27 of FIG. 4 through input terminal 147 (4) electrically interconnected with output terminal 147 of FIG. 3. This signal is conducted through diode 148 of OR gate 27 and is impressed across resistors 149 and 150. The base electrode of type NPN transistor 152 is connected to the junction between resistors 149 and 150, consequently, this signal provides one input to two input AND gate 28. As the emitter electrode of transistor 152 is connected to the positive bias potential through terminal 60 (4), which is electrically interconnected with terminal 60 of FIG. 6, through the collector-emitter electrodes of transistor 154, the positive polarity signal applied to the base electrode of transistor 152 provides the correct base-emitter polarity relationship for base-emitter current flow through a type NPN transistor. However, since transistor 154 is not conductive at this time, this signal only enables transistor 152. As the breech is closed at this time, a "breech closed" signal, which is of a positive polarity with respect to ground, is applied to input terminal 155 of FIG. 4 through a circuit which may be traced from output terminal 52 of FIG. 6, input terminal 52 (5) of FIG. 5, of FIG. 6, movable contact 156 of the breech opening limit switch, stationary contact 157 and output terminal 155 (5) to input terminal 155 of FIG. 4, with which it is electrically interconnected, and is impressed across series resistors 159 and 160. As the base electrode of type NPN transistor 154 is connected to the junction between resistors 159 and 160, this "breech closed" signal provides the second input signal to two input AND gate 28 and is impressed across the base-emitter electrodes of type NPN transistor 154. As the emitter electrode of transistor 154 is connected to the positive bias potential through terminal 60 (4), the "breech closed" signal produces base-emitter current flow through this type NPN transistor, a condition which provides for the completion of a circuit for base-emitter current flow through type NPN transistor 152 and, in turn, a circuit for emitter-base current flow through type PNP transistor 161, the emitter electrode of which is connected to the regulated potential source through terminal 52 (4). Consequently, type PNP transistor 161 conducts through the emitter-collector electrodes thereof and an output signal from AND gate 28 appears across resistor 162.

This output signal is returned to one of the input circuit terminals of OR gate 27 and is conducted through diode 151 to maintain this device in its on mode, is applied to one input circuit terminal of OR gate 17 and is taken from output terminal 164 and applied to one of the input terminals of OR gate 29 through terminal 164 (2) of FIG. 2, with which terminal 164 is electrically interconnected.

The resulting current flow through conducting diode 164 of OR gate 29 is impressed across resistors 165 and 166. As the base electrode of type NPN transistor 168 is connected to the junction between resistors 165 and 166 and the emitter electrode thereof is connected to the positive bias potential through terminal 60 (2), this signal provides the correct base-emitter polarity relationship to produce base-emitter current flow through type NPN transistor 168. As the gun returns to the "in battery" position, the "in battery-pressure normal" signal previously described, again appears on input circuit terminal 75. Consequently, transistor 168 conducts through its collector-emitter electrodes thereof to remove the base bias from transistor 81 of ready to fire AND gate 20 to inhibit this device and remove the output signal therefrom at this time to prevent another "ready to fire" signal output from ready to fire AND gate 33.

The output signal from AND gate 28, FIG. 4, is also applied through diode 168 of OR gate 17, FIG. 4, and is impressed across series resistors 169 and 170 as an input signal indicating that the breech is to be opened. As the base electrode of type NPN transistor 172 of breech open AND gate 10 is connected to the junction between transistors 169 and 170, this signal provides one input signal for three input breech open AND gate 10. As the emitter electrode of transistor 172 is connected to the positive bias potential through the collector-emitter electrodes of type NPN transistor 174 and terminal 60 (4), this signal provides the correct polarity relationship for base-emitter current flow through a type NPN transistor. However, this transistor is only enabled at this time and does not conduct as the base-emitter circuit thereof is interrupted by nonconducting transistor 174. The "breech closed" signal appearing across series resistors 159 and 160 through terminal 155, previously described, is also impressed across the emitter-base electrodes of type PNP transistor 175 to provide the second input signal for three input open breech AND gate 10. Although this signal is impressed across the emitter-base electrodes of type PNP transistor 175 in the correct polarity relationship to produce emitter-base current flow therethrough, this transistor is only enabled thereby as the emitter-base circuit is interrupted by nonconducting transistor 174.

When the gun recoil mechanism has returned the gun to the in battery position, a limit switch on the gun recoil mechanism, not shown, places the "in battery" potential signal, which may be obtained from source 37 of FIG. 6, across input terminal 176 and point of reference or ground potential 5 which is of a positive polarity with respect to ground. This signal is impressed across the base-emitter electrodes of type NPN transistor 174 in the correct polarity relationship to produce base-emitter current flow through a type NPN transistor as the emitter electrode of transistor 174 is connected to the positive polarity bias potential through terminal 60 (4). The resulting base-emitter current flow through transistor 174 triggers this device conductive through the collector-emitter electrodes thereof to establish a circuit for base-emitter current flow through enabled transistor 172 which, in turn, completes a circuit for emitter-base current flow through transistor 175, which is enabled by the "breech closed" signal present upon input terminal 155 and impressed upon the emitter electrode thereof. Consequently, emitter-collector current flows through transistor 175 and an output signal from breech open AND gate 10 appears across resistor 178 which is of a positive polarity at junction 179 with respect to point of reference or ground potential 5.

The output signal from breech open AND gate 10 is applied to diode 180 of OR gate 12, is applied across the emitter-base electrodes of type PNP transistor 182 as one input signal to two input breech operating motor armature open AND gate 14 and across series resistors 186 and 187. As the base electrode of type NPN transistor 188 is connected to the junction between resistors 186 and 187 and the emitter electrode thereof is connected to point of reference or ground potential 5, the correct base-emitter polarity relationship is established to produce base-emitter current flow through a type NPN transistor. Consequently, this device is enabled for conduction through the collector-emitter electrodes thereof in the event a spurious closed breech signal should appear upon input terminal 35 (4), a condition which will place the base electrode of transistor 190 of breech close AND gate 11 at substantially ground potential, thereby inhibiting this gate.

The output signal from OR gate 12 is applied across the collector-emitter electrodes of transistor 192 of the 75-millisecond delay circuit 13, across the series combination of resistor 193 and silicon controlled rectifier 194 and across the operating coil of motor field relay 195 of FIG. 5 through output terminal 164 of FIG. 4 and input terminal 164 (5) of FIG. 5, which are electrically interconnected. The output signal from OR gate 12 is also applied across series resistors 200 and 201 of the motor engaging solenoid trigger circuit of FIG. 5. As the base electrode of type NPN transistor 202 is connected to the junction between series resistors 200 and 201 and the emitter electrode thereof is connected to point of reference or ground potential 5, the positive polarity signal, with respect to ground, from OR gate 12 is of the correct polarity relationship to produce base-emitter current flow through this type NPN transistor. The collector-electrode of transistor 202 is connected to a source of direct current potential, which may be source 37 of FIG. 6 through input terminal 35 (5) which is electrically interconnected with terminal 35 of FIG. 6. Consequently, transistor 202 conducts through the collector-emitter electrodes thereof. As the base electrode of type PNP transistor 205 is connected to the junction between series resistors 203 and 204 and the collector electrode thereof is connected to point of reference or ground potential 5 through motor solenoid 206, this device conducts through the emitter-collector electrodes thereof to energize motor solenoid 206. The positive polarity signal from OR gate 12 also energizes the operating coil of motor field relay 195 which operates to close its normally open contacts. Upon the closure of the contacts of relay 195, the positive polarity potential with respect to ground 5 appearing at input terminal 35 (5) is applied across field coil 206 of the operating motor and, through output terminal 208, is applied across the base-emitter electrodes of type NPN transistor 192 of the 75-millisecond delay circuit 13 of FIG. 4 through input terminal 208 (4) which is electrically interconnected with output terminal 208. As this is the correct polarity relationship for base-emitter current flow through a type NPN transistor and since the output signal from OR gate 12 is also applied to the collector electrode thereof, the resulting base-emitter current flow therethrough triggers this device conductive through the collector-emitter electrodes thereof and an output signal appears across resistor 210. This signal is applied across the series combination of resistor 212 and capacitor 214 to place a charge upon the latter. When capacitor 214 has charged to a magnitude substantially equal to the breakdown potential of unijunction transistor 215, this device conducts through the base electrodes and an output signal appears across resistor 216. This signal is applied through resistor 218 across the gate-cathode electrodes of silicon controlled rectifier 194 in the correct polarity relationship to produce gate current therethrough. As the output signal from OR gate 12 is applied across the anode-cathode electrodes of silicon controlled rectifier 194, this device conducts to establish a circuit for emitter-base current flow through type PNP transistor 182 of breech operating motor armature open AND gate 14. Consequently, the output signal from open breech AND gate 10 is conducted through diode 220 and the emitter-collector electrodes of transistor 182 and an output signal from breech operating motor armature open breech AND gate 14 appears across resistor 222 which is of a positive polarity with respect to ground at junction 224. This output signal may be taken from output terminal 225 and applied to input terminal 225 (5) of FIG. 5. This signal, consequently, is applied across the gate-cathode electrodes of silicon controlled rectifiers 230 and 231 of operating motor direction of rotation control circuit 16. As the anode electrodes of these silicon controlled rectifiers are connected to a positive polarity potential, which may be source 37 of FIG. 6 through output terminal 35 (5) electrically interconnected to output terminal 35 of FIG. 6, silicon controlled rectifiers 130 and 131 are biased conductive through the respective anode-cathode electrodes thereof to complete an energizing circuit for motor armature 232 which may be traced from the direct current potential source 37, to terminals 35 and 35 (5), the anode-cathode electrodes of conducting silicon controlled rectifier 130, through motor armature 231, through the anode-cathode electrodes of conducting silicon controlled rectifier 131 to point of reference or ground potential 5. Consequently, the breech operating motor is energized to open the breech.

When the breech is fully opened, the "breech closed" input signal appearing across input terminal 155 of FIG. 4 is removed from the emitter electrode of transistor 175 of breech open AND gate 10. Upon the removal of this signal from one of the input circuits of breech open AND gate 10, the output signal therefrom is removed and the remainder of the breech opening circuitry returns to its reset condition awaiting the next open breech output signal from open breech AND gate 10.

When the breech has been fully opened by the operating motor, movable contact 76 of the breech closing limit switch of FIG. 5 places the regulated direct current potential upon the emitter-electrode of type NPN transistor 190 of the breech close AND gate 11 of FIG. 4 through a circuit which may be traced from input terminal 52 (5) of FIG. 5, which is electrically connected to terminal 52 of the power supply circuit of FIG. 6, through movable contact 76, through stationary contact 77, output circuit terminal 232, to input circuit terminal 232 (4) of FIG. 4. As transistor 190 of closed breech AND gate 11 is not conducting at this time, this signal only enables transistor 191.

When it is desired to close the breech, a close breech signal is manually supplied by closing a switch, not shown, which places a direct current potential, which may be obtained from source 37 of FIG. 6, across the base-emitter electrodes of type NPN transistor 190 through terminal 35 (4). As the emitter electrode of transistor 190 is connected to the positive bias potential through terminal 60 (4), the correct base-emitter polarity relationship is established to produce base-emitter current flow through NPN transistor 190, consequently, this device is triggered conductive through its collector-emitter electrodes thereof. With transistor 190 conducting through the collector-emitter electrodes thereof, a circuit is established for emitter-base current flow through enabled type PNP transistor 191, consequently, this device conducts thru through the collector-emitter electrodes thereof and the output signal from breech close AND gate 11 appears across resistor 234 and is of a positive polarity with respect to ground at junction 235.

This output signal is applied to diode 181 of OR gate 12, to diode 246 of OR GATE gate 18 to inhibit breech close AND gate 10, and to the emitter electrode of type PNP transistor 183 of breech operating motor armature closed AND gate 15 through diode 236. The resulting output signal from OR gate 12 produces the same sequence of events as that previously described in regard to the opening of the breech.

After a 75-millisecond delay introduced by delay circuit 13, silicon controlled rectifier 194 is again triggered conductive to establish a circuit for emitter-base current flow through type PNP transistor 183 and an output signal from breech operating motor armature close AND gate 15 appears across resistor 238 which is of a positive polarity with respect to ground at junction 240.

This output signal is taken from output terminal 242 and applied, through input terminal 242 (5) of FIG. 5, across the gate-cathode electrodes of silicon controlled rectifiers 236 and 237 of the operating motor direction of rotation control circuit 16, thereby triggering these devices to conduction to establish an energizing circuit for motor armature 231 which may be traced from input terminal 35 (5) through conducting silicon controlled rectifier 236, through motor armature 231 and conducting silicon controlled rectifier 237 to point of reference or ground potential 5.

After the breech is closed the sequence of events hereinabove explained may be repeated to fire the next round.

In the event the round does not fire, the "out of battery" signal is not applied to one of the input terminals of two input AND gate 25 of FIG. 3, consequently, this device does not produce an output signal. Therefore, OR gate 24 is not inhibited by the .2-second timer, consequently, this device remains in its "on" mode to maintain an input signal upon diode 246 of OR gate 18 of FIG. 4 through output terminal 248 of FIG. 3 and input terminal 248 (4) of FIG. 4 which are electrically interconnected. As this signal is applied across series resistors 248 and 250 of the base electrode of a type NPN transistor 251 which is connected to the junction between resistors 248 and 250, this device is triggered conductive through the collector-emitter electrodes thereof to place the base electrode of transistor 174 of open breech AND gate 10 at substantially ground potential. Under these conditions, open breech AND gate 10 is inhibited as transistor 174 cannot be rendered conductive by a signal applied to input circuit terminal 176, consequently, the breech cannot be opened through use of the control circuit of this invention but must be manually opened.

The operation of the circuitry will be now described in regard to the firing of a conventional round.

Assuming that the gun is in the in battery position with the pressure normal, that the conventional round is loaded in the gun breech, that the loader is clear and that the breech is closed, a limit switch, not shown, on the gun recoil mechanism applies a direct current potential, which may be obtained from source 37 of FIG. 6, across input terminal 75 of ready to fire AND gate 20 of FIG.2 and ground 5, movable contact 76 of the breech closing limit switch, FIG. 5, places the regulated potential across input terminal 78 (2) and ground 5 of FIG. 2 through stationary contact 80 and output terminal 78 (5) which is electrically interconnected with input terminal 78 (2) of FIG. 2, and a limit switch, not shown, mounted upon the loader mechanism places a direct current potential which may be obtained from source 37 of FIG. 6, across input terminal 81 of FIG. 2 and ground 5, all of a positive polarity with respect to point of reference or ground potential 5.

The "in battery-pressure normal" input signal appearing across input terminal 75 and ground 5 is of the proper base-emitter polarity relationship for base-emitter current flow through type NPN transistor 81, the "breech closed" input signal appearing across input terminal 78 (2) and ground 5 is of proper base-emitter polarity relationship for base-emitter current flow through type NPN transistor 82 and the "loader clear" input signal appearing across input terminal 79 and ground 5 is of the proper base-emitter polarity relationship for base-emitter current flow through type NPN transistor 83. Therefore, transistors 81 and 82 are conducting through the collector-emitter electrodes thereof and transistor 83 is not conducting through the collector-emitter electrodes thereof as this circuit is interrupted by nonconducting type PNP transistor 84, consequently, there is no output from ready to fire AND gate 20.

By closing a switch, not shown, a direct current potential "-conventional loaded" input signal, which may be obtained from source 37 of FIG. 6, is applied across input terminal 279 and ground 5 which is of a positive polarity with respect to ground 5. This positive polarity potential is applied to the base electrode of type NPN transistor 286 through resistor 287.

As the emitter electrode of transistor 286 is connected to ground 5 through resistor 288, the proper base-emitter polarity relationship for base-emitter conduction through type NPN transistor 286 is provided. Consequently, this device conducts through the collector-emitter electrodes thereof as the collector electrode is connected to the regulated direct current potential source through terminal 52 (2). As transistor 286 conducts through the collector-emitter electrodes thereof, an output signal appears across resistor 288. This output signal is applied to diode 292 of OR gate 19 and to the emitter electrode of type PNP transistor 95 of fire missile AND gate 33. This signal is of the correct polarity to enable type PNP transistor 95 to conduct throtigh the emitter-base electrodes thereof, however, this device does not conduct at this time as transistors 96 and 97 are nonconductive to interrupt the emitter-base circuit therefor.

The signal appearing across resistor 288 is conducted through diode 292 of OR gate 19 and is applied across the emitter-base electrodes of type PNP transistor 84 of ready to fire AND gate 20 and is of the correct polarity relationship to produce emitter-base current flow through a type PNP transistor. As transistors 81 and 82 of ready to fire AND gate 20 are conducting through the respective collector-emitter electrodes thereof, as previously described, and transistor 83 is conducting through the base-emitter electrodes thereof, as previously described, the enabling of transistor 84 to conduct through the emitter-base electrodes thereof permits current flow through the emitter-collector electrodes of transistor 84 and the collector-emitter electrodes of respective transistors 83, 82 and 81. Therefore, transistor 84 conducts through emitter-collector electrodes thereof and an output signal from ready to fire AND gate 20 appears across resistor 96 which is of a positive polarity at junction 99 with respect to ground 5.

This signal may be taken from output terminal 101 and employed to energize an external "ready for firing" signal which may be, for example, a light. This is also applied across the base-emitter electrodes of type NPN transistor 96 of fire missile AND gate 21 through resistor 102. As this is the correct base-emitter polarity relationship for base-emitter conduction through a type NPN transistor, transistor 96 is enabled but does not conduct at this time as its base-emitter circuit to the two volt bias potential is interrupted by nonconducting transistor 97.

At this time, two input signals are being supplied to respective input circuit terminals of three input fire missile AND gate 21. When it is desired to fire the gun, a "fire main gun-missile" signal may be supplied to input terminal 107 by manually closing a switch, not shown, which places a direct current potential, which may be obtained from source 37 of FIG. 6, upon input terminal 107 which is of a positive polarity with respect to ground 5. This signal is conducted through diode 256 of OR gate 30 and is applied across the base-emitter electrodes of type NPN transistor 97 through resistor 106. As the emitter electrode of transistor 97 is returned to the 2 volt direct current bias potential through terminal 60 (2), the correct base emitter polarity relationship is established for base-emitter current flow through type NPN transistor 97. As transistor 97 conducts through its base-emitter electrodes, a circuit is completed for collector-emitter current flow through transistor 96 which, in turn, establishes a circuit for emitter-base current flow through transistor 95. Therefor, transistor 95 conducts through its emitter-collector electrodes and the output signal from fire missile AND gate 21 appears across resistor 255 and may be taken from output terminal 257. This positive polarity output signal from fire missile AND gate 21 is conducted through diode 119 of OR GATE 23 of FIG. 3 to diode 117 of OR gate 24 and across the operating coil of firing relay 31. Conducting diode 117 of OR gate 24 places this positive polarity signal across the base-emitter electrodes of type NPN transistor 118 through resistor 116. As the emitter electrode of transistor 118 is connected to the positive bias potential produced by the regulator circuit of FIG. 6 through terminal 60 (3), which is electrically connected to output terminal 60 of FIG. 6, the positive polarity signal applied across the basecemitter electrodes of type NPN transistor 118 produces base-emitter current flow therethrough. As the collector electrode of transistor 118 is connected to the base electrode of transistor 120 through resistor 121, conducting transistor 118 establishes a circuit for emitter-base current flow through transistor 120. As the emitter electrode of transistor 120 is connected to the source of regulated supply potential through terminal 52 (3), which is electrically connected to terminal 52 of the potential regulator circuit of FIG. 6, this device conducts through the emitter-base electrodes thereof and, consequently, through the emitter-collector electrodes thereof and an output signal from OR gate 24 appears across resistor 122 which is of a positive polarity at junction 123. This positive polarity signal is also applied to the 2.5-second timer 22 of FIG. 3 through terminals 257 and 258, respectively, which are electrically connected together.

The 2.5-second timer produces an output pulse of 2.5-second duration which should permit sufficient time for the missile to fire. The output signal therefrom is directed to the other input circuit terminal of AND gate 23 through diode 119.

The 2.5-second timer is set forth in detail in FIG. 3. The regulated potential is applied across the base-emitter electrodes of type NPN transistor 260 through input terminal 52 (3), electrically interconnected with output terminal 52 of FIG. 6, and resistor 261. As the emitter electrode of this type NPN transistor is connected to point of reference or ground potential 5 through Zener diode 136, the correct base-emitter polarity relationship is established for a base-emitter current flow through type NPN transistor. As the regulated potential is also applied across the collector-emitter electrodes of type NPN transistor 260 through input terminal 52 (3) and resistor 262, this device is normally conducting through the collector-emitter electrodes thereof. Conducting transistor 260 places the base and emitter electrodes of type NPN transistor 264 at substantially the same potential, consequently, this device is base biased nonconductive. Nonconducting transistor 264 interrupts the base-emitter circuit of type PNP transistor 265, consequently, this device is also nonconducting. The output signal from fire missile AND gate 2 is applied to input terminal 257 (3), electrically interconnected with output terminal 257 of FIG. 2. This positive polarity signal charges capacitor 266 through resistor 267 and diode 268 and applies the positive polarity potential to the gate electrode of field effect transistor 270 through resistor 271. This positive polarity potential present upon the gate electrode of field effect transistor 270 turns this device "on". Conducting field effect transistor 270 places the base and emitter electrodes of conducting type NPN transistor 260 at essentially the same potential, therefore, transistor 260 is base biased to the nonconducting condition. With transistor 260 not conducting, a positive polarity potential appears at junction 263 and is applied across the base-emitter electrodes of transistor 260. As this is the correct polarity relationship for base-emitter current flow through a type NPN transistor, transistor 260 is enabled to conduct through the collector-emitter electrodes thereof, thereby establishing a circuit for emitter-base current flow through type PNP transistor 265. As the emitter-collector electrodes of type PNP transistor 265 are connected across the source of regulated potential and point of reference or ground potential 5 through input terminal 52 (3) and resistor 272, enabled transistor 264 conducts through the collector-emitter electrodes thereof to complete the emitter-base circuit through transistor 265, consequently, this device conducts through the emitter-collector electrodes thereof. Conducting transistor 265 produces an output signal across resistor 272. This signal is applied to and conducted by diode 119 of OR gate 23 and is applied across the operating coil of firing relay 31 to supply a firing potential to a firing probe within the gun chamber, in a manner previously described. This output signal may also be taken from output terminal 258 and applied to diode 274 of AND gate 29 of FIG. 2 through input terminal 258 (2) electrically interconnected with terminal 258 of FIG. 3. This positive polarity signal is conducted through diode 274 and applied across the base-emitter electrodes of type NPN transistor 168. This produces collector-emitter conduction through this device which inhibits ready to fire AND gate 20, in a manner previously explained, to remove the output signal from fire missile AND gate 21 and, consequently, diode 268 and capacitor 266. When the gate potential of field effect transistor 270 falls below the value required for conduction therethrough, this device returns to its "off" state, consequently, transistor 265 is also turned "off" and the 2.5-second timer is reset. If the missile fires before 2.5 seconds, the "round fired" signal produced by the .2 second-timer 26 of FIG. 3 is applied across the base-emitter electrodes of type NPN transistor 275. As this is the correct polarity relationship for conduction through a type NPN transistor, base-emitter current flows therethrough to trigger this device conductive through collector-emitter electrodes thereof in the presence of an output signal from fire missile AND gate 21 present upon input circuit terminal 257 (3). Conducting transistor 275 establishes a shunt circuit about transistor 266, thereby disenabling the 2.5-second timer after a the "round fired" signal has been produced.

In the event it may be desired to open the breech manually, a switch, not shown, may be closed to place a potential of positive polarity with respect to ground upon input terminal 276 of FIG. 4. This positive polarity potential with respect to ground 5 is applied to and conducted by diode 278 of AND gate 17 to render transistor 172 of breech close AND gate 10 conductive. The remainder of the breech open logic circuitry operates in a manner previously described to effect a manual opening of the breech.

From this point on, the remainder of the circuit operates in a manner identical to that previously described with regard to the conventional round firing.

While specific electrical components, potential values and polarity relationships have been recited throughout this specification, it is to be specifically understood that alternate electrical components with compatible potentials and polarities may be employed without departing from the spirit of the invention.

While a preferred embodiment of the present invention has been shown and described, it will be obvious to those skilled in the art that various modifications and substitutions may be made without departing from the spirit of the invention which is limited only within the scope of the appended claims.

I claim:

1. A circuit for automatically operating the breech of a large caliber gun in response to predetermined combinations of externally generated electrical input signals comprising in combination with a reversible direct current electric breech operating motor, a source of regulated direct current potential and a source of unregulated direct current potential, a breech open AND gate circuit for producing an output signal in response to the presence of the combination of an electrical input signal indicating that the breech is closed, an electrical input signal indicating that the gun is in the in battery position and an electrical input signal indicating that the breech is to be opened upon respective input circuit terminals thereof, a breech close AND gate circuit for producing an output signal in response to the presence of the combination of an electrical input signal indicating that the breech is open and an electrical input signal indicating that the breech is to be closed upon respective input circuit terminals thereof, a breech operating OR gate circuit for producing an output signal in response to an output signal from either said breech open AND gate or said breech close AND gate upon a respective one of the input circuit terminals thereof, a breech operating motor armature open AND gate circuit for producing an output signal in response to the presence of the combination of said output signal from said breech open AND gate and said output signal from said breech operating OR gate upon respective input circuit terminals thereof, a breech operating motor armature

close AND gate circuit for producing an output signal in response to the presence of the combination of said output signal from said breech close AND gate and said output signal from said breech operating OR gate upon respective input circuit terminals thereof, operating motor field energizing circuit means responsive to said output signal from said breech operating OR gate for establishing an energizing circuit for the field coil of said operating motor across said source of unregulated direct current potential, operating motor armature energizing circuit means responsive to said output signal from said breech operating motor armature open AND gate and to an output signal from said breech operating motor armature close AND gate for establishing respective energizing circuits for the armature of said operating motor across said unregulated source of direct current supply potential in a polarity relationship to produce rotation thereof in a direction to open said breech and to close said breech, a ready to fire AND gate circuit for producing an output signal in response to the presence of the combination of an electrical input signal indicating that the breech is closed, an electrical input signal indicating that the gun is in battery and the pressure is normal, an electrical input signal indicating that the loader is clear and an electrical input signal indicating that the gun is loaded upon respective input circuit terminals thereof, a fire AND gate circuit for producing an output signal in response to the presence of the combination of said output signal from said ready to fire AND gate, an electrical input signal indicating that the gun is loaded and an electrical input signal indicating the gun is to be fired upon respective input circuit terminals thereof, firing circuit means responsive to said output signal from said fire AND gate for establishing an energizing circuit for a firing probe within the gun chamber across said source of unregulated direct current potential and logic circuit means responsive to said output signal from said fire AND gate for generating an electrical signal indicating that the breech is to be opened and applying said signal to an input circuit terminal of said breech open AND gate circuit after the gun has fired and has returned to the in battery position as an input signal thereto indicating that the breech is to be opened.

2. A circuit for automatically operating the breech of a large caliber gun in response to predetermined combinations of externally generated electrical input signals comprising in combination with a reversible direct current electric breech operating motor, a source of regulated direct current potential and a source of unregulated direct current potential, a breech open AND gate circuit for producing an output signal in response to the presence of the combination of an electrical input signal indicating that the breech is closed, an electrical input signal indicating that the gun is in the in battery position and an electrical input signal indicating that the breech is to be opened upon respective input circuit terminals thereof, a breech close AND gate circuit for producing an output signal in response to the presence of the combination of an electrical input signal indicating that the breech is open and an electrical input signal indicating that the breech is to be closed upon respective input circuit terminals thereof, a breech operating OR gate circuit for producing an output signal in response to an output signal from either said breech open AND gate or said breech close AND gate upon a respective one of the input circuit terminals thereof, a breech operating motor armature open AND gate circuit for producing an output signal in response to the presence of the combination of said output signal from said breech open AND gate and said output signal from said breech operating OR gate upon respective input circuit terminals thereof, a breech operating motor armature close AND gate circuit for producing an output signal in response to the presence of the combination of said output signal from said breech close AND gate and said output signal from said breech operating OR gate upon respective input circuit terminals thereof, operating motor field energizing circuit means responsive to said output signal from said breech operating OR gate for establishing an energizing circuit for the field coil of said operating motor across said source of unregulated direct current potential; operating motor armature energizing circuit means responsive to said output signal from said breech operating motor armature open AND gate and to an output signal from said breech operating motor armature close AND gate for establishing respective energizing circuits for the armature of said operating motor across said unregulated source of direct current supply potential in a polarity relationship to produce rotation thereof in a direction to open said breech and to close said breech, a ready to fire AND gate circuit for producing an output signal in response to the presence of the combination of an electrical input signal indicating that the breech is closed, an electrical input signal indicating that the gun is in battery and the pressure is normal, an electrical input signal indicating that the loader is clear and an electrical input signal indicating that the gun is loaded upon respective input circuit terminals thereof, a fire AND gate circuit for producing an output signal in response to the presence of the combination of said output signal from said ready to fire AND gate, an electrical input signal indicating that the gun is loaded and an electrical input signal indicating the gun is to be fired upon respective input circuit terminals thereof, firing circuit means responsive to said output signal from said fire AND gate for establishing an energizing circuit for a firing probe within the gun chamber across said source of unregulated direct current potential, first logic circuit means responsive to said output signal from said fire AND gate for producing a breech open inhibit signal and for applying said inhibit signal to said breech open AND gate for preventing said breech open AND gate from producing an output signal at this time, second logic circuit means responsive to said output signal from said fire AND gate and to an electrical input signal indicating that the gun has gone out of battery for generating an electrical signal indicating that the gun has fired and for removing said inhibit signal from said breech open AND gate and third logic circuit means for applying said signal indicating that the gun has fired to an input circuit terminal of said breech open AND gate circuit after the gun has returned to the in battery position as an input signal thereto indicating that the breech is to be opened.

3. A circuit for automatically operating the breech of a large caliber gun in response to predetermined combinations of externally generated electrical input signals comprising in combination with a reversible direct current electric breech operating motor, a source of regulated direct current potential and a source of unregulated direct current potential, a breech open AND gate circuit for producing an output signal in response to the presence of the combination of an electrical input signal indicating that the breech is closed, an electrical input signal indicating that the gun is in the in battery position and in electrical input signal indicating that the breech is to be opened upon respective input circuit terminals thereof, a breech close AND gate circuit for producing an output signal in response to the presence of the combination of an electrical input signal indicating that the breech is open and an electrical input signal indicating that the breech is to be closed upon respective input circuit terminals thereof, a breech operating OR gate circuit for producing an output signal in response to an output signal from either said breech open AND gate or said breech close AND gate upon a respective one of the input circuit terminals thereof, a breech operating motor armature open AND gate circuit for producing an output signal in response to the presence of the combination of said output signal from said breech open AND gate and said output signal from said breech operating OR gate upon respective input circuit terminals thereof, a breech operating motor armature close AND gate circuit for producing an output signal in response to the presence of the combination of said output signal from said breech close AND gate and said output signal from said breech operating OR gate upon respective input circuit terminals thereof, operating motor field energizing circuit means responsive to said output signal from said breech operating OR gate for establishing an energizing circuit for the field coil of said operating motor across said source of unregu-

lated direct current potential, operating motor armature energizing circuit means responsive to said output signal from said breech operating motor armature open AND gate and to an output signal from said breech operating motor armature close AND gate for establishing respective energizing circuits for the armature of said operating motor across said unregulated source of direct current supply potential in a polarity relationship to produce rotation thereof in a direction to open said breech and to close said breech, a ready to fire AND gate circuit for producing an output signal in response to the presence of the combination of an electrical input signal indicating that the breech is closed, an electrical input signal indicating that the gun is in battery and the pressure is normal, an electrical input signal indicating that the loader is clear and an electrical input signal indicating that a conventional round has been loaded within the gun breech upon respective input circuit terminals thereof, a fire conventional AND gate circuit for producing an output signal in response to the presence of the combination of said output signal from said ready to fire AND gate, an electrical input signal indicating that a conventional round has been loaded within the gun breech and an electrical input signal indicating the gun is to be fired upon respective input circuit terminals thereof, an auxiliary power supply circuit for generating a direct current potential of a magnitude greater than said source of unregulated direct current potential in response to said output signal from said fire conventional AND gate, firing circuit means responsive to said output signal from said fire conventional AND gate for connecting said auxiliary power supply and said source of unregulated direct current potential across a firing probe within the gun chamber and logic circuit means responsive to said output signal from said fire conventional AND gate for generating an electrical signal indicating that the breech is to be opened and applying said signal to an input circuit terminal of said breech open AND gate circuit after the conventional round has fired and the gun has returned to the in battery position as an input signal thereto indicating that the breech is to be opened.

4. A circuit for automatically operating the breech of a large caliber gun in response to predetermined combinations of externally generated electrical input signals comprising in combination with a reversible direct current electric breech operating motor, a source of regulated direct current potential and a source of unregulated direct current potential, a breech open AND gate circuit for producing an output signal in response to the presence of the combination of an electrical input signal indicating that the breech is closed, an electrical input signal indicating that the gun is in the in battery position and an electrical input signal indicating that the breech is to be opened upon respective input circuit terminals thereof, a breech close AND gate circuit for producing an output signal in response to the presence of the combination of an electrical input signal indicating that the breech is open and an electrical input signal indicating that the breech is to be closed upon respective input circuit terminals thereof, a breech operating OR gate circuit for producing an output signal in response to an output signal from either said breech open AND gate or said breech close AND gate upon a respective one of the input circuit terminals thereof, a breech operating motor armature open AND gate circuit for producing an output signal in response to the presence of the combination of said output signal from said breech open AND gate and said output signal from said breech operating OR gate upon respective input circuit terminals thereof, a breech operating motor armature close AND gate circuit for producing an output signal in response to the presence of the combination of said output signal from said breech close AND gate and said output signal from said breech operating OR gate upon respective input circuit terminals thereof, operating motor field energizing circuit means responsive to said output signal from said breech operating OR gate for establishing an energizing circuit for the field coil of said operating motor across said source of unregulated direct current potential, operating motor armature energizing circuit means responsive to said output signal from said breech operating motor armature open AND gate and to an output signal from said breech operating motor armature close AND gate for establishing respective energizing circuits for the armature of said operating motor across said unregulated source of direct current supply potential in a polarity relationship to produce rotation thereof in a direction to open said breech and to close said breech, a ready to fire AND gate circuit for producing an output signal in response to the presence of the combination of an electrical input signal indicating that the breech is closed, an electrical input signal indicating that the gun is in battery and the pressure is normal, an electrical input signal indicating that the loader is clear and an electrical input signal indicating that a missile has been loaded within the gun breech upon respective input circuit terminals thereof, a fire missile AND gate circuit for producing an output signal in response to the presence of the combination of said output signal from said ready to fire AND gate, an electrical input signal indicating that the missile has been loaded within the gun breech and an electrical input signal indicating the gun is to be fired upon respective input circuit terminals thereof, firing circuit means responsive to said output signal from said fire AND missile gate for connecting said source of unregulated direct current potential across a firing probe within the gun chamber and logic circuit means responsive to said output signal from said fire missile AND gate for generating an electrical signal indicating that the breech is to be opened and applying said signal to an input circuit terminal of said breech open AND gate circuit after the missile has fired and the gun has returned to the in battery position as an input signal thereto indicating that the breech is to be opened.

5. A circuit for automatically operating the breech of a large caliber gun in response to predetermined combinations of externally generated electrical input signals comprising in combination with a reversible direct current electric breech operating motor, a source of regulated direct current potential and a source of unregulated direct current potential, a breech open AND gate circuit for producing an output signal in response to the presence of the combination of an electrical input signal indicating that the breech is closed, an electrical input signal indicating that the gun is in the in battery position and an electrical input signal indicating that the breech is to be opened upon respective input circuit terminals thereof, a breech close AND gate circuit for producing an output signal in response to the presence of the combination of an electrical input signal indicating that the breech is open and an electrical input signal indicating that the breech is to be closed upon respective input circuit terminals thereof, a breech operating OR gate circuit for producing an output signal in response to an output signal from either said breech open AND gate or said breech close AND gate upon a respective one of the input circuit terminals thereof, a breech operating motor armature open AND gate circuit for producing an output signal in response to the presence of the combination of said output signal from said breech open AND gate and said output signal from said breech operating OR gate upon respective input circuit terminals thereof, a breech operating motor armature close AND gate circuit for producing an output signal in response to the presence of the combination of said output signal from said breech close AND gate and said output signal from said breech operating OR gate upon respective input circuit terminals thereof, a motor field relay having an operating coil and being of the type which closes an electrical circuit upon the energization of said operating coil, means for applying said output signal from said breech operating OR gate across said operating coil of said motor field relay for establishing an energizing circuit for the field coil of said operating motor across said source of unregulated direct current potential, operating motor direction of rotation circuit means responsive to said output signal from said breech operating motor armature open AND gate and to an output signal from said breech operating motor armature close AND gate for connecting the armature of said operating motor

across said unregulated source of direct current supply potential in a polarity relationship to produce rotation thereof in a direction to open said breech and to close said breech, respectively, a ready to fire AND gate circuit for producing an output signal in response to the presence of the combination of an electrical input signal indicating that the breech is closed, an electrical input signal indicating that the gun is in battery and the pressure is normal, an electrical input signal indicating that the loader is clear and an electrical input signal indicating that the gun is loaded upon respective input circuit terminals thereof, a fire AND gate circuit for producing an output signal in response to the presence of the combination of said output signal from said ready to fire AND gate, an electrical input signal indicating that the gun is loaded and an electrical input signal indicating the gun is to be fired upon respective input circuit terminals thereof, a firing relay having an operating coil and being of the type which closes an electrical circuit upon the energization of said operating coil, means for applying said output signal from said fire AND gate across said operating coil of said firing relay for establishing an energizing circuit for a firing probe within the gun chamber across said source of unregulated direct current potential and logic circuit means responsive to said output signal from said fire AND gate for generating an electrical signal indicating that the breech is to be opened and applying said signal to an input circuit terminal of said breech open AND gate circuit after the gun has fired and has returned to the in battery position.

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# UNITED STATES PATENT OFFICE
# CERTIFICATE OF CORRECTION

Patent No. 3,537,353 Dated November 3, 1970

Inventor(s) Robert E. Nelson

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 11, line 54, should read, after "FIG. 5," -- electrically interconnected with output terminal 52 --; Column 17, line 2, "basecemitter" should read -- base-emitter --.

SIGNED AND
SEALED
MAR 2 1971

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents