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Covarrubias et al.

[11] **3,892,182**

[45] **July 1, 1975**

[54] **SQUIB CONTROL CIRCUIT**

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[52] **U.S. Cl.** ..... **102/70.2 R**; 317/80

[51] **Int. Cl.** **F42c 15/40**

[58] **Field of Search** ..... 102/70.2 R, 70.2 A, 22, 102/28 R; 317/80

[56] **References Cited**

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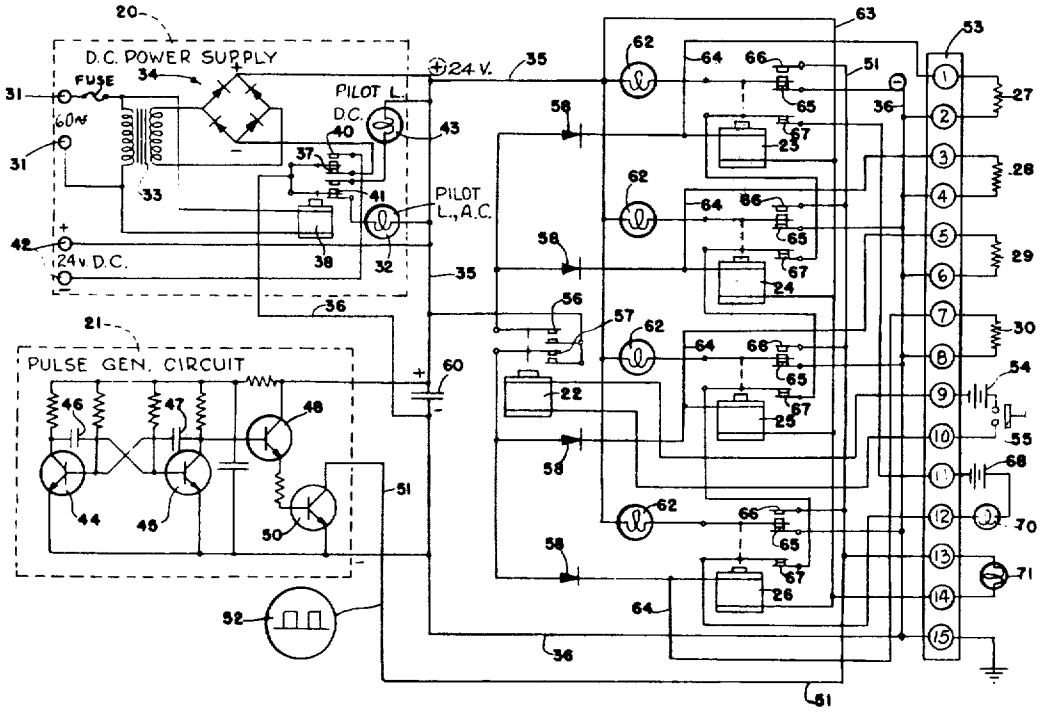
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[57] **ABSTRACT**

A control and indicating circuit for use with squib operated explosive units. The squib filaments are each connected in series with a relay winding and a small current applied to the circuit. This current operates the relay but does not explode the squib. Relay lamps connected to relay contacts are lighted when the relay is operated, indicating that the circuit and squibs are ready. In order to fire the squibs, an alarm circuit applies the charge on a capacitor to the squib filaments, melting them and exploding the powder surrounding the filaments. After this operation, the circuit applies a pulsed current to the lamps, causing them to light intermittently, thereby indicating the end of the operation. The pulsed current is also applied to the indicating lamps whenever any one of the squib supply lines is opened, as for example, when a line is inadvertently cut.

11 Claims, 2 Drawing Figures



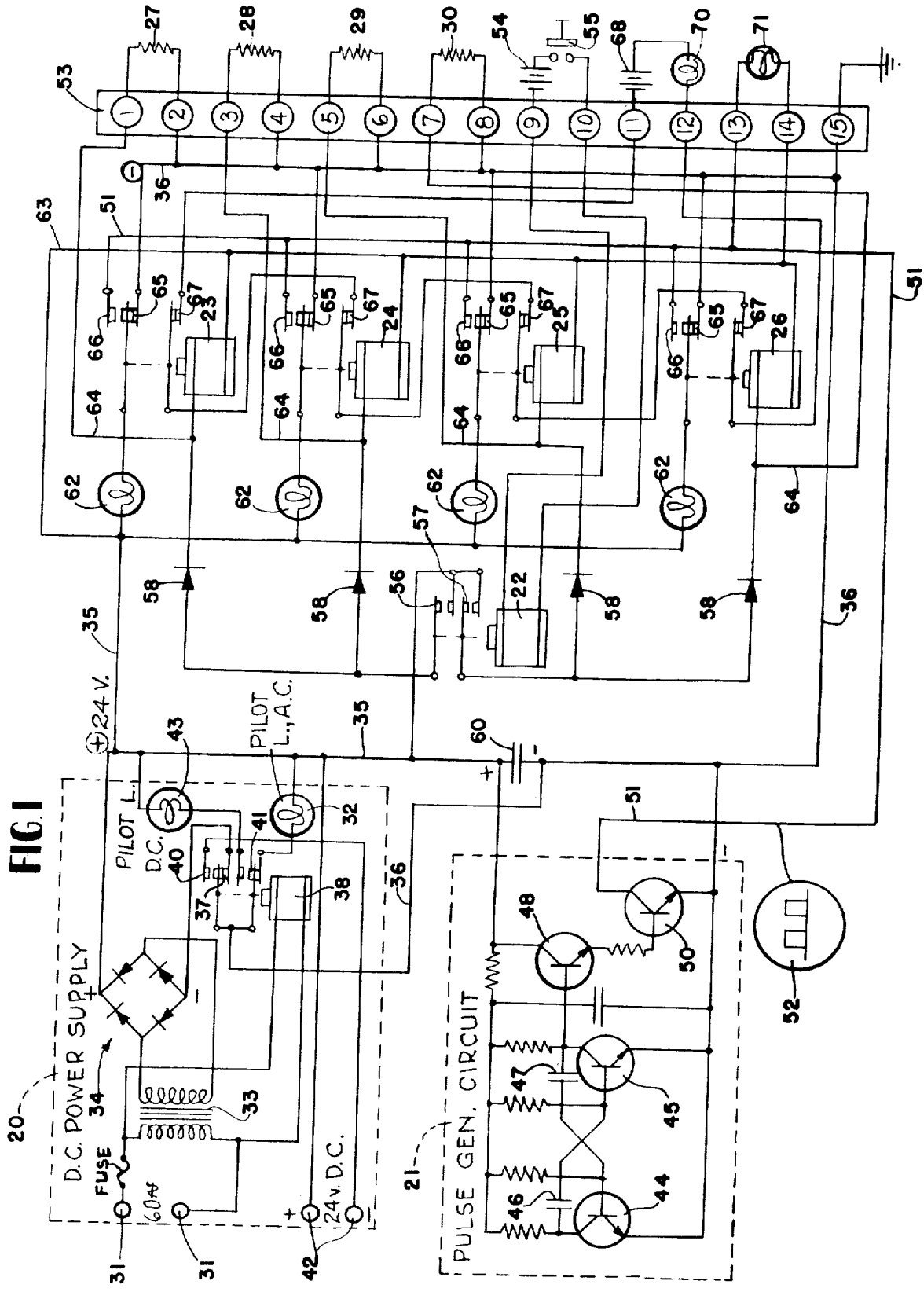

D.C. POWER SUPPLY
PULSE GEN. CIRCUIT
PILOT L., D.C.
PILOT L., A.C.
+24 V.
24v. D.C.
FUSE
6 Amp

FIG 1

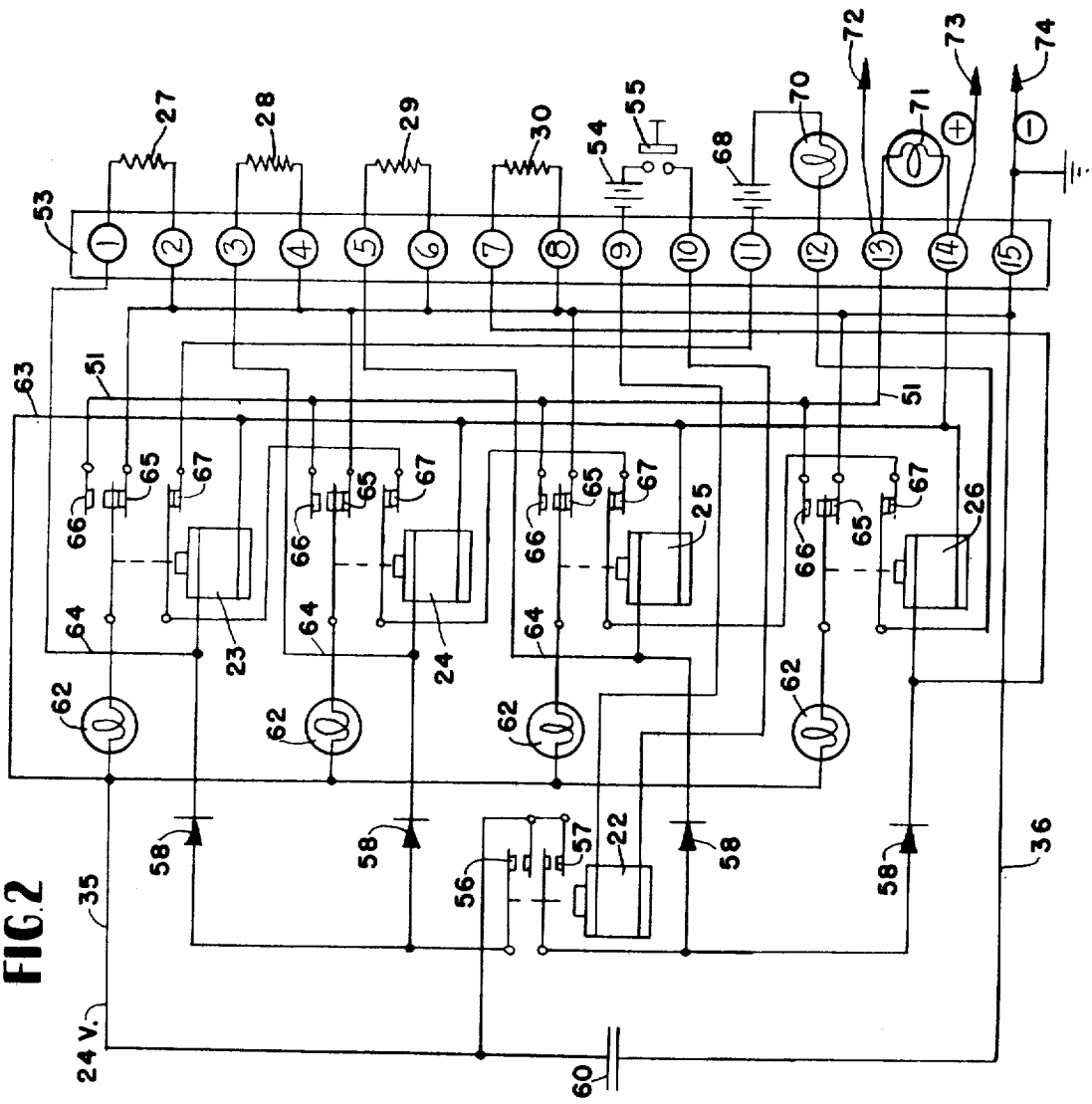

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63
51
65
67
66
64
23
24
25
26
62
58
57
22
56
35
36
24 V.
60

FIG.2

SQUIB CONTROL CIRCUIT

BACKGROUND OF THE INVENTION

Squib control circuits are old in the art and electric lamps have been used to indicate when the squib filament is conducting and ready for firing. However, in prior arrangements, the indicating lamps went out after the filaments were fired and there was no positive assurance that the squib filaments were melted. The circuit to be described hereinafter produces a pulsating current when the filaments are destroyed and this current is applied to the indicating lamps causing them to blink. This signal gives a positive indication that the squibs have been operated or the squib circuit has been opened. Also, a supervision circuit is arranged to show when all the relays are working and in their operative condition.

The control circuit can be used to operate squibs to open release valves on containers which store fire fighting fluids. The circuit can also be used to explode charges of dynamite in quarries and underground locations.

SUMMARY OF THE INVENTION

The invention comprises a source of direct current power which may be applied to one or more squibs for actuating valves or exploding charges. A chargeable storage capacitor is connected in series with normally open relay contacts for providing the current to disrupt the squib filaments and generate heat necessary for the explosive action. A lamp relay is associated with each squib unit and the relay winding is connected in series withe the squib filament. When the relay is operated, an indicating lamp is lighted, showing that the circuit is ready for action. The firing action is controlled by an alarm circuit which may be actuated by a manually operated switch or by an automatic alarm means. The alarm circuit operates an alarm control relay which connects a storage capacitor to all the filaments to melt them. After firing, each squib relay is normalized and a pulsating current from a multivibrator generator is connected to the signal lamps to produce a blinking light.

Additional details of the invention will be disclosed in the following description, taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE FIGURE

FIG. 1 is a schematic diagram of connections of the main control circuit.

FIG. 2 is a schematic diagram of connections of an auxiliary circuit for connection to the main circuit.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, the circuit includes a source of direct current power **20**, shown within dotted lines, a pulse generating circuit **21**, also shown within dotted lines, and a relay control circuit. The relay control circuit includes a firing relay **22**, four lamp relays **23, 24, 25**, and **26**, and four resistors **27, 28, 29**, and **30** representing the squib filaments. The squibs in this case are any explosive containers which include resistive filaments surrounded by explosive charges. When the filament is heated by the passage of current, the charge explodes and creates a substantial pressure wave which

can be used to operate valves, explode larger charges, or move pistons for other results.

The direct current power supply **20** includes a pair of terminals **31** for connection to a supply of alternating current power. A transformer **33** reduces the voltage to a predetermined value and applies it to a rectifier bridge **34** which produces direct current power having a predetermined output voltage (for example, **24** volts). This voltage is applied over positive conductor **35** and negative conductor **36** in series with relay contacts **37**. The presence of this voltage, derived from the AC power lines is indicated by a pilot lamp **32**, connected across the bridge terminals in series with relay contacts **37** and **41**. Terminals **31** are also connected to the winding **38** of a relay which operates the relay contacts to a position as shown in the drawing. If, for any reason, the alternating power should fail or be disconnected, relay **38** then receives no current, contacts **37** are opened and contacts **40** and **41** are closed. This action transfers the power lines **35, 36** to terminals **42** which are to be connected to a standby battery (not shown) having a voltage substantially equal to the voltage supplied by bridge **34**. When the standby battery is connected, pilot lamp **43** is lighted.

The pulse generating circuit **21** comprises a free running multivibrator circuit including transistors **44** and **45**, this type of pulse generating circuit being generally well known. The frequency of pulses is adjusted by varying the values of the capacitors **46** and **47**. The frequency output of this circuit is not critical and may vary from two per second to eight per second. The output from the multivibrator is applied to a first transistor amplifier **48** and then to a second transistor amplifier **50**, after which it is connected to a pulse output conductor **51**. The pulse shape of the output wave is shown in circle **52**. Output conductor **51** is connected to a contact **66** on all four of the lamp relays.

The firing relay **22** has its winding connected to terminals **9, 10** on terminal strip **53**, these terminals being connected to the alarm circuit which may include a source of electric current **54** and a switch **55**. The latter may be operatively associated with conventional temperature sensing means (not shown), whereby said switch may be operated automatically upon actuation of said temperature sensitive means. A separate battery is not necessary as terminal **14** may be connected to the positive conductor **35** and the power supply **20** used instead. The firing relay contacts **56, 57** are connected to the four squib resistors **27, 28, 29**, and **30** in series with diodes **58**, the other side of the contacts **65** being connected to the negative side of a storage capacitor **60**. This capacitor **60** has its positive side connected to the **24** volt supply line, and charges relatively slowly since its direct current supply is in series with the resistance of the rectifier bridge **34** and the secondary winding of transformer **33**. When the capacitor **60** is fully charged, it is ready to apply its full quantity of electricity fo the squib resistors to heat them to incandescence.

Lamp relays **23, 24, 25**, and **26** are each coupled to an indicator lamp **62** which burns steadily when the squib resistors are conductive but blinks intermittently after the resistors have been destroyed. It should be noted that under normal conditions, all four lamp relay windings take current and remain in their operating condition as shown in the figure. As an example, the current which operates relay **23** can be traced from the positive conductor **35**, over conductor **63**, through winding **23**, over conductor **64**, then through squib resistor **27**, to the negative conductor **36**. At the same

time, lamp 62 is lighted by current from conductor 35, through the lamp 62, then through contacts 65, and to the negative conductor 36. All four lamp relays have the same type of operating circuits.

When the winding 22 of the firing relay receives current from the closing of the alarm switch 55, contacts 56 and 57 are closed and operating current flows from the upper side of storage capacitor 60 through the contacts, then through diodes 58 and conductors 64, to terminals 1, 3, 5, and 7, and through the resistors 27, 28, 29, and 30, heating them to incandescence, exploding the charge and disrupting the resistors. After the firing act, there can be no current through the resistors and the lamp relay windings receive no current, permitting their armatures to spring back to their normal position, opening contacts 65 and closing contacts 66. This action connects all the lamps 62 to conductor 51 and the pulse generator 21. As a result, the lamps blink instead of burning steadily.

Another indicating circuit is provided by connecting contacts 67, on each lamp relay in series with each other and terminals 11 and 12. A source of potential 68 and an indicating means 70 can be connected to terminals 11 and 12 and, prior to firing a lighted lamp 70 indicates that all the lamp relays are in their actuated condition. Still another indicating lamp 71 can be used to monitor the operation of the pulse generating circuit 21. If lamp 71 blinks at the proper frequency, it indicates that the generating circuit is operating satisfactorily.

Lamps 62 produce a steady light prior to firing and a pulsating light after firing, thereby indicating normal operation. If any one or all of the lamps show a pulsating light before firing, it indicates that the associated relay is not functioning properly or that the squib resistor is open and will not fire.

The circuit shown in FIG. 1 is arranged for firing four squib resistors. When more than four are to be controlled, an auxilliary circuit, shown in FIG. 2 is used. This circuit has many of the components used in FIG. 1 but contains no power supply and no pulse generating circuit. The auxiliary circuit uses the power supplies in the main circuit, these supply circuits connected to the auxiliary circuit by means of conductors 72, 73, and 74 connected to terminals 13, 14, and 15. Conductor 72 is to be connected to terminal 13 on the main circiut and supplies pulsating current from line 51 and circuit 21 to contacts 66 and lamps 62 in the auxiliary circuit.

Conductor 73 is to be connected to terminal 14 on the main circuit (FIG. 1) and supplies direct current power of 24 volts from lines 63 and 35. This power charges capacitor 60, operates the auxiliary relay 22 to fire the squibs and also powers the four relays, 23, 24, 25, and 26. Conductor 74 is to be connected to terminal 15 on the main circuit. This is the ground return and the negative conductor for the 24 volt power.

It has been found that at least 10 auxiliary circuits can be added to the system using only one main circuit with a 24 volt power supply 20 and a pulse generating circuit 21. This series of connections adds up to 40 additional squib control units, each circuit with its own indicating lamps and firing contacts. Again, it should be noted that battery 68 can be eliminated, if desired, by connecting the right hand terminal of lamp 70 to the positive terminal 14 and then connecting terminal 11 to terminal 15. In a similar manner, the upper terminal of switch 55 can be connected to terminal 14, and terminal 9 connected to terminal 15, thereby eliminating battery 54.

The embodiments of the invention, in which an exclusive property or privilege is claimed, are defined as follows:

1. A squib control and indicating means for indicating the condition of a squib filament by means of an indicating lamp before and after firing comprising:
   a. a source of direct current power;
   b. a source of pulsating current;
   c. a lamp relay including a winding connected in series between the source of direct current and the squib filament for activating the relay, said relay also including a pair of contacts connected in series between the source of direct current and the indicating lamp for lighting the lamp whenever the relay is actuated;
   d. means for firing the squib filament; and
   e. means for indicating when the squib filament has been fired, including a pair of relay contacts on said lamp relay connected between the lamp and said source of pulsating current.

2. A squib control means as claimed in claim 1 wherein said source of pulsating current includes a free running multivibrator circuit.

3. A squib control means as claimed in claim 1 wherein said relay contacts include a single pole double throw switching means, the common contact connected directly to one side of the indicating lamp.

4. A squib control means as claimed in claim 1 wherein said means for firing the squib filament includes a chargeable capacitor and a firing relay including a pair of contacts connected between the capacitor and the squib filament.

5. A squib control means as claimed in claim 1 wherein the source of pulsating current has a frequency of less than ten cycles per second.

6. A squib control means as claimed in claim 4 wherein said firing relay includes a winding connected to a source of electric power and a switch.

7. A squib control means as claimed in claim 6 wherein said switch is operated automatically by a temperature sensitive means.

8. A squib control means as claimed in claim 4 wherein said chargeable capacitor is charged by the source of direct current power.

9. A squib control means as claimed in claim 1 wherein a plurality of squib filaments are provided, each squib filament being associated with a lamp relay including a winding connected in series with the source of direct current and the squib filament.

10. A squib control means as in claim 9 further including auxiliary circuit means for connecting additional squib filaments to the squib control and indicating means.

11. A squib control means as claimed in claim 1 wherein said source of direct current power includes a main source of power derived from alternating current and a standby battery coupled to the control means through a relay which is operated when the main source of power is disconnected.

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