March 6, 1951 A. BARRY 2,543,823

CASING PERFORATING GUN

Filed March 26, 1948 3 Sheets-Sheet 1

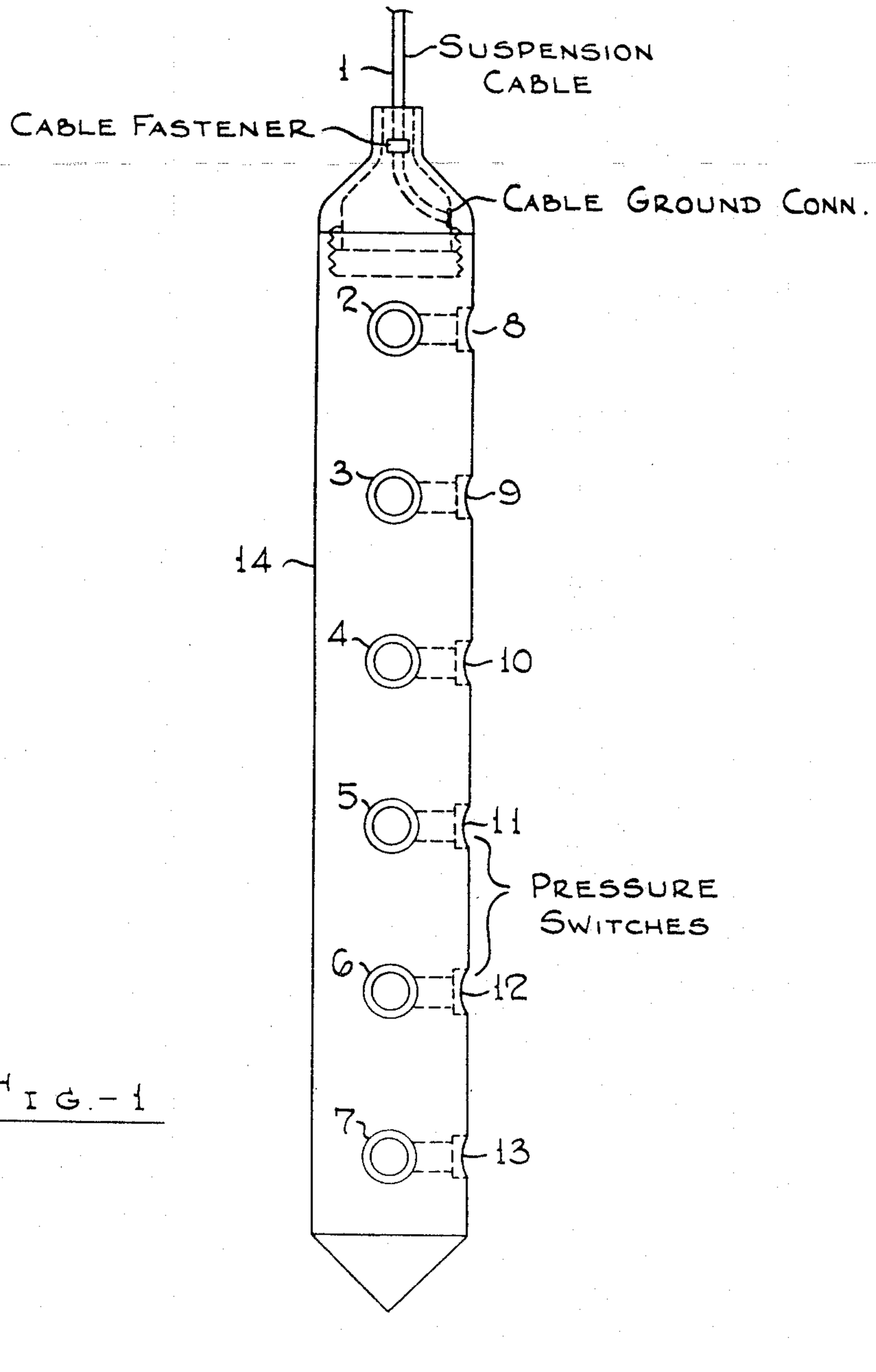

FIG.-1

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CASING PERFORATING GUN

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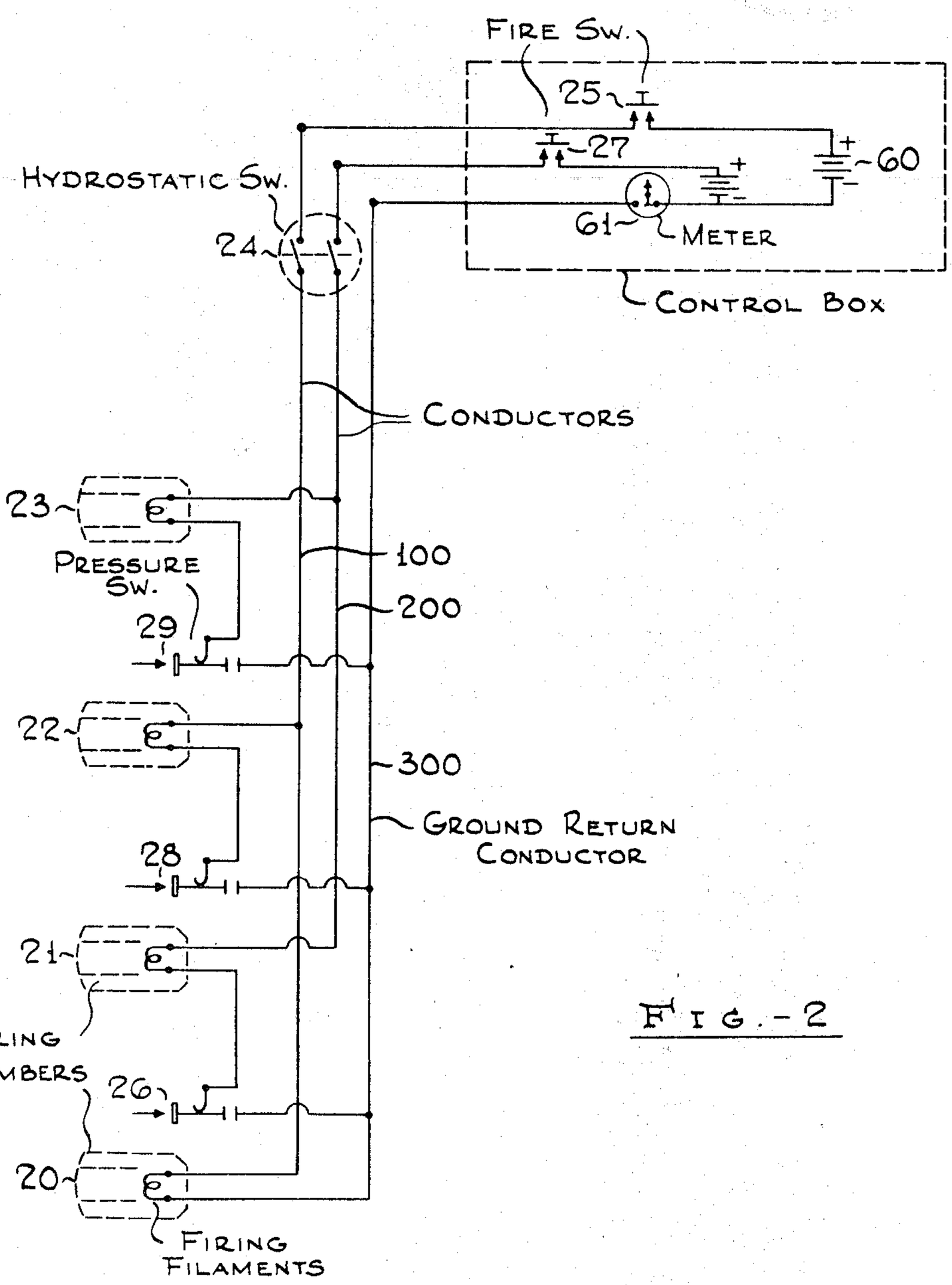

FIG.-2

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CASING PERFORATING GUN

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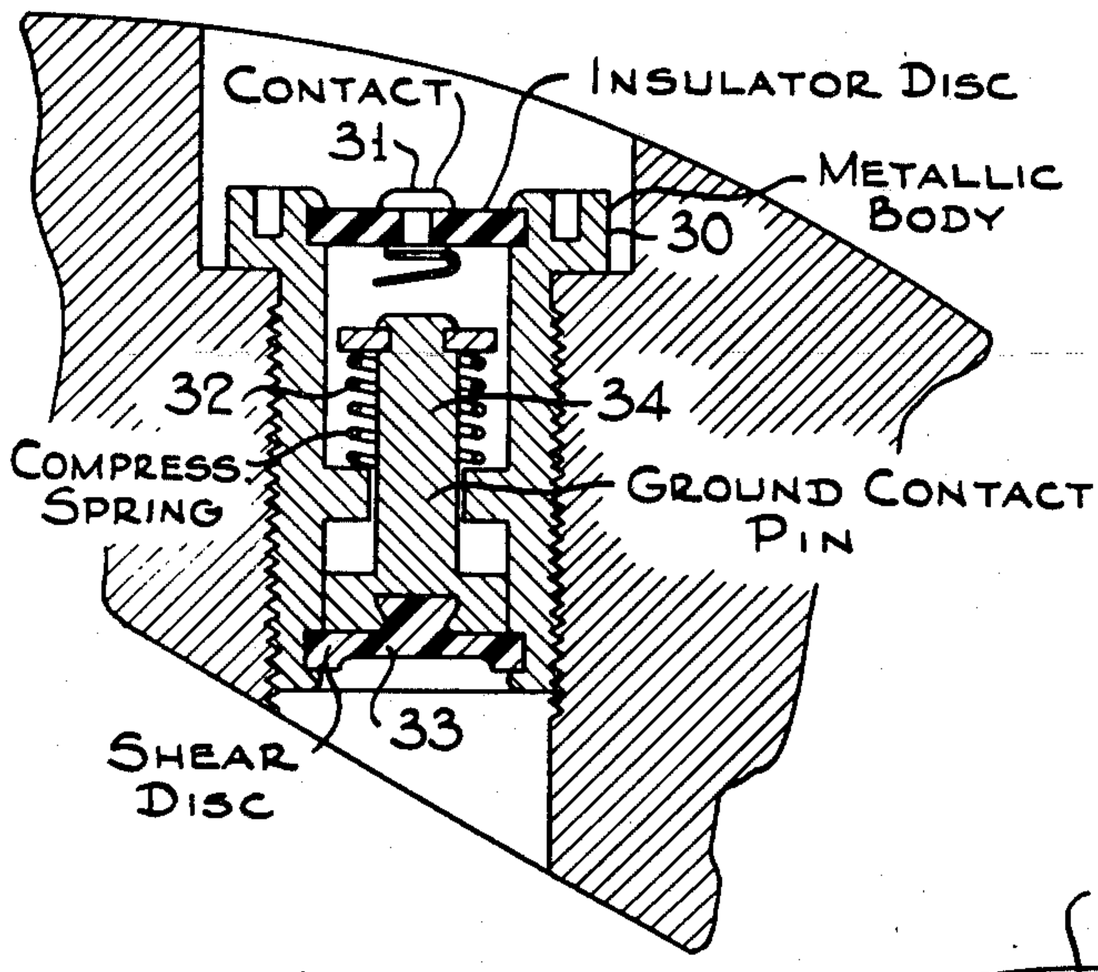

FIG.-3

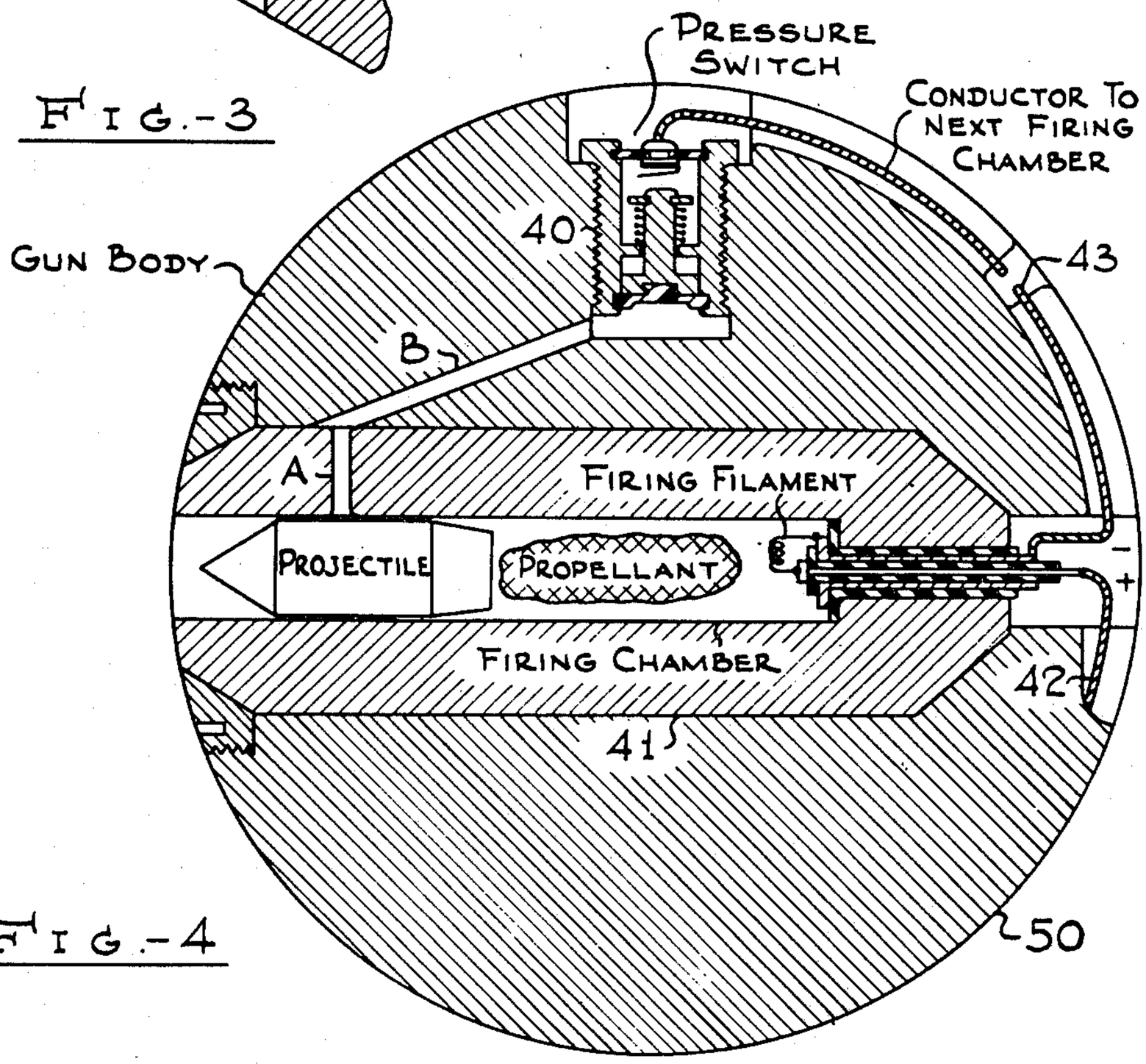

FIG.-4

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Patented Mar. 6, 1951 2,543,823

UNITED STATES PATENT OFFICE

2,543,823

CASING PERFORATING GUN

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2 Claims. (Cl. 164—0.5)

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The present invention is concerned with an improved apparatus and method of perforating oil casing and solid formations in a well borehole. The invention is more particularly concerned with an improved perforating gun by which it is possible to positively control the number of shots fired at any one time or at any particular level. The invention is specifically directed to an improved electrical circuit wherein pressure arming switches are utilized in conjunction with the firing of any one or of any series of shots.

In the production and recovery of oil from subterranean areas, it is well known in the art to drill the borehole and line it with steel casing to seal off undesirable fluids or unproductive formations. It is also the usual practice to cement between the steel casing and the formation adjacent the borehole to secure the casing in place.

Since these boreholes extend into the earth for considerable depth, they in many instances pass through a plurality of oil-containing formations disposed at various depths. It is the usual practice to leave upper productive formations sealed off until such time as lower formations are depleted of oil at which time the lower formation is cemented or plugged closed, and the casing is then perforated adjacent the next higher productive formation to allow entry of the oil or gas into the casing. Usually a plurality of holes through the casing is necessary to produce the desired volume of flow.

One method of accomplishing the desired perforation is to lower a gun into the borehole adjacent the area at which perforation is desired. The gun can then be fired and pulled to the surface for reloading. Subsequent firings and reloadings are then necessary to accomplish the desired amount of perforation. This procedure is, however, very time consuming and expensive. It is, thus, very desirable that the gun employed for perforating the casing be capable of firing a multiplicity of shots without the necessity of withdrawing from the bore hole for reloading. This feature is additionally desirable when it it necessary to perforate several formations at different levels and reduces the possibility of errors in the depth measurements.

Numerous suggestions and methods have been proposed using various instruments in order to secure the desired flexibility in a casing perforating gun. For example, one gun perforator utilized is an instrument, the operation of which is a function of differences in resistances of a

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plurality of electrical resistors in an electrical circuit.

A new method and an improved perforating gun have now been discovered by which it is possible to have the desired control. The perforating gun of the present invention utilizes an electrical circuit connected to a plurality of firing mechanisms in a manner that the firing mechanism or firing circuit of the next succeeding circuit is not closed except by the force of the explosion of the preceding circuit which activates a pressure actuated switch in the succeeding circuit.

The invention may be readily understood by reference to the drawings illustrating embodiments of the same.

Fig. 1 illustrates the firing gun containing firing charges at spaced intervals.

Fig. 2 illustrates the firing and electrical hookup utilized in conjunction with Fig. 1.

Fig. 3 illustrates one suitable type of pressure actuated switch which is employed in conjunction with the electrical circuits.

Fig. 4 comprises a diagrammatical cross-sectional view of the method of employing my gun for piercing solid formations in a well borehole.

Referring specifically to Fig. 1, casing perforating gun **14** is adapted to be lowered to any point in a borehole by means of suspension cable **1**. The gun may comprise and contain any number of firing chambers. For the purpose of illustration, firing chambers **2**, **3**, **4**, **5**, **6** and **7** are shown. The pressure switches employed in conjunction with my circuit and methods of operating the casing perforating gun are also illustrated as **8**, **9**, **10**, **11**, **12** and **13**.

Referring specifically to Fig. 2, the firing circuits are illustrated. The method of operation is as follows. For the purpose of illustration, four firing chambers, **20**, **21**, **22** and **23** are shown. As a safety precaution the firing circuits are opened as the device is lowered into the well until hydrostatic switch **24** is closed which is set to close at a predetermined pressure. When the gun has reached the predetermined depth at which it is desired to perforate the casing, firing switch **25** is closed. This completes the circuit through the battery **60** and indicator meter **61** and closes the circuit through the firing filament in firing chamber **20**. It is to be understood that any suitable firing means may be utilized in conjunction with the invention. For example, the detonation elements may be of any suitable type, the propellant charge likewise may comprise conventional means as well as the projectile.

Under certain circumstances it may be desirable to use merely the force of the explosive charge to secure penetration as, for example, the effect of a shaped charge.

Upon detonation of the explosive in firing chamber 20 part of the gases are utilized to operate pressure switch 26 which closes the circuit between conductor 200 through firing switch 27 and ground return conductor 300. Due to the current load, the filament of firing chamber 20 is broken, thus breaking the circuit through conductor 100, firing switch 25 and ground return conductor 300.

The casing perforating gun may then be moved to the next level at which it is desired to perforate the casing, and firing chamber 21 fired by closing firing switch 27. The circuit operates similarly to that described with respect to the circuit in firing chamber 20. The filament in firing chamber 21 is broken by the explosion, thus breaking the circuit through conductor 200, firing switch 27 and ground return conductor 300. Simultaneously pressure actuated switch 28 is closed thus establishing a completed circuit through conductor 100, firing switch 25 and ground return conductor 300. The gun may then be moved to a new location and a similar procedure followed. Upon firing of chamber 22 by closing firing switch 25 the filament in firing chamber 22 is broken thus breaking the conductor 100 circuit. Simultaneously pressure switch 29 is closed, which establishes a completed circuit through conductor 200 controlled by firing switch 27. Chamber 23 may then be fired by the closing of switch 27.

It is to be understood that any number of firing chambers may be employed in conjunction with the alternate circuits as shown. As pointed out, the firing chamber may fire a projectile or merely an explosive charge. If it is desired that all charges be fired substantially simultaneously, this is accomplished by merely closing the two control switches 27 and 25.

Referring specifically to Fig. 3, one type of pressure switch is illustrated. The control mechanism is housed in a metallic body 30 which is rigidly attached to the wall of the perforating gun. The electrical contacts 31 and 34 are maintained apart against the force of compression spring 32 by means of shear disc 33. The shear discs may comprise a frangible plastic disc or any suitable equivalent means. Upon the explosion of a preceding charge the disc is shattered or sheared, thus releasing the compression spring. Compression spring moves the ground contact 34 against contact 31 thus closing the circuit. It is to be understood that any suitable or equivalent gas-operated contact switch may be employed. Furthermore, the method of positioning the contact switch in the perforating gun may be varied as deemed advisable.

Referring specifically to Fig. 4, a diagrammatical sketch is given showing one method by which the invention may be operated. The pressure switch 40, the firing chamber 41 with its accompanying firing mechanism is all positioned in gun body 50. Current is passed through the firing filament by impressing voltage between wires 42 and 43. The firing filament by means of a suitable booster, causes the propellant charge to be ignited and to force the projectile through the firing chamber from the gun body into the area in which perforation is desired.

As the projectile moves through the firing chamber and passes port A, some of the combustion gases from the propellant powder passes through ports A and B, and exerts pressure against the frangible disc causing it to break. Thus the pressure switch is actuated as heretofore described. The pressure switch functions to close the contacts and set up a completed circuit as described with respect to Fig. 2.

Having described the invention, it is claimed:

1. An improved casing perforating gun which comprises a plurality of firing chambers and a plurality of circuit closing switches comprising two contacts held apart against the tension of a closing spring by means of a breakable disc, means for closing a circuit switch of a succeeding firing chamber actuated by the combustion gases of the explosion in a preceding firing chamber, said means comprising conduits from the firing chamber to one face of said disc, and means for raising and lowering said gun to any desired point in a well bore hole.

2. An improved casing perforating gun which comprises a plurality of firing chambers and a plurality of pressure actuated closing switches which comprise two contacts held apart against the tension of a closing spring by means of a breakable disc, said firing chambers being alternately connected to one of two electrical circuits which are separately controlled by individual hand firing switches, said firing chambers having disposed therein a firing filament through which current is passed in firing and which filament is broken upon firing, means for closing a pressure actuated circuit switch of a succeeding firing chamber actuated by the combustion gases of the explosion in a preceding firing chamber, said means comprising conduits from the firing chamber to one face of said disc and means for raising and lowering said gun to any desired point in a well bore hole.

ADELBERT BARRY.

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