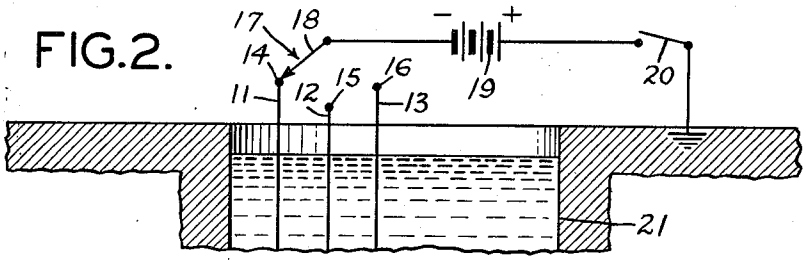
Sept. 4, 1956 M. SCHLUMBERGER 2,761,385

DEVICES FOR CONTROLLING THE FIRING OF CHARGES OF POWDER OR EXPLOSIVES FROM A DISTANCE

Filed Oct. 24, 1951 3 Sheets-Sheet 1

FIG.2.



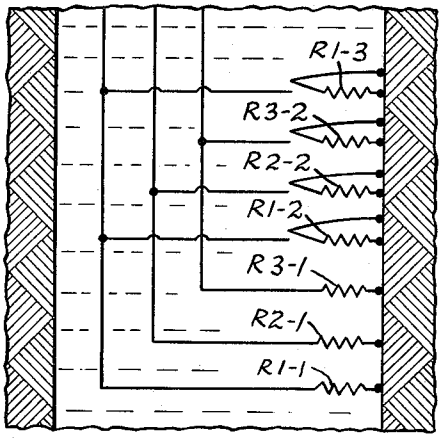
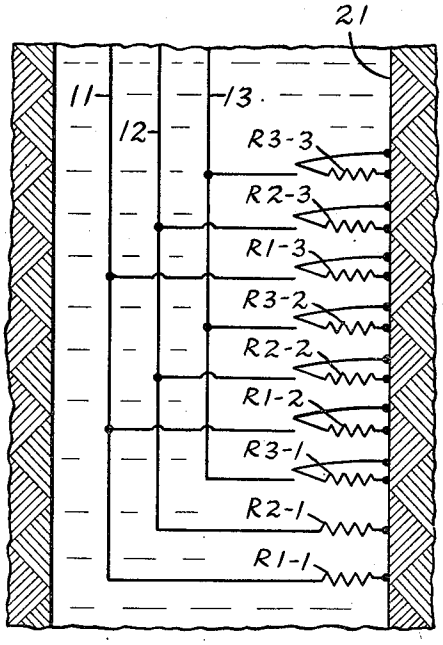


FIG.1.



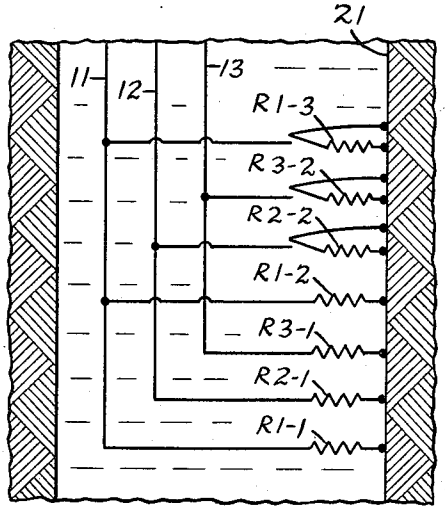


FIG.3.

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FIG. 4.

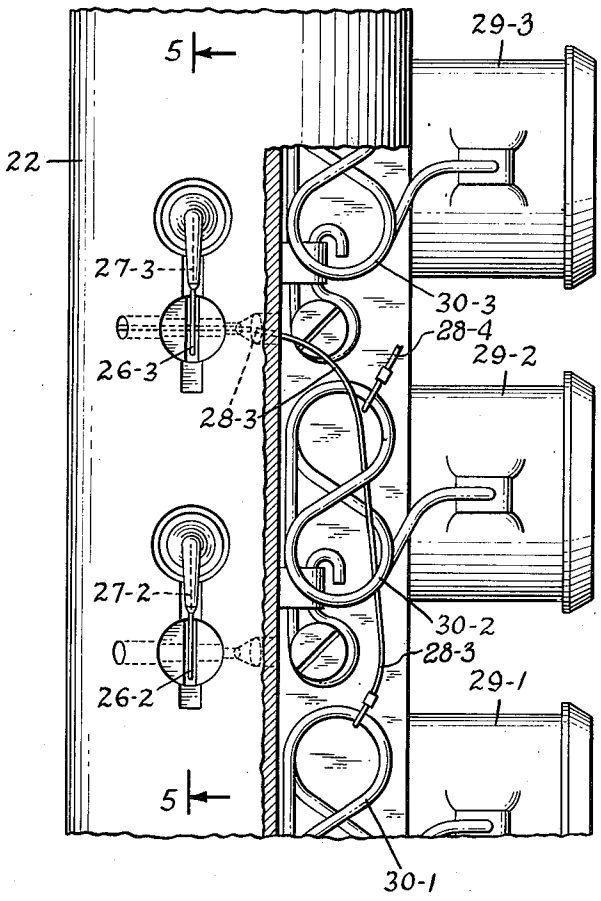

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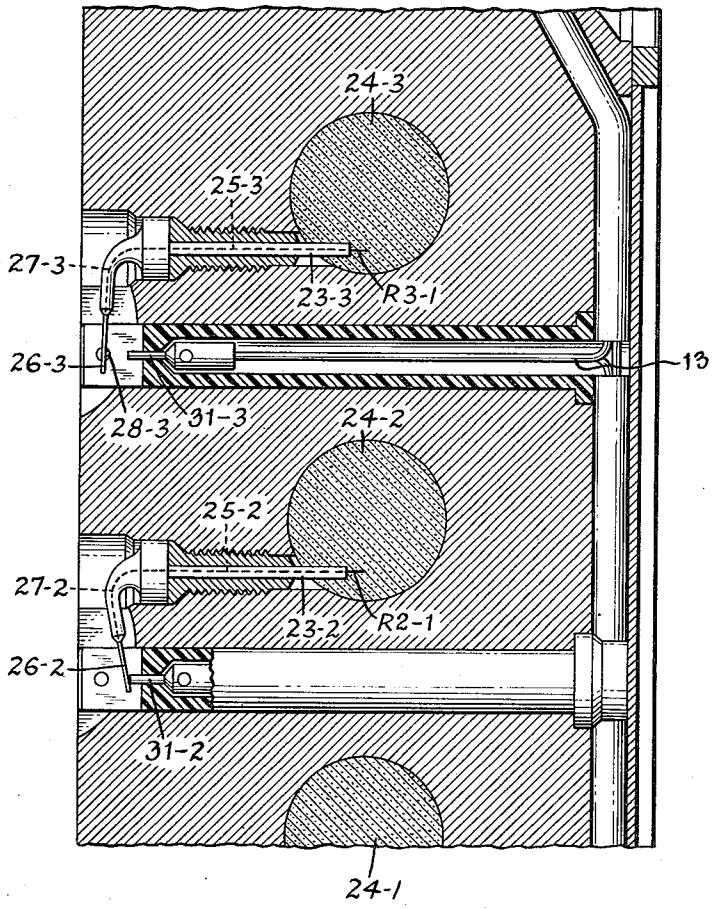
FIG.5.



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DEVICES FOR CONTROLLING THE FIRING OF CHARGES OF POWDER OR EXPLOSIVES FROM A DISTANCE

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Application October 24, 1951, Serial No. 252,892

Claims priority, application France January 30, 1951

5 Claims. (Cl. 102—27)

The present invention relates to devices which permit the selective firing from a distance of a plurality of charges of powder or explosive disposed at a remote location as in a borehole drilled into the earth, for example. More specifically, it has to do with selective firing devices of the kind in which the firing of a primer causes the "priming" of a following charge by mechanical or other means, and it refers more particularly to devices of the type in which the firing is accomplished electrically.

In certain devices such as sample takers for use in wells, for example, a large number of sample taking tools are required to be ejected successively, and it is desired to know at each moment precisely which explosive tool is fired so as to insure that the shots will be made at the exact well depth desired. Usually, the tools are connected to the firing apparatus in the well by flexible cables and they are adapted to be withdrawn from the formations by pulling on the cable on which the firing apparatus is suspended. In such apparatus, it is of primary importance not to take any risk of possible simultaneous firing of the charges corresponding to several multiple-shot tools. If simultaneous firing were to take place, all of the multiple-shot tools would be driven into the earth formations and any effort to withdraw them simultaneously by pulling on the supporting cable would involve the risk of applying excessive stresses to the latter.

The principal object of the present invention is to provide new and improved selective firing devices which definitely make it impossible for a plurality of charges of powder or explosive to be fired simultaneously.

In firing devices of this type available heretofore, a misfire resulting in the failure of a charge to go off usually made it impossible for the subsequent charges to be fired because they could not be primed. In the case of devices used inside a borehole, such an occurrence made it necessary to pull up the entire equipment for examination and repair. Another object of the present invention is to obviate this drawback at least partially, and to permit firing of the following charges in spite of the misfiring of one charge.

These and other objects of the invention may be obtained by connecting the different charges whose selective ignition is to be brought about to three or more separate electric circuits which are incapable of being fed simultaneously, each circuit controlling one series of charges, the entire system being so arranged that only one charge in each series is primed simultaneously, the firing of one charge in a series causing the priming of a definite charge in each of the other series, in the event that this or these other definite charges have not already been primed by preceding firings.

According to another feature of the invention, the electric primers of the unprimed charges are grounded at their two ends so as to prevent any possibility of current leaks causing the premature firing of a charge. In addition, the charges are preferably distributed in three or more circuits so that, for instance, in the case of three

circuits, there are always two primed charges belonging to two different circuits, while two charges belonging to two different circuits are, in addition, primed in advance at the start of shooting.

It will be apparent, therefore, that even if one of the charges fails to go off, and because of the fact that there are always at any moment two primed charges, it is possible to continue shooting by causing the discharge of the other primed charge, because the firing of this other charge in turn causes or assures the priming of at least two other charges, and so forth.

It is also possible, according to the invention, to provide a device for continuing shooting even if two successive charges fail to go off. For this purpose, it is sufficient to arrange the system so that the discharge of each charge will cause the priming of three other charges, the charges being arranged in four separate groups fed separately and successively by four electric circuits, the discharge of one charge of a group assuring the priming of three charges located, respectively, in the other three groups in question. If it seems necessary, the possibility of three successive misfirings can be provided for by the priming of four successive charges disposed in four other circuits, etc.

Other objects and characteristics of the invention will appear in the course of the following detailed description of a representative embodiment, taken in conjunction with the attached drawings, in which:

Fig. 1 is a schematic diagram of a three-circuit electric firing device constructed according to the invention and intended, for instance, for firing charges in a multiple-shot device lowered in a borehole;

Figs. 2 and 3 illustrate schematically the state of the firing device of Fig. 1 after the first and second shots have been fired;

Fig. 4 is a view in side elevation of part of a multiple-shot device provided with a firing device according to the invention; and

Fig. 5 is a view in longitudinal section taken along line 5—5 of Fig. 4.

In the illustrative embodiment of the invention described below, the firing device comprises priming mechanism mounted separately in three electric circuits, the discharge of each igniter in one of the circuits assuring the priming of the two following igniters arranged, respectively, in the other circuits. In Fig. 1, the igniters are shown diagrammatically by small electric resistors R_{1-1}, R_{2-1}, R_{3-1}, R_{1-2}, R_{2-2}, R_{3-2}, R_{1-3}, R_{2-3} and R_{3-3} formed by filaments which cause the firing by the fact that they are brought to incandescence by the passage of the current. Although only nine resistors are shown in Fig. 1, obviously a greater or lesser number may be used and, in practice, the successive and selective firing of thirty charges or more may be readily provided for according to the invention. Resistors R_{2-3} and R_{3-3} are not shown in Figs. 2 and 3, since they are not immediately affected by the exemplary operation described hereinafter.

As stated, the igniters are distributed in three groups which are adapted to be energized by three different electric circuits, the igniters of the first group being denoted by the designation R_1, those of the second group by R_2, and those of the third group by R_3.

The three groups of igniters are fed separately by means of three electric conductors, 11, 12, and 13, running from the apparatus in the borehole to the surface of the earth where they are connected to the fixed contacts 14, 15 and 16, respectively, of a distributor 17, for instance, the movable contact 18 of which is connected in series with suitable source of current 19 and a conventional switch 20 to ground as shown. The different igniters belonging to each of the groups are adapted to be connected between the corresponding conductor, on the one hand, and

a ground formed by the body of the apparatus and designated by the reference character **21** in Figs. 1–3, inclusive as will be described in greater detail hereinafter.

Two of the igniters, i. e. the two lower igniters R_{1-1} and R_{2-1}, are connected, before the apparatus is lowered into the borehole, directly between the conductors **11** and **12** and the ground **21** so that they are primed before the start of the operations. On the other hand, the other igniters are not initially primed but their two ends are both connected to ground, as shown. Priming, which may, for instance, be effected in the manner described hereafter concerning more specifically the multi-shot apparatus proper, or in any other manner, will consist in disconnecting one of the terminals of an unprimed igniter from ground and connecting it to the corresponding conductor **11**, **12** or **13**.

After the apparatus has been prepared, as outlined above, it will function in the following manner: the first charge is fired by supplying electric current to the conductor **11** thereby energizing the first primed igniter R_{1-1}. The firing of the shot corresponding to the igniter R_{1-1}, primes the igniter R_{3-1}, so that the firing circuit is then in the condition shown in Fig. 2, i. e., the two igniters R_{2-1} and R_{3-1} alone being primed. Thereupon current is passed into the conductor **12** and the firing of the shot corresponding to the igniter R_{2-1} primes the igniter R_{1-2}, so that the firing circuit is then in the state shown in Fig. 3. In this state, the igniter R_{3-1} can be ignited by causing a current to be passed into the conductor **13** and the firing of the shot corresponding thereto will prime the igniter R_{2-2} and so forth.

Hence, it will be seen that, in normal operation of the system described above, two igniters will always be primed but that, with a single source connected successively to each line, only one shot can be fired at a time.

In case an igniter misfires for one reason or another, it is still possible to continue firing. For example, if the igniter R_{3-1} were to misfire, firing could be continued by passing current through the conductor to energize the igniter R_{1-2} (Fig. 2). The firing of the shot corresponding to this igniter simultaneously primes the igniters R_{2-2} and R_{3-2} as will be described in greater detail below. From this moment on, by causing the current to pass successively into the conductors **12** and **13** the firing of the shots corresponding to the igniters R_{2-2} and R_{3-2} can be assured, which, in turn, will result in priming the igniters R_{1-3} and R_{2-3}, and so forth; hence, a misfire by one igniter will not prevent the following shots from being fired.

As stated above, Figs. 4 and 5, respectively, show part of a sample taking device for use in wells which is equipped with mechanism constructed according to the invention. The sample taker is similar to those used at the present time in that it consists of an elongated cylindrical body in which there have been provided transversely extending recesses forming gun barrels (there may be as many as thirty gun barrels formed along the body, or even more). In Figs. 4 and 5, only a portion of a sample taker having three guns is shown for purposes of illustration. Inside the gun barrels are disposed projectiles such as sample taking tools which may be formed by tubes which are adapted to be projected into the ground by the explosion of a charge of powder. Each of the sample taking tools is connected to the body of the apparatus by a flexible cable so that it can be pulled up with the body of the apparatus. Apparatus of this general character is shown in prior Patent No. 2,055,506 to Marcel Schlumberger.

In Figs. 4 and 5 the body of the apparatus **22** has formed therein a plurality of recesses **24—1**, **24—2**, **24—3** which form powder chambers. In front of these powder chambers are disposed a plurality of sample taking tools **29—1**, **29—2**, **29—3** which are connected to the body of the apparatus by the cables **30—1**, **30—2**, **30—3**, respectively. The powder in the powder chambers **24—1**, **24—2**, **24—3**, is adapted to be ignited by a plurality of igniting means which are connected, respectively, to the three conductors **11**, **12** and **13** (in Fig. 5 only the conductor **13** is seen). The igniting devices are preferably of the type disclosed in the copending application Serial No. 128,323, filed November 19, 1949, by Marcel Schlumberger, for "Electrical Igniters," now Patent No. 2,681,701, issued June 22, 1954.

At the end of a metallic hollow tube **23—3**, outwardly connected to the ground, is connected the filament R_{3-1} which goes into the powder chamber **24—3**. One end of the filament R_{3-1} is connected to the tube **23—3** and, therefore, to the ground and its other end is connected by means of an insulated conductor **25—3** inside the tube **23—3** to a small blade **26—3** carried by an elastic element **27—3** which forms a spring. Normally, this blade **26—3** (Fig. 5) rests on a metal short-circuiting wire **28—3** which keeps it away from an insulated contact **31—3** carried by the conductor **13** and which, at the same time connects this blade to the ground. The wire **28—3**, which is associated with the sample taker tool **29—3** which is adapted to be ejected by the combustion of the charge in the chamber **24—3** passes (Fig. 4) through the cable **30—2** which connects the tool **29—2** to the apparatus and is attached to the cable **30—1** which connects the tool **29—1** to the apparatus.

In Fig. 5, the igniter R_{3-1} is shown in the unprimed condition, while the igniter R_{2-1} is primed. In the primed position, the short-circuiting wire is missing, and the blade **26—2**, because of the elasticity of the element **27—2**, will make contact with the contact **31—2**. In this position, the igniter R_{2-1} is connected between ground and the corresponding conductor **12**. Assume now that the igniter R_{1-1} is also primed and that the corresponding sample taking tool is to be fired. The sample taking tool **29—1** is projected into the adjacent earth formation (not shown) and carries with it the cable **30—1** and the wire **28—3** attached to the latter. When the wire **28—3** is pulled out, the blade **26—3** will engage the contact **31—3** thereby priming the igniter R_{3-1}.

If for some reason or another, the igniter R_{1-1} misfires and that, therefore, the sample taking tool **29—1** has remained in place, the firing can, nevertheless, be continued. Since the igniter R_{2-1} is primed, by causing current to pass into this igniter from the conductor **12**, the tool **29—2** can be ejected, and the cable **30—2**, through which the wire **28—3** passes, will pull out the latter wire so that the igniter R_{3-1} will be primed. At the same time, since the cable **30—2** is also connected to the end of a wire **28—4** associated with the immediately following igniter R_{1-2} (Fig. 1), ejection of the sample taker tool **29—2** will prime the following igniter R_{1-2} so that, in all cases, after firing this shot, there will still be two primed igniters.

From the foregoing, it will be understood that the invention provides novel and highly effective firing mechanism for setting off a plurality of explosive charges from a distance. By providing a single energizing conductor for each of a plurality of groups of charges and maintaining the majority of the igniters normally short circuited, possible simultaneous firing of all of the charges is avoided. Further, by causing the firing of any one charge to prime at least one charge in each of at least two other groups of charges, it is possible to continue with the firing operations even if a misfire takes place.

Obviously, the specific embodiment described above may be modified within the scope of the invention. Thus, as stated above, provision can be made for the priming of more than two igniters so as to be able to continue firing operations even in the case of two consecutive misfires. The invention, therefore, is not to be limited save as defined in the following claims.

I claim:

1. In apparatus for firing a plurality of explosive charges from a distance, the combination of at least two

electrical igniter means for said charges, means for short-circuiting one of said igniter means, a firing circuit including the other of said igniter means, and means responsive to ignition of said last-named igniter means for rendering said short-circuiting means ineffective.

2. In apparatus for firing a plurality of explosive charges from a distance, the combination of at least two electrical igniter means for said charges, means for short-circuiting at least one of said igniter means, a first firing circuit including a primed igniter means, a second firing circuit, means for rendering said short-circuiting means ineffective and for connecting the igniter means corresponding thereto in said second firing circuit thereby priming said corresponding igniter means, and means actuated upon ignition of said first firing circuit igniter means for operating said connecting means.

3. In apparatus for firing a plurality of explosive charges from a distance, the combination of at least two electrical igniter means for said charges, means for short-circuiting one of said igniter means, a first firing circuit including the other of said igniter means, a second firing circuit, means responsive to ignition of said last-named igniter means for rendering said short-circuiting means ineffective and for connecting said one of said igniter means in said second firing circuit, a source of electrical energy, and means for connecting said source selectively to said first and second firing circuits.

4. In apparatus for firing a plurality of explosive charges from a distance, the combination of a plurality of short-circuited electrical igniter means and at least two primed electrical igniter means for said charges, a first firing circuit including one of said primed igniter means, a second firing circuit including another of said primed electrical igniter means, a third firing circuit, a plurality of means for rendering the short-circuiting of said short-circuited electrical igniter means ineffective and for connecting them in said first, second and third firing circuits, and means actuated upon ignition of the igniter means in one of said first and second firing circuits for operating at least one of said rendering and connecting means.

5. In sample taking apparatus including a body adapted to be lowered into a well and having a plurality of laterally directed, longitudinally spaced apart gun barrels formed therein, a sample taking projectile in each of said gun barrels, and powder chamber means for each of said gun barrels each having electrical igniter means therefor, the combination of a plurality of means for short-circuiting all but at least two of said igniter means, a first firing circuit including one of said two igniter means, a second firing circuit including the other of said two igniter means, a third firing circuit, means actuated by ejection of the projectile corresponding to one of said two igniter means for rendering one of said short-circuiting means for a third igniter means ineffective and connecting said third igniter means in said third firing circuit, means connected to each projectile other than said projectile corresponding to said one of said two igniter means for rendering ineffective said short-circuiting means for the igniter means in two adjacent powder chambers and for connecting them in two different ones of said three firing circuits, respectively, a source of electrical energy at the surface, and switching means for connecting said source selectively to said first, second, and third firing circuits.

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