Sept. 27, 1966 L. H. ROBINSON, JR., ETAL 3,274,933

APPARATUS FOR EXPLOSIVE CHARGE DRILLING

Filed May 24, 1963 2 Sheets-Sheet 1

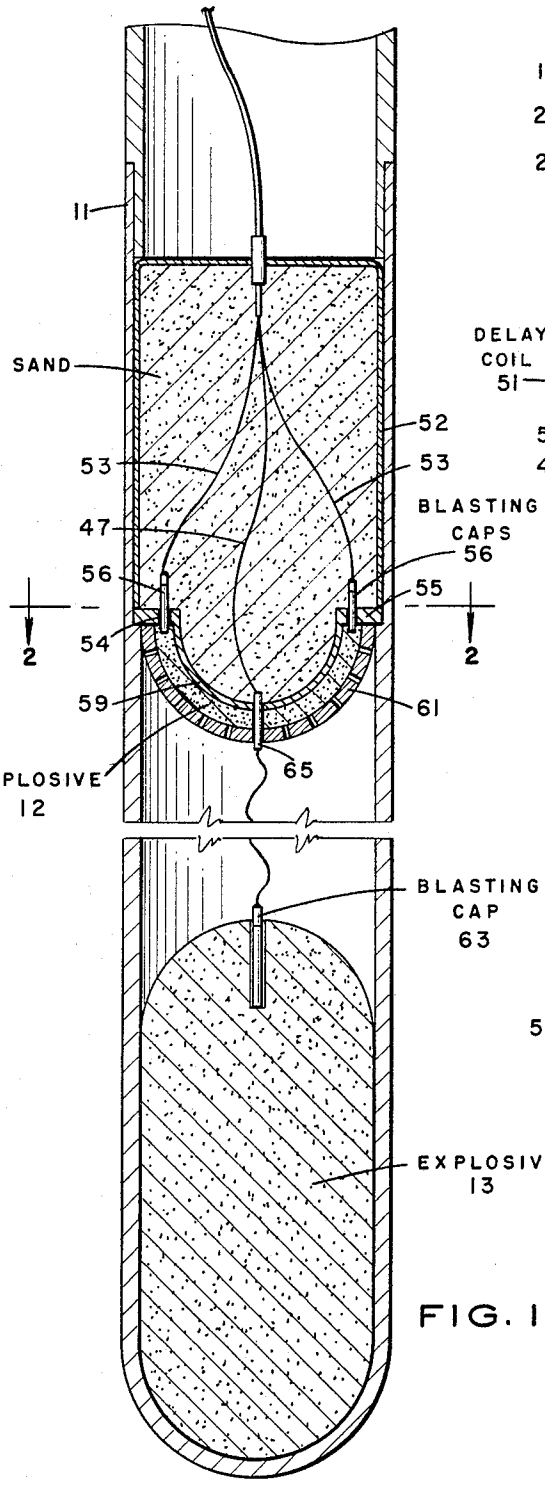

FIG. 1B.

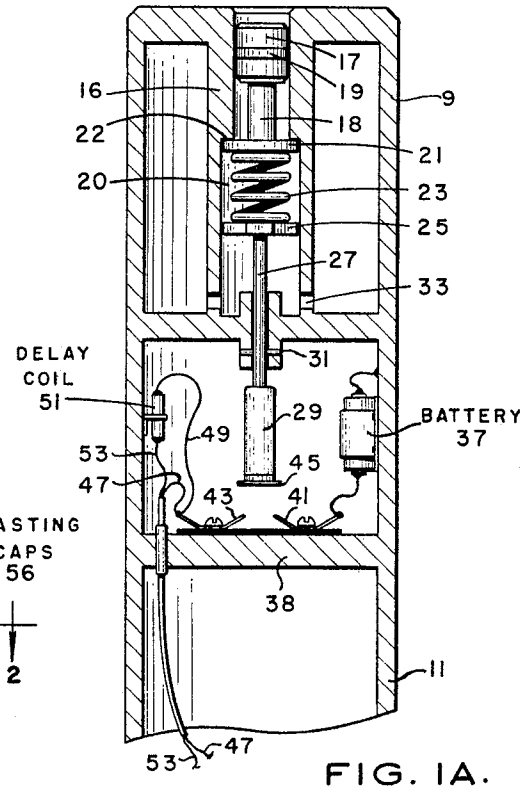

FIG. 1A.

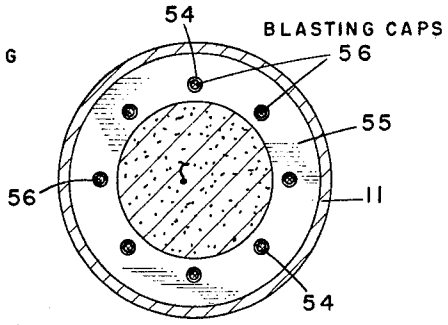

FIG. 2.

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APPARATUS FOR EXPLOSIVE CHARGE DRILLING

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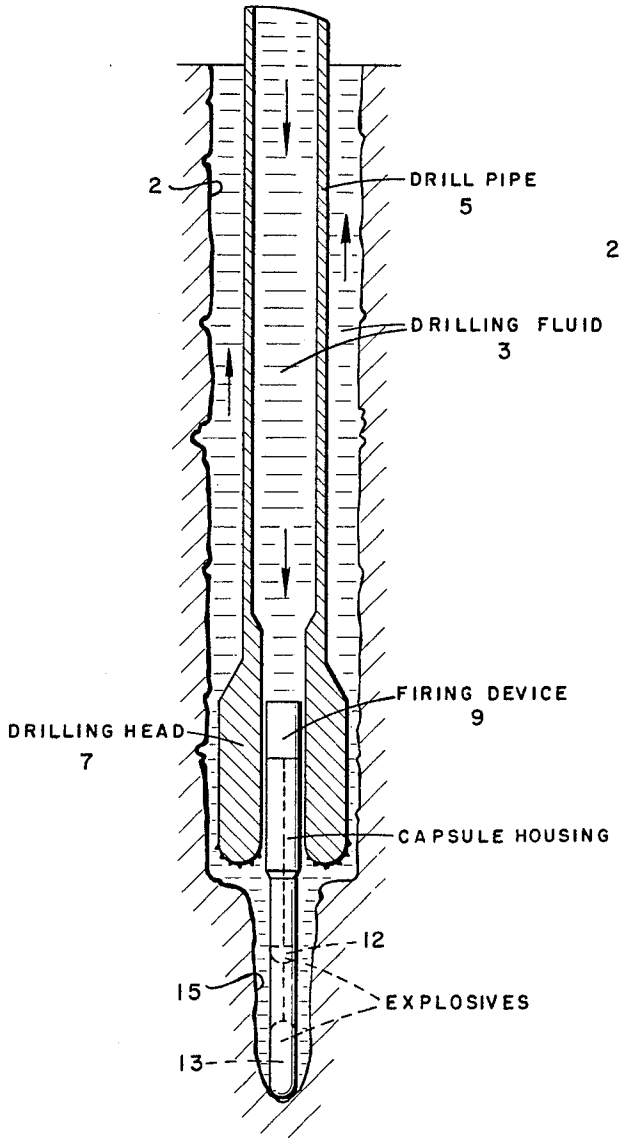

FIG. 3.

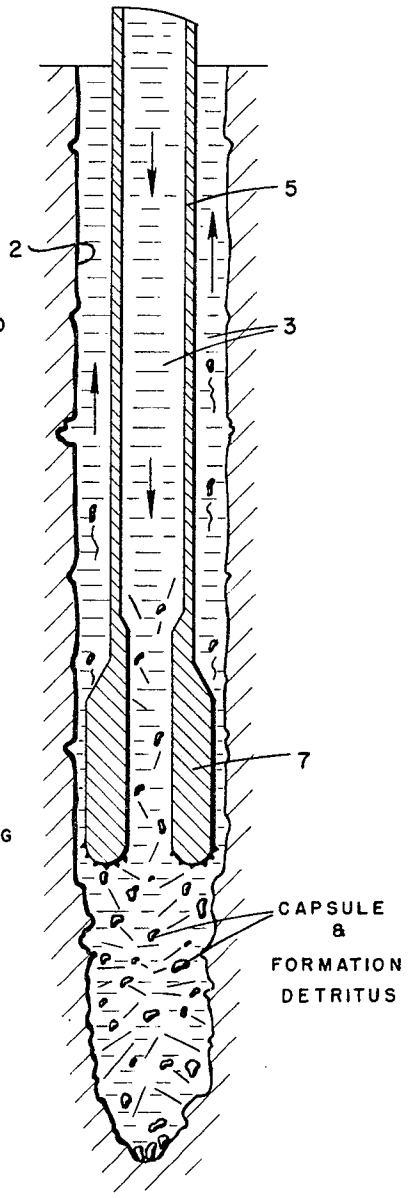

FIG. 4.

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APPARATUS FOR EXPLOSIVE CHARGE DRILLING

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4 Claims. (Cl. 102—21.6)

This invention relates generally to drilling boreholes with explosive charges, and more particularly to drilling boreholes with a combination of shaped charges and nondirectional gauging charges.

The technique of drilling boreholes with a predetermined sequence of shaped charges and gauging charges is described in U.S. Patent No. 3,070,010, Robinson. In this technique the jet charges and gauging charges are injected into a stream of drilling fluid going down a well pipe. Each shaped charge pumped down the pipe is followed by one or more gauging charges. After the shaped charge is seated at the bottom of the well pipe, the explosive portion of the charge is spaced from the bottom of the borehole, and the explosive charge is detonated. A gauging charge is thereupon injected into the hole left by the preceding shaped charge so as to extend as far as possible thereinto. Preferably, the gauging charge is long enough to extend substantially the entire length of the hole blasted by the shaped charge. The gauging charge is detonated and blasts a hole of substantially uniform diameter. Drilling fluid is circulated after each detonation of each shaped and gauging charge so as to remove earth fragments and fragments of the explosive charge housings.

While the drilling technique described above in general terms has been found to be quite satisfactory, certain problems have arisen in practice. For example, a substantial portion of the energy produced by the nondirectional explosive charge is directed upwardly and serves only to blow drilling fluid up the borehole. Manifestly, it would be desirable for as much as possible of this energy to be directed laterally of the borehole in order to most economically and effectively use the explosive material available in the explosive charge.

In accordance with one aspect of this invention, there is provided an elongated housing having a first nondirectional explosive charge at one end thereof. Positioned in the housing directly above the nondirectional explosive charge is a second nondirectional explosive charge formed generally like a cup and extending upwardly and away from the longitudinal axis of the elongated housing. Within the second charge is means for reflecting outwardly the energy produced upon detonation of the second charge. Connected to the first and second charges is means for detonating the second charge a predetermined interval after the first charge is detonated such that the upwardly-going energy produced by the first charge is deflected outwardly into the surrounding earth formation by the energy proudced by the second charge.

The invention will be further described with reference to the drawings, wherein:

FIGS. 1A and 1B are sectional views illustrating a preferred embodiment of the invention;

FIG. 2 is a cross-sectional view taken along section 2—2 of FIG. 1B; and

FIGS. 3 and 4 are a simplified cross-sectional view of a portion of a well installation illustrating the utility of the present invention.

With reference now to the embodiment of the invention illustrated in FIGS. 1A and 1B, there is shown an elongated housing **11**, which preferably is formed from an electrically conductive material such as aluminum for reasons that will become apparent below. Disposed in the lower end of the housing **11** is a nondirectional explosive charge **13** which may be of an explosive material such as RDX, TNT, PETN, ammonium nitrate, or combinations of any two or three of these. In the upper end of the mass of explosive material **13** is an electrically activated blasting cap **63** for detonating the explosive material **13**.

Positioned immediately above the explosive material **13** and spaced therefrom by a distance of from 1 to 12 inches is a generally cup-shaped mass of exploive material **12** which may be the same type as explosive mass **13**. The cup-shaped explosive material **12** is held within a housing therefor comprising a lower liner **61** and an upper liner **59** having an annular flange **55** connected to the upper end thereof. Both liners may be of a frangible plastic or of a light metal such as aluminum which may be easily circulated out of the borehole when shattered by the explosion of explosive mass **12**. A number of holes **54** are drilled in the flange **55**, and blasting caps **56** extend therethrough for detonating the cup-shaped explosive charge **12**. Held within a liner **52** and filling the cup volume within liner **59** is a quantity of a material such as sand to act as a backup for liner **59** so that most of the energy produced upon detonation of explosive charge **12** will be reflected outwardly.

Disposed in the upper end of housing **11** is apparatus for detonating blasting caps **63**, and for detonating the blasting caps **56** a predetermined time interval after detonation of blasting caps **63**. This apparatus is responsive to a predetermined differential pressure between the inside and outside of housing **11**. As illustrated, the apparatus comprises a rod **27** held in place by a shear pin **31**, and terminating at its lower end in a spring biased over-travel plunger **29**. Supported on laterally-extending wall **38** are a pair of electrical contacts **41** and **43** which are positioned immediately below over-travel plunger **29**. An electrically conductive bridging member **45** at the lower end of over-travel plunger **29** is adapted to engage contacts **41** and **43** so as to complete an electrical circuit between the contacts. Contact **41** is connected to a battery **37**; the other terminal of the battery **37** is connected to the electrically conductive housing **11**. The other contact **43** is connected directly to the blasting cap **63** by means of electrical lead **47**. Contact **43** also is connected to each of blasting caps **56** through electrical lead **49**, delay coil **51**, and a plurality of branching electrical leads **53**. The function of the delay coil is to delay the rise in electrical current produced when conductive bridging member **45** bridges the gap between contacts **41** and **43** so that blasting caps **56** will be activated a predetermined interval of time after activation of blasting cap **63**.

Electrical lead **47** extends through the explosive mass **12** and is insulated therefrom by an electrically insulating sleeve **65**.

Rod **27** is disposed in a chamber **20** formed by a generally cylindrical inner housing member **16**. The cham-

ber **20** is of greater diameter at the lower end thereof than at the upper end thereof to form a shoulder **22**. The rod **27** has a cross head or plate **25** connected to the upper end thereof. A plunger comprising piston **17**, cross head or plate **21**, and connecting rod **18**, is disposed in the upper end of chamber **20**. The piston **17** is provided with a piston ring **19** adapted to provide a sliding seal with the walls of the cylinder. The cross head **21** engages shoulder **22** so that the plunger is held within the chamber **20**. A compression spring **23** is disposed between cross heads **21** and **25**. Port **33** provides fluid communication between the lower end of chamber **20** and the annular chamber between housing member **11** and inner housing member **16**. When a predetermined differential pressure exists between the inside and outside of the housing **11**, the plunger will be forced downwardly until shear pin **31** is sheared, thereby forcing rod **27** downwardly until bridging member **45** bridges the gap between contacts **41** and **43**.

The operation of the apparatus described above will be best understood by referring to FIGS. 3 and 4. In the figures there is shown a borehole **2** having disposed therein a drill pipe **5** which may terminate in a drilling head **7** having a drill bit, which may be a diamond drill bit, at the lower end thereof. The drilling head **7** is provided with an annular bore **10** which preferably is only slightly larger than the maximum outside diameter of the housing **11**.

As described generally above, a shaped charge capsule is initially pumped down the drill pipe **5** in the drilling fluid **3** until it is landed at the bottom of the well bore. When it is detonated, as by increasing the pressure of the drilling fluid to actuate a differential pressure responsive firing device, a tapering hole will be produced below the lower end of the borehole. Thereupon the apparatus illustrated in FIGS. 1A and 1B is pumped down the borehole until it protrudes into the tapered hole **15** left by the detonated shaped charge. Drilling fluid is circulated prior to the time that the apparatus illustrated in FIGS. 1A and 1B is so inserted in order to remove detritus produced by the shaped charge. Hydrostatic pressure is then again increased until shear pin **31** is sheared to detonate explosive charge **13**. The upwardly-going energy produced by detonation of the explosive charge **13** will not have reached explosive charge **12** by the time that blasting caps **56** detonate the explosive charge **12**. The energy produced by the explosive charge **12** will for the most part be directed downwardly and outwardly so as to deflect the upwardly-going energy produced by explosive charge **13**. Thus, the energy produced by both of the explosive charges will be more effectively utilized.

Preferably, the shape of the cupped explosive charge **12** is that of a paraboloid of revolution, as it has been found that this shape is most effective in achieving the desired results.

Manifestly, while the electrical firing device shown is preferred, other types may be utilized, such as delay blasting caps of the type illustrated in The Science of High Explosives, M. A. Cook, Reinhold Publishing Co., New York, pp. 16–17. In this case the blasting caps may be activated simultaneously, and the time interval between detonation of the explosive charges will be determined by the inherent delay provided by the blasting caps.

The above description and examples of the invention are for the purpose of illustration, and it is not intended that the invention be limited except by the scope of the appended claims.

What is claimed is:

1. Apparatus for use in earth drilling, comprising:
an elongated housing;
nondirectional first explosive charge means at the lower end of said housing;
a thin cup-shaped supporting member positioned in said housing above said explosive charge means, extending outwardly from the axis of said housing and upwardly and away from said explosive charge means;
a second explosive charge means lining the inner surface of said supporting member;
first detonating means connected to said first explosive charge means;
second detonating means connected to said second explosive charge means adapted upon activation thereof to detonate said second explosive charge means a predetermined interval after activation of said first detonating means and before the energy produced by detonation of said first explosive charge means reaches said second explosive charge means; and
means for simultaneously activating said first and second detonating means.

2. Apparatus for use in earth drilling, comprising:
an elongated housing;
nondirectional first explosive charge means at the lower end of said housing;
a thin cup-shaped second explosive charge means positioned in said housing above said first explosive charge means and extending outwardly from the axis of said housing and upwardly and away from said first explosive charge means;
first detonating means connected to said first explosive charge means;
second detonating means connected to said second explosive charge means adapted upon activation thereof to detonate said second explosive charge means a predetermined interval after activation of said first detonating means and before the energy produced by detonation of said first explosive charge means reaches said second explosive charge means; and
means for simultaneously activating said first and second detonating means.

3. Apparatus for use in earth drilling, comprising:
an elongated housing;
nondirectional first explosive charge means at the lower end of said housing;
a thin cup-shaped second explosive charge means positioned in said housing above said first explosive charge means and extending outwardly from the axis of said housing and upwardly and away from said first explosive charge means;
first detonating means connected to said first explosive charge means;
second detonating means connected to said second explosive charge means adapted upon activation thereof to detonate said second explosive charge means a predetermined interval after activation of said first detonating means and before the energy produced by detonation of said first explosive charge means reaches said second explosive charge means;
means for simultaneously activating said first and second detonating means;
said cup-shaped explosive charge means being in the form of a paraboloid of revolution.

4. Apparatus for use in earth drilling, comprising:
an elongated housing;
nondirectional first explosive charge means at the lower end of said housing;
a thin cup-shaped second explosive charge means positioned in said housing above said first explosive charge means and extending outwardly from the axis of said housing and upwardly and away from said first explosive charge means;
first detonating means connected to said first explosive charge means;
second detonating means connected to said second explosive charge means adapted upon activation thereof to detonate said second explosive charge means a predetermined interval after activation of said first detonating means and before the energy produced by detonation of said first explosive charge

means reaches said second explosive charge means;
means for simultaneously activating said first and second detonating means; and
means within said second explosive charge means for reflecting outwardly the energy released upon detonation of said second explosive charge means.

References Cited by the Examiner

UNITED STATES PATENTS

60,573	12/1866	Shaffner	102—23
87,372	3/1869	Shaffner	102—23
704,465	7/1902	Kirsanov	102—24
2,363,234	11/1944	Doll	102—20 X
2,543,823	3/1951	Barry	166—55.5
2,609,750	9/1952	McFarland	102—23
2,671,400	3/1954	Duesing	102—24
2,775,940	1/1957	Klotz	102—23
3,022,729	2/1962	Robinson	102—20

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