

Dec. 25, 1962

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3,070,010

DRILLING BOREHOLES WITH EXPLOSIVE CHARGES

Filed Nov. 27, 1959

4 Sheets-Sheet 1

FIG. 1.

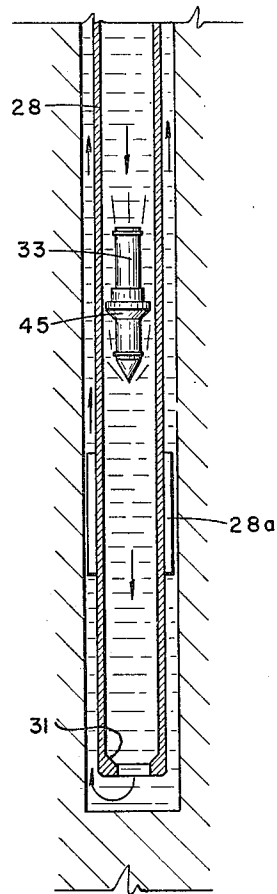
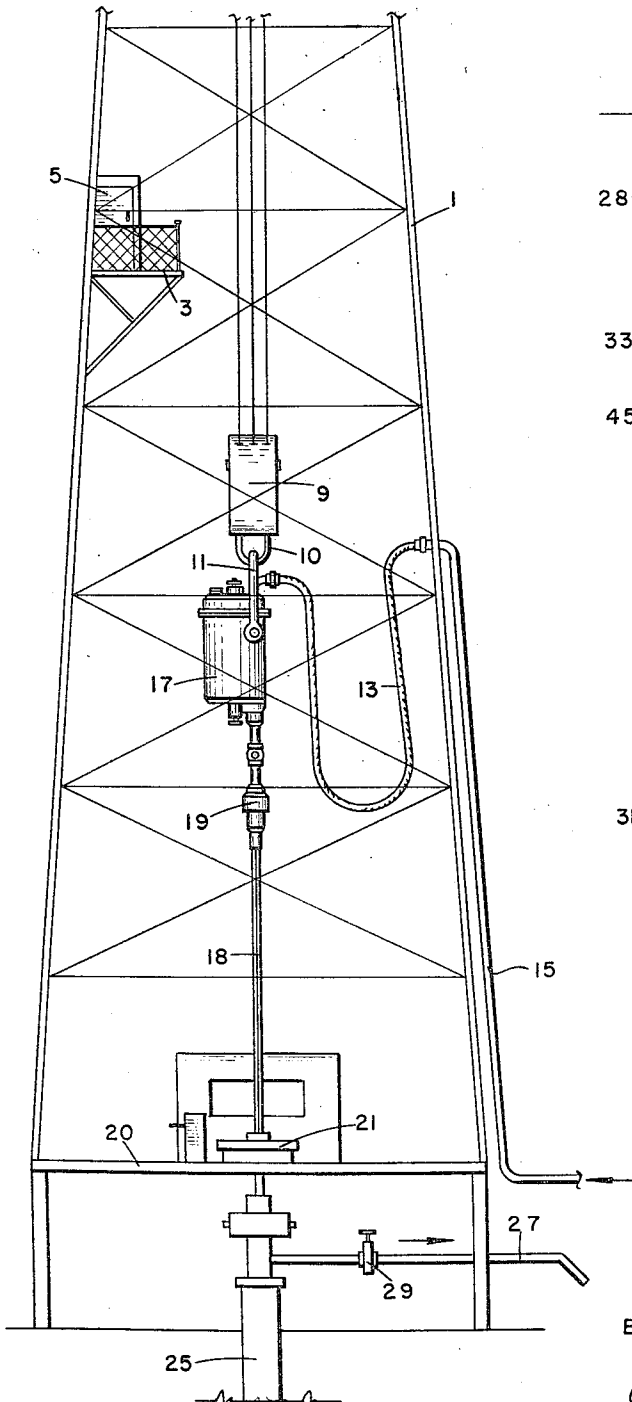


FIG. 2.

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FIG. 3.

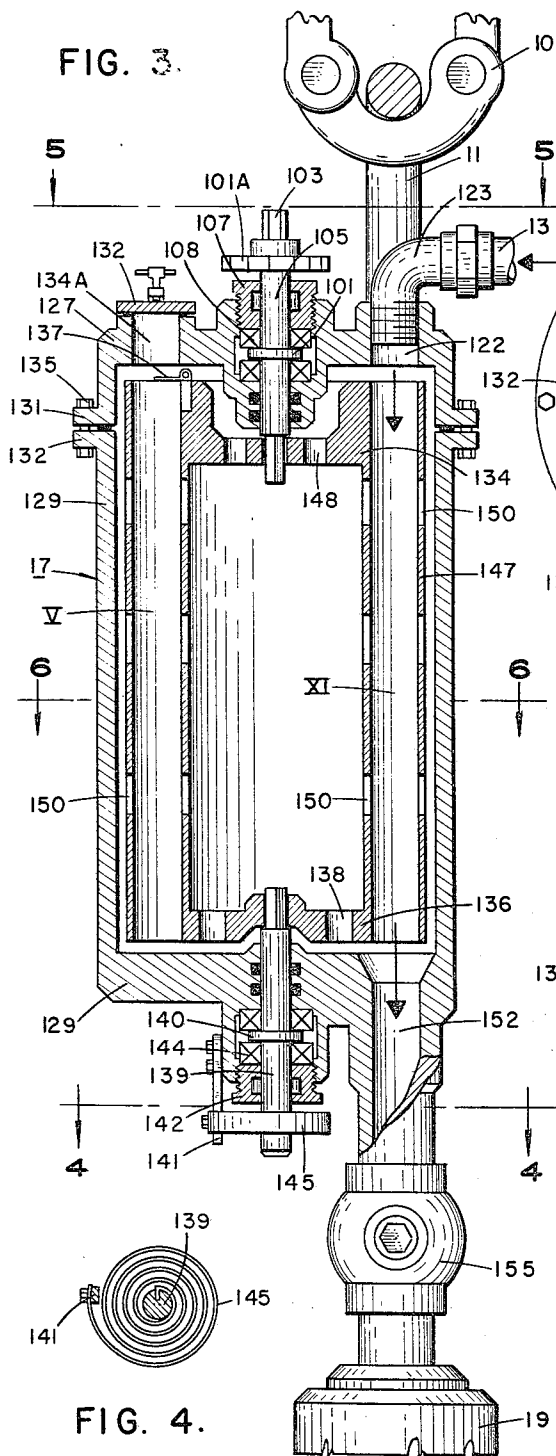


FIG. 4.

FIG. 5.

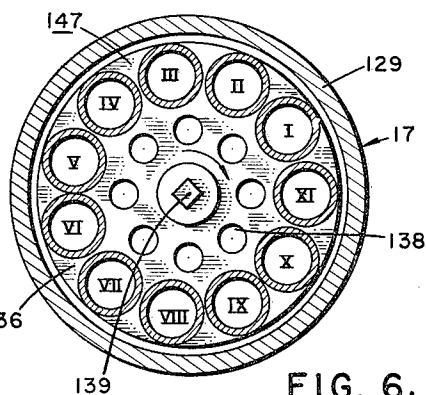
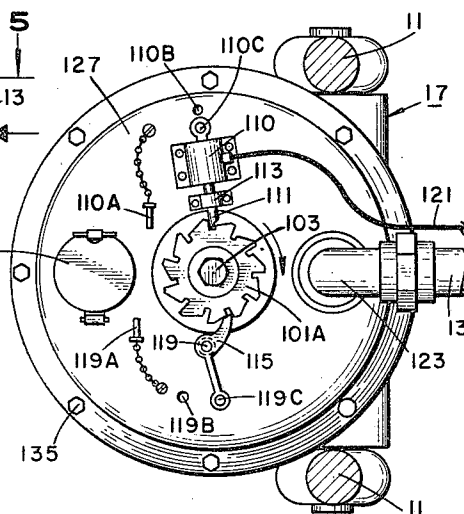


FIG. 6.

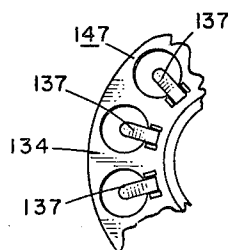


FIG. 6A.

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FIG. 7.

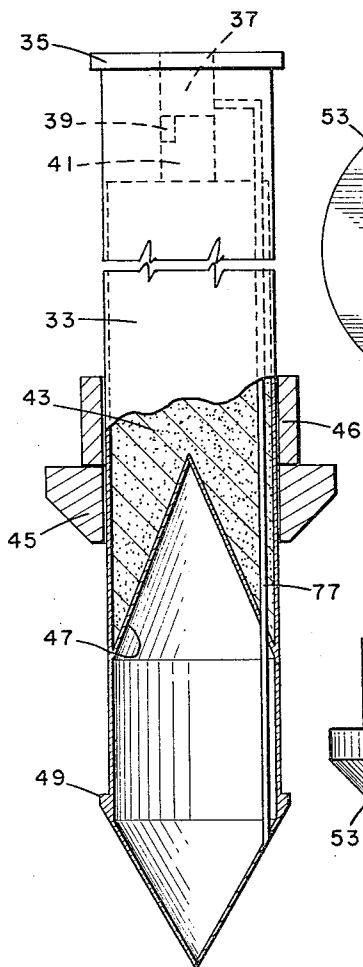


FIG. 8.

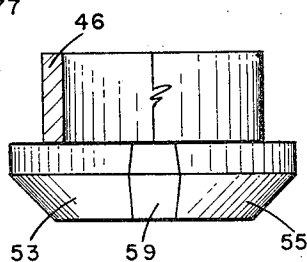
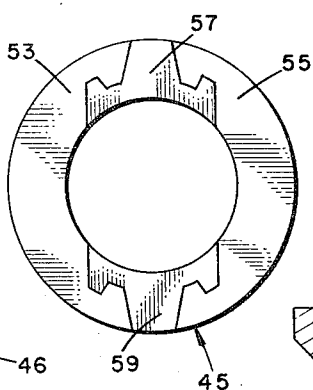


FIG. 9.

FIG. 11.

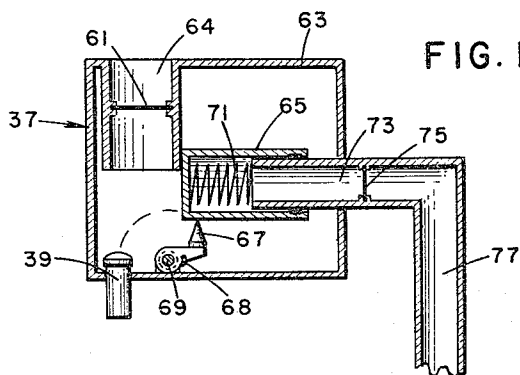
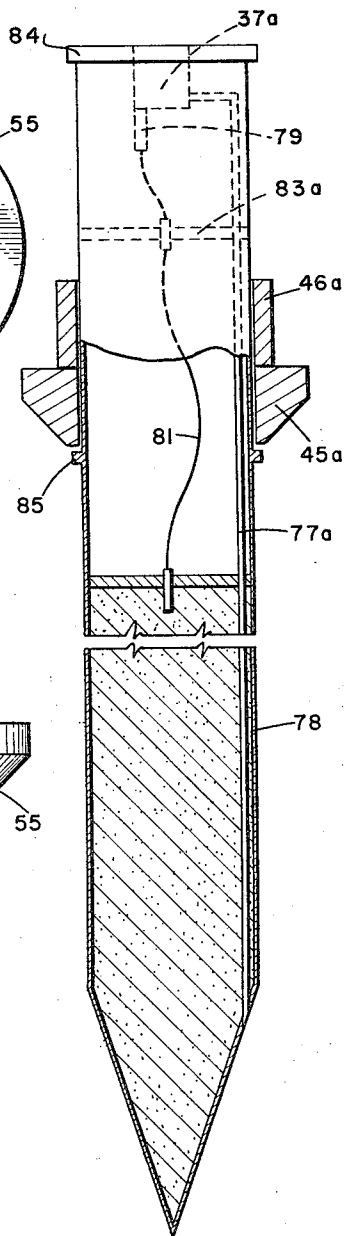


FIG. 10.

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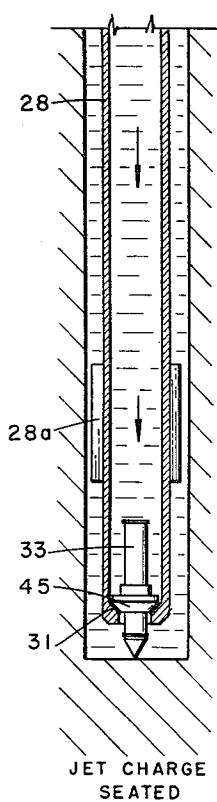


FIG. 12.

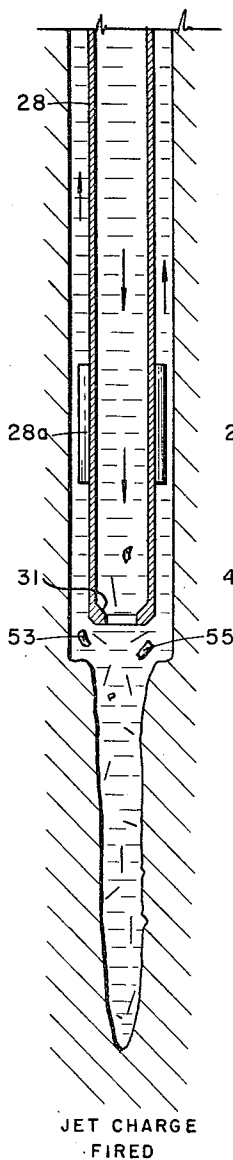


FIG. 13.

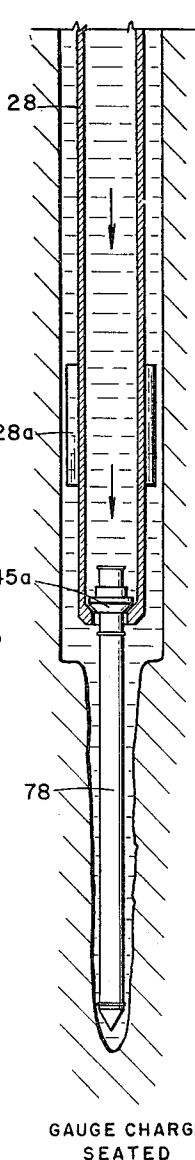


FIG. 14.

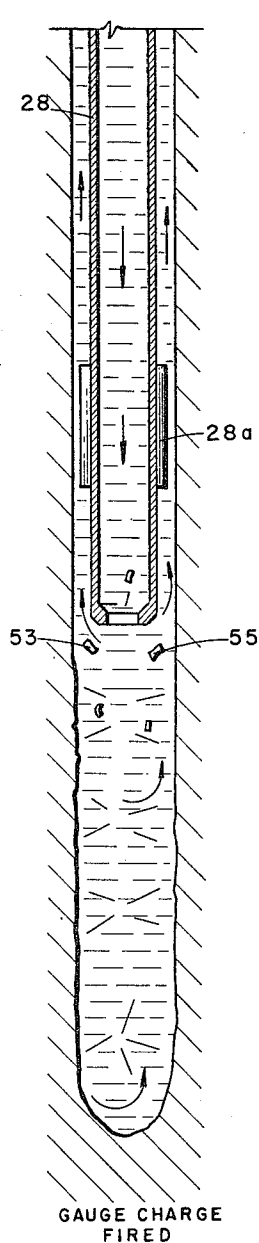


FIG. 15.

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3,070,010 DRILLING BOREHOLES WITH EXPLOSIVE CHARGES

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Filed Nov. 27, 1959, Ser. No. 855,899
9 Claims. (Cl. 102—21)

This invention relates to the drilling of boreholes, and more particularly to drilling boreholes utilizing a succession of explosive charges including shaped jet charges.

In connection with drilling boreholes for the purpose of exploiting possible hydrocarbon deposits in the earth, it has been known to utilize explosive charges for the purpose of expediting drilling operations. It has also been known to use shaped jet charges in combination with nondirectional blasting charges. Examples of the prior art use of explosive charges for drilling operations may be found in U.S. Patent No. 2,897,756 to L. Borins et al. and U.S. Patent No. 2,587,243 to W. Sweetman.

Previous attempts to use explosive charges for earth drilling have been characterized by very slow penetration rates, great expense, and the necessity for using more or less cumbersome equipment. While the development of shaped jet charges has made the use of explosives for drilling more attractive because of the directional characteristics of the shaped charge, it has not proved to be a cure-all for the deficiencies of explosive drilling. A prime reason is that, while the shaped charge is capable of penetrating further into the earth than can a nondirectional explosive charge, it blasts a hole that is quite wide at its mouth but which narrows rapidly and terminates in an elongated cavity that is far too narrow to accommodate a well or drill pipe. The use of blasting charges in the manner taught by the aforesaid Borins et al. patent has not particularly helped the situation because the blasting charges do not deepen or widen the hole drilled by the shaped charge to any great extent.

The present invention makes use of a well pipe having a landing seat or nipple at or near its lower end. The well pipe is connected to conventional mud circulating equipment at the surface so that drilling fluid is pumped down the well pipe and up the annulus around the well pipe. Use is made of elongated shaped jet charges and elongated nondirectional gauging charges adapted to be pumped down the well pipe, and further adapted to seat on the landing nipple or seat so that a differential pressure is built up thereacross.

The jet charges and gauging charges are injected into the stream of drilling fluid going down the well pipe, according to a predetermined sequence. First, a shaped charge is pumped down the well pipe. After it seats on the landing seat, the explosive portion of the jet charge is spaced from the bottom of the borehole a predetermined distance of predetermined magnitude that is built up across the shaped charge. Responsive to differential pressure, the charge is detonated so as to blast a hole in the earth at the bottom of the well bore. A gauging charge is then landed on the seat so as to extend into the hole produced by the preceding shaped jet charge. Preferably, the gauging charge is long enough to penetrate substantially the entire length of the hole blasted by the shaped charge. The gauging charge, which may be of a brisant or unbrisant explosive material or a combination thereof, is detonated while tamped with drilling fluid and preferably while under a hydrostatic pressure of at least 1000 p.s.i. Drilling fluid is circulated after each detonation of a shaped charge and a gauging charge so as to remove earth fragments and fragments of the explosive charge housing. Preferably, the explosive charges are injected into the drilling stream so as to be spaced apart substan-

tially 100 to 4000 feet, and the drilling fluid is circulated so that particles therein are travelling at the rate of between 100 and 400 feet per minute so that the successive explosive charges are detonated between 1 and 10 minutes apart.

The invention will be more completely understood, and the various objects and features of the invention will become apparent upon consideration of the following description thereof when taken in connection with the accompanying drawings, wherein:

FIG. 1 is a perspective diagram of a portion of equipment that may be used at the earth's surface in connection with the practice of the invention;

FIG. 2 is a view of a shaped jet charge being pumped down a well pipe, showing a preferred construction of the lower end of the well pipe;

FIG. 3 is an elevational view, partially in section, of the explosive charge magazine housing shown in FIG. 1, which view shows certain of the details of the magazine housing;

FIG. 4 is a fragmentary cross-sectional view taken along section 4—4 of FIG. 3;

FIG. 5 is a top view of the magazine housing shown in FIG. 4;

FIG. 6 is a cross-sectional view taken along section 6—6 of FIG. 3;

FIG. 6A is a fragmentary top view of the explosive charge container shown in FIG. 3;

FIG. 7 is a side view, partially in cross-section, of a preferred jet charge capsule to be used in connection with the invention;

FIG. 8 shows certain details of the firing collar shown in FIG. 7;

FIG. 9 is a side view of a portion of the firing collar of FIG. 7;

FIG. 10 is a cross-sectional view showing the differential pressure responsive firing mechanism shown in FIG. 7;

FIG. 11 is a side view, partially in cross-section, of a gauging charge to be used in connection with the present invention; and

FIGS. 12, 13, 14, and 15 illustrate successive steps in the use of explosive charges for drilling according to the teachings of the present invention.

In FIG. 1 there is shown surface equipment for use in connection with the present invention. The usual drilling rig 1 is provided with an explosive charge loader's platform 3 at a distance above the drilling floor 20 determined by the length of well or drill pipe to be run into the hole to be drilled with the apparatus. An explosive charge housing 5 for storing explosive charges is located on the loader's platform 3.

The usual traveling block 9 is suspended from a crown block (not shown) by cables in the usual manner. Located between the swivel 19 and hook 10 is an explosive charge magazine housing 17 which is illustrated in detail in FIGS. 3 through 6 and 6A. Connected to swivel 19 is a Kelly joint 18 which extends through the rotary table 21 into the surface casing 25. The function of the magazine housing is to provide a remotely controlled apparatus for injecting a plurality of explosive charges into the well according to a predetermined sequence. Drilling fluid is circulated through the magazine housing 17 into the swivel 19 and Kelly joint 18 from the usual standpipe 15 and hose connection 13. A mud pump (not shown) supplies pressurized drilling fluid to the stand-pipe. Below the drilling floor 20 is located the usual mud return line 27 which may be controlled by a valve 29. The mud control line is hydraulically coupled to the annular space around the drill pipe in the usual manner.

As shown most perspicuously in FIG. 2, the drill or well pipe 28 is provided with a landing seat 31 at or near

its lower end. The purpose of this landing seat is to receive a collar 45 fitted around an explosive charge 33 which is pumped down the well. When the collar 45 lands on the seat 31, flow of drilling fluid down through and out the lower end of the well pipe will be either stopped or substantially reduced so that a differential pressure will be built up across the explosive charge. As will be described in detail below, differential pressure is used for the purpose of firing the explosive charge.

The details of the explosive charge magazine housing 17 are shown in FIGS. 3, 4, 5, 6, and 6A. The housing 17 is suspended from the traveling block by the usual hook 10 and bales 11. A housing bonnet 127 is connected to the lower part 129 of the magazine housing by a plurality of bolts 135 connecting together the housing flanges 131, 132. A drilling fluid inlet port 122 and an exhaust port 152 are provided in the housing 17. A coupling pipe 123 interconnects the inlet port to the drilling fluid hose 13. The exhaust port 152 is connected to swivel 19 by suitable pipes and a valve 155. The housing is also provided with an additional port 134A in housing bonnet 127 for the purpose of loading the magazine with charges. A suitable plug 132 is provided for the purpose of sealing port 134A after the magazine has been loaded with explosive charges, so that drilling fluid cannot escape from the housing through port 134.

Enclosed within magazine housing 17 is an explosive charge transport member 147 comprising an upper end section 134, a lower end section 136, and a plurality of tubes which are designated by Roman numerals I through XI for the purpose of acting as open-ended explosive charge receptacles. The transport member is supported between shafts 105 and 139 which respectively extend through the bonnet 127 and the lower portion 129 of the magazine housing. Shafts 105 and 139, respectively, include bearing flanges 101 and 140, which respectively are fitted between bearing members 108 and 144. The bearing members 108 and 144 are respectively positioned in the ends of the housing bonnet 127 and lower housing member 129. Retaining nuts 107 and 142 are provided for the purpose of holding the shafts 105 and 139 in place.

A ratchet gear or wheel 101A is affixed to the upper end of shaft 105. As shown most perspicuously in FIG. 5, a solenoid-actuated pawl 111 is positioned on the housing bonnet 127 by guide member 113 to engage the notches in the ratchet wheel 101. The notches are provided with small recesses at the bottoms thereof so as to minimize back-lash when the pawl engages the ratchet wheel. The pawl may be biased by a spring means in the conventional manner to normally fit into the notches of the ratchet wheel. The solenoid 110 is provided for the purpose of momentarily disengaging the pawl from the notches. The solenoid may be energized through a control cable 121 which extends to the driller's position on the derrick floor. A small hole 110B is provided in the housing bonnet 127 and an eye 110C is provided in the pawl 111 so that the pawl may be locked out of engagement with the notches of the ratchet wheel by means of pin 110A. An auxiliary pawl 115, which may be spring-biased into engagement with the ratchet wheel and which may pivot around a pivot point 119, is provided for the purpose of engaging the ratchet wheel and to permit counterclockwise movement of the ratchet wheel when the shaft 105 is manually turned in a counterclockwise direction. Pin 119A is adapted to fit through eye 119C into hole 119B to lock the pawl 115 out of engagement with the ratchet wheel. Pawl 115 is normally spring-biased into engagement with the ratchet wheel by means of a spring (not shown) which tends to rotate it in a counterclockwise direction as viewed in FIG. 5.

Inasmuch as the explosive charge capsules contemplated for use in connection with the present invention are considerably less dense than the drilling mud that is ordinarily used, the charges will tend to float in the drilling mud. For the purpose of holding the explosive charges within

the receptacles in the transport member, there is provided at the top of each receptacle a flipper member 137. The flipper is normally held in a horizontal position by a spring means (not shown) and is rotated to a vertical direction when an explosive charge is slid into the receptacle corresponding thereto. As soon as the explosive charge is in the receptacle, the flipper 137 will swing to a horizontal position to prevent the explosive charge from floating up out of the receptacle.

In each of the receptacles there are a number of ports 150 for the purpose of permitting free fluid flow through the interior of the housing. Likewise, ports 148 and 138 are provided for the same purpose in the upper and lower portions of the transport mechanism.

A spiral spring 145 is affixed to a bar or strap 141 and to the lower end of shaft 139. The spring spirals in a manner such that it will be wound when the ratchet wheel 101A is rotated in a counterclockwise direction as viewed in FIG. 5. Thus, the spring will tend to rotate shaft 139 responsive to withdrawal of pawl 111 from a notch of the ratchet wheel after the spring is wound. Strap or bar 141 is bolted to the lower end of the housing 17.

FIGS. 7, 8, 9, and 10 illustrate a preferred embodiment for the shaped jet charge, its container, and the firing collar illustrated in FIG. 2. As shown in FIG. 7, the brisant explosive charge material 43 is encapsulated in a housing or container 33 along with the usual booster charge 41 and detonator 39. In addition, there is provided a firing mechanism 37 for the purpose of firing the detonator 39 responsive to a predetermined differential pressure across the opposed ends of the explosive charge container. The details of the firing mechanism will be described below with reference to FIG. 10. Inasmuch as the use of a shaped jet charge is contemplated, the usual conical liner 47 is provided. At the upper and lower ends of the container 33 there are provided stop members 35 and 49. The purpose of the stop members is to hold a seating ring or firing collar 45 on the charge container. The firing collar is longitudinally slidable along housing 33 and has a tapered lower surface for the purpose of seating on the seat 31 at the bottom of the drill pipe so that a differential pressure can be produced across the charge. A frangible sleeve 46 is attached to the upper end of collar 45 by a suitable adhesive, the sleeve 46 serving to keep the collar 45 properly aligned on the housing 33. The details of the firing collar are best illustrated in FIGS. 8 and 9. The firing collar is formed of members 53 and 55 and locking members 57 and 59. The purpose of the locking members is to prevent the firing collar from coming apart before the charge is fired and to permit the firing collar to collapse inwardly when the container is destroyed by firing the charge. As shown in FIG. 9, the outer edges of the locking members have a V shape so that they will not drop away from the members 53 and 55 when in locking engagement therewith.

The details of the firing mechanism are shown in FIG. 10. The firing mechanism includes a housing 63 having an inlet tube 64 open to borehole pressure, and an outlet tube 73 opening into a low pressure tube 77. The low pressure tube 77 extends the length of the shaped charge container to the bottom of the container so that it is exposed to the pressure outside of the drill pipe when the firing collar 45 is seated on seat 31. The outlet tube 73 extends into the interior of the housing 63. A flexible, resilient diaphragm 61 of rubber-like material such as neoprene seals the inlet tube 64. A similar diaphragm 75 seals the outlet tube 73. The interior of the housing 63 thus is fluid-tight and is filled with water, glycerin, or other suitable, substantially incompressible liquid. A release collar 65 is in sliding fit over the tube 73. A spring 71 normally biases the release collar 65 away from the tube 73 so that it engages the tube 64 of the inlet port. A firing pin 67 is pivoted about a pivot member 69 and is spring-biased by means of spring 68 to rotate counterclockwise as shown in FIG. 10. The firing pin will be

released when release collar 71 is moved to the right so as to strike detonator 39 at one end of its arc of movement. The release collar is moved to the right when a sufficiently large differential pressure exists between the inlet tube 64 and the low pressure tube 77. The differential pressure will cause diaphragm 61 to bulge downwardly into the housing 63 so as to force the release collar to the right and release the firing pin 67 so that it will strike the detonator 39.

The diaphragms 61 and 75 are not absolutely necessary, but serve to keep clean fluid around the working parts of the firing mechanism. This is desirable to insure that the firing mechanism will function properly.

FIG. 11 illustrates a gauging charge particularly adapted for use with the present invention. The gauging charge comprises a housing 78 similar to the housing used with the shaped charge. A firing collar 45a is provided that is similar to firing collar 45. A frangible sleeve 46a is also attached to the collar 45a. The firing mechanism 37a may be substantially the same as firing mechanism 37. A low pressure tube 77a extends from the firing mechanism 37a to the lower end of the charge container in the same manner as described above with respect to low pressure tube 77. A substantial section of the lower portion of the container is filled with a brisant or unbrisant explosive material or a mixture of brisant and unbrisant explosives. There is no conical liner provided with the device so that the explosive effects of the gauging charge are substantially nondirectional. A stop 85 is provided above the topmost level of the explosive so that firing collar 45a will land on seat 31 in such a manner that the topmost level of the explosive charge will be spaced from the bottom of the well pipe. The housing 78 is also provided with an upper stop 34. This construction is for the purpose of preventing damage to the well pipe when the explosive charge is detonated. The container may be formed of a frangible material so as to be destroyed easily. The blasting cap 79, when struck by firing pin 67, will be detonated and will ignite a length of primacord 81. To facilitate destruction of the container, the primacord may be wound in a spiral around the inner surface of the container. Also, an auxiliary disintegrating charge 83a of tetryl or like material may be used to complete the destruction of the container. The container may be formed of a plastic material. A particularly suitable explosive for use in connection with the gauging charge is PEIN or composition B(RDX and TNT). Other suitable explosives may be found on page 4 of the text "The Science of High Explosives" by M. A. Cook (Reinhold Publishing Company, 1958). The length of the lower end of the container 78 containing the explosive preferably is long enough to extend substantially the length of the hole blasted by the shaped charge.

The operation of the apparatus described in FIGS. 1 through 11 will be explained with reference to FIGS. 12, 13, 14, and 15. Before the apparatus described above is used, a borehole may be drilled in the earth through the relatively soft earth formations near the earth's surface by means of conventional rotary drilling equipment. Alternatively, the apparatus described above may be utilized from the time that the well is spudded. However, it usually will be found to be more economical to use a rotary drilling procedure for the initial stages of drilling the borehole until relatively hard earth formations are encountered.

When a hole has been drilled to a desired depth in the conventional manner, the rotary drill pipe may be pulled out of the hole and a thinner walled pipe 28 such as shown in FIG. 2 and FIGS. 12 through 15 may be substituted therefor. An advantage associated with utilizing thinner walled pipe is that larger explosive charges can be run down the pipe. The lower stand of the pipe may be provided with reamer blades 28a for the pur-

pose of reaming the hole should such become necessary. Likewise, the lowermost edge of the pipe may be studded with diamonds to rotary-drill for short time intervals should relatively soft earth formations be encountered.

Plug 132 (see FIG. 5) is removed from the magazine housing, pawl 111 is locked out of engagement with ratchet wheel 101, and pawl 115 is allowed to engage the ratchet wheel. Explosive charges are inserted into the magazine housing into each of the explosive charge receptacles. The charge transport means is rotated by a wrench or other means that engages the hex end 103 of shaft 105. When the transport mechanism is fully loaded with explosive charges, with shaped charges, and gauging charges in a predetermined sequence around the mechanism, pawl 111 is released to engage the ratchet wheel and pawl 115 is locked out of engagement with pin 119a. Seal 132 is locked into position and drilling fluid pressure is applied so that drilling fluid is circulated down the well pipe. Initially, a shaped charge 33 is injected into the drilling fluid stream. At intervals of approximately 1 to 10 minutes, the driller may inject the other charges in the magazine housing by energizing solenoid 110 through control line 121 from a suitable source of electrical power (not shown). When a shaped charge is seated at the bottom of the well pipe, manifestly the differential pressure across the shaped charge will detonate the charge as described above. An elongated tapered hole will be produced as shown in FIG. 13. Drilling fluid circulation will continue so that detritus including earth fragments, fragments of the shaped charge container, and the fragments 53 and 55 of the firing collar 45 will be circulated up the annulus around the well pipe.

One or more gauging charges are landed in succession at the bottom of the pipe after each shaped charge. It will be found that one gauging charge is sufficient to enlarge the entire hole to a desired diameter. As mentioned above, the gauging charges should extend substantially to the bottom of the hole formed by the jet charge. Collar 45a, inasmuch as it is slidable along at least a portion of the gauging charge container, will readily seat on the seat 31 so that a differential pressure will build up to detonate the gauging charge. Manifestly, the gauging charge will be tamped; a hydrostatic pressure of at least 1000 p.s.i. will be exerted thereon. When a gauging charge is detonated, it will be found that an almost perfect cylindrical hole will be blasted into the earth formations by the gauging charge. The hole will be amazingly uniform in diameter and will be of a sufficiently large diameter so that the well pipe 28 may be lowered to the depth of the hole blasted by the shaped charge 33. It will be found that, by virtue of the fact that the gauging charge is tamped and under hydrostatic pressure, the volume of earth that is spalled by the gauging charge will be between 50 and 100 percent greater than when the explosive charge is not tamped and is not under hydrostatic pressure. A hydrostatic pressure of at least 1000 pounds has been found to be satisfactory. Much higher hydrostatic pressures may be utilized with the effectiveness of the gauging charge increasing as the hydrostatic pressure is increased. Detritus produced by the gauging charge may be circulated out of the hole formed as described above, as the well pipe is lowered.

If the well pipe used as described above is of the type referred to as "casing," cement may be circulated when the borehole has reached desired depth for the purpose of bonding the pipe to earth formations surrounding the borehole. The usual completion techniques may then be followed and the well produced. In this manner a costly "round-trip" is avoided.

The invention described above is truly remarkable in that a hole of uniform diameter comparable to holes drilled by conventional rotary drill bits may be formed by the sequential use of shaped charges and nondirectional gauging charges. Penetrations of 6 feet and more

may be obtained through earth formations such as limestones, dolomites, quartzites, anhydrite, salt, granite, some shales and some sandstones. Increased drilling rates of up to 400 percent will be obtained in hard formations. The relative increase in the penetration rate will be found to increase as the formation hardness increases.

The invention is not to be restricted to the specific structural details, arrangement of parts, or circuit connections herein set forth, as various modifications thereof may be effected without departing from the spirit and scope of this invention.

What is claimed is:

1. A method of drilling with shaped explosive charges and elongated, nondirectional explosive charges through a well pipe lowerable into a borehole and having explosive charge landing means at the lower end thereof, comprising: individually landing said shaped charges at the bottom of the well pipe, and detonating each shaped charge after it is landed so as to blast the earth material below the well pipe; after detonation of each shaped charge, landing at least one of the elongated, nondirectional charges at the bottom of the well pipe; extending said at least one nondirectional charge from the mouth of the opening left by the immediately preceding shaped charge as far as possible into the hole so that the explosive material thereof extends substantially the length of said hole blasted in the earth below the well pipe by the immediately preceding shaped charge; and detonating each nondirectional explosive charge after it is so landed.

2. A method of drilling with shaped explosive charges and elongated, nondirectional explosive charges through a well pipe lowerable into a borehole and having explosive charge landing means at the lower end thereof, comprising: circulating drilling fluid down the well pipe and up the annulus therearound; injecting the shaped charges and the nondirectional explosive charges into the stream of drilling fluid going down the well pipe according to a predetermined sequence with at least one nondirectional explosive charge following each shaped charge; detonating the shaped charges as they reach the bottom of the well pipe so that they blast the earth material below the well pipe; inserting each nondirectional charge into the hole blasted by the immediately preceding shaped charge so that said each nondirectional explosive charge extends from the mouth of the hole as far as possible thereinto; and detonating said each nondirectional explosive charge after it is so inserted.

3. A method of drilling with shaped explosive charges and elongated, nondirectional explosive charges through a well pipe lowerable into a borehole and having explosive charge landing means at the lower end thereof, comprising: circulating drilling fluid down the well pipe and up the annulus therearound; injecting the shaped charges and the nondirectional explosive charges into the stream of drilling fluid going down the well pipe according to a predetermined sequence with at least one nondirectional explosive charge following each shaped charge; detonating the shaped charges as they reach the bottom of the well pipe so that they blast the earth material below the well pipe; inserting each nondirectional charge into the hole blasted by the immediately preceding shaped charge until the explosive in said each nondirectional explosive charge extends from the mouth of the hole as far as possible into said hole; detonating said each nondirectional explosive charge after it is so inserted; and circulating drilling fluid after detonation of each explosive charge for a time interval sufficient to remove detritus from the bottom of the borehole.

4. A method of drilling with explosive charges through a well pipe lowerable into a borehole, comprising: circulating drilling fluid down the well pipe and up the annulus around the well pipe; injecting shaped charge capsules into the drilling fluid stream going down the well pipe and seating each capsule at the bottom of the well

pipe so that the directional explosive effect of each shaped charge is directed downwardly; detonating each shaped charge when it is seated at the bottom of the well pipe; after detonation of each shaped charge, inserting at least one elongated nondirectional explosive charge into the hole blasted by said each shaped charge until explosive material extends substantially the length of the hole, and detonating said at least one nondirectional explosive charge; and after detonation of each explosive charge, circulating drilling fluid for a period of time sufficient to clean the detritus from the bottom of the borehole.

5. A method for drilling with explosive charges through a well pipe lowerable into a borehole, comprising: circulating drilling fluid down the well pipe and up the annulus around the well pipe; injecting shaped charge capsules into the drilling fluid stream going down the well pipe and seating each capsule at the bottom of the well pipe so that the directional explosive effect of each shaped charge is directed downwardly; detonating each shaped charge when it is seated at the bottom of the well pipe; after detonation of each shaped charge, inserting at least one elongated nondirectional explosive charge into the hole blasted by said each shaped charge until explosive material extends substantially the length of the hole, and detonating said at least one nondirectional explosive charge while tamping said at least one nondirectional explosive charge with drilling fluid so that the hydrostatic pressure in the bottom of the borehole is at least 1000 pounds per square inch; and after detonation of each explosive charge, circulating drilling fluid for a period of time sufficient to clean the detritus from the bottom of the borehole.

6. A method of drilling with explosive charges through a well pipe lowerable into a borehole, comprising: circulating drilling fluid down the well pipe and up the annulus around the well pipe; injecting shaped charge capsules into the drilling fluid stream going down the well pipe and seating each capsule at the bottom of the well pipe so that the directional explosive effect of each shaped charge is directed downwardly; detonating each shaped charge when it is seated at the bottom of the well pipe; after detonation of each shaped charge, inserting at least one elongated nondirectional explosive charge into the hole blasted by said each shaped charge until explosive material extends substantially the length of the hole, and detonating said at least one nondirectional explosive charge while tamping said at least one nondirectional explosive charge with drilling fluid so that the hydrostatic pressure in the bottom of the borehole is at least 1000 pounds per inch; after detonation of each explosive charge, circulating drilling fluid for a period of time sufficient to clean the detritus from the bottom of the borehole; and lowering the well pipe after detonation of each nondirectional explosive charge.

7. In a method of drilling with shaped charges and nondirectional, elongated explosive charges, wherein the charges are landed at the lower end of a well pipe and are detonated by differential pressure across the upper and lower portions thereof, the improvement comprising: circulating drilling fluid down the well pipe and up the annular space therearound; injecting the shaped charges and the nondirectional explosive charges into the drilling fluid flowing down the well pipe according to a predetermined sequence, with at least one nondirectional explosive charge following each shaped charge; individually landing the shaped charges in the landing means at the bottom of the well pipe, and increasing fluid pressure in the well pipe after a shaped charge is landed to detonate the shaped charge and blast the earth material below the well pipe; individually landing the nondirectional explosive charges at the bottom of the well pipe; extending each nondirectional explosive charge as far as possible into the hole left by the immediately preceding shaped charge from the mouth of the hole until explosive material extends substantially the length of the hole,

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and increasing fluid pressure in the well pipe after an individual nondirectional explosive charge is landed to detonate the landed charge; and circulating drilling fluid after detonation of each explosive charge for a time interval sufficient to remove detritus left in the bottom of the borehole.

8. The method set forth in claim 7 wherein each nondirectional explosive charge is tamped with drilling fluid so that the hydrostatic pressure at the bottom of the borehole is at least 1000 p.s.i.

9. In a method of drilling with shaped charges and nondirectional, elongated explosive charges, wherein the charges are detonated by differential pressure across the upper and lower portions thereof, the improvement comprising: circulating drilling fluid down the well pipe and up the annular space therearound; injecting the shaped charges and the nondirectional explosive charges into the drilling fluid flowing down the well pipe according to a predetermined sequence, with at least one nondirectional explosive charge following each shaped charge; individually landing the shaped charges at the bottom of the well pipe, and increasing fluid pressure in the well pipe after a shaped charge is landed to detonate the shaped charge and blast the earth material below the well pipe;

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individually landing the nondirectional explosive charges at the bottom of the well pipe; extending each nondirectional explosive charge as far as possible into the hole left by the immediately preceding shaped charge from the mouth of the hole until explosive material extends substantially the length of the hole, and increasing fluid pressure in the well pipe after an individual nondirectional explosive charge is landed to detonate the landed charge; circulating drilling fluid after detonation of each explosive charge for a time interval sufficient to remove detritus left in the bottom of the borehole; and lowering the well pipe in the borehole after detonation of each nondirectional explosive charge.

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