Jan. 27, 1942. J. J. GREBE 2,271,005

SUBTERRANEAN BORING

Filed Jan. 23, 1939 5 Sheets-Sheet 1

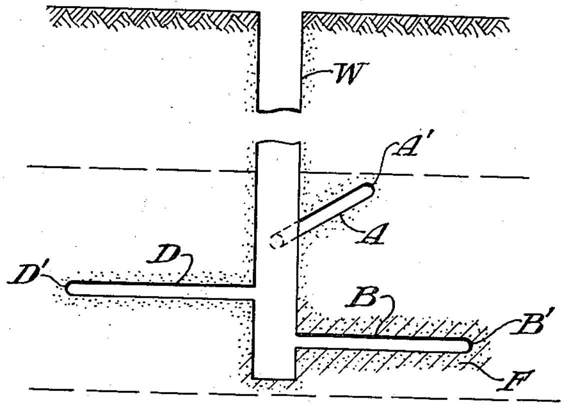

Fig. 1

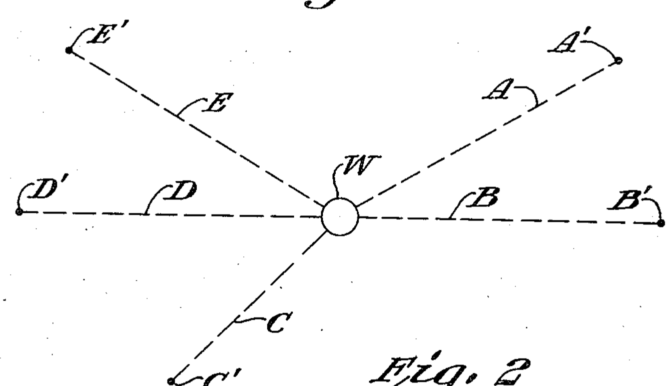

Fig. 2

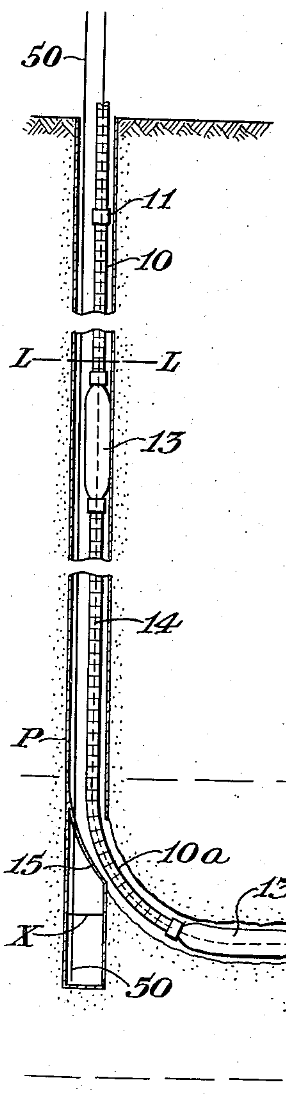
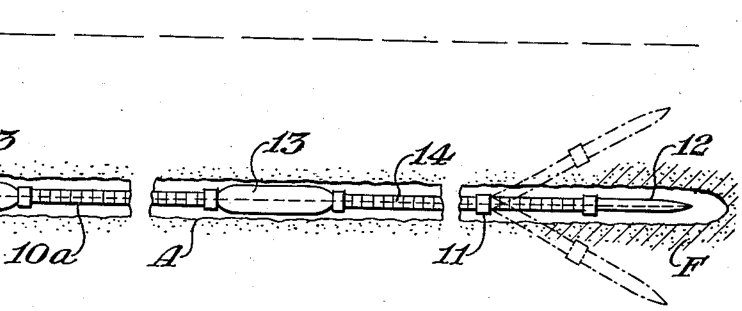

Fig. 3

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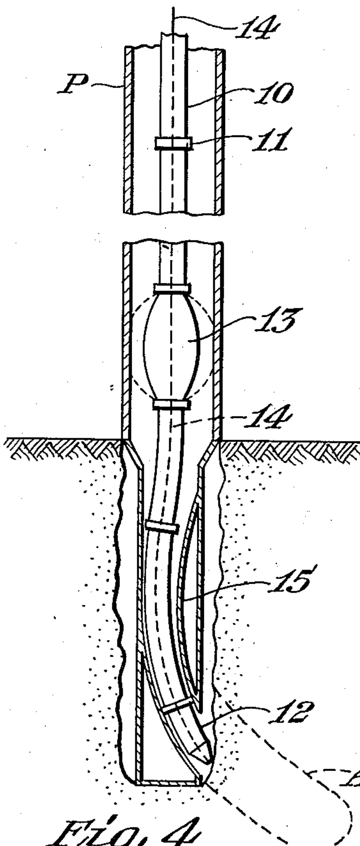

Fig. 4

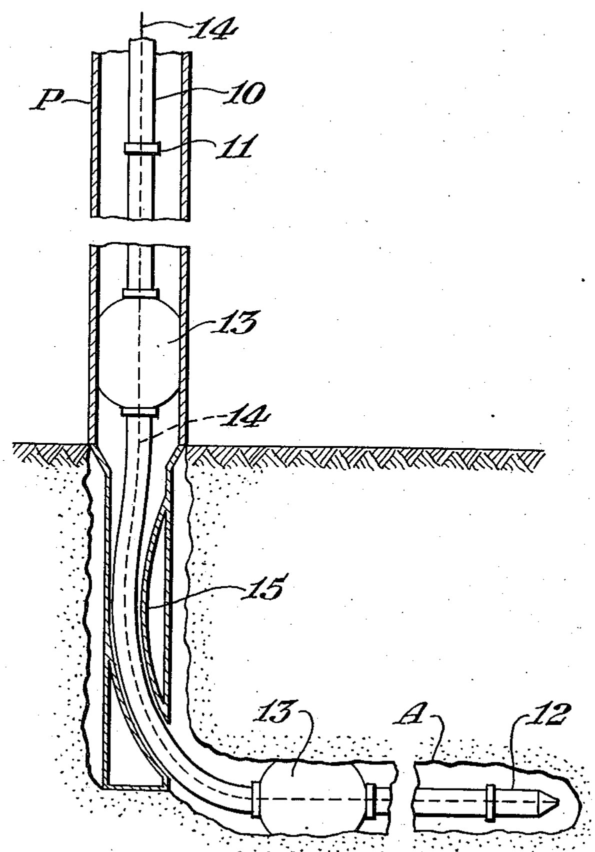

Fig. 5

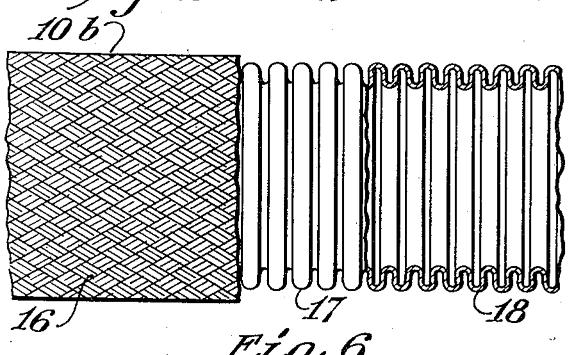

Fig. 6

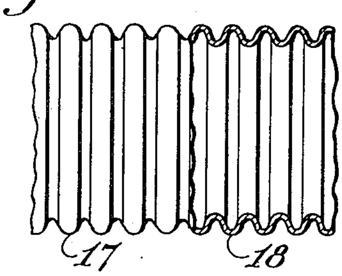

Fig. 7

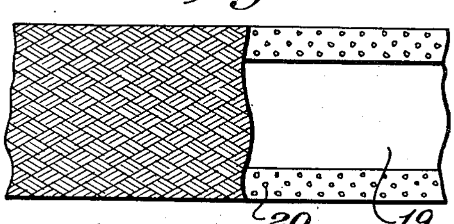

Fig. 8

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SUBTERRANEAN BORING

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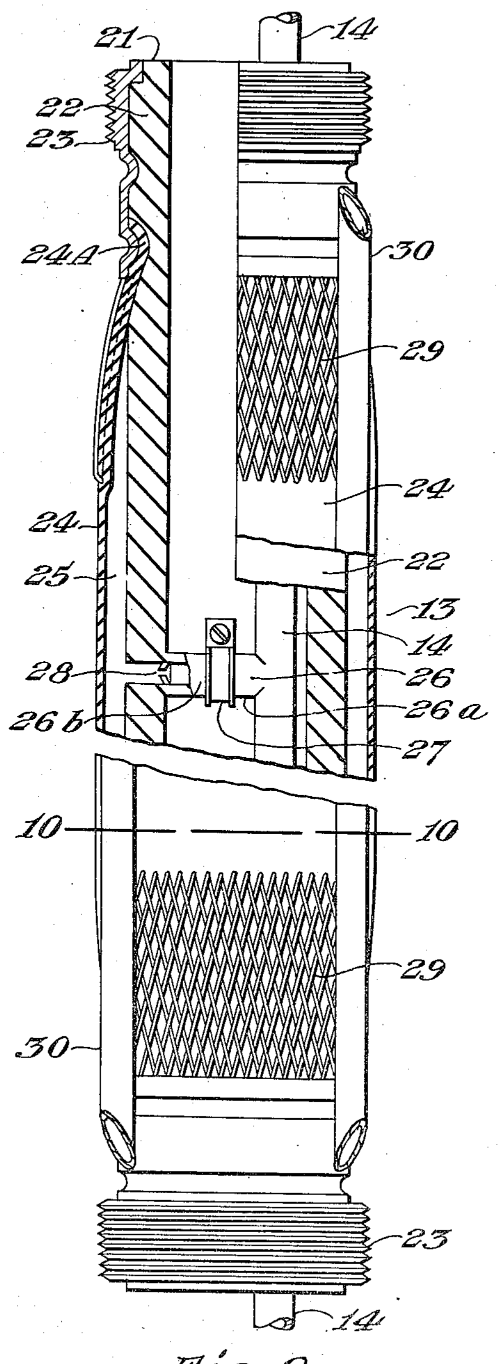

Fig. 9

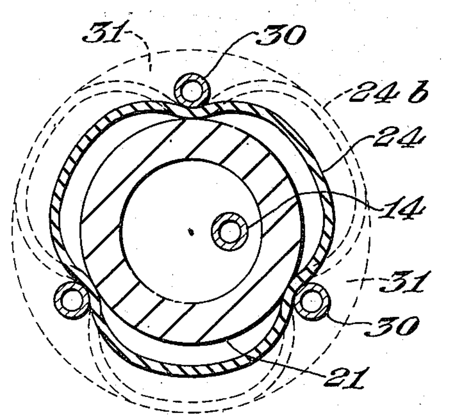

Fig. 10

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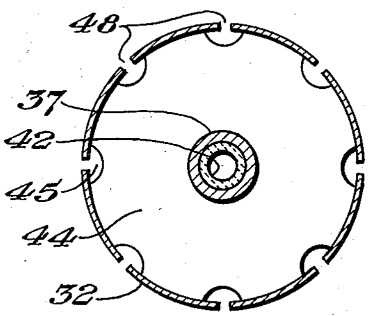

Fig. 12

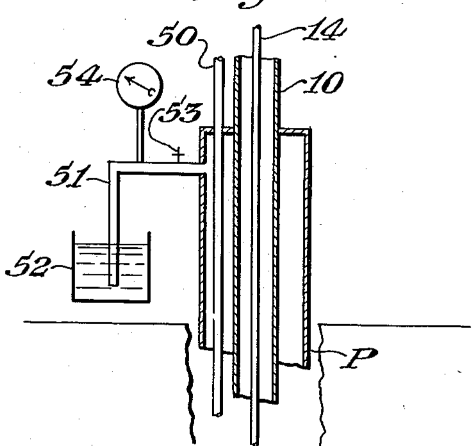

Fig. 13

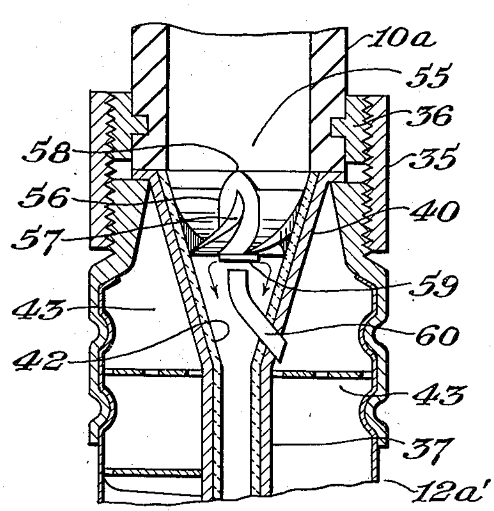

Fig. 14

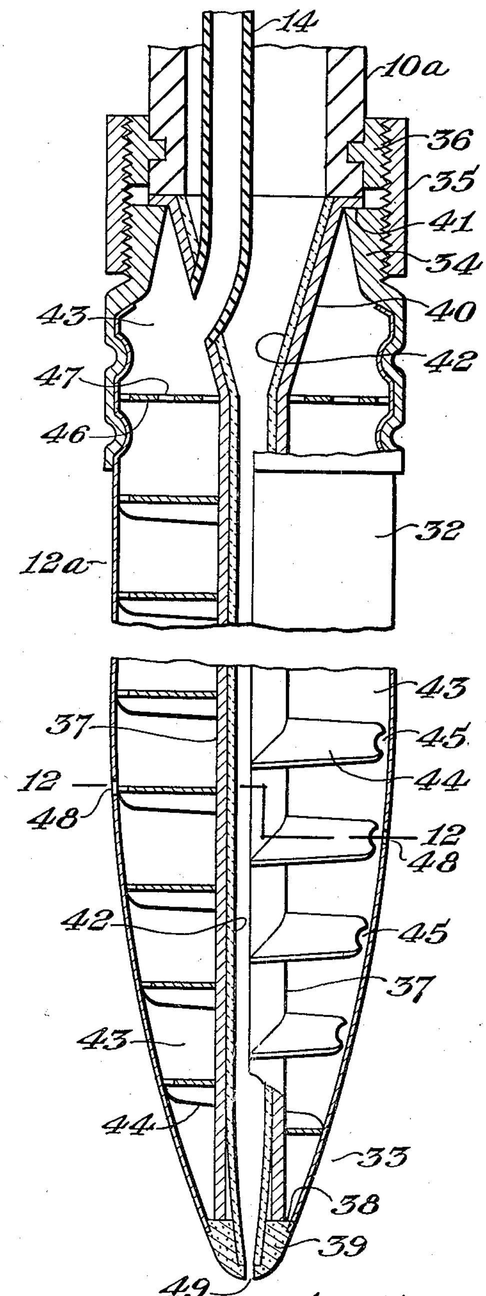

Fig. 11

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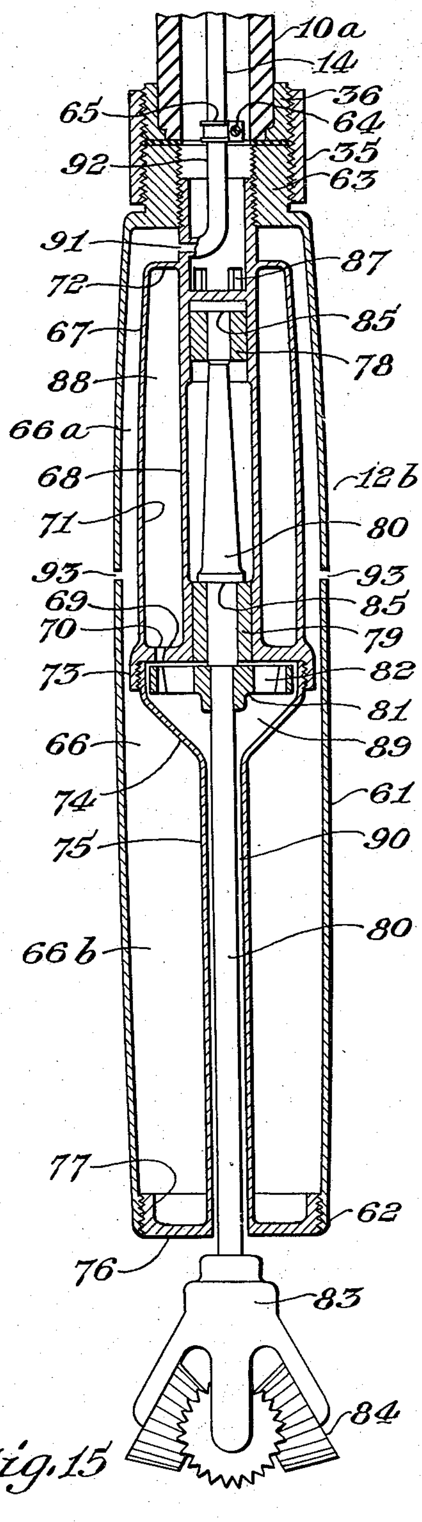

Fig. 15

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Patented Jan. 27, 1942 2,271,005

UNITED STATES PATENT OFFICE

2,271,005

SUBTERRANEAN BORING

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Application January 23, 1939, Serial No. 252,295

17 Claims. (Cl. 255—1.8)

This invention relates to subterranean boring and particularly to a method and apparatus for drilling or forming vertical, lateral, tangential or horizontal well holes, and/or drilling or forming subterranean channels or passages radiating laterally, tangentially or horizontally from a well hole or bore.

This invention has for one of its specific applications the use of a stream of acid supplied under pressure in the form of a jet, together with mechanical drilling tools which may be used in conjunction therewith, to drill or form well holes or subterranean passages in earth formations with the aid of a flexible conduit, and especially to form such holes or passages through acid-soluble or partly acid-soluble formations. However, the present invention will nevertheless be applicable when drilling into and through non-acid-soluble formations, in which case the mechanical drilling tools or bits will be employed, without the aid of the acid stream or jet. The practice of this invention is not limited to the forming or drilling of any specific type well hole or channels therein, and it may be practiced in forming oil, gas, water or any other kind of a well hole.

By the practice of the method and apparatus comprising this invention not only may vertical or substantially vertical well holes be drilled, but horizontal or tangential holes or passages also may be drilled tangentially therefrom radiating from the well hole at any desired depth and angle.

While this invention may be practiced to form or drill any type of well hole or passage therein, one of its main applications will be in drilling a single vertical, or series of single vertical oil wells to a depth adjacent to or penetrating the pay or oil-bearing formation. These single wells may be vertical, or substantially vertical, and may be drilled as convenience dictates. Thereafter within a single well horizontal, tangential or lateral passages may be drilled into the pay formation from the well bore. In this manner a single well with the plurality of lateral or tangential passages drilled therefrom will serve to give far greater production than that of a conventionally drilled well, as the various lateral or tangential passages are drilled from the well bore and radiate therefrom to penetrate the pay formation. Substantially all portions of these passages will pass through the pay formation and serve to collect the oil as it drains thereinto, and will further serve to conduct the oil into the well bore from which it can be recovered by known methods.

The object of this invention is to provide an improved method and apparatus for subterranean boring (drilling oil, gas, water, brine, and other types of well holes).

Another object is to provide a method and apparatus for drilling horizontal and/or vertical passages in oil, gas, brine, and other type well holes.

Another object is to provide a method and apparatus for drilling a well hole and/or a passage radiating therefrom with a flexible conduit.

Another object is to provide a method and apparatus for drilling a well hole with a flexible conduit and a nozzle capable of floating, or of being made to float, in either vertical, lateral, tangential or horizontal portions of a well hole.

Another object is to provide a method and apparatus for drilling a well hole or a passage radiating therefrom with a flexible conduit capable of making progress into the hole or passage under the controlled application of pressure to the conduit.

Another object is to provide a method and apparatus for drilling a well hole or a passage radiating therefrom with a flexible conduit capable of expanding and/or contracting.

Another object is to provide a method and apparatus for drilling a well hole or a passage radiating therefrom with a flexible conduit capable of being caused to move into the hole or passage upon the elongation of the conduit as caused by the application of pressure thereto.

Another object is to provide a method and apparatus for drilling a well hole or a passage radiating therefrom with a flexible conduit capable of moving into the hole or passage upon the elongation of the conduit as caused by the reduction of pressure on the interior thereof.

Another object is to provide a method and apparatus for drilling a well hole or a passage radiating therefrom with a flexible conduit provided with anchors, and capable of being made to move into the hole or passage by the controlled setting and releasing of the anchors.

Another object is to provide a method and apparatus for drilling a well hole or a passage radiating therefrom with a flexible conduit capable of controlled intermittent anchorage in said hole or passage and capable of moving into said hole or passage by the controlled application of pressure to the conduit.

Another object is to provide a method and apparatus for drilling a well hole or a passage radiating therefrom with a flexible conduit and a stream of acid.

Another object is to provide a method and apparatus for drilling a well hole or a passage radiating therefrom with a flexible conduit capable of being made to move into the hole or passage and with the aid of a nozzle.

Another object is to provide a method and apparatus for drilling a well hole or a passage radiating therefrom with a nozzle carried by a flexible conduit capable of moving into the hole or passage, and for controlling the direction of the nozzle.

Another object is to provide a method and apparatus for drilling a well hole or a passage radiating therefrom with a nozzle carried by a flexible conduit capable of making progress into the hole or passage, and further to control the direction of the nozzle and the forming of the hole or passage by controlled fluid loading of the nozzle.

Another object is to provide a method and apparatus for drilling a well hole or a passage radiating therefrom with a flexible conduit capable of progressing within the hole or passage and a mechanical drilling tool carried by the conduit.

Another object is to provide a method and apparatus for drilling a well hole or a passage radiating therefrom with a mechanical drilling tool carried by a flexible conduit capable of making progress within the hole or passage, and further to control the direction of the tool and of the hole or passage by controlled fluid loading of the tool.

Still other objects and advantages of this invention will be appreciated upon consideration of the following specification and the accompanying drawings, which constitute a part of said specification, and wherein:

Fig. 1 is a vertical cross-sectional view of an earth formation containing an oil bearing stratum and illustrates, in part, this present invention.

Fig. 2 is a diagrammatic plan view illustrating a substantially vertical drilled well and a plurality of horizontally, laterally or tangentially disposed passages drilled therefrom at points below the surface and into the pay formation.

Fig. 3 is a vertical cross-sectional view of a well hole showing the pay formation thereof, and illustrates the flexible drilling conduit partly in the well hole and extending therefrom into the passage formed in the pay formation.

Fig. 4 is a vertical cross-sectional view of a well hole showing the pay formation thereof, and the flexible drilling conduit in the well hole, and further illustrates a whipstock or guide for laterally directing the flexible drilling conduit into the pay formation.

Fig. 5 is the same as Fig. 4 except that it illustrates the channel or passage formed into the pay formation, and shows the initial progress made thereinto by the nozzle or cutting tool and the flexible drilling conduit.

Fig. 6 illustrates partly in longitudinal cross-section a preferred embodiment of a flexible drilling conduit which is so constructed as to elongate upon application of pressure to the interior thereof.

Fig. 7 illustrates partly in longitudinal cross-section an enlarged detail portion of the conduit illustrated in Fig. 6 showing it in an elongated state.

Fig. 8 illustrates partly in longitudinal cross-section the detail construction of a flexible drilling conduit which is so constructed as to elongate upon the decrease of pressure on the interior thereof.

Fig. 9 is a side view partly in longitudinal cross-section of one embodiment of a packer or anchor employed in this invention.

Fig. 10 is a transverse cross-sectional view of Fig. 9 taken on line 10—10 thereof.

Fig. 11 is a side view partly in longitudinal cross-section of one embodiment of a cutting tool which in this instance consists of a nozzle.

Fig. 12 is a transverse cross-sectional view of Fig. 11 taken on line 12—12 thereof.

Fig. 13 is an enlarged detail illustration of one mode of connecting the well casing and the flexible conduit at the surface.

Fig. 14 is a longitudinal cross-sectional view of a portion of a modified type of nozzle.

Fig. 15 is a modified cutting tool, and illustrates partly in longitudinal cross-section a fluid driven rotary type drilling tool or bit.

With reference now to Fig. 1, wherein there is illustrated in vertical cross-section a well hole or bore W which is drilled in any suitable manner from the surface to the oil-bearing or pay formation F, it will be seen that radiating from the bottom of this well there are a plurality of channels or passages A, B, and D which may be drilled into the formation in a tangential, lateral or horizontal manner at any angle to the well bore, and which penetrate into the pay formation to drain it of oil so it can flow into the well. Fig. 2 is a diagrammatic plan view of the well hole shown in Fig. 1, and here illustrates the well hole W, and a plurality of lateral passages or channels A, B, C, D and E which are drilled or formed horizontally, laterally or tangentially from the well bore W and into the pay formation to drain it of oil at the points A′ to E′, and at all points in the pay formation traversed by these several channels or passages.

Thus, it may be seen that by the practice of this invention great economy is effected, for instead of drilling a plurality of independent wells to each of the points A′ to E′ to drain them of oil, it is possible by this invention to drill but a single well hole W from the surface. Then from a point adjacent the pay formation the laterals A to E may be drilled or formed not only to the points A′ to E′ to get the potential production at those points, but also the production of all parts of the stratum that the several channels traverse.

With reference now to Fig. 3 wherein there is illustrated in vertical cross-section a well hole, the pay formation F thereof, and the conventional casing pipe P, there is shown disposed in the bore of the well a hollow flexible drilling conduit 10 which is suspended from the surface and is composed of the several sections 10*a*, which may be of any convenient length and joined by suitable couplings 11. The hollow flexible drilling conduit 10 is illustrated as extending into a lateral passage or channel A within the pay formation, which passage has been formed by the drilling member 12, which may be a nozzle adapted to eject a stream of acid or other fluid therefrom in the form of a jet, or a fluid driven mechanical cutting tool.

When the drilling member 12 is a nozzle of the type illustrated in Fig. 11 and generally designated therein by the reference numeral 12*a*, a conduit 10 is utilized to supply a stream of acid thereto under pressure for attacking and cutting away acid soluble formations to make the passage, or when the drilling member 12 is a fluid driven mechanical tool such as illustrated in Fig.

15 and therein generally designated by the reference numeral 12b, conduit 10 will then be utilized to supply a fluid under pressure, which may be acid, to drive the tool. At suitably spaced intervals, the flexible drilling conduit is provided with a series of inflatable and deflatable anchors or packers 13 by which the drilling conduit may be anchored in the well hole. Extending from the surface and passing internally through the hollow flexible drilling conduit, and the series of packers, and connecting with the drilling member 12, there is provided a flexible hose 14, which supplies a fluid under pressure to the packers 13 to inflate them and cause them to frictionally contact the sides of the well casing, well hole or passage formed therefrom and so securely anchor the drilling conduit in place. Hose 14 exhausts into the drilling member 12, and by controlling the weight of the fluid in hose 14, as by selecting gas or liquid, the weight of the drilling member can be varied so as to control its direction of cutting to substantially either an acute upward, downward or intermediate position, and in this manner the direction of the passage or channel being formed or drilled into the pay formation can be conveniently controlled from the surface, as will hereinafter be explained more fully.

To make more readily understandable the principle of this invention and its various modifications that will be presented hereinafter, it is deemed best to explain in conjunction with Figs. 3, 4, and 5 one of the basic phases of this invention. In one mode of practicing this invention the main or substantially vertical well hole is drilled by any convenient means or method until it penetrates or partially penetrates the pay formation, after which the conventional casing pipe P may be set. Thereafter, a whip-stock or guide 15 of any conventional type, or its equivalent, is placed in the lower portion of the well hole slightly above or opposite the pay formation. The guide 15 is utilized to guide or direct the hollow flexible drilling conduit 10 to the face or wall of pay formation in a horizontal, lateral or tangential direction, as desired, with respect to the vertical bore of the well. As illustrated in Fig. 4, the flexible drilling conduit 10 and assembly, composed of its several sections 10a connected by the joints 11 and the series of spaced expandible and deflatable packers 13, and the fluid hose 14, and having secured to its end the cutting member 12, is now lowered into the bore of the well and into the guide 15 until the cutting member is adjacent or in contact with the pay formation. During the lowering of conduit 10, the packers have been in a deflated condition, but when the drilling or cutting member 12 is in this position the packers are inflated, as shown in dotted lines in Fig. 4 by fluid under pressure supplied through hose 14 from the surface to cause them to frictionally contact the walls of the casing, and/or walls of the guide 15 to anchor the drilling conduit 10 against movement out of the well hole. Assuming the pay stratum to be composed of acid-soluble material such as limestone, or other calcareous material, the cutting tool then employed will preferably comprise a nozzle 12a, such as the one shown in Fig. 11, and in order to channel or drill through the formation a solution of hydrochloric acid is now forced into the hollow drilling conduit 10 at the surface and forced downwardly therein under pressure and out of the nozzle 12a in the form of a jet of acid to attack and dissolve the formation and channel through it in a tangential direction with respect to the well hole. After the acid has issued from the nozzle 12a for a short period of time, it will have effected a channeling of the pay formation to form therein the channel A substantially to the extent shown by the dotted lines in Fig. 4.

It will now be necessary to move the nozzle forward so that it will be effectively repositioned to lengthen the channel A, rather than further enlarge its diameter, as would result with continued application of the acid with the cutting tool or nozzle in the position illustrated. This is effected by releasing the pressure in the hose 14, so deflating the several packers 13 and free the drilling conduit 10 from its anchorage in the channel.

At this time, due to the inherent structure of this particular type of the hollow drilling conduit 10, it will be caused to elongate as the pressure is released, or decreased, in the interior thereof, and it will creep forward into the lateral channel A bored into the pay formation. This is effected by first deflating and releasing the anchors, and in the primary stages of boring or drilling such a channel, an additional section or sections 10a, of the drilling conduit 10 are coupled at the surface and fed into the casing by gravity, but additionally the drilling conduit 10 will creep into the lateral channel as it may be formed of any one of several different types all having the property or ability to creep forward into the lateral channel under properly controlled conditions. For example, each of the sections 10a of the drilling conduit 10 may be so constructed, as will herein later be described in detail, that upon the application of pressure to the interior of the conduit 10 it will increase in diameter and decrease in length. With such a drilling conduit, when the pressure on the acid or other fluid therein is released or materially decreased, the diameter of the conduit tends to contract and the conduit elongates and causes the entire length thereof to creep forward. When each of the individual sections 10a of the conduit lengthens upon the decrease of pressure therein, which pressure is applied and controlled through hose 14, there is then effected a considerable forward movement or creeping of the nozzle or other cutting tool at the end of the flexible drilling conduit. This forward creeping movement is further pronounced and materially assisted when the conduit 10 is secured at its end adjacent the surface, or anchored by one or a multiple of the packers 13 at a point relatively remote from the cutting tool, so that as the conduit 10 elongates the movement thereof will be all in one direction, namely, downwardly into the vertical hole of the well and/or into the channel A bored into the pay formation.

A further type of such a flexible drilling conduit that can be caused to creep forward under controlled conditions of pressure, and which will herein also later be described in detail, is one that has a tendency to elongate upon the application of a fluid under pressure to the interior thereof. When employing such a conduit as this and it is desired to move the cutting member 12 into, or further into, the channel A, it will only be necessary to release the pressure in the several packers 13, which is done from the surface through hose 14, and so unanchor the conduit 10 and feed additional lengths of conduit into the well hole from the surface if they are needed. Thereafter with the conduit secured at the surface, or by the inflation of one or more of the packers at a point relatively remote from the cutting tool, pressure can be put on the fluid in the conduit 10 causing it to elongate and creep in the only direction in which it is free to move, namely forward into the well hole and into the channel. The conduit 10 will be forced to creep forward, as it is anchored by the packers at the surface against elongation in both directions. When conduit 10 has reached its limit or approximate limit of forward elongation and has crept as far into the channel as it will for the single step, pressure is applied to the interior of the remaining packers so that they will serve to securely anchor the conduit in its maximum forward position with the drilling tool repositioned for further drilling of the channel. When employing this type of flexible drilling conduit, it may prove desirable to anchor the packers in a predetermined order so as to obtain the maximum forward creeping movement of the conduit. This can be realized by anchoring the packers in the order of their relation to the earth surface, i. e. anchor first those packers nearest the surface so that when pressure is applied to the interior of the conduit, it is not free to stretch both forward into the hole and backward out of it, but by being so anchored it will of necessity be forced to elongate only in one direction, namely downwardly into the well hole and forwardly into the channel, and thereafter the packers next nearest the surface will be set while continuing or maintaining the internal pressure in the conduit 10. Thereafter the remaining packers are progressively set, setting first those nearest the surface and setting last the ones adjacent the cutting tool. By this manner of setting the packers the full effect of the elongation and stretch of the conduit 10 will be more readily realized to cause the cutting member 12 to move into the channel A.

It should be obvious that when the conduit 10 is to be caused to creep forward for the first time into the initial part of the channel bored by the cutting member, that the mere weight of the conduit 10 standing in the well bore, when the packers are released or unanchored, will serve to some extent to force the bottom or forward part of the conduit and its cutting member at least a slight distance into the channel to take up a more advantageous position for further boring of the channel. The weight of the conduit to force the drilling member into such a position by gravity can be further augmented by a positive force or feeding of the conduit 10 into the well hole from the surface.

With reference now to Fig. 5, it will be appreciated that the cutting member 12 has been caused to progress and move forward, as above described, into the channel A formed by it, and as illustrated, the packers 13 are inflated to anchor the conduit 10 and the cutting tool in the hole against backward movement out of the hole and away from the lateral channel.

It is to be understood that by a substantial repetition of such steps, as above described, for causing the conduit 10 and its cutting member 12 to progress into the channel A, the cutting member can be caused to travel forward into the channel as the same is drilled and take up therein a new and more advantageous position at various intervals as is needed.

At this point it should be understood that the well hole, such as the one illustrated in Fig. 3, from which the passages or channels are bored into the pay formation, may be formed or drilled in any convenient manner, such as by the conventional rotary or cable drilling tools, or in some instances by the practice of this invention.

When the cutting member employed to drill the well hole or a lateral channel therefrom is a nozzle, such as illustrated in Fig. 11 and adapted to issue therefrom a stream of acid in the form of a jet, it may be desirable in some instances to add to the acid an agent which will cause it to foam, such as gum arabic or saponin. By the addition of such foaming agents the acid will be caused to issue from the nozzle 12 in the form of a jet of foam and after acting to form the channel will have less tendency to settle therein and ineffectively attack the bottom of the channel. In this manner channels of more uniformly circular cross-section may be drilled, and additionally the acid is more effectively applied so as to further the lateral or tangential extension of the channel, as distinguished from the mere cutting of holes or pits in the bottom thereof. Agents to cause the acid to foam may be added thereto in relatively small amounts such as from about 0.1 to 1.0 per cent by weight.

The drilling conduit employed in the realization of this invention is formed of relatively flexible and lightweight material and may be constructed so as to withstand differential pressures up to 1000 pounds per square inch. Moreover, this conduit may be formed so as to be of such lightness and structure that it will float in liquids normally encountered in drilling a well such as water, brine, oil, etc., and will also float in fluids utilized in drilling or treating a well, such as mud-laden drilling liquids, and acid solutions such as used in the practice of this invention.

A portion of one embodiment of such a conduit is illustrated in Fig. 6, wherein the conduit is generally designated by the reference numeral 10*b*, and is formed of an external sheath 16 which may be formed of woven wire strands, fabric or other suitable material so arranged that they are capable of movement to vary the diameter and length of the sheath. Within the sheath 16 and protected thereby is positioned the metallic core 17 of the conduit which is made of relatively thin gauge flexible metal, such as copper, stainless steel, brass, nickel or the equivalent, and is formed with a series of spaced annularly disposed flexible corrugations 18. When a fluid under pressure is passed through such a conduit and the interior thereof is subjected to pressure, the corrugations 18 will tend to expand and take the shape illustrated in Fig. 7, thus allowing the metal core 17 to expand and increase in length, and as the sheath 16 is flexible it too will expand and increase in length together with the core. When the pressure within the conduit is reduced sufficiently, it will again resume its original shape. Such a conduit as above described in connection with Fig. 6 may be built in convenient lengths, such as those ranging from about 50 to 1000 feet, and with outside diameters from ¾ to 3 inches and inside diameters from ⅜ to 2½ inches. A conduit of this type will safely withstand internal pressures up to 1000 pounds per square inch or more and can be built so that it is substantially uniformly capable of stretching or elongating about 5 to 10 feet for every 100 feet of its length when pressure in excess of 10 pounds per square inch is applied to the interior thereof.

A portion of a further embodiment of a flexible drilling conduit is illustrated in Fig. 8, and in this instance the conduit, generally referred to by the reference character 10c, comprises a hollow flexible core 19 made of rubber or similar flexible material which is reinforced with fabric or cord 20 or its equivalent, which is preferably incorporated therein on a bias. However in this instance, the conduit 10c together with its reinforcing fabric or cord, is so formed that upon the application of pressure to the interior thereof, the diameter of the conduit increases and the length thereof decreases, and when the pressure is released or diminished, the diameter decreases and the length increases. A conduit of the type described in connection with Fig. 8 may be built in convenient lengths, such as those ranging from 50 to 1000 feet, and with outside diameters from ½ to 3 inches, and inside diameter from ¼ to 2½ inches. Such a conduit will safely withstand internal pressure up to 1000 per square inch, and is substantially uniformly capable of shortening or decreasing its length 2 feet for every 100 feet of its original length when pressure in excess of 40 pounds per square inch is applied to the interior thereof, and conversely, such a conduit will increase 2 feet for every 100 feet thereof when the pressure therein is dropped below 20 pounds per square inch.

Shown in Fig. 1 is the hose 14 adapted to conduct therethrough a fluid under pressure which passes through the sections 10a of the flexible drilling conduit 10. Hose 14, although forming no integral part of conduit 10, may nevertheless be disposed internally throughout the entire length of any of the modifications thereof and their numerous sections 10a and the various packers 13, and as illustrated in Figs. 3, 4 and 5, it is utilized to supply a fluid under controlled pressure from the surface to inflate and deflate the various packers 13 and so control the anchoring and unanchoring of the conduit 10 in the well hole. Hose 14 may be assembled and positioned interiorly of the conduit 10 at the surface, and the various sections thereof may be coupled in any suitable manner to prevent the leakage of the fluid contained therein.

Interposed at spaced intervals in the conduit 10, there are provided a series of packers 13 as illustrated in Figs. 3, 4 and 5 for anchoring the conduit in position in the well hole and channel. The packers are controllably supplied from the surface through hose 14 with a fluid under pressure, such as air or gas, to inflate them and so frictionally anchor them to the walls of the well hole and channel to hold the conduit in place. The packers are deflated to unanchor them when it is desired or necessary to release the conduit for movement into or out of the well hole and channel.

With reference to Figs. 9 and 10 wherein one type of packer 13 is illustrated, it will be seen that the same comprises a flexible internal core 21 formed of rubber or similar suitable material which may be reinforced with fabric 22, or cord, or the like. At either end of the packer 13 there are secured externally screw-threaded couplings 23 for engagement with and connection to conduit sections 10a through any suitable means carried thereby. Underlying the couplings 23, and secured in position thereby, are the ends 24a of the sleeve shaped expandable and contractable flexible diaphragm 24 which is disposed in spaced relation to the flexible core 21 so as to form thereabout the annular space or chamber 25. The hose 14 for supplying fluid under pressure from the surface passes longitudinally through the packer 13 and all of such packers and each section of the flexible conduit 10 as hereinbefore taught. The annular space 25 of the packer is in communication with the hose 14 by virtue of a stub hose 26 connecting the same. This connection may be realized in any convenient manner, for example, by providing hose 14 with a short hollow extension 26a and the flexible core 21 with a similar short hollow extension 26b and securing them together with a clamp 27. Obviously any equivalent means may be utilized to effect the connection between chamber 25 and hose 14. When hose 14 is under fluid pressure it may be desirable in some instances to restrict the flow of such fluid from hose 14 through the stub conduit 26 and into the annular space 25, and this is effected by providing the extension 26a or 26b, preferably the latter, with a restriction or plate 28 having an orifice of small diameter with relation to the inside diameter of the stub conduit 26. The orifice plate or restriction 28 will also serve to retard the exhaustion of the fluid under pressure from the annular space 25.

On the diaphragm 24 of the packer 13, or elsewhere, there may be provided rough surfaces to assist the packer, when inflated as shown by the dotted lines 24b in Fig. 10, to frictionally engage the walls of the well hole and thus anchor it in place. Such rough surfaces may comprise wire and/or fabric, or similar mesh 29 formed at either end of the diaphragm 24, or such mesh or rough surface may extend over the entire surface of the diaphragm. It will be necessary that the wire mesh 29, or its equivalent, be so constructed and attached to the diaphragm 24 that it will be capable of expanding and contracting to some extent therewith when the packer is inflated and deflated.

Additionally the packer may be provided on the exterior thereof with a plurality of hollow rigid or semi-rigid tubes 30 which are preferably arranged at spaced intervals parallel to the longitudinal axis of the packer and secured thereto by fastening the ends thereof to the couplings 23 as by welding, soldering or any equivalent manner. Such tubes 30 are fitted on the packer 13 so that even though the diaphragm 24 thereof be expanded and in contact with the walls of the well hole to anchor the packer and the flexible conduit in place, there will still be provided a by-pass through tubes 30 for fluids in the well hole, such as acid, spent acid, water mud-laden drilling fluids, etc., to pass. Such function of this type packer may more readily be appreciated by reference to Fig. 10 wherein the dotted lines 24b illustrate the position of the diaphragm when the packer is inflated, clearly showing that although the more extended portions of the diaphragm would contact the walls of the well hole, fluid in the hole would be free to flow pass the packer through the tubes 30 or through the space 31 formed by the tube 30 preventing the diaphragm from expanding and contacting all parts of the well walls.

The orifice plates 28 of the packers 13 may be constructed so that the port or orifice therein are of varying sizes so as to allow anchors 13 provided with large orifice plates 28 to inflate and deflate rapidly, and those of the packers 13 provided with small orifice plates 28 to inflate and deflate more slowly. Thus by controlling the size of the orifice plates 28, packers 13 positioned near the surface can be provided with large, or relatively large orifice plates, the size of which will decrease as they go down into the well hole so that those adjacent the cutting tool are the smallest, so that when fluid under pressure is introduced into hose **14** to set or anchor the packers, those packers nearest the surface will set first as the fluid can more readily enter the annular spaces **25** thereof, but the fluid under pressure will not so readily enter the annular space **25** of the packers further down in the hole due to the smaller restricted orifices provided therefor. Thus when such a flexible drilling conduit as the one **10***b*, shown in Fig. 6 is employed, it will first be anchored by the packers **13** at or adjacent the surface leaving the remainder of the conduit ample opportunity to stretch and creep into the well hole when the pressure is applied to the interior thereof before the packers further down in the well hole and in the channel are caused to set and arrest the elongation of the conduit into the channel. By so supplying the packers with progressively smaller orifice plates **28** starting at the surface with large ones and decreasing the size of the ports therein as they approach the cutting member **12** carried by conduit, positive assurance is made that the conduit will progress and creep into the well hole to its fullest ability and will not be anchored at any point which would tend to hamper its creeping action.

When an acid solution is employed to drill the channel A the spent acid and solution thereof, after dissolving the acid-soluble formation or attacking the same to drill the channel, may be disposed of by forcing it under pressure into the pay formation. Such disposal of the spent acid will be materially assisted by positively anchoring the packer, or packers, immediately adjacent the acid nozzle so that the spent acid and solution thereof may not escape back into the channel that has been drilled but is forced into the formation by virtue of the pressure on the acid supplied through the conduit **10**. The acid and spent acid may be further prevented from escaping past the packers **13** if some relatively heavy seal, such as a drilling fluid or the equivalent, is positioned behind the packer, or packers, immediately adjacent the acid nozzle. Such a seal may comprise a mud-laden drilling liquid of any convenient or efficient type, and may conveniently be positioned by introducing it into the well hole through conduit **10** and expelling it through the acid nozzle, while the packers or the ones immediately adjacent the acid nozzle are deflated. In this manner, the sealing medium may be positioned behind the packer or packers desired, which are then inflated and anchored, and thereafter when acid is introduced into conduit **10** and expelled from the nozzle to form the channel A, the spent acid will be forced into the formation and be prevented from passing behind the packers and channeling or enlarging the hole or channel at undesirable points.

Or in lieu of forcing the spent acid into the formation and placing the sealing medium behind the packers to assist in forcing it into the formation, the cuttings, spent acid and matter dissolved therein may be washed or flushed out of the hole. This may be done by deflating the packers **13** and then forcing a fluid, such as water or mud-laden drilling fluid down the conduit **10** and out of the nozzle orifice **49** and into the channel A to wash the cuttings, spent acid and carbonates dissolved therein back past the several deflated packers and up to the surface. After the channel A has been so cleaned, the packers will be reset and the acid drilling continued.

To remove the cuttings, spent acid and carbonates dissolved in drilling the channel A, it is not necessary to intermittently deflate and collapse the packers **13** in order to force the cuttings, etc. past the same and to the surface. In lieu of such procedure, the packers such as illustrated in Fig. 9, may be employed, in which instance the cuttings, etc. may be intermittently or continuously forced out of the channel A and past the packers by virtue of their construction, notably the tubes **30** thereof which permit the cuttings to flow therethrough and past the packers and so to the surface.

In one manner of forming or drilling the lateral, tangential or horizontal passages into the pay formation the cutting member **12** may take the form of a nozzle **12***a*, illustrated in Fig. 11, which is adapted to eject in the form of a jet the stream of acid supplied thereto under pressure. The nozzle comprises an elongated cylindrical housing **32** terminating at its discharge end in a conical shaped head **33**, and is provided on the opposite end thereof with the externally screw-threaded portion **34** to which the internally screw-threaded sleeve **35** is secured. Any suitable type of flexible drilling conduit, such as the portion **10***a* thereof, has attached to its end a screw-threaded ring **36** to which the sleeve **35** is screwed to join the nozzle **12***a* to the end of the flexible drilling conduit. The nozzle is preferably of predominantly uniform diameter and formed of relatively thin metal or equivalent lightweight material.

Within the nozzle housing **32** and extending longitudinally therethrough is a metal tube **37** which at the conical end **33** of the nozzle seats and abuts against the shoulder **38** of the nozzle tip **39**. The other end of the metal tube **37** is formed with a flared portion **40** terminating in the circular flange **41**, which by virtue of the sleeve **35**, is securely held against the end of section **10***a* of the flexible drilling conduit so as to make a tight connection between the conduit and nozzle and put the interior of conduit section **10***a* in communication with the interior of tube **37**. As acid, such as a solution of hydrochloric acid, is to be passed through nozzle **12***a* under high pressures, it is preferable to line the entire inside of tube **37**, including the flared portion **40** thereof, with a glass or other vitreous liner **42**, as is shown in Fig. 11. As a portion of the tip **39** at the conical end of the nozzle **12***a* in which the liner **42** seats may be exposed to the acid, it is desirable to form the tip of some resinous or other acid-resisting material, and to further so form the tip as to protect the end of the glass liner **42** and form a seat therefor as is shown.

Intermediate the housing **32** of the nozzle and the tube **37** passing therethrough, there is formed a chamber **43** in which is disposed a plurality of supporting fins or blades, or a helical support **44** which gives strength and rigidity to the nozzle and the housing **32** thereof. The support **44** may be secured to the outside of the tube **37** and to the inside of the housing **32** in any convenient manner, such as by welding or soldering, and the support **44** is further formed with cut-away portions **45** so that all portions of chamber **43** are in communication and fluid is free to flow into all portions thereof. Similarly, at one end of the nozzle and interiorly thereof in the chamber **43**, there is provided a disc **46** to assist in supporting the tube **37** and to give strength and rigidity to the upper end of housing **32**. Disc **46** is formed with the apertures 47 so that all portions of chamber 43 are in communication and in communication with the interior of the hose 14, the end of which passes through the flared portion 40 of the tube 37 and its liner 42 so that fluid flowing through hose 14 is introduced into the chamber 43 of the nozzle.

With further reference to Figs. 11 and 12, and particularly the latter, it will be seen that the nozzle housing 32 is provided with a series of ports 48 arranged circumferentially thereabout for the exhaust of fluid under pressure from the chamber 43 out into the well hole for the purpose hereinafter to be explained. The conical end 33 of the nozzle is formed with a relatively small discharge orifice 49 which is in communication with the glass-lined tube 37 for the escape therethrough of the acids or other chemicals under high pressure and velocity.

When the nozzle is functioning in the well hole to drill the lateral channel A, the force of the pressure in the conduit 10 and in the nozzle will serve to assure that the acid jet is being applied in a manner parallel to the axis of the channel and not at a tangent thereto. The maintenance of such position of the nozzle in the channel will be materially assisted by the exhaust of fluid through the ports 48 of the nozzle which will tend to center it in the channel. However, it is necessary that the nozzle be so controlled that it may be caused to cut a horizontal channel or one running upwardly or downwardly from such a horizontal, as is desired. This may be effected by convenient loading of the nozzle, which can be done by introducing fluids of varying kinds and weights into the chamber 43 of the nozzle so as to make it lighter or heavier to direct the acid jet issuing from the orifice 49 upwardly or downwardly. For example, if the nozzle is drilling a channel in the pay formation and is in substantially a horizontal position, such as illustrated in Fig. 3, and it is desired to change the application of the acid jet issuing from orifice 49 to a different angle so that it will then cut or drill downwardly from the channel A, it will only be necessary to introduce a liquid into hose 14 from the surface and the liquid will ultimately pass through the entire length of the hose and into the chamber 43 of the nozzle 12*a*, making it heavier and causing it to tilt downwardly, as illustrated by the dotted lines in Fig. 3, and so cause the further forming of channel A in the pay formation in that direction.

If it is desired to cut or drill upwardly from the channel A with the nozzle 12*a*, the position thereof for such drilling can be effected by introducing a fluid such as air or gas under pressure into hose 14 at the surface and forcing it downwardly therethrough and into the chamber 43 of the nozzle to cause it to float or rise in the spent acid or other liquid contained in the channel A and so effect an upward direction to such further drilling of said channel, as indicated by the position of the nozzle illustrated in dotted lines in Fig. 3.

The fluid supplied under pressure from the surface through hose 14 to chamber 43 of the nozzle to control the direction thereof will exhaust from said chamber through the circumferentially arranged ports or orifices 48, and serve to keep the acid nozzle 12*a* floating in the center of channel.

However, before any beneficial change in direction can be made relative to the direction of the acid nozzle 12*a*, it will be desirable, if not necessary, to know at what depth it is drilling so as to ascertain if the nozzle should be directed upwardly or downwardly for further drilling of channel A. One embodiment of the apparatus and method of ascertaining the depth of the channel A at the point therein where the acid nozzle 12*a*, or other type cutting member, is drilling is illustrated in Figs. 3 and 13, the latter being an enlarged detail view of the pipe assembly at the top of the well hole. It will be appreciated that before the lateral channel A is commenced a well hole W is drilled to a given depth, which depth is here represented in Fig. 3 by the reference numeral X and the depth of which is already known or easily ascertained by measuring lines. A pipe 50 extending from the surface where it is connected with a suitable source of fluid under pressure, such as air or gas, extends downwardly within the casing P to a point adjacent the bottom of the vertical well hole wherein liquid is standing at the level L—L. The fluid pressure hose 14 heretofore described also extends from the surface down into the vertical well hole and is in communication with the furthermost end of channel A by virtue of the fact that hose 14 is positioned within the flexible drilling conduit 10 and terminates in the chamber 43 of the acid nozzle 12*a*, which, via the ports or orifices 48, is in communication with the furthermost portion of channel A. The top of the casing pipe P is provided with suitable packings through which extend the upper ends of pipe 50 and the conduit 10 with its fluid hose 14 extends. Formed on the top portion of the casing and in communication with the interior thereof is the elbow pipe connection 51, the lower end of which is disposed in a liquid seal, such as water, contained in the vessel 52. Pipe 51 is provided with the valve 53 and the pressure gauge 54.

The liquid standing in the vertical well hole W is arbitrarily considered as standing at level L—L. Therefore, the ultimate upper level of the liquid standing in channel A will be the same, and to positively assure this condition the pressure on the fluid in conduit 10 and hose 14 is released and the packers 13 deflated so that the liquid in channel A will flow up into the well hole to its natural level, namely, level L—L. Now assuming that the liquid in both the well hole W and the channel A is of identical specific gravity and it is desired to determine the depth at which the nozzle 12*a* is drilling in the channel A so as to determine if the nozzle should be directed upwardly or downwardly to control and possibly correct the further drilling of that channel, it will be necessary to introduce a fluid, such as air, under pressure into the top of pipe 50 at the surface. Such air under pressure will then pass downwardly through pipe 50, displacing the liquid and the air bubbles standing therein out of the lower end of pipe 50 and into the bottom of the well, from whence it will bubble upwardly through the liquid therein within the casing pipe P to the upper end thereof at the surface and enter the elbow pipe 51 and bubble outwardly therefrom into the liquid seal contained in the vessel 52. When this takes place, a visual means is afforded to show that all of the liquid standing in pipe 50 has been displaced by the air under pressure, and during such displacement the pressure gauge 54 will indicate the constant increase in pressure needed to displace the liquid until all such liquid is displaced, at which time the gauge 54 will indicate the maximum pressure required for such displacement of liquid and so record the hydrostatic head of the liquid that stood in pipe 50. During this operation valve 53 has, of course, been allowed to remain open.

To measure the hydrostatic head of the liquids standing in hose 14, which is disposed both in the well hole and the channel, the air under pressure in pipe 50 is released and reduced to normal, allowing pipe 50 to refill with liquid. Then air under pressure is introduced into hose 14 to displace therefrom the liquid column standing in it, which when completely displaced, will be evidenced by the air bubbling out of the liquid seal in container 52, and at which time the reading on the gauge 54 is noted, which will give the hydrostatic head of the liquid that was displaced from hose 14.

Thus, having ascertained the hydrostatic head of the liquid standing in the pipe 50 disposed in the well hole, the depth of which is known, it is but a simple matter, after having ascertained the hydrostatic head of the liquid in hose 14, to then compute the depth of the end of channel A from the surface.

For instance, assuming that both the well hole and channel A are filled with water and the depth of the well hole at point X therein is 1800 feet, and the hydrostatic head of the water standing in pipe 50 is 774 pounds per square inch, and the depth of the channel A at the end thereof is unknown but the hydrostatic head of the liquid standing in the channel is found, when measured, to be 778.3 pounds per square inch, then obviously the depth of channel A at its furthermost point, where the acid nozzle is drilling, would be 1810 feet. This will be true for the hydrostatic head will be in direct proportion to the depth in this instance where the same type liquid, e. g. water, is standing both in the vertical well hole and the channel A.

However, if other liquids are standing in the vertical well hole and channel A, the ascertainment of the depth of channel A will not be so simple, but determinable, however, by the same principle and general method. For instance, assume that drilling mud with a specific gravity of 1.1 is standing in the vertical well hole and in the channel A, that the depth of the vertical well hole is known or found to be 1800 feet, and that the hydrostatic head of the mud standing in pipe 50 was measured as 851.4 pounds per square inch, while the hydrostatic head of the drilling mud standing in hose 14 was measured as 856.1 pounds per square inch, then it is seen that the depth of the channel A at the point where the acid nozzle is drilling is 1810 feet.

Thus, when the depth and thickness of the pay formation is known, and this is readily ascertainable, and the depth at which the nozzle is drilling has been ascertained, the nozzle can then readily be directed and/or controlled as herein before described to drill in the pay formation as desired.

In all instances, it will not be necessary to provide the hose 14 within the drilling conduit 10, in which case the conduit 10 and the sections 10*a* thereof will serve to conduct all the necessary fluid or fluids under pressure and supply them to the packers 13 and the cutting member 12. For instance, in Fig. 14 there is illustrated a portion 10*a* of such a conduit without the hose 14, and which is illustrated as connected to a nozzle 12*a'*. In this instance the nozzle is modified in some slight respects from the nozzle 12*a* hereinbefore described and illustrated in Fig. 11, and it will be seen that the chamber 43 thereof is not formed so as to make connection with any such hose, as the one 14 included in nozzle 12*a*. Instead, nozzle 12*a'* has a fluid separator 55 positioned in the flared portion 40 of the tube 37. The separator 55 comprises a body 56 radiating from which are a plurality of spiral vanes 57, the outer ends of which seat against and are secured to the flared portion of the glass liner 42. The forward end of the separator 55 forms a conically tapered head 58 radiating from which the plurality of vanes are so disposed with relation to the body that a centrifugal action or motion will be imparted to fluids flowing therepast under pressure. Ports are provided in the separator at the point 59 for the fluid to pass through the same and flow into the flared portion 40 of tube 37. A tube 60 is positioned just back of the centrifugal separator 55 and the ports 59 thereof, and passes through the walls of the flared portion 40 of tube 37 and its glass liner 42 to connect the inside thereof at the flared portion with the interior of chamber 43 of the nozzle 12*a'*.

The apparatus shown in Fig. 14 is employed as follows, a solution of hydrochloric acid together with air, is introduced under pressure into the drilling conduit 10 at the surface from which it flows downwardly into the well hole and into the channel A through the section 10*a* thereof connected to the nozzle 12*a'*. During such passage of the acid solution and air, the pressure thereon can be regulated and controlled from the surface to operate packers of the type hereinbefore described. When the acid solution and air have traversed the entire length of conduit 10 and are about to enter the nozzle 12*a'*, they are compelled to pass the separator 55 which imparts a centrifugal or swirling action or motion to the acid and air, resulting in its separation, or substantial separation, so that the air, being lighter, will remain substantially in the center of the flowing stream of acid and air, while the acid being the heavier of the two fluids, will displace the air and be concentrated on the outside of the flowing stream. With this condition and positioning of the air and acid effected, the air or a large portion thereof, will flow into tube 65 and into the chamber 43 of the nozzle to assist in controlling its direction, as heretofore described, while the acid will flow into the glass liner 42 of the tube 37 and so to the nozzle orifice 49 from whence it issues to attack the pay formation.

Obviously the separator 55 may be positioned either in the nozzle 12*a'* or in the conduit 10 at a point relatively close to the nozzle.

The drilling member 12 employed for drilling the passage or channel, such as the one A, may take the embodiment of a fluid driven tool, such as a rotary, oscillating, or impact drill tool or bit. One example of such a tool is shown in Fig. 15, wherein is illustrated a rotary drilling tool or bit adapted to be driven by a fluid under pressure, such as air, gas, water, mud-laden drilling fluid, or a solution of acid which may be supplied to the tool through conduit 10. Obviously, such a rotary drilling tool may be employed to drill channels or passages through formations which are not soluble in acid or acted on thereby, or it may also be employed to drill channels in acid-soluble formations, in which instance the tool will be materially assisted in its drilling function if it is driven by an acid solution under pressure, which will assist in dissolving or attacking the formation.

With reference now to Fig. 15 wherein the mechanical drilling tool is generally designated by the reference numeral 12b, it will be appreciated that therein is illustrated a mechanical cutting tool or drill adapted to be driven by a fluid under pressure. The tool comprises a cylindrical housing 61 which is formed at its working end with an open internally screw-threaded end 62, and at the other end with a boss 63 which is both exteriorly and interiorly screw-threaded. The boss 63 is connected by the internally screw-threaded coupling sleeve 35 to the externally screw-threaded ring 36 of the flexible conduit section 10a which causes the boss 63 to abut the end of the conduit section and make a tight leak-proof contact therewith. Disposed within the conduit section 10a and carried thereby is the fluid hose 14 which is secured in place at the end of the conduit section by a bracket 64 and coupling member 65.

Within the housing 61 of the cutting tool, and spaced from the inner walls thereof so as to form the annular chamber 66a there is positioned a combination fluid chamber and shaft-bearing member 67 which is formed of spaced, concentrically arranged tubular members, namely, an inner tube 68 which at one end is screw-threadedly engaged with the interior of the boss 63 and at the other end is provided with the outwardly projecting annular flange 69, which is formed with a series of ports 70; and an outer tube 71, which at one end is formed with the inwardly projecting annular flange 72 which is secured to the end of tube 68 at a point adjacent boss 63 and which at the other end is secured to the flange 69 of tube 68 and is formed with the internally screw-threaded portion 73 of the tube 71 is the externally screw-threaded portion 74 of the tube 75, which at its other end is formed with the outwardly projecting flange 76 formed with the depending screw-threaded flange 77 which screws into the end 62 of the housing 61 to close the same. Tube 75 is so disposed within the housing 61 as to form the annular chamber 66b therebetwen, which, together with annular chamber 66a, heretofore described, constitutes the annular chamber 66 which extends the entire length of housing 61.

Within the tube 68 there are provided bearings 78 and 79 for the shaft 80, which is disposed within tubes 68 and 75 and has keyed thereto substantially intermediate its ends an impeller blade 81 provided with the ports 82. The lower end of shaft 80 passes out of housing 61 and is provided with a head 83 on which is rotatably mounted a plurality of drilling or cutting discs 84. Shaft 80 is formed with an annular shoulder 85 adapted to engage bearing 79 and limit the outward thrust of the shaft, while the inward thrust of shaft 80 is limited by the stop 86 which completely closes the interior of tube 68. Adjacent the stop 86, there is formed in tube 68 a series of apertures 87 which puts the interior of one end of tube 68 in communication with chamber 88 formed between tubes 68 and 71. By virtue of the apertures or ports 70 formed in flange 69 of tube 68, the chamber 88 is in communication with chambers 89 and 90, which are formed within the bell-shaped portion 74 of tube 75, and tube 75, respectively.

In one end of tube 68 there is provided a port 91 in which is fitted one end of the stub pipe 92, the other end thereof making connection with the hose 14 and being joined thereto by the connection 65. By virtue of stub pipe 92, the fluid in hose 14 is free to flow therefrom through port 91 and into chamber 66, from whence it may exhaust through ports 93 which are arranged about the circumference of the housing 61.

When such a mechanical drilling tool as above described is utilized in the practice of this invention, a fluid under pressure, which may be water, gas, drilling mud, or of hydrochloric acid solution, is supplied at the surface and forced down through the flexible conduit 10, and the various sections thereof, until it enters the last section, such as the one 10a illustrated in Fig. 15, from whence it flows into the end of tube 68 and escapes therefrom the apertures 87 into the chamber 88. From chamber 88 the fluid under pressure escapes through ports 70 and impinges against the impeller blades 81, which are keyed to shaft 80. Insomuch as the fluid issuing through ports 70 is under pressure, it will strike the blades 81 and rotate them together with the shaft 80 and the cutting head 83 carried at the end thereof, and in this manner the drilling discs 84 will be caused to cut and drill into the formation.

If the fluid under pressure utilized to drive the impeller blades 84 and shaft 80 is a solution of acid, such as hydrochloric acid, it in issuing through ports 70, will impinge upon the blades 81 and flow through the ports 82 formed therein and flow into chambers 89 and 90 and be expelled from the cutting tool housing at the end thereof adjacent the cutting discs 84 and materially assist them in drilling into the formation, especially if the same contains calcareous or acid-soluble constituents.

Fluid under pressure will be supplied from the surface to the hose 14 for actuating the packers or anchors 13 heretofore described, and as this fluid, which may be any suitable liquid or gas, enters the last portion of hose 14 shown in Fig. 15, it will flow therefrom into the stub conduit 92 and through the port 91 into chamber 66 formed within the housing 61 of the cutting tool, and therein serve to support the tool in the fluid of the well hole and function to control the direction of the cutting tool as has been described. Fluid from chamber 66 exhausts through port 93 into the well hole.

If desired, a mechanical cutting tool, such as described in connection with Fig. 15, may be utilized in connection with a flexible drilling conduit, without hose 14, but utilizing the centrifugal separator 55 illustrated in Fig. 14, the structure and function of which has hereinbefore been described.

Certain practices of this invention will now be briefly summarized in the following paragraphs. A well hole may be first drilled in any desired manner, and therein at any depth a guide is set, and a flexible drilling conduit of the type illustrated in Fig. 6 or 8 is lowered into the well hole with a cutting member, such as illustrated in Fig. 11 or 15, connected to the lower end thereof until the cutting member passes through the guide and is directed to the formation of the well hole wall. Assuming that the formation in which it is desired to drill the channel is formed of or contains limestone, calcareous material, there will then in that case be employed a nozzle of the type shown in Fig. 11 and a solution of hydrochloric acid of from about 10 to 25 per cent concentration.

With the nozzle suspended at the end of the conduit, it is then lowered into the well hole until it passes through the guide and the end of the nozzle abuts the pay formation as shown in Fig. 3. A fluid, such as air or gas, is then put under pressure into the hose 14 at the surface and is forced downwardly into the well hole, and a part thereof will enter the chambers 25 of the packers 13 to inflate them so that they anchor the conduit in place. Thereafter a solution of hydrochloric acid is supplied to conduit under pressure and forced downwardly therethrough to issue from the orifice 49 of the nozzle in the form of a jet of acid which is directed by the guide against the wall of the pay formation.

After the jet of acid has been applied to the pay formation for a period of time, it will form a channel therein such as the one designated by the reference numeral A in Fig. 4. Thereafter, further application of the acid jet will be less effective because as the channel progresses the distance between the end thereof and the nozzle increases. Therefore, it is desired to move the nozzle into the channel so as to be in closer proximity to the end thereof to further effect the channeling of the formation. This is done by releasing or reducing the pressure on the fluid in hose 14 and deflating the packers 13. At this stage of the practice of this invention the flexible drilling conduit can be caused to progress into the well hole and into the channel by merely forcing it into the hole from the surface, or due to its weight it will move down into the hole and forward into the channel. At this time, additional sections of the flexible drilling conduit may be added at the surface if needed.

By forcing the conduit into the well hole and the lateral or tangential channel being formed therefrom, or by allowing the weight of the conduit to force itself into the hole and channel, the nozzle will be repositioned and assume a position in the channel A substantially as illustrated in Fig. 5 with the nozzle advantageously located to further form the channel at which time the packers are reset and drilling resumed.

During the repositioning of the conduit, the flow of acid in conduit may be continued or disrupted as desired. However it may be preferable to discontinue the acid flow during this period, and at that time while the packers are deflated, a fluid such as water or drilling mud may be forced under pressure through conduit and out through the nozzle and into the channel to wash it clean of the cuttings, etc.

After the channel has been formed into the formation to such an extent that the weight of the flexible drilling conduit, or a force applied thereto at the surface, can no longer be satisfactorily relied upon to move the conduit into channel A as it is formed, the creeping action of the flexible drilling conduit is then resorted to for causing it to reposition itself in the channel as the same increases in length. As need for this arises, it is effected by deflating and so releasing the packers, and adding the necessary additional sections to the flexible drill conduit at the surface, and thereafter preferably setting first the packer, or packers, immediately adjacent the surface and then forcing the acid solution under pressure through the drilling conduit, and if such a conduit, as illustrated in Fig. 6 and heretofore described, is employed, each section thereof will immediately increase in length, resulting in a considerable overall elongation thereof which will all be in one direction, namely downwardly into the well hole and forwardly into the channel. The conduit will creep into the well hole and channel because that is the only direction in which it is free to move as it is anchored to the well walls adjacent the surface. After the conduit has been so caused to creep into the well hole and channel and has moved thereinto as far as it is capable, the remaining packers throughout the length of the conduit are inflated to anchor it against movement out of the hole and the channel, and thereafter drilling of the channel with the acid jet is resumed. The above manner of repositioning the nozzle is repeated whenever the need arises for causing the nozzle to progress into the channel.

By providing the packer or packers nearest the surface with relatively large orifice plates, designated by the reference numeral 28 in Fig. 9, it will be possible to cause those packers to anchor first as the fluid under pressure supplied through hose 14 will more readily enter the chamber, or chambers, 25 of such packers and inflate them. By providing the succeeding packers with successively smaller and smaller orifice plates, decreasing in size as the packers progress into the well hole and channel, it will be possible to cause the packers nearest the nozzle to set or anchor last after all of the other packers have been anchored and so give the entire length of conduit ample time to stretch and creep into the hole and channel to its maximum extent before finally anchoring it against movement out of the hole.

Instead of using a drilling conduit that will elongate upon the application of internal pressure, as above described, a conduit of the type illustrated in Fig. 8 may be substituted. Such a flexible conduit has heretofore been described and is so constructed that it decreases in length when pressure is applied to the interior thereof and elongates upon the release of such pressure. When this type of flexible drilling conduit is employed and it is desired to cause the hose to progress into the well hole and channel, the packers are deflated and unanchored, and additional sections of conduit added thereto if necessary. Thereafter the conduit is secured at the surface against movement out of the well hole, and this may be accomplished by preferably anchoring only the packer or packers adjacent the surface, or by securing the conduit at that point in any other desirable manner. Thereafter the pressure on the interior of the conduit is released, at which time it will elongate. And when the conduit has stretched or elongated to its maximum, which will be in a direction into the hole and channel, the packers are then set or anchored so as to anchor the conduit in the hole and channel in its foremost position.

In order to flush the cuttings, etc. from the channel and remove them to the surface, it may be expedient to deflate the packers. Although this is not necessary as the cuttings, etc. can be constantly flushed out of the channel by the pressure on the acid or other fluid issuing from the nozzle and forced back out of the channel through tubes 30 formed on the packers and up out of the well hole. In lieu of relying on the acid and spent acid under pressure to force the cuttings, etc. to the surface, a fluid, such as water or a drilling mud, may intermittently be forced down through the conduit and out of the nozzle and into the channel to force the cuttings, etc. to the surface.

It will not be necessary in all instances to supply the packers with a fluid under pressure via the hose 14 in order to anchor them, as in some instances the hose 14 can be eliminated from the flexible conduit. In which instance the flexible drilling conduit 10 is utilized to convey both the acid solution and the fluid under pressure to inflate the packers. However when hose 14 is eliminated, it will be preferable to employ a modified type nozzle provided with the centrifugal separator 60, such as is illustrated in Fig. 14.

The directional control of the nozzle or any other type of cutting member that may be employed has hereinbefore been fully described, however such control of the nozzle and its direction will be materially assisted if the channel being formed contains a liquid, such as water, acid solution, spent acid, drilling mud, etc., or any combination thereof in which the cutting member can float or substantially float. Moreover, the presence of such liquids in both the channel and the well hole serves to materially assist and make possible the creeping action of the flexible drilling conduit as the same will substantially float therein, and additionally this condition makes it possible for the drilling conduit to be readily withdrawn from the channel and hole whenever desired.

In lieu of using the nozzle 12*a* to drill the well hole or channel, a mechanical fluid pressure driven tool such as the one 12*b*, illustrated in Fig. 15, may be employed. The cutting tool 12*b* may be used with or without an acid solution to assist its drilling operations. However, when acid is used with this tool, it will serve as the fluid under pressure to drive it, and in such case the acid will materially assist the tool in forming the channel in acid-soluble formations. However, the cutting tool 12*b* will find particular application for drilling in non-acid-soluble formations, in which case any suitable fluid under pressure, such as air, gas, water or drilling muds, may be employed to drive the cutting tool. However, it is to be understood that the fluid pressure driven mechanical cutting tool 12*b* is interchangeable for the nozzle 12*a* and its direction in the channel A is controllable in the same manner.

Other modes of applying the principle of my invention may be employed instead of those explained, change being made as regards the method and apparatus herein disclosed, provided the step or steps stated by any of the following claims or the equivalent of such stated step or steps be employed.

I therefore particularly point out and distinctly claim as my invention:

1. The method of forming a channel radiating from a well hole, which comprises positioning a flexible conduit provided with a drilling member in said well hole and locating said member adjacent to the formation to be channeled, introducing a liquid into said conduit and directing it from said member in the form of a jet so as to drill a channel radiating from said well hole, advancing said flexible conduit into the channel so formed, and expanding portions of said conduit to anchor the same.

2. The method of forming a channel radiating from a well hole with a flexible conduit and a jet of acid, which comprises introducing acid into a flexible conduit and directing it therefrom in the form of a jet, positioning said conduit adjacent to the formation to be channeled and drilling a channel therein with said jet of acid, subjecting the interior of said conduit to such pressures as will cause it to elongate and creep into said channel, and expanding portions of said conduit to anchor the same.

3. The method of drilling a well hole in earth formations with a flexible conduit and a jet of acid, which comprises introducing acid into a flexible conduit and causing said acid to issue therefrom in the form of a jet, directing the end of said conduit to the earth formation so as to drill a channel therein, advancing the conduit into the channel formed in the earth formation by said acid, and expanding portions of said conduit so that they frictionally contact the walls of said channel and anchor the conduit therein

4. The method of drilling a well hole with a flexible conduit provided with a nozzle adapted to eject a stream of acid therefrom in the form of a jet, which comprises feeding an acid solution through said conduit to said nozzle and directing the acid issuing therefrom to drill said well hole, repositioning said conduit and nozzle in the well hole as the same is drilled by subjecting the interior of said hose to such pressures as will cause it to elongate and creep forward into the hole formed by said jet.

5. The method of drilling a well hole which comprises directing a fluid driven mechanical tool to the formation to be drilled, supplying a stream of liquid through a flexible conduit to said tool to drive the same, drilling a well hole in the formation with said tool and a jet of liquid resulting from said stream of liquid supplied to drive said tool, and causing said flexible conduit to progress into the hole as it is drilled by said tool and liquid jet.

6. The method of drilling a lateral channel radiating from a well hole with a flexible conduit and a cutting member adapted to eject a stream of acid supplied thereto in the form of a jet, and controllably directing said cutting member and jet of acid issuing therefrom to drill said channel, which comprises ascertaining with relation to the earth's surface the depth of said channel wherein said cutting member is cutting said channel, and loading said cutting member with a fluid of selected specific gravity to control the weight of said cutting member and thereby alter its direction within said channel.

7. The method of drilling a channel radiating from a well hole with a flexible conduit provided with a nozzle adapted to eject a stream of acid therefrom in the form of a jet, which comprises feeding an acid solution to said nozzle through said conduit while positioned in the well hole, directing the acid jet to the formation to be drilled, repositioning said conduit and nozzle in said channel as the same is drilled by subjecting the interior of said conduit to such pressures as will cause it to elongate and creep forward into the well hole and the channel formed by said jet, and loading said nozzle with a fluid of a selected specific gravity to control the weight of said nozzle so as to cause it to tilt in the desired direction within said channel to so change the direction of said nozzle and the channel being drilled thereby.

8. The method of drilling a well hole which comprises directing a fluid driven mechanical tool to the formation to be drilled, supplying a stream of acid through a flexible conduit to said tool to drive the same drilling a well hole in the formation with said tool and a jet of acid resulting from said stream of acid supplied to drive said tool, causing said flexible conduit to progress into the hole as it is drilled by said tool and acid jet, and loading said cutting tool with a fluid of selected specific gravity to control the weight

of said tool so as to cause it to tilt in the desired direction within said hole and so change the direction of said tool and the hole being drilled thereby.

9. The method of drilling a channel radiating from a well hole which comprises positioning a flexible conduit provided with a drilling member in said well hole and locating said member adjacent to the formation to be channeled, introducing an acid solution into said conduit and directing it from said member in the form of a jet so as to drill a channel radiating from said well hole, forcing said flexible conduit into the channel so formed, expanding portions of said conduit to anchor the same in said channel, and adding a foaming agent to said acid solution so that said jet thereof will foam and after serving to drill the channel will be dispersed therein.

10. A mechanism for subterranean boring comprising a drilling member adapted to eject a stream of fluid therefrom in the form of a jet, a flexible drilling conduit for supplying a fluid to said member, and an anchor interposed in said drilling conduit for anchoring the same in the well hole.

11. A mechanism for subterranean boring comprising a drilling member adapted to eject a stream of fluid therefrom to drill the well hole, a flexible drilling conduit for supplying fluid to said member, an inflatible packer interposed in said conduit for anchoring the same in place in said well hole, and a hose for supplying fluids under pressure to said packer to inflate the same and anchor them in the well hole.

12. A mechanism for subterranean boring comprising a flexible drilling conduit adapted to convey a stream of fluid under pressure, a drilling member connected to said flexible conduit adapted to receive fluid under pressure therethrough and eject it in the form of a jet, a plurality of packers interposed throughout the length of said conduit adapted to receive fluid under pressure from said hose to inflate said packers and anchor them and said conduit and member in the well hole, and restricted ports in said packers to control the entry of fluid under pressure thereinto and the inflation and anchoring thereof.

13. A mechanism for drilling well holes comprising a flexible drilling conduit adapted to convey a stream of fluid under pressure, a nozzle connected to said flexible conduit and adapted to receive fluid under pressure therethrough and eject it in the form of a jet, a plurality of packers interposed throughout the length of said conduit adapted to receive fluid under pressure from said conduit to inflate said packers and anchor them and said conduit and nozzle in the well hole, and restricted ports in said packers of graduating selected sizes to controllably regulate the entry of fluid under pressure thereinto and the resultant inflation and anchoring thereof.

14. A mechanism for drilling a well hole comprising a cutting member adapted to eject a stream of fluid therefrom for cutting away the earth formation, a flexible drilling conduit for supplying fluid to said cutting member, an anchor interposed in said conduit for anchoring the same in place in said well hole, and a fluid bypass in said anchor to permit the earth cuttings resulting from said stream of fluid to pass the anchor.

15. A mechanism for drilling well holes comprising a drilling conduit adapted to convey a stream of fluid therethrough under pressure, a cutting member connected to said conduit to receive fluid therefrom and eject fluid in the form of a jet to drill said well hole, and a fluid chamber having an inlet and an outlet associated with said cutting member adapted to receive fluid from said conduit to control the buoyancy of said cutting member.

16. A mechanism for drilling well holes comprising a drilling conduit adapted to convey a plurality of immiscible fluids of different specific gravities therethrough under pressure, a packer interposed in said conduit and adapted to receive a fluid under pressure therefrom to inflate the same and anchor said conduit in the well hole, a cutting tool connected to said conduit and adapted to receive fluid under pressure therefrom and eject fluid in the form of a jet to drill said well hole, a fluid chamber associated with said cutting tool adapted to receive fluid from said conduit to control the buoyancy of said cutting tool, and a fluid separator associated with said cutting tool to separate the fluids into a lighter and a heavier portion and direct the former to said chamber and the latter to another part of said tool for ejection therefrom in the form of said jet.

17. A mechanism for drilling well holes comprising a drilling conduit adapted to convey a stream of fluid therethrough under pressure, a fluid pressure driven cutting tool connected to said conduit and adapted to receive fluid under pressure therefrom to drive said tool, and a chamber associated with said tool adapted to receive a portion of said fluid under pressure to control the buoyancy of said tool.

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