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Oct. 7, 1941. L. C. CHAMBERLAIN 2,258,001

SUBTERRANEAN BORING

Filed Dec. 23, 1938 2 Sheets-Sheet 1

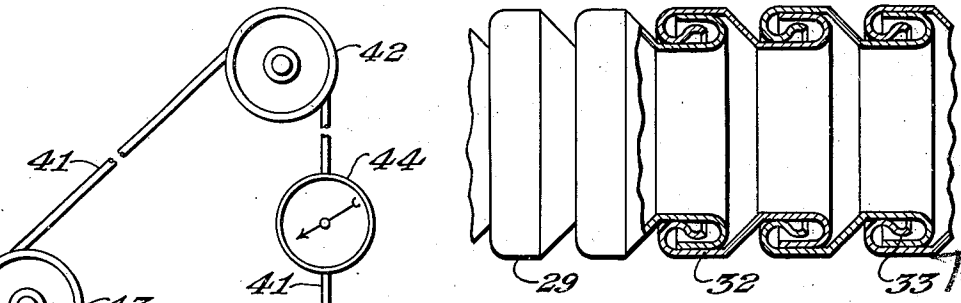


Fig. 2

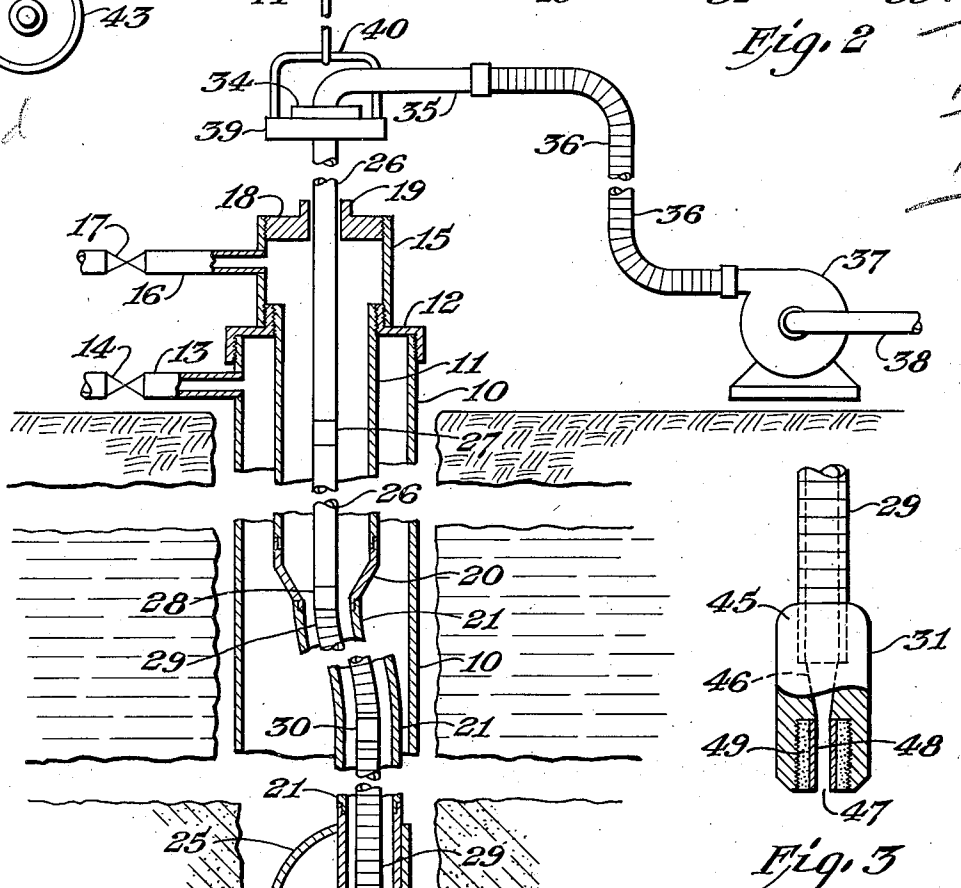


Fig. 1

Fig. 3

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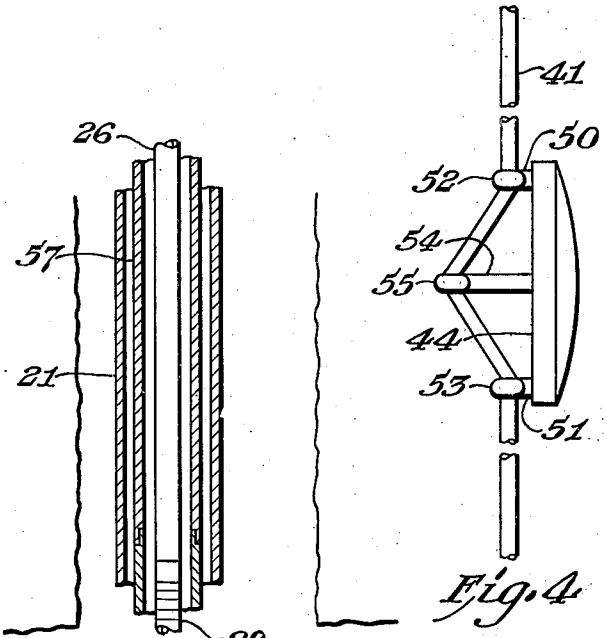


Fig. 4

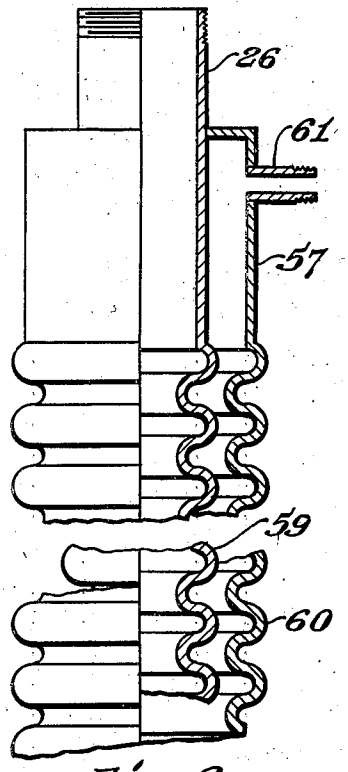


Fig. 6

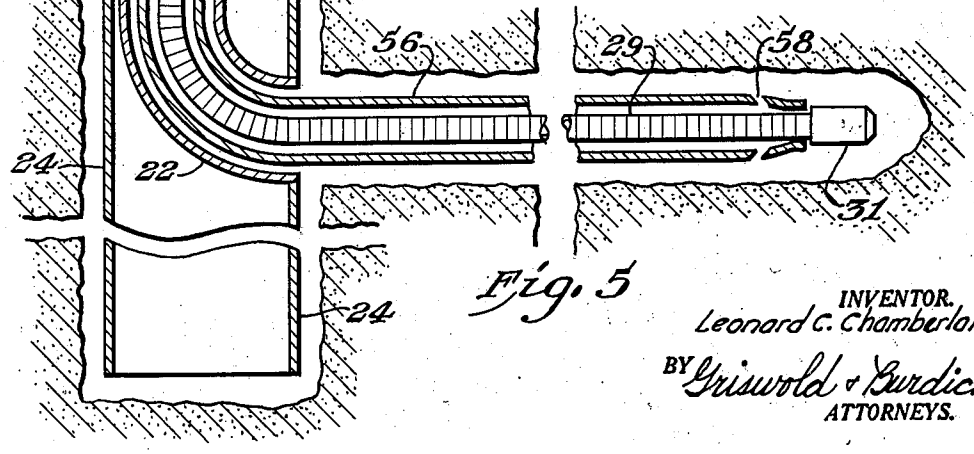


Fig. 5

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UNITED STATES PATENT OFFICE

2,258,001

SUBTERRANEAN BORING

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Application December 23, 1938, Serial No. 247,308

16 Claims. (Cl. 255—1)

This invention relates to a method and apparatus for drilling wells, and in particular it relates to a new and improved method and apparatus for drilling or forming a lateral, tangential or horizontal passage, bore, or channel in a well, and/or enlarging such passages or channels as may already exist in the well bore.

By the practice of this method and apparatus a lateral, tangential or horizontal passage or channel, or a plurality thereof, may be drilled or formed in the hole or bore of an oil, gas, water, brine or other type well at substantially any depth therein and radiating from the main, or substantially vertical, well hole at any angle desired. These channels may be drilled or formed with a nozzle, a highly flexible conduit or hose, or one that is substantially so, and capable of making relative acute turns, and with the aid of a stream of chemical which is preferably under pressure and in the form of jet. The chemical is such that it will dissolve or attack at least a part of the formation wherein the channel or passage is to be formed.

When the passage or channel is to be formed in a limestone or other calcareous formation, it will be advantageous to employ hydrochloric acid as it will dissolve, or partially dissolve, the formation, and when it is applied or directed thereto under pressure in the form of jet it will serve to effectively form the channel and also wash away the cuttings and dissolved matter being removed to form or drill the channel in the formation.

Thus by forming such channels in a well hole or bore new drainage passages for the well are formed, and existing ones enlarged, so that conditions favoring increased production of the well are furthered, and the production of the well is actually increased. Additionally the well is put in a better and more favorable condition for subsequent treatments thereof intended to increase its production. For instance after forming new channels in the well, and/or enlarging existing ones, the well is then better conditioned for subsequent acidizing, re-pressuring, water-plugging, and numerous other treatments thereof.

This invention is not limited to the use of any particular chemical, but any and all such chemicals may be employed in practicing this invention which are capable of attacking and dissolving, or partly dissolving, the formation wherein the channel is to be formed. For instance channels in limestone formations may be formed with hydrochloric acid, and hydrofluoric acid may be employed in forming channels in siliceous formations.

As above stated the practice of this invention is not limited to any particular type or kind of well, but for the sake of brevity this invention will be explained and described herein with relation to its practice in an oil well. Thus it should be appreciated that by forming passages or channels, or by enlarging existing ones, in the pay formation of an oil well, that the drainage channels thereof will be greatly augmented and the production of the well materially increased.

An object of this invention is to provide a method and apparatus for forming a lateral, tangential or horizontal passage, channel or bore, or a plurality thereof, in a well hole.

Another object is to provide a method and apparatus for forming such channels as above recited in a well hole and enlarging existing ones.

Another object is to provide a method and apparatus for forming a lateral, tangential or horizontal channel, or channels, in a well hole at any desired depth therein and radiating therefrom at any selected depth and angle.

Another object is to form such channels or passages in well holes, and/or enlarge existing ones, so as to favor conditions for increased production of the well, and/or so as to condition the well for subsequent treatment thereof to favor its increase in production.

Another object is to provide a method and apparatus for forming such channels in well holes with a flexible, or relatively flexible, conduit or hose and the aid of a stream of chemical, such as an acid.

Another object is to provide a method and apparatus for forming such a channel in well holes with a stream of chemical, such as an acid, under pressure, in such a manner that the unreacted chemical will be materially prevented from enlarging the cross-sectional areas of that part of the channel previously formed.

Still another object is to provide a method and apparatus for forming such a channel in a well hole with a flexible conduit and a nozzle mounted on the end thereof and to form said channel in such a manner that the location of the nozzle can be readily ascertained with respect to the end of the channel being formed and/or with respect to the wall of the well hole bore.

Attention is now directed to the drawings wherein there is illustrated the method and an apparatus for the practice of this invention, and which comprises a part of this specification, and wherein—

Fig. 1 is a longitudinal view, partly in vertical cross-section, illustrating one form of apparatus for practicing this invention.

Fig. 2 illustrates, partly in longitudinal cross-section, a portion of one type of flexible conduit that may be employed in practicing this invention.

Fig. 3 is a detail view, partly in longitudinal cross-section, of one form of a nozzle that may be employed in practicing this invention.

Fig. 4 is a side view of a part of the apparatus shown in Fig. 1, and illustrates one manner of interposing a weight measuring device into a cable.

Fig. 5 is a longitudinal view, partly in cross-section, of detail of a modification of the apparatus illustrated in Fig. 1, and additionally shows a flexible conduit and nozzle engaged in forming a channel in the formation.

Fig. 6 illustrates, partly in longitudinal cross-section, a portion of one type of a flexible and concentric conduit that may be employed in the practice of this invention, and which concentric conduit is generally illustrated in Fig. 5.

An apparatus, and a modification thereof, will now be described with which the method of this invention may be practiced and realized. By the employment of this apparatus channels or passages may be drilled or formed laterally, tangentially or horizontally into the formation bordering the well bore or hole. To realize this result a flexible conduit is extended into the well hole and guided to a point adjacent to, or opposite, the formation to be drilled or wherein the passage is to be formed. A nozzle adapted to eject a stream of fluid in the form of a jet is secured to the end of the flexible conduit and supplied therethrough with a chemical under pressure, and by directing the nozzle to the formation by means of the guide the jet of chemical is applied to the formation. When the formation to be drilled is of limestone or the like and hydrochloric acid is supplied to the conduit the acid jet will dissolve the formation and form a passage therein. However, it is to be understood that the practice of this invention is not limited to the forming or drilling of passages in any specific formation or with any specific acid, as any acid, or chemical, may be employed which will dissolve the formation wherein the passages are to be formed. For example, when it is desired to form passages in siliceous formations, hydrofluoric acid may be directed thereto in the form of a jet to channel therein.

The apparatus and method comprising this invention will now be described and explained. With reference to Fig. 1 it will be seen that there is illustrated a well hole which extends from the surface to an oil-bearing stratum, and which well hole is provided with the conventional casing pipe **10**. For the realization of this invention it is desirable to provide tubing **11** which extends into the well hole to a point therein adjacent or above the formation F in which the passage or channel is to be formed. The tubing **11** is suspended from the top of the casing pipe by a form of casing head **12** to which it is screw-threadedly fitted, and to which casing head is also screw-threadedly connected the top of casing pipe **10**. Secured in the top of the casing pipe and in communication with the interior thereof is a stub pipe **13** provided with the valve **14** interposed therein, through which pipe and valve the casing may be vented. To the upper end of the casing head **12** there is screw-fitted a section of pipe **15** into which is connected a second stub pipe **16** provided with valve **17**. Pipe **16** is in communication with the interior of pipe **15** and the tubing **11** so that the latter may be vented therethrough. In the top of pipe **15** there is screw-fitted a plug **18**, which is formed with the central opening **19**.

To the lower end of the tubing **11** there is screw-threadedly connected a reducer pipe **20**, at the lower end of which there is screw-fitted the off-set tubing **21** of reduced diameter which is so formed as to gradually curve throughout a distance of about 50 to 75 feet to one side of the well wall at a point just below the reducer, and which then continues downwardly in the hole in a straight line along one side of the casing. To the end of the off-set tubing **21** there is screw-fitted a guide **22** formed with the outlet opening **23** in the lower end thereof. The guide **22** may be formed so as to curve at any desired angle through any degree of curvature, and may be so formed as to be interchangeable with similar guides of varying degrees of curvature, so as to present the end opening **23** thereof to the wall of the well hole at any selected angle. In order that the entire weight of the tubing **11**, reducer **20**, off-set tubing **21**, and guide **22** may not be suspended entirely from the casing head **12**, it may be desirable to provide the guide **22** with a support **24**, which may be welded to the guide, or otherwise fastened thereto. In the present instance, the guide support **24** consists of a section of pipe or tubing of a diameter smaller than the casing **10** to permit the guide being lowered into the well hole therethrough. The support **24** will be welded, or otherwise secured to the guide **22**, and it is proposed to turn the upper end of the support inwardly as at **25** so that the top thereof securely fits about the guide and presents an upper surface which will not snag or foul on the walls of the well hole when being lowered or raised into and out of the well. Any other convenient manner of support may be employed for supporting the guide **22**, and the tubing assembly connected thereto, in the well hole, and it is proposed that such supporting means as the support or pipe **24** may be formed so as to be interchangeable with like or similar supporting means of varying length so that the guide can be supported in the well hole at any desired distance from the bottom thereof.

The tubing **11**, reducer **20**, and tubing **21**, and guide **22** may be made of metal or other suitable material, but the tube **21** is preferably made of flexible material, which may be metal, so that it can be formed substantially as illustrated or equivalently thereto. The guide **22** may be preformed with any desired degree or manner of curvature, and assembled on the surface to the reducer **20** and tubing **21**, and then lowered into the well, or the several parts may more readily be assembled as they are lowered into the well.

The interior of guide **22** is preferably just slightly larger than the flexible conduit **29**, hereinafter to be described, so that the conduit will conveniently slide therethrough yet be prevented from kinking and so occasioning undue friction between the interior of the guide and the flexible conduit. Further, by the employment of a guide with the proper size passage therethrough so that the conduit cannot bend upon itself or kink, the conduit will be confined by the guide and when forced therefrom will pass out into the well hole and will be directed to the wall thereof at the same angle as that of the lower end of the guide.

A string of pipe **26**, connected by the joints **27**

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and which is preferably rigid and of a reduced diameter, extends from the surface, where it is suspended in a manner later to be described, down into the well hole through the tubing 11. Pipe 26 has connected thereto, as by any convenient joint such as the one 28, the length of flexible conduit 29 which may be formed of metal, metal alloys, rubber, fabric or any suitable combination thereof so long as the result is a conduit with a relatively high degree of flexibility. Conduit 29 may consist of a single section thereof, or of a plurality of such sections, connected by the joint 30. However, conduit 29 extends from the lower end of the pipe 26 down into the well hole wherein it passes through the interior of reducer 20, tubing 21, guide 22, and ultimately terminates, as shown in Fig. 1 at the opening 23 in the end of guide 22, in a nozzle 31.

Due to the construction and flexibility of conduit 29 it has no material trouble in passing through the reducer 20, nor the tubing 21 and bending in the manner shown in Fig. 1 through the guide 22, and the string of pipe 26 has no material trouble in passing through the off-set tubing 21 due to the gradual bend thereof.

In order to realize the practice of this invention it is essential that the conduit 29 be fluid-tight and leak-proof, yet sufficiently flexible to permit it traversing the interior of the reducer 20, the off-set tubing 21, and especially the curved interior of the guide 22 and capable of making the bend described thereby. The construction of one such type of flexible conduit capable of traversing guide 22 is illustrated in Fig. 2, wherein it will be seen that the conduit consists of a continuous length of spirally arranged metal strip or ribbon 32 which is so formed as to present a hollow tube or conduit 29, and wherein the abutting edges overlap and are pressed together to form a fluid-proof joint 33. Suitable packing may be interposed between the abutting edges to make them leak-proof, however they are capable of some movement with relation to each other which results in flexibility throughout the length of the conduit without affecting the fluid-tightness of the seal. By virtue of the structure of conduit 29 it is such that it is capable of withstanding a compressive load equal to the weight of a considerable length of such conduit when the same is confined in substantial alignment as by the tubes 11 and 21. The conduits 29 is able to withstand such compressive loads due to the fact that the edges of the spiral metal ribbon, of which it is formed, abut each other and are supported thereby.

To support the pipe 26 and conduit 29 in the well hole, and to lower and raise the same therein and out of, the upper end of pipe 26 is provided with an enlarged hollow head or collar 34, as shown in Fig. 1, to which is connected any suitable type of flexible joint 35 which joins the top end of the pipe 26 and collar 34 to a flexible hose 36 connected to the discharge side of a compression pump 37 provided with an inlet conduit 38 leading thereto. A centrally apertured disc 39 through which pipe 26 passes is mounted beneath the collar 34 so that the collar sets thereon and the pipe 26 is supported by the disc. A bail 40 is formed on the disc 39 and has attached thereto a cable 41 which runs over a pulley 42 supported in any suitable manner, but preferably in the crown block of a derrick, not shown, so that the pipe 26 and conduit 29 can be lowered into and pulled out of the well hole as desired. Cable 41 after passing over pulley 42 proceeds to a drum 43 upon which it is wound. Drum 43 may be caused to rotate in either direction, by suitable power and means not shown, and employed for raising and lowering pipe 26 and conduit 29 out of and into the well hole. Interposed in cable 41 at any convenient point, but preferably at a point between the supporting disc 39 and the pulley 42, there is provided a weight scale or weight measuring device 44 which is designed to measure and indicate the weight of the pipe 26 and conduit 29 when they are extended into the well and suspended from pulley 42 through cable 41 and the supporting disc 39.

In Fig. 3 there is illustrated one form of nozzle which may be employed in the practice of this invention. Here the nozzle is designated by the reference numeral 31, and is adapted to be secured in any suitable manner to the flexible conduit 29. The nozzle is preferably formed of metal, however, it may be made of any suitable material such as glass, or may be formed from any number of suitable plastic materials. In the present instance the nozzle is formed with an interiorly screw-threaded opening at the end 45 thereof, which screws onto the conduit 29 by virtue of the same being formed in this instance of a spirally wound strip of material, such as metal, the outer surface of which serves as threads for engagement with the threads carried by the nozzle. A bore 46 passes longitudinally through the nozzle and is in alignment, or communication, with the interior or bore of the conduit 29. An outlet orifice 47 is formed at one end of the nozzle and is preferably lined with some material which is resistant to and not attacked by the acids or other chemicals which are employed in the practice of this invention. For instance, if hydrochloric acid is to be used, then it will be well to provide the outlet orifice 47 with a glass liner or tube 48 which may be set in and retained by a body of sulfur 49. Obviously, it is not intended to restrict the practice of this invention to the use of any specific type of nozzle, and any suitable nozzle may be employed.

The weight measuring device or scale heretofore referred to is illustrated in Figs. 1 and 4 and may consist of any suitable device 44 for measuring weights of a magnitude comparable with the combined weight of the pipe 26 and tube 29 when they are extended in the well hole and supported by the cable 41. From Fig. 4 it will be seen that the weight measuring device 44, which may be of the spring type, has a pair of short shafts 50 and 51 stationarily secured to the back thereof and which terminate in ring shaped clamps 52 and 53, respectively. A third arm 54, which is materially longer than the arms 50 and 51 is positioned intermediately thereof and in vertical alignment therewith, and is likewise provided on its end with a ring shaped clamp 55. The cable 41 passes through the clamps 52, 55, and 53 of the arms 50, 54, and 51, respectively, and when the upper end of cable 41 is secured, as to the pulley 42, and a load, such as the pipe 26 and conduit 29, is put on the lower end of the cable, that part of the cable threaded through the clamps 52, 55, and 53 will have a tendency to straighten out which will result in the cable exerting a horizontal force to the right on the shaft 54, which force when shaft 54 is connected to the mechanism of the weight measuring device 44 is then translated into pounds and indicated on the scale dial by the pointer thereof so the weight suspended from cable 41 can be ascertained.

Clamps 52, 55, and 53 are of the friction type

which normally hold the scale 44 at one point on the cable 41, but are such that the scale can be conveniently slid up and down the cable for repositioning.

In certain instances, and for the reasons hereinafter to be explained, it will be desirable to augment the flexible conduit 29 with a second flexible conduit concentrically arranged thereabout and extending throughout the length thereof and of at least the major part of pipe 26 disposed in the tubing 11. Such a concentrically arranged conduit or housing conduit 56 is illustrated in Fig. 5, and it is proposed to have the flexible housing conduit 56 concentrically arranged about the flexible conduit 29 and the pipe 26 from a point immediately adjacent the nozzle 31 at which point it is secured to conduit 29 in any suitable manner, to a point above the guide 22 where it is connected to and supported by a pipe or string of rigid pipe 57 which is suitably supported from the surface. Adjacent the nozzle 31 the flexible housing conduit 56 is provided with a plurality of ports, such as the one 58, which may be so formed as to direct a stream of fluid issuing therefrom in a direction away from the nozzle, or in a direction substantially opposite to that of the liquid issuing therefrom.

The flexible housing conduit 56 may be formed of any suitable metal and in any suitable manner, and, for example, may consist of a flexible conduit of sufficient diameter having the same structure as the flexible conduit 29 illustrated in Fig. 2. However, in Fig. 6 there is illustrated a modification of the flexible conduit 29, which is formed of flexible metal and is designated by the reference numeral 59 and is of the bellows type and may be used to replace the conduit 29 previously described, and as before is suspended from a pipe or string of pipe 26. Also illustrated in Fig. 6 is a modified type of flexible housing conduit 60, also of the bellows type and formed of flexible metal. The upper end of the conduit 60 is connected to and suspended from the rigid pipe 57, or a string thereof, the upper end of which is adapted to project out of pipe 15 secured to the casing 10 and is formed with a screw-threaded stub pipe 61, through which a diluent fluid, the purpose and function of which will hereinafter be explained, may be introduced into the conduit 60 and the annular space therein on the outside of conduit 59 for passage through conduit 60 and exit through ports 58. The flexible conduits 59 and 60 may be formed of any suitable material, such as metal, and in any suitable manner, for example as illustrated and described, or in any other suitable form adapted to perform the functions thereof as will hereinafter be taught, so long as they are capable of withstanding a considerable compressive load such as the weight of a material length of their individual structure when the same is confined or substantially confined, such as in the tube 11 and 21.

The practice of this invention is not limited to the use of any particular or specific apparatus, such as that herein described. Such apparatus is given merely as embodiments of mechanism that can be employed to realize this invention, and it is to be understood that this invention is not in any way limited thereto except as by the appended claims. And with respect to the claims hereto attached, the method of practicing this invention is in no way intended to be limited by the claims directed to the apparatus.

The function of the above-described apparatus and the preferred method of practicing this invention will now be described. Assuming that a well hole provided with the casing 10, such as shown in Fig. 1, is to be treated or acted upon in accordance with this invention in order to form a passage or channel in the pay formation thereof, and/or to enlarge existing channels.

The guide 22, provided with a suitable support, such as the pipe 24, is first lowered into the well through the casing. There is then attached to the upper end of the guide 22 the off-set tubing 21 and it is lowered down into the well, and thereafter the reducer 20 is connected to the upper end of the tubing 21 and finally sections of tubing 11 are connected to the reducer, and the entire assembly lowered into the well until the support 24 formed on the guide 22 comes to rest at the bottom of the well hole so as to maintain the guide in the well hole at a point opposite the formation in which the passage or channel is to be formed.

It may be desirable, and in some instances necessary, to position the guide 22 opposite the formation so that the opening 23 in the end thereof faces in a certain direction, so that the channel formed will radiate from the well hole in a predetermined course. With the proper knowledge of the well hole and its formations, which may be already known, or acquired by surveying or coring, the guide 22 may be placed therein so that the channel will radiate therefrom in a controlled and predetermined direction. This can readily be accomplished by lowering the assembly, comprising the guide 22, off-set tubing 21, reducer 20 and tubing 11, down into the well hole until the guide support comes to rest on the bottom of the hole, thereafter the entire assembly may be raised a slight distance upwardly in the well hole, so as to relieve any torque or tendency of the assembly to twist, and then the assembly can be turned slowly so that the guide 22 and the opening 23 therein are facing in the desired and proper direction. Thereafter the entire assembly is lowered into the hole and supported therein by the pipe 24, or by the casing head 12. However, in order not to put unnecessary strain on the assembly comprising tubing 11, the assembly preferably will be supported by pipe 24.

Thereafter the flexible drilling conduit 29, or sections thereof, with the nozzle 31 secured to the lower end thereof, are lowered into the well through the interior of the tube 11. The flexible conduit 29, as made up of the various sections thereof, will preferably be of a relatively short length, for example, from about 50 to 500 feet. After the conduit 29 is lowered into tubing 11, there is then secured to the top end thereof a section of pipe 26 and a plurality of such sections are added until the flexible conduit 29 and its nozzle 31 are lowered into the hole through the interior of the tube 11, reducer 20, off-set tubing 21 and guide 22 until the nozzle 31 and the portion of the conduit 29 immediately attached thereto pass out of the opening 23 of guide 22 and the nozzle contacts the face of the well hole wall, as shown in Fig. 1. That the nozzle 31 has passed through opening 23 of guide 22 and contacted the wall of the well hole can be positively ascertained through the weight measuring device 44. This is possible in the following manner. The weight of the nozzle 31 and of the various sections of the flexible conduit 29 and pipe 26 that are lowered into the well hole through the assembly comprising the tubing 11, are known, or can be readily ascertained or computed. So that as the conduit 29 and nozzle 31 are lowered in to

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the well hole by adding additional sections of pipe 26 to the flexible conduit, the weight of this assembly will increase as additional sections of pipe 26 are added and as it is lowered into the well hole, and the weight of this entire assembly will be measured by and readable on the weight measuring device 44. Thus when the nozzle 31 contacts the wall of the formation as shown in Fig. 1, the weight of part of this entire assembly will then be supported by virtue of the nozzle contacting the well wall, and possibly by the conduit 29 frictionally engaging the interior of guide 22. This condition, and position of the nozzle, will then be apparent as the weight measuring device will then show a lesser reading or weight measurement than before because the cable 41 will not then be supporting the entire assembly in the well hole. Thus in this manner it will be readily ascertainable at the surface through the weight measuring device when the nozzle 31 is in contact with the formation to be drilled, as is shown in Fig. 1.

At this time, when all of the conduit 29 and pipe 26 necessary to cause nozzle 31 to contact the well wall have been lowered into the well, it is then desirable to provide means for later raising and lowering this assembly, comprising the nozzle 31, conduit 29 and pipe 26, out of and into the well hole. This may be accomplished by providing the upper end of the top section of pipe 26 with a collar 34 so that the collar rests on an apertured supporting disc 39, through which the pipe 26 passes, and which in turn is supported by virtue of the bail 40 being secured to the cable 41 which passes over a pulley 42 and is anchored to and wound upon the drum 43. By this arrangement the pipe 26, conduit 29 and nozzle 31 may be entirely or partially supported in the well hole, and may also thereby be lowered into and raised out of the well hole.

When all is in readiness for the actual forming of the channel in the formation the various parts of the apparatus will be in substantially the position as shown in Fig. 1. That is the nozzle 31 will be in contact with the wall of the well hole at the point therein where there is located the formation to be drilled or channeled, or the nozzle may be positioned so as to be adjacent the well hole wall and just out of contact therewith, as is desired, or found to be expedient. This last condition may be realized by raising up on cable 41 a slight distance to disengage the nozzle from the well hole wall. A flexible connection 35 is now secured to the top of pipe 26 and to said connection a flexible conduit 36 is coupled, which in turn is connected to the discharge side of compression pump 37 connected by a pipe or other conduit 38 to a suitable source of acid. In this instance it will be assumed that the formation to be channeled is of calcareous material, such as limestone, and that the acid employed is hydrochloric acid of from about 10 to 25 per cent concentration, although other suitable concentrations of the acid may be employed if found suitable and/or desired.

When pump 37 is started, hydrochloric acid is drawn in through intake pipe 38 and forced from the pump through pipe 36 and connection 35 into the top of pipe 26 under any suitable pressure, sufficient to realize this invention. The acid is then forced down through the pipe 26, or the plurality of sections thereof, and through the flexible conduit 29 and out through the nozzle 31 mounted on the end thereof from whence it issues in the form of a stream of acid under pressure, or a jet of acid, and directed the guide by the nozzle to the formation of the well hole wherein the channel or passage is to be formed. The calcareous formation, such as limestone, will be attacked by the hydrochloric acid and dissolved, or at least partly dissolved, and the initial part of a channel formed therein radiating from the well hole.

If the nozzle 31 is in contact with the formation or adjacent thereto, when the acid under pressure is initially supplied therethrough to attack the formation, it will thereafter form a channel therein, such as shown in Fig. 5, and the nozzle and conduit 29 will progress therein as far as is possible and permissible by the amount of conduit 29 that is in the hole.

This initial progress of the nozzle and conduit into the channel will be caused by the weight of the conduit and pipe 26 supporting it, and by the tendency of said conduit to straighten out and to extend into the well hole, which will be especially true if the conduit is cramped in the assembly comprising tubing 11 through the interior of which it passes. During the progress of the nozzle 31 into the channel, it will remain in substantial contact with the end thereof by virtue of the weight of the conduit 29 and pipe 26, but after a while when the conduit has progressed down into the hole and outwardly into the channel so far as it will due to the amount and lengths thereof originally in the well hole, the nozzle 31 will then have formed a passage or channel of a material length, such as shown in Fig. 5 and the nozzle 31 will no longer be in contact with the end of the channel although the jet or stream of acid will still be functioning to form the channel, although not as effectively as if the nozzle were contacting the end of the channel or was positioned immediately adjacent thereto. When this condition arises, it will be noted on the measuring device 44 that the full weight, or substantially the full weight, of the conduit 29 and pipe 26 and nozzle 31 is being supported by the cable 41. This will indicate that the nozzle is not in contact with the end of the channel and that the end of the channel is not assisting, or materially assisting, in supporting the flexible conduit and pipe 26 in the hole. At this time it is then desirable to move the nozzle 31 forward into the channel and thereby more advantageously reposition it therein for further forming and lengthening of the channel so that the jet or stream of acid is directed to the end of the channel to lengthen and deepen it into the formation, and not wasted by merely enlarging the cross-sectional area thereof.

The nozzle 31 is now moved forward into the channel by unwinding the drum 43 and playing out the cable 41 and thus lowering pipe 26 and conduit 29 further into the well through the interior of the assembly comprising tube 11, reducer 20, off-set tubing 21 and guide 22, and when needed by adding additional sections of pipe 26 to the already existing string thereof. As the pipe 26 and conduit 29 are lowered into the well the weight measuring device will show the weight of this assembly as being entirely or substantially supported from the surface by the cable 41, but as soon as the nozzle 31 again contacts the end of the channel it will serve to support a part of the conduit and pipe 26 that is in the well hole, and the weight measuring device will then show a smaller reading than immediately before and thus apprise the operator that the nozzle 31 is once again in contact with the end of the chan-

nel and repositioned for further forming thereof. At this point the conduit 29 and pipe 26 may be raised slightly if desired so that the nozzle 31 is not in actual contact with the end of the channel but is in extremely close proximity thereto when further drilling is resumed or continued.

During the repositioning of the nozzle in the channel the pump 37 may be stopped so that the acid jet ceases, but this is not necessary unless additional sections of pipe 26 are to be added in which case the connection 35 would be broken and an additional section, or sections, of pipe 26 added to the already existing string thereof.

Thus, by noting the readings on the measuring device 44 and by raising or lowering the pipe 26 and conduit 29, the nozzle 31 may be maintained in constant, or substantially constant, contact with the end of the passage or channel or other formation being drilled by the acid jet, or the nozzle may be maintained at a uniform or substantially uniform distance from the end of said channel or other formation as is desired or found expedient under the conditions encountered.

As the channel increases in length, the nozzle is caused to progress forward by repetition of the steps above described, and, if after the channel has been formed in the formation to a considerable extent and difficulty is experienced in maintaining the nozzle in contact with the end of the channel or adjacent thereto, it may be desirable to apply a positive downward force on pipe 26, which may be done in any desirable manner, to augment the weight of pipe 26 and conduit 29 and thereby positively cause the nozzle to contact the end of the channel or to be positioned adjacent thereto as is desired.

During the application of the stream of acid, or jet thereof, issuing from the nozzle and directed against the formation to channel therein, the dissolved matter and ther cuttings will be washed out of the channel by the force of the acid jet, and into the well hole, where they may be removed at convenient intervals as is necessary by any desired manner such as flushing or bailing them out of the well hole. It is proposed that the top of casing 10 and/or the top of tubing 11 may be left open by the employment of valves 13 and 17 associated therewith, so that the gases generated by the action of the hydrochloric acid on the calcareous formation will be free to escape and not build up and hinder the function of the jet of acid.

In lieu of using a single flexible conduit and drilling or forming passages or channels in a well hole formation as above taught, two concentrically arranged flexible conduits may be employed when arranged substantially as shown in Fig. 5, and both of which may be of the same construction as conduit 29, or of the construction shown in Fig. 6. When using two concentrically arranged flexible conduits, the inner one, such as one of those designated by the reference numerals 29 and 59 illustrated in Figs. 1 and 5, respectively, will function in the same manner as that heretofore described for the flexible conduit 29. But the flexible housing conduit or the outer one, designated by the reference numerals 56 and 60 in the Figs. 5 and 6 respectively, is employed for the purpose of supplying a diluent liquid, such as water, under pressure, which may be introduced thereinto through such pipe as the one 60, shown in Fig. 6, and conducted down through the outer conduit into the channel being formed so that the water or other liquid will issue from the ports 58 and dilute any unspent acid that may be washing back out of the channel, so that the acid in diluted form will not act to attack the walls of the channel and enlarge their cross-sectional area. In this manner, the cross-sectional area of the channel will be kept to a minimum, yet will be formed large enough for the entry thereinto of the flexible conduit, and there will be less danger and chance of the conduit bending or kinking which would tend to result in changing the direction of the nozzle and acid jet, and in shutting of the flow of acid through the conduit.

If desired, the tubing 11 and off-set tubing 21 may be dispensed with and the reducer 20, or a structure equivalent thereto, attached directly to the top of guide 22. In such an instance the top of reducer 20 will preferably be flared or funnel-shaped to such an extent that the upper periphery thereof, while permitting the introduction of the reducer into the casing 10, will be but slightly smaller than the interior of the casing so that when the conduit 29 is lowered into the well hole, the flared or funnel-shaped part of the reducer will intercept the lower end of the conduit and direct it into the guide 22. Or, if desired, only tubing 11 may be dispensed with, in which case a flared or funnel-shaped reducer, as above described, will be connected directly to the top of the off-set tubing 21. However, in either instance the funnel-shaped reducer becomes a primary guide to initially direct the flexible conduit into the top of guide 22. When the tubing 11 and/or off-set tubing 21 are not employed, the funnel-shaped reducer and guide 22 may be lowered into and raised out of the well in any suitable manner desired.

By the practice of this invention as above taught, channels of considerable length may be formed in the formations of well holes at any desired depth and radiating from the well hole at any selected point and angle. The guide 22 may be replaced and interchanged for one having a more acute, or lesser, angle or bend, so that the opening 23 thereof will direct the nozzle 31 to the formation at substantially any predetermined and controllable angle. Additionally, it is to be remembered that the guide 22, or any suitable substitute therefor having a more acute or lesser bend therein, may be positioned in the well hole at any depth therein, and be supported therein by the pipe 24 and/or by the casing head 12, so as to form channels in the well hole formations at any selected depth. Moreover, the tube 11 and its associated parts may be rotated so as to direct the opening 23 of guide 22 to any part of the well hole wall so that the channels formed therein will radiate therefrom at any selected degree, or so that a plurality of channels may be formed at a common depth in the well and into the same formation but radiating from the well hole at various different degrees or points.

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 drilling or forming a channel in a calcareous formation of a well hole, which

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comprises positioning in said well hole a nozzle adapted to effect therefrom a stream of hydrochloric acid supplied thereto under pressure, guiding said nozzle and said stream of acid issuing therefrom to the formation to be channeled so as to drill a channel therein, and measuring the weight of the nozzle suspending means that is supported from the surface and suspended in the well hole to ascertain the position of said nozzle with respect to its proximity to said formation.

2. The method of drilling or forming a channel in a calcareous formation of a well hole, which comprises positioning in said well hole a nozzle adapted to eject therefrom a stream of hydrochloric acid supplied thereto under pressure, guiding said nozzle and said stream of acid issuing therefrom to the formation to be channeled so as to drill a channel therein, measuring the weight of the nozzle suspending means that is supported from the surface and suspended in the well hole to ascertain the position of said nozzle with respect to its proximity to said formation, and diluting said acid after it has served to form said channel.

3. The method of drilling or forming a channel in a calcareous formation of a well hole, which comprises positioning in said well hole a nozzle adapted to effect therefrom a stream of hydrochloric acid supplied thereto under pressure, guiding said nozzle and said stream issuing therefrom to the formation to be channeled so as to drill a channel therein, measuring the weight of the nozzle suspending means that is supported from the surface and suspended in the well hole to ascertain the position of said nozzle with respect to its proximity to said formation and introducing a stream of diluent liquid into said well hole and releasing it at a point adjacent said nozzle to dilute said acid after it has served to form said channel.

4. The method of drilling or forming a channel in a calcareous formation of a well hole, which comprises positionnig in said well hole a nozzle adapted to eject therefrom a stream of hydrochloric acid supplied thereto under pressure, guiding said nozzle and said stream of acid issuing therefrom to the formation to be channeled so as to drill a channel therein, and measuring the weight of the nozzle suspending means that is supported from the surface and suspended in the well hole to ascertain the position of said nozzle with respect to its proximity to the end of said channel formed thereby.

5. The method of drilling or forming a channel in a calcareous formation of a well hole, which comprises positioning in said well hole a nozzle adapted to eject therefrom a stream of hydrochloric acid supplied thereto under pressure, guiding said nozzle and said stream of acid issuing therefrom to the formation to be channeled so as to drill a channel therein, measuring the weight of the nozzle suspending means that is supported from the surface and suspended in the well hole to ascertain the position of said nozzle with respect to its proximity to said formation, and correcting the position of said nozzle with respect to said formation.

6. The method of drilling or forming a channel in a calcareous formation of a well hole, which comprises positioning in said well hole a nozzle adapted to eject therefrom a stream of hydrochloric acid supplied thereto under pressure, guiding said nozzle and said stream issuing therefrom to the formation to be channeled so as to drill a channel therein, measuring the weight of the nozzle suspending means that is supported from the surface and suspended in the well hole to ascertain the position of said nozzle with respect to its proximity to said formation, causing said nozzle to move into said channel as it is formed, and introducing a stream of diluent liquid into said well hole and releasing it at a point adjacent said nozzle to dilute said acid after it has served to form said channel.

7. The method of forming a channel from a well hole into the surrounding formation thereof, which comprises introducing a nozzle suspended on a flexible conduit into the well hole and placing the nozzle therein at a point adjacent the formation to be channeled, supplying a stream of acid under pressure to said nozzle through said conduit and directing said nozzle against said formation and so forming a channel therein with said acid, measuring the weight of said conduit and nozzle that is supported from the surface and suspended in the well hole to ascertain the position of said nozzle with respect to said formation, and correcting the position of said nozzle with respect to said channel and/or formation to expedite the further forming of the channel.

8. The method of forming a channel in well holes, which comprises introducing a stream of acid under pressure through a flexible conduit provided at its discharge end with a nozzle adapted to eject said acid therefrom in the form of a jet, positioning said nozzle in said well hole at a point adjacent the formation thereof to be channeled, directing said nozzle to said formation so as to form a channel therein with said acid, measuring the weight of said conduit and nozzle that is supported from the surface and suspended in said well hole to ascertain the proximity of said nozzle to the end of the said channel, and repositioning said nozzle in said channel to expedite the further forming thereof.

9. A method of forming channels in well holes, which comprises lowering a nozzle suspended from the surface by a conduit into a well hole through a guide contained entirely within said hole, positioning said guide in said well hole with respect to the formation to be channeled, introducing said nozzle into said guide and passing it through the same to a point in said well hole adjacent the formation thereof to be channeled, supplying a stream of acid to said nozzle through said conduit, measuring the weight of said conduit and nozzle that is supported from the surface to ascertain the position of said nozzle with respect to the formation to be channeled, and repositioning said nozzle with respect to said formation to facilitate the forming of the channel therein with said jet.

10. The method of forming a channel in a well hole, which comprises lowering a flexible conduit provided with a discharge nozzle into the well hole through a guide contained therein, orientating said guide in said hole with respect to the formation of said well hole to be channeled, forcing said nozzle through said guide until said nozzle reaches a point in said well hole adjacent the formation to be channeled, introducing a stream of liquid under pressure into said conduit so as to be discharged from said nozzle in the form of a jet to form therewith a channel in said formation, and introducing a second stream of liquid into said well hole and

releasing it therein at a point adjacent said jet of liquid.

11. The method of forming a channel in a well hole, which comprises lowering a flexible conduit provided with a discharge nozzle into a well hole through a guide contained therein, orientating said guide in said hole with respect to the formation of said well hole to be channeled forcing said nozzle through said guide until said nozzle reaches a point in said well hole adjacent the formation to be channeled, introducing a stream of acid under pressure into said conduit so as to be discharged from said nozzle in the form of a jet of acid to form therewith a channel in said formation, and introducing a stream of diluent liquid into said well hole and releasing it therein at a point adjacent said jet of acid.

12. A mechanism for forming or drilling lateral channels in a well hole, which comprises a nozzle adapted to eject therefrom a stream of liquid under pressure in the form of a jet so as to form a channel in a formation of a well hole, a flexible conduit connected to said nozzle for positioning the same in the well hole and for supplying said stream of liquid thereto, and a second conduit for supplying a liquid adjacent to said nozzle to dilute the said stream of liquid issuing therefrom after it has served to form said channel.

13. A mechanism for forming a lateral channel in a well hole, which comprises a nozzle adapted to eject therefrom a stream of liquid in the form of a jet, a conduit connected to said nozzle for lowering it in a well hole and for supplying said stream of liquid thereto, a guide adapted to be positioned in said well hole for directing said nozzle from the well hole to the formation of said well hole to be channeled, and a second conduit for supplying a liquid adjacent to said nozzle to dilute the said stream of liquid issuing therefrom after it has served to form said channel.

14. A mechanism for forming a lateral channel in the formation surrounding a well hole, which comprises a nozzle, a conduit connected thereto for lowering it into the well hole, a guide for directing said conduit and nozzle to the formation of the well hole to be channeled, and a weight measuring device to determine the weight of said conduit and nozzle supported from the surface to ascertain the position of said nozzle with respect to the formation to be channeled.

15. A mechanism for forming a lateral channel or passage in the bore of a well hole, which comprises a nozzle adapted to eject therefrom a stream of liquid in the form of a jet for attacking and dissolving the formation of said well hole and forming a lateral passage therein, a flexible conduit connected to said nozzle for lowering it into the well hole and for supplying thereto said stream of liquid, a guide adapted to be positioned in said well hole for directing said nozzle and conduit from the bore of the well hole to the formation to be channeled, a support for said guide for positioning it in said well hole opposite the formation to be channeled, and a second flexible conduit for supplying liquid to a point adjacent said nozzle.

16. A mechanism for forming a lateral channel in the formation surrounding a well hole, which comprises a nozzle, means for supplying a liquid to said nozzle, additional means for supplying a second liquid to a point exteriorly of but adjacent said nozzle, a guide for directing said nozzle from the bore of the well hole to the formation to be channeled, and a support for said guide for positioning it in said well hole opposite the formation to be channeled.

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