

April 21, 1953

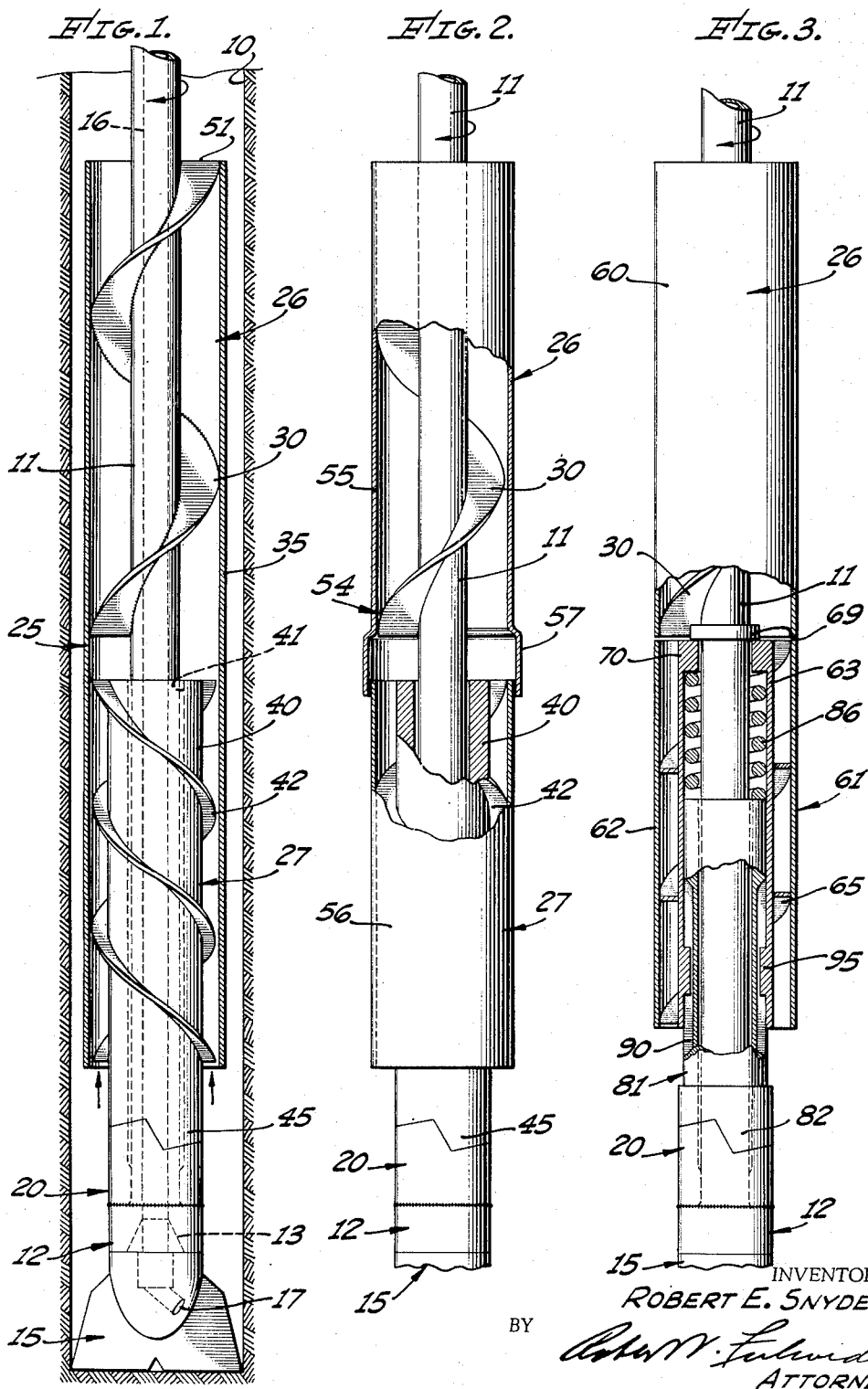
R. E. SNYDER

2,635,852

IMPACT DRILL:

Filed Dec. 5, 1946

2 SHEETS--SHEET 1



April 21, 1953

R. E. SNYDER

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IMPACT DRILL

Filed Dec. 5, 1946

2 SHEETS--SHEET 2

FIG. 4.

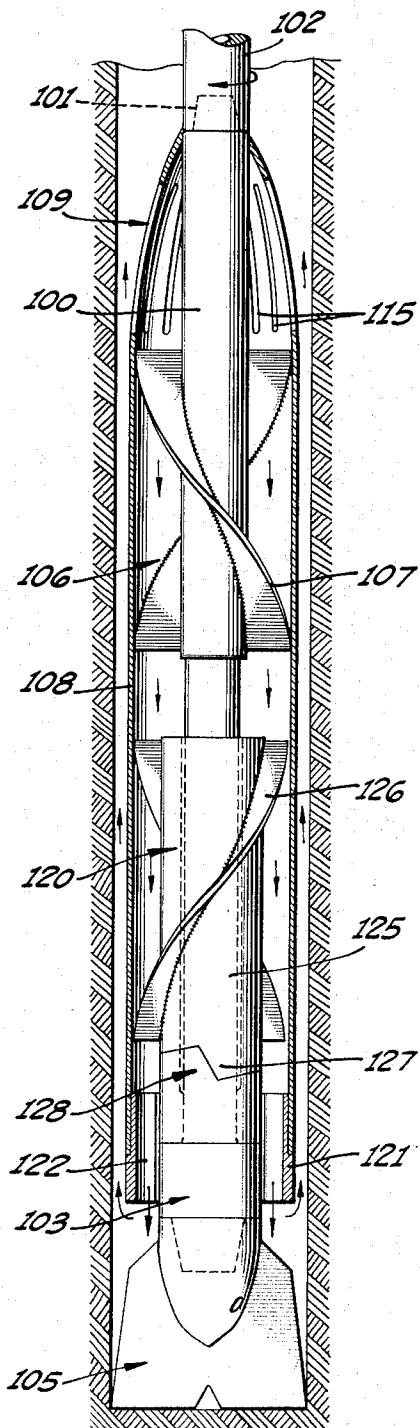
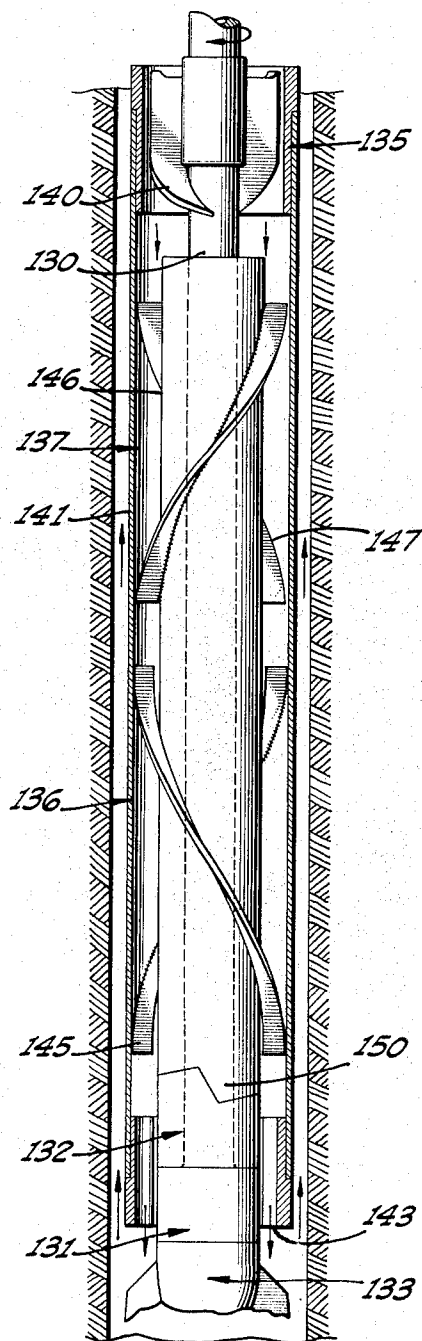


FIG. 5.



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UNITED STATES PATENT OFFICE

2,635,852

IMPACT DRILL

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Application December 5, 1946, Serial No. 714,339

16 Claims. (Cl. 255—3)

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My invention relates generally to drills used in earth boring, and more particularly to a rotary drill having a hammer which impacts against a constantly rotating bit.

In my previous applications Nos. 527,179, filed March 20, 1944, now Patent No. 2,425,012, issued August 5, 1947, and 674,526, filed June 5, 1946, I have discussed the need for impact drills of this general type and have disclosed several different forms of drills. I have also developed another type of drill which operates in a manner basically similar to that of my previously described drills, but which possesses certain features and advantages not found in any of these prior devices. In the present form I provide an impact-producing hammer which is operated by a fluid motor located on the outside of the drill stem. This motor does not derive its power from the pressure of the mud being pumped through the well, as some other devices have done, but instead is operated by the rotary energy of the drill stem which drives an adjacent pump on that stem.

My present invention is an improvement over the disclosure of my copending application Serial No. 527,179, filed March 20, 1944, now Patent No. 2,425,012, issued August 5, 1947, and consists essentially of the addition of a helical-blade fluid pump and motor located on the drill stem near the bit to increase the operating frequency of the impact mechanism.

The present invention provides means to increase the magnitude of the resistance acting against the fluid engaging means of the hammer, thereby causing a greater lagging of the hammer with respect to the drill stem and increasing the frequency of impacts delivered to the bit. Broadly, this is accomplished by placing a fluid pump on the drill stem operated by the rotation of the stem to urge a fluid motor mounted on the hammer in the opposite direction.

It is therefore a major object of my invention to provide a rotary drill having a fluid pump and motor assembly at its lower end to reciprocate a hammer which delivers impacts to a bit. It is to be understood that this system is entirely separate and distinct from the pumping system used to circulate the fluid or mud customarily used in well drilling. Practically none of the energy of the fluid circulatory system is used in my device, and the latter will, in fact, work equally well when rotated by the drill stem if the mud or fluid in the well merely remains there and is not externally circulated.

Another object of my invention is to provide a helical blade fluid pump and a helical blade fluid

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motor which may be placed in close proximity to each other within a well so that the pump recirculates the fluid in the well, outside of the drill stem, to drive the motor.

It is a further object of my invention to provide a fluid pump and motor combination wherein the pumped fluid is adapted to retard the rotation of the motor portion with respect to the drill stem.

Still another object of my invention is to provide a hydraulically-operated rotary impact drill which derives its motive power from the drill stem and which is entirely separate and independent of the fluid circulatory system.

It is still a further object of my invention to provide such a drill in which the discharged fluid may be directed toward the outer surface of the bit to wash the latter.

These and other objects and advantages of my invention will become apparent from the following description of a simple form and modifications thereof, and from the drawings illustrating those forms in which:

Fig. 1 is a side elevational view of an impact drill embodying the principles of the present invention with the housing cut away to reveal the interior construction;

Fig. 2 is a similar view of a modification of the structure shown in Fig. 1;

Fig. 3 is a side elevational view of another modification of the drill shown in Fig. 1;

Fig. 4 is a side elevational view of a device similar to that shown in Fig. 1, but in which the flow of fluid therethrough has been reversed to secure slightly different results; and

Fig. 5 is a side elevational view of a device having a single motor mounted between two pumps.

Referring now to the drawings and particularly to Fig. 1 thereof wherein I have illustrated the simplest form of my invention, the numeral 10 indicates a well or hole formed in the earth by my improved impact drill. The drill includes a shank 11 which is adapted to be attached at its upper end to a conventional drill stem by suitable means (not shown), and which has an operating head 12 at its lower end provided with means 13 for attaching a standard bit 15 thereto. The attaching means 13 and the means for attaching the shank 11 to the drill stem may be of the customary pin and box type threaded coupling commonly used in the art, or any other suitable type. Extending axially through the shank 11 is a bore 16 through which a fluid, commonly termed a "mud," is transferred from the hollow drill stem to the bit 15 where it emerges through an orifice

17 into the drilled hole 10. In the conventional system, this mud is forced by a pump, located on the surface of the ground, through the drill stem to the bottom of the well and then upwardly in the well around the outside of the drill stem, carrying with it the cuttings and other detritus from the drilling operation. In general, the terms drill stem, drill column, and drill string are used interchangeably to describe the assembly of drill pipe, drill collars and other elements making up the shaft suspended in the hole to carry the bit. These terms are used in this generally accepted sense throughout this specification and claims.

On the upper end of the operating head 12 is a lower or shank cam 20 which is firmly attached to shank 11 by welding, threading, or other suitable means to rotate with the shank at all times, and which provides the impact receiving face of the drill. Mounted on shank 11 above the lower cam 20 is a combination hydraulic pump and motor 25 which operates the impact mechanism of the drill. In the form of device shown in Fig. 1, a pump 26 is mounted above a motor 27 and is spaced a slight distance from the latter on shank 11. Essentially, pump 26 comprises one or more helical blades or fluid impellers 30 which are attached to shank 11 by welding or other suitable means to rotate with the latter at all times and drive fluid upwardly. The pitch of the blades 30 is selected so that with the estimated average rotational speed of shank 11, the desired rate of fluid flow will be secured. As mentioned, this flow is directed upwardly around the outside of shank 11, and a guide tube or housing 35 completely surrounds the helical blade 30 and extends downwardly to a point near the lower end of motor 27 to substantially enclose the latter. The housing 35 thus confines and directs the fluid moved by pump 26 so that it passes through the fluid motor 27, and in this form, the housing is suitably attached to the helical blade 30 to rotate with it at all times. Consequently, in the construction of the form shown in Fig. 1, shank 11 has helical blade 30 and housing 35 affixed at its upper end, and operating head 12, bit 15, and lower cam member 20 at its lower end. Since these members are all firmly and rigidly connected, they rotate with the shank as a unitary structure.

Motor 27, which is rotatably and reciprocally mounted on the shank 11 within the guide tube 35, consists essentially of a central tubular body 40 having an axial bore 41 therein of sufficient size to provide for the free movement of the body with respect to the shank. Welded or otherwise suitably attached to the outside of body 40 are one or more helical blades 42 which rotate with the body at all times, and whose pitch is opposite to that of the pump blade 30. The maximum diameter of the helical blade 42 is such that there is a sufficient clearance between the blade and the inside of guide tube 35 to avoid all contact between the two and there is consequently no rubbing of the blades against the guide tube. It will thus be seen that the motor 27 consists of the body 40 with the helical blades 42 rotating within the guide tube 35, and at the lower end of the body, I mount an upper cam 45 which is shaped complementally to lower cam 20 and which is driven by the motor to impact against the lower cam.

When motor 27 is rotated with respect to shank 11, upper cam 45 is rotated with respect to lower cam 20 and overrides the latter to raise the body

40 and then permit it to drop. Sufficient clearance is provided between the upper end of body 40 and the lower end of the helical blade 30 of the pump 26 so that the body may be raised the full distance of the lift of the cams without touching the blade 30. As a result, when the motor 27 is rotated it touches only the shank 11 and the lower cam 20 so that frictional forces are reduced to a minimum. In addition, the overriding of cams 45 and 20 raises the motor 27 and then allows it to drop to deliver an impact to the lower cam 20 which is transmitted to the bit 15. A complete description of an impact drill embodying certain of these features is given in my copending application Serial Number 527,179, now Patent No. 2,425,012, where the operation is also discussed in considerable detail.

In the operation of the rotary impact drill shown in Fig. 1, the entire unit is placed in a hole having fluid therein and lowered until the bit 15 encounters the floor of the hole, whereupon the bit is rotated by revolving the shank 11. Since the hole is filled with fluid, the space between the guide tube 35, and the shank 11 and body 40 will be filled with fluid, and rotation of the helical blades 30 with the shank 11 will urge the fluid upwardly through the housing 35. This fluid will be replaced by other fluid which will enter the bottom of the housing 35 as indicated by the arrows, and will eventually pass out the upper end of the housing, having impinged against the blades 42 of the motor 27 and the blades 30 of the pump 26 during its travel through the housing. Friction between the faces of cams 20 and 45 will tend to drive the motor body 40 in the same direction as the shank 11, but the pitch of blade 42 is such that this rotation would tend to force fluid downwardly. However, the fluid capacity of pump 26 is so much greater than that of motor 27 that the pump is the controlling element, and fluid is forced upwardly, thereby tending to drive the motor in a direction opposite to that of the shank 11.

While the friction between the cam faces tends to rotate the body 40 with the shank 11, the fluid within the well 10 acts upon the blade 42 to provide a frictional drag which opposes this rotation and as a result the body and the upper cam 45 tend to lag behind or be retarded with respect to the lower cam 20. For a more complete description of this operation, reference should be had to my copending application Serial Number 527,179, now Patent No. 2,425,012. It is to be understood that the frictional drag is in addition to the positive drive of motor 27, and both act to retard the rotation of body 40 with respect to shank 11.

It will be realized that the pitch of blades 42 is steep enough to offer substantial resistance to rotation through the upwardly moving fluid but will not be great enough to seriously retard or cushion the fall of the hammer after cam 45 has overridden cam 20. If the pitch of the blade 42 is very flat, there is a tendency for the hammer to float or fall very slowly due to the dashpot action within the housing 35, thereby reducing the magnitude of the impact of cam 45 upon cam 20. However, by proper construction, and the selection of the correct pitch for blade 42, substantial resistance to rotation may be obtained while permitting a very heavy hammer blow to be directed against lower cam 20. The same considerations as to the pitch of the blade extending from the motor body applies to all of the forms

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of the drills shown and described in this specification.

It will be apparent that the guide tube or housing 35 may be rigidly attached to the helical blade 42 of the motor 27 instead of to the blade 30 of the pump 26. This is such an obvious modification that its illustration is not believed necessary in view of the other forms which are shown in this specification. One of the principal results of such a change would be to increase the weight of the reciprocating members so that a greater impact is delivered to the lower cam 20, should such a procedure seem desirable. Another modification, that of reversing the pitch of both the blade 30 and the blade 42 so that the fluid is forced downwardly instead of upwardly, is discussed in conjunction with the modification shown in Fig. 4.

Description of Fig. 2

In Fig. 2 I have shown a modification wherein a portion of the weight of the guide tube or housing is carried by the reciprocating element, while the remainder of the weight is supported by the non-reciprocating element. In Fig. 2, as in Fig. 1, the numeral 11 indicates a shank having an operating head 12 at its lower end to which is attached a bit 15, and which is provided with a lower or shank cam 20. A fluid pump 26 is mounted on shank 11 for rotation therewith, and between the pump and the lower cam 20 is a fluid motor 27 having an upper cam 45 at its lower end adapted to bear against the lower cam 20. A guide tube or housing 54 encloses the pump 26 and motor 27 as in my previously described form, but the tube is formed in two parts, an upper section 55 and a lower section 56. Pump 26 includes a helical blade 30 which is welded or otherwise securely attached to shank 11, and the upper section 55 of guide tube 54 is firmly attached to the blade to be supported by the latter and rotate with it.

Motor 27 includes a rotatable and reciprocable body 40 provided with one or more helical blades 42 mounted on its outer surface and having a pitch opposite to that of the helical blade 30 of pump 26. The lower section 56 of guide tube 54 is firmly attached to the helical blades 42 to move with the latter, and all of the reciprocable elements are designed so that they may be raised the full distance of the rise of cams 20 and 45 without hitting the non-reciprocable elements of pump 26.

At the lower end of upper portion 55 of guide tube 54, the housing is enlarged to form a bell 57 which extends downwardly to enclose the upper end of the lower section 56 of the guide tube. The bell 57 is made sufficiently large so that ample room is provided for the lower section 56 to move within the bell without rubbing or binding, and the lower section may therefore move with the body 40, independently of the upper portion 55 of the guide tube 54. In addition, the provision of the bell 57 insures that all of the fluid moved upwardly by pump 26 will be drawn through motor 27 to drive the latter in a manner similar to that described in connection with the form shown in Fig. 1.

The advantages of this form of my invention will become apparent when it is realized that an element rotating in a very thick or viscous fluid tends to drive a considerable portion of the fluid with it. The rotation of this fluid, because of friction, tends to rotate the next adjacent surface or object so that all rotate as a unit. In

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the form shown in Fig. 1, guide tube 35 rotates at all times with the shank 11 and so tends to rotate the fluid within the housing. This movement of the fluid tends to rotate the blade 42 of motor 27, and acts as an additional frictional force tending to cause the rotation of the motor in synchronism with the shank 11. This force is thus in the same direction as that existing between the faces of the cams 20 and 45 and hence requires the application of a greater contrarotational force to retard the motor 27 with respect to shank 11. If the fluid is not too viscous, the energy transferred thereby from the guide tube 35 to the body 40 is not sufficient to cause a substantial change in the retardation of the body with respect to shank 11.

However, if the mud or fluid used in the well 10 is particularly viscous, the retardation will be decreased and the frequency of impact of the reciprocable elements upon the lower cam 20 will be materially decreased. Consequently, under these conditions I prefer to use the form illustrated in Fig. 2 where the lower section 56 of the guide tube 54 is attached to the blade 42 to rotate in synchronism with the body 40 so that rotational energy of the housing is not transmitted by the fluid to the body. Similarly, the upper portion 55 of the guide tube 54 is connected to the blades 30 so that it rotates in synchronism with shank 11, and there is thus no transfer of rotational energy from the housing to either the pump 26 or motor 27. In addition, the attachment of the lower section 56 of the guide tube 54 to the blade 42 increases the weight of the reciprocable members so that the previously mentioned floating of these members, particularly noticeable in very viscous fluids, is materially decreased.

Description of Fig. 3

To reduce to a minimum any possibility of the reciprocating members floating downwardly to impact against cam 20 when very viscous fluids are used, the form shown in Fig. 3 has been developed in which the vanes or blades of the motor have substantially no axial movement but instead merely rotate about the shank 11. As in the previously described forms, the shank 11 is adapted to be attached to the lower end of a drill string and is provided with an operating head 12 at its lower end which is adapted to receive a bit 15 and has a lower or shank cam 20 rigidly attached to its upper surface. In addition, a hydraulic pump 26 is mounted on shank 11 and driven by the latter, while a hydraulic motor 61 is mounted on the shank between the pump and the lower cam 20.

As in the case of the previously described pumps, pump 26 includes a helical blade 30 rigidly attached to shank 11 and enclosed within a cylindrical guide tube or housing 60 which is firmly attached to it. The guide tube 60 and the blade 30 thus rotate with the shank 11, and cooperate to move fluid upwardly, thereby providing one of the motive sources for motor 61. As will become apparent, the motor 61 is somewhat different from the motor 27 used with the previously described form, since it, unlike the others, reciprocates a hammer member while its helical blades have substantially no axial movement. The motor 61 includes a guide tube or housing 62 which is substantially the same diameter as the pump housing 60 and is aligned with the latter though spaced a slight distance axially therefrom. Centrally mounted within the guide

tube 62 is a tubular body 63 which is rotatably mounted on shank 11, and which is provided with a series of helical blades 65 attached to both the body and the housing 62 so that an axial flow of fluid between the body and the housing will tend to rotate this assembly.

At the lower end of pump 26 I mount a shoulder or collar 69 on shank 11, and provide a cooperating shoulder or collar 70 at the upper end of the tubular body 63 to bear against and be held by the collar 69. Upward movement of the body 63 and the housing 62 is thus limited, and by the proper positioning of collars 69 and 70, there is no possibility of guide tube 62 touching guide tube 60.

Slidably mounted within the tubular body 63 at the lower end thereof is a hammer 81 which is rotatably and reciprocally mounted on shank 11. An upper cam 82, similar to cam 45 and shaped complementally to lower cam 20, is firmly mounted on the lower end of hammer 81. Rotation of upper cam 82 with respect to lower cam 20 will thus raise the hammer 81 and then, as the cams override, permit the hammer to drop and deliver an impact which will be transmitted to bit 15.

To transmit the rotary motion of the hydraulic motor 61 to the hammer 81, the latter is provided with a series of keyways 90 which extend vertically, parallel to the axis of shank 11, and are engaged by one or more keys or splines 95 attached to the inner surface of the lower end of the tubular body portion 63. A sufficient clearance, of course is provided between the hammer 81 and the tubular body 63 to permit the free movement of the hammer with respect to the latter, while the use of keyways 90 and keys 95 insures that the rotary motion of the tubular body 63 will be transmitted to the hammer 81 while the latter moves axially with respect to the body.

To hold the body 63 in its uppermost position, I provide a resilient member such as a spring 86 extending between the upper surface of hammer 81 and the lower surface of collar 70. Like the other members of the hydraulic motor assembly 61, spring 86 is formed to provide a clearance from shank 11 so that a minimum amount of rotational energy is transferred from the shank to the tubular body 63. It will be noted that spring 86 carries the weight of the tubular body 63, the guide tube 62 and the helical blades 65, thereby causing a certain compression of the spring which must be taken into consideration when the drill is being designed. In addition, as cams 20 and 82 approach their crests, spring 86 is further compressed until the cams override, whereupon the spring aids gravity in forcing the hammer 81 downwardly to cause cam 82 to impact against cam 20.

The operation of the form shown in Fig. 3 is somewhat similar to that of the previously described forms in that the pump 26 draws fluid upwardly through the guide tubes 60 and 62 to drive the motor 61 which operates the hammer 81. However, in this form, the spring 86 urges the guide tube 62, tubular body 63, and blade 65 upwardly so that collar 70 bears against collar 69 at all times, and there is thus no reciprocatory motion of these parts of the motor 61. Their rotary motion, however, is transmitted by keys 95, acting in keyways 90, to the hammer 81, so that the latter is reciprocated as it is rotated on shank 11. One distinction of this form from the previously described forms is that hammer

81 is separate from motor 61, whereas in the previously described forms, the hammer and motor were combined in a single unit.

As the rotor of motor 61 rotates with respect to shank 11, hammer 81 will likewise be rotated and consequently will be raised by the action of cams 20 and 82. When these cams override, the energy which has been stored in spring 86 during the raising of the hammer will be returned to drive the hammer downwardly and produce a greater impact between the faces of the cams. It is possible by a suitable choice of springs 86, rotational speed of shank 11 and other miscellaneous factors, to cause the hammer 81 to oscillate at a frequency approximately equal to the natural period of oscillation of spring 86. When this occurs, a condition of resonance may be set up which will even further increase the impact delivered to bit 15. It is apparent that various spring suspensions may be used to achieve this result, and for more information in this regard, reference should be had to my copending application Serial Number 674,526 filed June 5, 1946.

Description of Fig. 4

Another modification of my improved impact drill is shown in Fig. 4, and an inspection of the drawing will show that this form operates in a manner substantially opposite to that of the form shown in Fig. 1. However, certain advantages are secured by this reverse operation which are not obtainable by using the form shown in Fig. 1, and these advantages will sometimes indicate the use of this form in preference to those previously described.

As in my previously described forms, a central shank 100 is provided with an attaching or coupling means 101 at its upper end, adapted to be connected to the lower end of a drill string 102 of the usual type. An operating head 103 is connected to the lower end of shank 100 and is adapted to receive a bit 105 of the type customarily used in earth boring.

Near the upper end of shank 100 I provide a hydraulic pump 106 which includes one or more helical blades 107 welded or otherwise securely attached to the shank 100 and enclosed within a guide tube or housing 108 which is preferably welded to the blades. At its upper end, the guide tube 108 extends for a substantial distance above the helical blades 107 and is "necked in" to form a constricted portion 109 which abuts shank 100 at its extreme upper end. In this constricted region 109 I provide a series of slots or apertures 115 which permit the passage of fluid into guide tube 108 while preventing the admission of larger stones and other detritus therein. In addition, attaching the upper end of the constricted portion 109 to the shank 100 provides a stronger and more rigid construction for this equipment which is normally subjected to very rough usage.

Below pump 106 and above operating head 103 is a hydraulic motor 120 which is similar to the motor 27 previously described in connection with the forms shown in Figs. 1 and 2. As indicated in Fig. 4, motor 120 includes a central body 125 rotatably and reciprocally mounted on shank 100 with one or more helical blades 126 firmly attached thereto. Guide tube or housing 108 extends downwardly below the lower end of blades 107 of pump 106 to enclose the blades 126 of motor 120, and the blades of the latter are provided with a pitch opposite to that of blades 107 so that rotation of the pump in one direction will tend to drive the motor in the opposite direc-

tion. Blades 126, are, of course, provided with sufficient clearance from guide tube 108 so that they may rotate freely with respect to the latter.

The lower end of the central body 125 is provided with an upper cam 127 which is adapted to cooperate with a lower cam 128 mounted on the operating head 123 to raise and drop the reciprocable members including the body 125, blades 126 and cam 127. It should be noted that in this construction, as in the forms shown in Figs. 1 and 2, the motor and hammer are integral and the whole motor reciprocates upon shank 100 when it is rotated with respect thereto.

To complete the drill, the lower end of guide tube 108 is extended downwardly to a point adjacent the operating head 103 where it is provided with a collar 121 which may be held to the operating head, and which is provided with a series of orifices 122 adapted to direct the fluid downwardly onto bit 105. With this construction, guide tube 108 is firmly mounted on shank 100 at both the upper and lower ends of the former and a very rugged device is provided.

In the operation of the device, fluid is forced through the drill string 102 and out through an orifice in the bit 105 from whence it then moves upwardly carrying bits of rock and other detritus with it. When the drill string 102 is being rotated in the direction indicated by the arrow, a portion of this fluid will be drawn inwardly through the apertures 115 of the constricted portion 109 where it will be forced downwardly by the action of pump 106. The fluid then impinges against the blades 126 of motor 120 to urge the blades and body 125 in a direction opposite to that of the shank 100, thereby causing cam 127 to rotate and override the lower cam 128. As a result, the body 125 is raised and then dropped to deliver an impact which is transmitted to bit 105, while the fluid which has completed its passage through housing 108 is directed downwardly by orifices 122 against the bit where a washing action of the latter takes place. This fluid again moves upwardly, on the outside of the guide tube 108, and a portion of it is again drawn in through apertures 115 while the remainder moves upwardly through the well as is customary in such work.

It will thus be seen that the modification shown in Fig. 4 is similar to that shown in Fig. 1 with the exception that the hydraulic motor 120 is located so as to be on the outlet or pressure side of hydraulic pump 106 and the passage of the hydraulic fluid or mud is axially downward through housing 108. Furthermore, this downward movement of the fluid acts to wash the bit 105, and involves a recycling of a portion of the fluid through the housing instead of requiring but a single passage therethrough.

Description of Fig. 5

In Fig. 5 I have shown a modification which combines the forms shown in Figs. 1 and 4 to provide a drill having a centrally mounted fluid motor with a hydraulic pump on either side thereof. The use of such a form will be particularly advantageous where a very viscous fluid or mud is being used, and it is important that the greatest possible amount of energy be delivered to the motor section of the device. In addition, this combination assures a more steady flow of fluid through the motor and minimizes pocketing or buffing action of fluid passing through the pump and impinging upon fluid traveling in an opposite direction from the motor. In this

form, a shank 130 is adapted to be attached at its upper end to a standard drill stem and has an operating head 131 at its lower end. On the upper surface of operating head 131 I mount a shank or lower cam 132, and provision is made for the attachment of a bit 133 to the lower end of the head.

Near the upper end of shank 130 I mount a hydraulic pump 135, and near the lower end I mount a second pump 136. Between the pumps 135 and 136 I mount a hydraulic motor 137 which is driven by the stream of fluid moved by the pumps. Pump 135 includes one or more helical blades 140 which are welded or otherwise securely attached to shank 130 for rotation therewith, and includes a guide tube 141 which encloses pump 135, motor 137, and pump 136. If desired, the guide tube 141 may be provided with apertures at its upper end similar to the apertures 115 of the form shown in Fig. 4, and it is preferably provided with orifices 143 at its lower end which will direct a stream of fluid against the bit 133. Guide tube 141 is firmly attached to helical blades 140 of pump 135, and at its lower end is provided with interiorly extending helical blades 145 which cooperate with the other elements to form pump 136. Helical blades 140 and 145 thus rotate with the shank 130 at all times, and their pitches are so correlated that both tend to move the same quantity of fluid through tube 141 for each revolution of the shank.

Motor 137, which is reciprocally and rotatably mounted on shank 130 between pumps 135 and 136, includes a central tubular body portion 146 having one or more helical blades 147 rigidly attached thereto. These blades 147 have a pitch opposite to that of helical blades 140 and 145 of pumps 135 and 136, respectively, and are formed to have a sufficient clearance between them and the guide tube 141 to permit their free rotation with respect to the tube. Similarly, blades 145 of pump 136 are spaced from the central tubular body 146 so that no rubbing between the two occurs. The lower end of body 146 is provided with a hammer or upper cam 150 which is shaped complementally to cam 132 so that relative rotation of the two cams will cause them to override each other, lifting body 146 and then permitting it to drop to deliver an impact which is transmitted to the bit 133.

The operation of this form of my device is quite similar to that of the previously described forms shown in Figs. 1 and 4. When fluid which has been forced down the drill string emerges from the usual outlet in bit 133, this fluid moves upwardly between the walls of the hole and the outside of guide tube 141 until the top of the latter is reached. At this time, a portion of this fluid is drawn into the guide tube and forced downwardly by the action of blades 140 of pump 135, and the fluid then strikes blades 147 of motor 137. Because of the pitch of the motor blades, the fluid urges them to rotate in a direction opposite to that of shank 130 so that a rotational differential will be set up between body 146 and shank 130. The fluid then passes from motor 137 to pump 136 where blades 145, in effect, suck the fluid downwardly through motor 137 to assist in driving the latter. Fluid from pump 136 is discharged through orifices 143 to impinge against bit 133 and assist in washing the latter. The fluid then passes upwardly between the walls of the hole and the outside of housing 141, and a portion of this fluid is

then recycled by passing it again through pumps 135 and 136, and motor 137. As body 146 is rotated, cam 150 is rotated with respect to cam 132, so that the two override each other and the body is first lifted and then dropped, as previously described, so that when the various frictional forces tending to rotate body 145 with shank 130 are overcome, the body is reciprocated to provide impacts which are transmitted to bit 133.

In the various modifications of this invention which I have illustrated, the drills may be roughly divided into two portions of which the first or driving portion includes the shank, the pump, the driving cam, and the bit. The second or driven portion includes the motor, the hammer, and the driven cam; and the retardation of the driven portion with respect to the driving portion operates the impact means in the drill. In each of the forms shown, the driving portion is rotated by its connection to the drill stem, and the driven portion is urged to rotate with the driving portion by frictional forces, such as that existing between the shank and hammer cams, until the force exerted by the motor means is sufficient to overcome the frictional force. When this occurs, the motor portion rotates with respect to the driving portion, and the hammer portion is reciprocated as described.

The motor portion of the drill may be located either in the inlet or suction side of the pump, or in the outlet or pressure side thereof. I have shown examples of both forms, of which the modifications in Figs. 1, 2 and 3 show the motor in the inlet or suction side, and the form shown in Fig. 4 shows the motor in the outlet or pressure side. In Fig. 5, these two types have been combined to provide a motor between two pumps so that the former is in the pressure or outlet side of one pump and in the inlet or suction side of the other pump. It would be possible, of course, to make a drill having two motors with a pump between them, should this be desired. In addition, it will be apparent that other modifications may be made in these devices, such as the use of an independent hammer and motor combination such as shown in Fig. 3. Various other combinations and modifications may be made which are so numerous as to make description and illustration of them impractical.

The hydraulic pump and motor combination described herein is adapted for use in a wide variety of impact means, some of which are shown in one or more of my copending applications. As previously mentioned, these applications show the use of a hammer which is retarded with respect to a rotated drill stem so that cams between the hammer and the drill override and thereby reciprocate the hammer to deliver impacts to a bit on the drill. In my prior drills, as shown in my previously mentioned copending applications, I have used a rotation retarding means which relies solely on the frictional effects secured by the rotation of blades in a fluid. Certain other drills have used hydraulic power secured from the fluid circulatory system to operate an impact means. Differing from these prior forms, the drill of my present invention provides a self-contained unit operated solely by the rotational energy derived from the drill stem to operate a hydraulic pump and motor combination located in the well hole above the bit to actuate the hammer of the drill.

While I have shown and described different forms of my invention, it will be apparent that

modifications, such as those previously suggested, may be made without departing from the spirit of the invention as disclosed herein, and I do not wish to be limited to the particular form or arrangement of forms herein described and shown or covered by my claims.

I claim:

1. An impact drill which includes: a shank adapted to be rotated; driving means mounted on said shank and attached thereto in such a manner that rotation of said shank drives fluid axially along the outside of said shank; rotor means mounted on the outside of said shank and rotatable with respect thereto, said rotor means including a tubular body member reciprocally mounted on said shank, and said rotor means being urged to rotate with respect to said shank by impingement thereon of the fluid moved by said driving means; and housing means enclosing said driving and rotor means to guide said fluid therethrough; and cam means connected between said rotor and said shank for axial reciprocation along said shank when relative rotation occurs between said rotor and said shank, said cam means including a cam surface attached to the lower portion of said shank for rotation therewith, and a complemental cam surface attached to the immediately adjacent portion of the tubular body member of said rotor means.

2. An impact drill which includes: a shank adapted to be rotated; helical blade means mounted on said shank and attached thereto in such a manner that rotation of said shank is adapted to cause fluid to move axially along the outside of said shank; a fluid rotor mounted on said shank for rotation with respect thereto, and including a body portion and a blade attached thereto in such a manner that said fluid moved by said pump will impinge against said blade to urge it and said body to rotate with respect to said shank; housing means enclosing both of said blade means to guide said fluid therethrough; and cam means connected between said rotor and said shank for axial reciprocation along said shank when relative rotation occurs between said rotor and said shank.

3. An impact drill which includes: a rotatable shank adapted to receive a bit at its lower end; fluid pump means mounted on the exterior of said shank and driven by the rotation of said shank to move a fluid axially along the outside of said shank; fluid motor means mounted on the exterior of said shank for rotation with respect thereto and adapted to be driven by said fluid moved by said pump; and cam means connected between said motor and said shank for axial reciprocation along said shank when relative rotation occurs between said motor and said shank, said cam means thereby causing impacts that are delivered to the bit-receiving end of said shank.

4. An impact drill which includes: a rotatable shank adapted to receive a bit at its lower end; pump blade means mounted on the exterior of said shank and driven by the rotation of said shank to move a fluid axially along the outside of said shank; motor blade means mounted on the exterior of said shank driven by said fluid axially moved by said pump and rotated thereby in a direction opposite to that of said shank; housing means enclosing said pump and motor to guide said fluid through said pump and motor; and cam means connected between said motor and said shank for axial reciprocation along said

shank when relative rotation occurs between said motor and said shank, said cam means thereby causing impacts that are delivered to the bit-receiving end of said shank.

5. An impact drill which includes: a rotatable shank adapted to receive a bit at its lower end; a fluid pump mounted on the exterior of said shank and driven by the rotation of said shank to move a fluid axially along the outside of said shank; a fluid motor mounted on the exterior of said shank for co-axial rotation with respect thereto in a direction opposite to that of said shank and driven by said axially driven fluid moved by said pump; housing means enclosing said pump and motor to guide said fluid moved by said pump through said motor; and cooperating cam means connected to said shank and said motor for operation by the relative rotation of said shank and motor, said cam means thereby causing impacts which are delivered to the bit-receiving end of said shank.

6. An impact drill which includes: a rotatable shank adapted to receive a bit at its lower end; a helical blade attached to said shank for rotation therewith; a housing attached to said helical blade for rotation therewith, and extending below the lower end thereof, said blade having a pitch such that normal rotation of said shank is adapted to urge fluid upwardly through said housing; a tubular body rotatably and reciprocally mounted on said shank below said blade and extending upwardly within said housing; a helical blade attached to and mounted on the exterior of said body for rotation therewith, the pitch of said last mentioned blade being opposite to the pitch of said first-mentioned blade; and cam means attached to and between said body and said shank, adapted to raise said body and then drop it as said body rotates relative to said shank, whereby an impact is delivered to the bit-receiving end of said shank.

7. An impact drill which includes: a rotatable shank adapted to receive a bit at its lower end; a helical blade attached to the outside of said shank for rotation therewith; a housing attached to said helical blade for rotation therewith, said blade having a pitch such that normal rotation of said shank is adapted to urge fluid upwardly through said housing; a tubular body rotatably and reciprocally mounted on said shank below said blade and housing; a helical blade attached to said body for movement therewith, said last mentioned blade having a pitch such that upward movement of fluid along said blade tends to rotate said body in a direction opposite to that of said shank; a second housing attached to said last mentioned blade for movement therewith, and adapted to direct the fluid moved upwardly by said first mentioned blade, along said last mentioned blade, whereby rotation of said shank in one direction tends to establish a rotation of said body in a direction opposite to that of said shank; and cam means attached to said tubular body and said shank, adapted to raise said body and then drop it as said body rotates, whereby an impact is delivered to the bit receiving end of said shank.

8. An impact drill which includes: a rotatable shank adapted to receive a bit at its lower end; a helical blade attached to the outside of said shank for rotation therewith; a housing attached to said helical blade for rotation therewith, said blade having a pitch such that normal rotation of said shank is adapted to urge fluid upwardly through said housing; a tubular body rotatably

mounted on said shank below said blade and housing; a helical blade attached to said body for movement therewith, said last mentioned blade having a pitch such that upwardly movement of fluid along said blade tends to rotate said body in a direction opposite to that of said shank; a second housing attached to said last mentioned blade for movement therewith, adapted to direct the fluid moved upwardly by said first mentioned blade, along said last mentioned blade, whereby rotation of said shank in one direction tends to establish a rotation of said body in a direction opposite to that of said shank; a hammer body rotatably and reciprocally mounted on said shank within said tubular body, and reciprocable with respect to the latter; spring means extending between said hammer body and said tubular body to urge the latter upwardly at all times; and cam means attached to said hammer body and said shank adapted to raise said body and then drop it as said body rotates with respect to said shank, whereby an impact is delivered to the bit receiving end of said shank.

9. An impact drill which includes: a rotatable shank adapted to receive a bit at its lower end; a helical blade attached to the outside of said shank for rotation therewith; a housing attached to said helical blade for rotation therewith and extending below the lower end thereof, said blade having a pitch such that normal rotation of said shank is adapted to urge fluid downwardly through said housing; a tubular hammer body rotatably and reciprocally mounted on said shank within said housing below said blade; a helical blade attached to said hammer body for movement therewith, the pitch of said last mentioned blade being such that downwardly moving fluid will tend to rotate said body in a direction opposite to that of said shank; and cam means attached to said hammer body and said shank adapted to raise said hammer body and then drop it as said hammer body rotates with respect to said shank, whereby an impact is delivered to the bit-receiving end of said shank.

10. An impact drill which includes: a rotatable shank adapted to receive a bit at its lower end; a helical blade attached to the outside of said shank for rotation therewith; a housing attached to said helical blade for rotation therewith, and extending below the lower end thereof, said blade having a pitch such that normal rotation of said shank is adapted to urge fluid downwardly through said housing; a tubular body rotatably and reciprocally mounted on said shank within said housing below said blade; a helical blade attached to said body for movement therewith, the pitch of said last mentioned blade being such that downwardly moving fluid will tend to rotate said body in a direction opposite to that of said shank; a helical blade attached to the interior of said housing below said second mentioned helical blade for rotation with said shank and with respect to said body, the pitch of said last mentioned helical blade being such that it tends to move fluid downwardly through said housing; and cam means attached to said body and said shank adapted to raise said body and then drop it as said body rotates with respect to said shank, whereby an impact is delivered to the bit-receiving end of said shank.

11. An impact drill which includes: a rotatable shank adapted to receive a bit at its lower end; a helical blade attached to the outside of said shank for rotation therewith; a housing substantially co-axial with said shank, attached to

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said helical blade for rotation therewith, and extending below the lower end thereof, said blade having a pitch such that normal rotation of said shank is adapted to urge fluid upwardly through said housing; a tubular body rotatably and reciprocally mounted on said shank, within said housing below said blade; a helical blade attached to and mounted on the exterior of said body for rotation therewith, the pitch of said last mentioned blade being opposite to the pitch of said first-mentioned blade; a cam member attached to the lower end of said shank for rotation therewith; and a complementally shaped cam attached to the lower end of said body, adapted to raise said body and then drop it as said cams rotate with respect to each other by reason of the rotation of said body with respect to said shanks, whereby an impact is delivered to said shank cam which is transmitted to the bit-receiving end of said shank.

12. An impact drill which includes: a rotatable shank adapted to receive a bit at its lower end; a helical blade attached to the outside of said shank for rotation therewith; a housing substantially co-axial with said shank, attached to said helical blade for rotation therewith, and having a bell portion at its lower end, said blade having a pitch such that normal rotation of said shank is adapted to urge fluid upwardly through said housing; a tubular body rotatably and reciprocally mounted on said shank below said blade and housing; a helical blade attached to said body for movement therewith, said last mentioned blade having a pitch such that upward movement of fluid along said blade tends to rotate said body in a direction opposite to that of said shank; a second housing substantially co-axial with said shank and slidably fitting into said bell portion of said first mentioned housing, said housing being attached to said last mentioned blade for movement therewith, and adapted to direct the fluid moved upwardly by said first mentioned blade, along said last mentioned blade, whereby rotation of said shank in one direction tends to establish a rotation of said body in a direction opposite to that of said shank; a cam member attached to the lower end of said shank for rotation therewith; and a complementally shaped cam attached to the lower end of said tubular body, adapted to raise said body and then drop it as said cams rotate with respect to each other by reason of the rotation of said body with respect to said shank, whereby an impact is delivered to said shank cam which is transmitted to the bit-receiving end of said shank.

13. An impact drill which includes: a rotatable shank adapted to receive a bit at its lower end; a helical blade attached to the outside of said shank for rotation therewith; a housing substantially co-axial with said shank, attached to said helical blade for rotation therewith, said blade having a pitch such that normal rotation of said shank is adapted to urge fluid upwardly through said housing; a shoulder formed on said shank at the lower end of said blade and housing; a tubular body rotatably mounted on said shank below said blade and housing; a helical blade attached to said body for movement therewith, said last mentioned blade having a pitch such that upward movement of fluid along said blade tends to rotate said body in a direction opposite to that of said shank; a second housing substantially co-axial with said shank attached to said last mentioned blade for movement therewith, adapted to

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direct the fluid moved upwardly by said first mentioned blade, along said last mentioned blade, whereby rotation of said shank in one direction tends to establish a rotation of said body in a direction opposite to that of said shank; a hammer body rotatably and reciprocally mounted on said shank within said tubular body, and reciprocally with respect to the latter, said hammer body and said tubular body being connected by splines and keyways to prevent the transmission of reciprocable motion therebetween while transmitting rotary motion; spring means extending between said hammer body and said tubular body to urge the latter upwardly against said shoulder at all times; a cam member attached to the lower end of said shank for rotation therewith; and a complementally shaped cam attached to the lower end of said hammer body, adapted to raise said body and then drop it as said cams rotate with respect to each other by reason of the rotation of said body with respect to said shank, whereby an impact is delivered to said shank cam which is transmitted to the bit-receiving end of said shank.

14. An impact drill which includes: a rotatable shank adapted to receive a bit at its lower end; a helical blade attached to the outside of said shank for rotation therewith; a housing substantially co-axial with said shank, attached to said helical blade for rotation therewith, and extending below the lower end thereof, said blade having a pitch such that normal rotation of said shank is adapted to urge fluid downwardly through said housing; a strainer portion formed at the upper end of said housing to prevent the admission therein of large members; a tubular body rotatably and reciprocally mounted on said shank within said housing below said blade; a helical blade attached to said body for movement therewith, the pitch of said last mentioned blade being such that downwardly moving fluid will tend to rotate said body in a direction opposite to that of said shank; jet means at the lower end of said housing to discharge said fluid, after its passage therethrough, against said bit; a cam member attached to the lower end of said shank for rotation therewith; and a complementally shaped cam attached to the lower end of said body adapted to raise said body and then drop it as said cams rotate with respect to each other by reason of the rotation of said body with respect to said shank, whereby an impact is delivered to said shank cam which is transmitted to the bit-receiving end of said shank.

15. An impact drill which includes: a rotatable shank adapted to receive a bit at its lower end; a helical blade attached to the outside of said shank for rotation therewith; a housing substantially co-axial with said shank, attached to said helical blade for rotation therewith and extending below the lower end thereof, said blade having a pitch such that normal rotation of said shank is adapted to urge fluid downwardly through said housing; a strainer portion formed at the upper end of said housing to prevent the admission therein of large members; a tubular body rotatably and reciprocally mounted on said shank within said housing below said blade; a helical blade attached to said body for movement therewith, the pitch of said last mentioned blade being such that downwardly moving fluid will tend to rotate said body in a direction opposite to that of said shank; a helical blade attached to the interior of said housing below said second mentioned helical blade, spaced from said

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tubular body for rotation with respect thereto, the pitch of said last mentioned helical blade being such that it tends to move fluid downwardly through said housing at the same rate as that of said first mentioned helical blade; jet means at the lower end of said housing to discharge said fluid, after its passage therethrough, against said bit; a cam member attached to the lower end of said shank for rotation therewith; and a complementally shaped cam attached to the lower end of said body adapted to raise said body and then drop it as said cams rotate with respect to each other by reason of the rotation of said body with respect to said shank, thereby an impact is delivered to said shank cam which is transmitted to the bit-receiving end of said shank.

16. An impact drill which includes: a rotatable shank adapted to receive a bit at its lowest end; a fluid pump mounted on the exterior of said shank adjacent its lower end for movement therewith, and including a helical blade; a generally tubular member rotatably and reciprocally mounted on said shank for movement with respect thereto; a second helical blade of opposite pitch attached to the exterior of said tubular member for movement therewith, axially aligned with said pump in a manner to be rotated with

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respect to said shank by fluid moved axially along said shank by said pump; a cylindrical member enclosing said helical blades to direct fluid therebetween; and cam means connected between said tubular member and said shank for axial reciprocation along said shank when relative rotation occurs between said tubular member and said shank, said cam means thereby causing impacts that are delivered to the bit-receiving end of said shank.

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