

Oct. 27, 1953

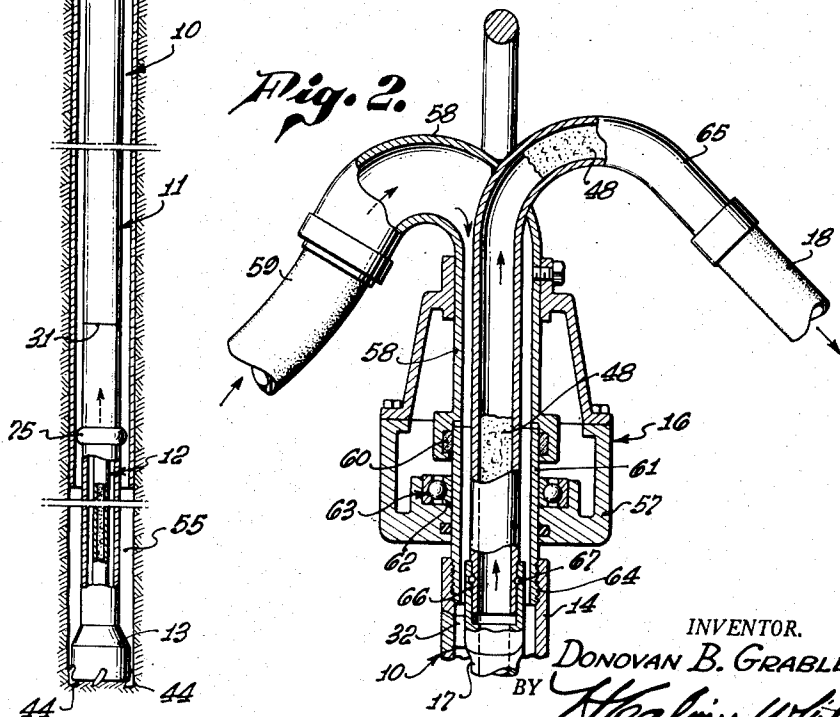
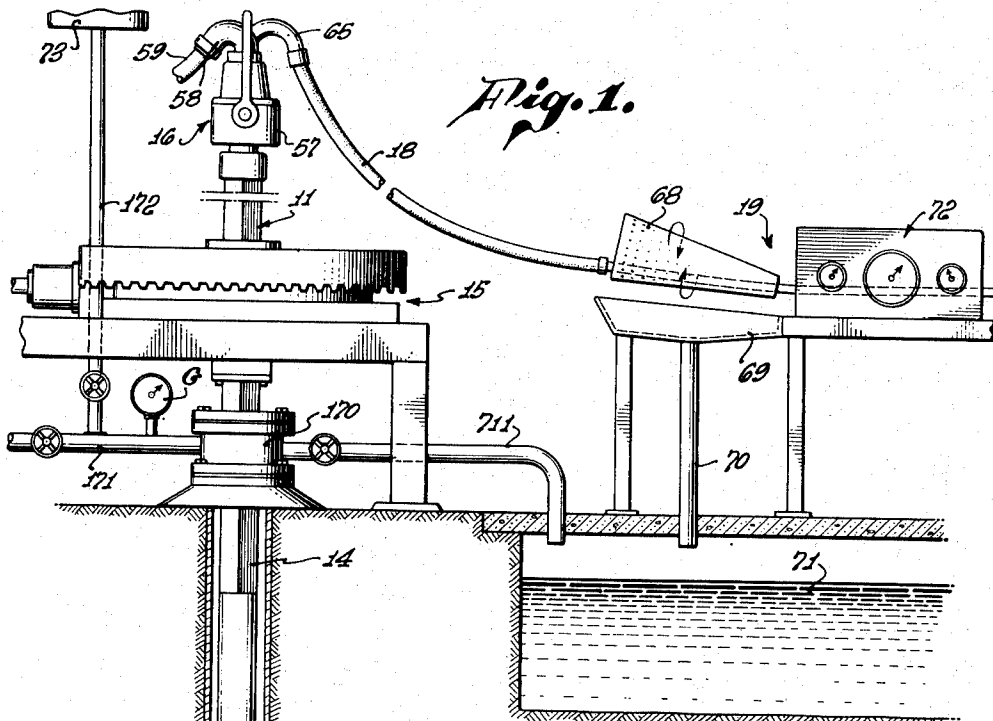
D. B. GRABLE

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FLUID CIRCULATION HEAD FOR DRILL STRINGS

Filed Jan. 20, 1950

2 Sheets-Sheet 1



INVENTOR.

DONOVAN B. GRABLE,

BY *Healdin White*

ATTORNEY.

Oct. 27, 1953

D. B. GRABLE

2,657,016

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Fig. 3.

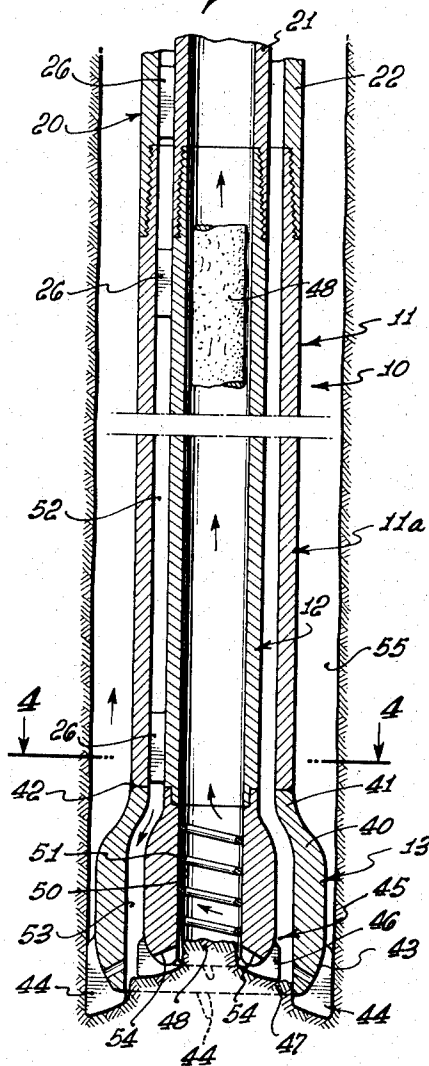


Fig. 5.

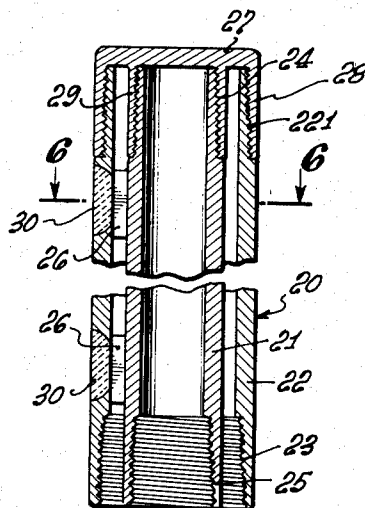


Fig. 6.

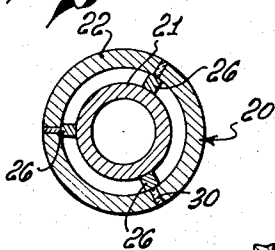


Fig. 4.

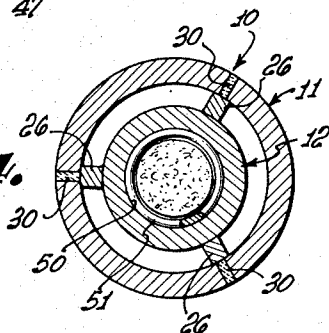
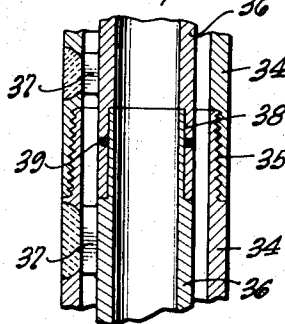


Fig. 7.



INVENTOR.
DONOVAN B. GRABLE,
BY *Walter White*
ATTORNEY.

UNITED STATES PATENT OFFICE

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FLUID CIRCULATION HEAD FOR DRILL STRINGS

Donovan B. Grable, Long Beach, Calif.

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5 Claims. (Cl. 255-25)

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This invention has to do with improved methods and equipment for drilling wells, and has for its general purpose to provide such innovations with respect not only to the drilling of the well bore, but also the procurement and testing of formation or core samples, as will enable a well to be drilled at faster speed and with greater knowledge and control over the various factors entering into the drilling operation, that are possible by the conventional or past practices.

The universal method of rotary well drilling is to carry the bit or cutting tool on a single pipe string through which circulating fluid is pumped down to the bit and then passed with its content of small formation cuttings, upwardly between the drill pipe and wall of the well to the ground surface. Exposure of the formation to the full circulation stream gives rise to such undesirable conditions as washouts, excessive mud deposits on the bore wall, and entrance to the fluid stream of formation particles which may be from sources other than the formation being drilled. This latter condition is particularly troublesome where the geological character of the formation is being determined (as by progressive surface tests of the cuttings) more or less continuously during drilling.

Frequently it is desirable to have and to test core samples of the formation to obtain information not available from the smaller size cuttings. According to conventional practice, drilling must be interrupted and a coring tool run into the well and operated to cut and receive a core, which is removed with the tool itself. Obviously, though at times desirable to obtain cores at closely successive intervals or depths, the nature and expense of the core-taking facilities have placed limitations on the number of cores which practically can be taken.

Briefly, the present invention contemplates a new system of drilling whereby it is made possible to form and displace to the ground surface, a continuous succession of core samples progressively and continuously as the well is drilled, while maintaining a course of circulating fluid flow which substantially isolates the fluid from contact with the formation, and thereby obviates the aforementioned difficulties which result from such exposure.

In accordance with the invention, the well is drilled by a combined cutting and coring tool carried by or connected to a composite drill string comprising an outer pipe spaced about an inner pipe to provide a passage for downward fluid circulation to the tool. As will appear, the lat-

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ter is designed to cut cores smaller than the internal diameter of the inner pipe string, and is adapted for the passage of circulating fluid from between the pipe strings, upwardly about the core and into the inner string so that the successive core pieces are carried progressively as they are formed by the fluid to the ground surface. There, provision may be made for separating the fluid from the cores and continuously passing the latter to an analyzing station, or through any of the known types of formation or core testing apparatus, to provide for continuous testing and recording of the formation characteristics by reference to successive cores.

Substantial isolation of the circulation fluid stream from the formation and bore wall, is accomplished by maintaining at the outside of the composite pipe string a column of fluid preferably exerting at the depth of the cutting tool a pressure greater than that of the circulation at the bit, so that any tendency for fluid displacement is from the outer column into the circulation stream, rather than the reverse. Accordingly, in this manner and by maintaining a comparatively static fluid column about the circulation course, I avoid the customary mud deposition on the wall of the well due to contacting circulation, and effect a fluid seal against entry to the circulation stream of consequential amounts of formation particles from sources other than the location being drilled and cored.

The invention has a number of aspects and details having to do with such features as the form and make-up of the drill string, core bit, swivel and fluid take-off at the ground surface, system of core testing and the general methods of operation in the well.

All these will be understood to best advantage from the following detailed description of certain illustrative practices and embodiments of the invention, as shown by the accompanying drawings, in which:

Fig. 1 is a general view illustrating the well drilling apparatus in conjunction with the core transferring and testing equipment;

Fig. 2 is an enlarged sectional view of the swivel head assembly;

Fig. 3 is a fragmentary enlarged sectional view of the composite pipe string and drill bit;

Fig. 4 is an enlarged cross section on line 4-4 of Fig. 3;

Fig. 5 is a sectional view illustrating a procedure employable in making up a stand of the drill pipe;

Fig. 6 is a cross section on line 5—6 of Fig. 5; and

Fig. 7 is a view illustrating a variational form of pipe string joint.

Referring first to the general illustration of Fig. 1, the well drilling, core producing and testing system is shown to comprise a drill pipe assembly generally indicated at 10 and including an outer string 11 and an inner concentrically spaced string 12 carrying at their lower ends the drill bit 13. The assembly 10 includes a polygonal outer Kelly section 14 connected to the pipe 10 and extending through the swivel 16, and an inner pipe section 17, see Fig. 2, connected to the pipe 12 for passage of circulating fluid and core sections through the swivel and hose 18 to the fluid separating and testing equipment generally indicated at 19.

Considering at this point Figs. 3 to 7, the concentric drill pipe strings 11 and 12 may be made up of connected stands 20, see Fig. 5, each comprising inner and outer pipe sections 21 and 22 of corresponding length, at least the outer section being terminally threaded at 22' and 23 typically to form threaded pin and box ends. In the form of Fig. 5, the inner section 21 has similar threaded pin and box ends 24 and 25, the thread pitch or lead of which corresponds to the outer section threads at 22 and 23. In making up a composite pipe stand, circularly spaced supports or ribs 26 may be welded to the inner section 21, say at locations near its threaded ends, and the pipe then inserted within the outer section 22. By then screwing onto the sections and to the shouldered position shown in Fig. 5 a setting cap 27 having threaded flanges 28 and 29 carrying threads corresponding to the threads on the pipe sections 21 and 22, and having the threads starting axially and circularly of the cap at exact corresponding positions, the pipe sections are brought into corresponding alignment with the thread position. With the sections thus aligned, the outer pipe may be cut through at the location of the ribs 26 and filled with welds 30 integrally bonding the ribs and through them the inner section 21, in concentric spaced relation.

The stands 20, thus preassembled, may be connected in end to end relation in making up the pipe string. As will be understood, the kelly 14 and inner pipe 17 may be similarly made up by threaded ends at the joint 31, see Fig. 1. At the upper end of the kelly, pipe 17 may be left unthreaded but attached to the outer section by ribs at 32.

It is contemplated that instead of providing for threaded joints between both the inner and outer sections of successive stands, I may provide simply for a sealed telescopic interfit between successive inner sections. Thus, referring to Fig. 7, the outer sections 24 are interconnected by threaded joint 35, while the inner sections 36 concentrically supported by the welded-in-place ribs 37 are telescopically interfitted at 38. Fluid leakage between the telescoped ends may be minimized or prevented by use of a seal ring 39.

Referring now to Fig. 3, the core cutting tool or bit 13 comprises a body 40, the shank 41 of which is secured at 42 to the bottom pipe stand 11a. As illustrative, I have shown at 42 a welded joint, although it is apparent that if desired either form of the threaded joints illustrated in Figs. 5 and 7 may be employed. At its bottom, the bit has an outer annular cutting portion or face, generally indicated at 43, carrying for ex-

ample a circular arrangement of cutters 44, and an inner, upwardly offset core cutting portion, generally indicated at 45, which may carry circularly arranged cutters 46 of suitable type. The cutting face 43 operates to drill the formation about a relatively large diameter core 47, which is reduced by the cutting face 45 down to a reduced diameter core 48 somewhat smaller than the internal diameter of the inner pipe string 12. Thus as the bit penetrates the formation, there is continuously formed a core, or successive core sections which enter the bore 50 wherein the core is engaged by a spiral projection 51 which may serve the two-fold purpose of spacing the core from the bore wall, and of exerting an elevating influence which, together with the circulation flow, displaces the core upwardly into the string 12. The core 48 will tend to sever into successive lengths or sections, to be carried as formed and severed, upwardly through the drill string to the ground surface. During drilling, a continuous circulation of fluid, which may have relatively low density and little content of any of the usual weight additives, is circulated downwardly through the annular passage 52 between the pipe strings and circularly arranged passages 53 in the bit 40, to be discharged beneath the cutting face 45, as through channels 54, upwardly through the bore 50 and string 12. The circulation fluid stream thus directed, and substantially isolated from the well bore at 55 outside the pipe string, carries away the relatively small formation particles being cut by the bit while the core pieces 48 are displaced up through the pipe string.

The swivel assembly 16, and as particularly illustrated in Fig. 2, comprises a body 57 containing a gooseneck 58 supplied with circulating fluid from the hose 59. The lower end of the gooseneck has sealed engagement at 60 with a rotating tube 61 carrying the inner race 62 of the roller bearing assembly 63. The tube 61 is screwed at 64 into the kelly. A second gooseneck 65 extends downwardly within gooseneck 58 and the tube 64 into telescopic relation at 66 with the rotating inner section 17 of the Kelly stand. Suitable seal means, such as one or more rings 67, prevents fluid leakage at the joint 66. As will be apparent, by virtue of the illustrated swivel head assembly construction, rotation of the Kelly stand is permitted while the swivel body and goosenecks remain stationary, with circulating fluid being discharged from hose 59 downwardly through the pipe string passage 52 into the bit and thence returned, together with the cuttings and core sections to be discharged through the gooseneck 65.

As previously indicated, provision may be made for continuously separating fluid from the core sections being taken from the well, and for continuously thence passing the cores through an analyzer station. As illustrative, the circulating fluid and cores are shown to be discharged through hose 18 to a diagrammatically illustrated rotating screen 68 through which the circulating fluid separates for collection in basin 69 and drainage through pipe 70 into the mud sump 71. From the screen 68, the core samples are advanced to or through suitable formation analyzing equipment, conventionally indicated at 72, which may be in the nature of the mobile or portable analyzer equipment currently in use for determining the properties and characteristics of formation cuttings brought to the ground surface by fluid circulated according to the customary methods.

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It is contemplated that fluid circulation through the composite drill string 10 under normal operating conditions, be substantially isolated from the well bore 55 outside the pipe string. For this purpose I maintain in the well and particularly at the depth of the bit 13, a pressure sufficiently great as to resist the tendency of the fluid circulation to pass openly into the well bore, instead of entering the return string 12. Such pressure condition preferably is established by maintaining about the pipe string a fluid column exerting at the depth of the bit a hydrostatic pressure greater than the circulating fluid pressure at the bit. The outer hydrostatic column may be composed of a relatively high density liquid, such as water rather heavily loaded with weight additives, extending to the ground surface. The hydrostatic column may be kept at the level of the casing head 170 by continuously feeding the heavier fluid under pressure through line 171 and at a rate compensating for any removal of the column fluid into the circulation stream at the bit 13. Should it be desired to feed the heavier fluid to the well column through a gravity system, the fluid may be discharged into line 171 through stand pipe 172 leading from a supply tank 73 sufficiently elevated to assure that the pressure of the hydrostatic column at the bit will exceed that of the circulation fluid at the same location.

The drilling methods and operations will be understood from the foregoing description. Certain further observations may be made however, with respect to the maintenance of proper drilling conditions and the capacity of the system for indicating that improper drilling conditions may at times exist. Normally, the fluid will have relatively free circulation down through the passage 52 and upwardly into the bit and inner drill string 12. And some flow of the heavier or higher pressure fluid will occur from the hydrostatic column in space 55 across the working faces of the bit into the circulation fluid stream. In the event of an adverse operating condition, such as a plugged bit which may tend to divert the circulation from passage 52 outwardly into the well, or in the event of a more or less sudden intrusion of liquid or gas from the formation into the well, reliance may be had upon a resulting displacement or pressure increase of the hydrostatic column at the ground surface, to indicate the necessity for modifying operations to correct the condition. Sudden sub-surface intrusion of fluid into the hydrostatic column will be indicated either or both by an excessive overflow through pipe 70 to the sump 71 and pressure increase in line 171 as may be indicated by the gauge G. To prevent fluid up-surge, or transmission of excessive pressure to line 171, I may apply to the drill string 10 at any suitable depth in the well, an annular restrictor or packer 75, the size of which is sufficiently great to check and attenuate a sudden upward fluid surge, while being sufficiently small to pass the hydrostatic column fluid downwardly at the rate at which it may be taken into the circulation fluid stream.

The invention contemplates and has adaptability to a modified general method of drilling where the removal of loose formations subject to caving into the well bore, is particularly desirable. Ordinarily, a given well may be drilled through sandy or other loose formations which if unrestrained, would tend to slough off into the well bore to a degree roughly determined by the angle of repose of the loose formation in any

particular instance. According to customary drilling practices, the circulation of drilling mud up through the well bore maintains against such loose formations sufficient pressure to allow relatively little sloughing off. Because of expectable difficulties that may be encountered by cave-ins subsequent to the drilling or completion of the well, it may be desirable to assure initial removal of all loose formations to the extent that the sand or the like will assume and resist further sloughing off, from its characteristic angle of repose.

Pursuant to this contemplation, drilling operations may be conducted by maintaining a circulation of air downwardly through passage 52 and upwardly through the smaller diameter string 12, at a velocity sufficiently high to conduct the core sections and bit cuttings to the ground surface, and at least during successive drilling periods, to the complete exclusion of any liquids or drilling muds either inside or outside the pipe string. Thus in the absence of any liquid or hydrostatic pressure against the bore wall, loose formations will tend to cave-in to the well until the loose formation sloughs off to its angle of repose. Then as the caved-in sands and the like accumulate in the bottom of the bore hole, the drill string 10 may be elevated somewhat, if necessary, and an appropriate liquid or drilling mud pumped down through either passage 52 or the inner string 12 and upwardly around the composite string into the well bore 55 and to the ground surface. In this manner the caved-in materials are carried out of the well and the latter is cleaned for continuance of drilling by air circulation in the manner previously described.

I claim:

1. For connection to the upper ends of a well drilling kelly and an inner pipe contained therein and spaced therefrom; a swivel assembly comprising a single hollow body structure having a bottom wall containing an opening, a vertically extending tube connectable to said kelly at a location beneath said bottom wall and journaled in said opening in the bottom wall for rotation relative thereto about a vertical axis, said tube extending upwardly through said wall opening into the hollow body, said body having an upper wall containing an opening at a location spaced above said bottom wall and located higher than the upper end of said tube, a fluid inlet pipe attached to said upper wall and extending downwardly through said opening therein and into said hollow body, said fluid inlet pipe being in communication with said rotatable tube at a location within the body, fluid seal means within said body preventing fluid leakage between said pipe and tube, and a fluid outlet pipe extending downwardly within said inlet pipe communicable with said inner pipe in the kelly and to which said inner pipe is rotatably connectable.

2. A swivel assembly as recited in claim 1, in which said hollow body comprises separately formed upper and lower sections attached together and forming said upper and lower walls respectively.

3. A swivel assembly as recited in claim 1, in which said fluid outlet pipe extends into the body through said opening in the upper wall and within said inlet pipe, and extends downwardly within said tube and through said bottom wall to a lower end which communicates with said inner pipe in the kelly.

4. A swivel assembly as recited in claim 1, in which said inlet pipe comprises a one piece tubu-

lar gooseneck extending upwardly through said upper wall opening and then curving laterally, and said outlet pipe comprises a one piece tubular gooseneck extending upwardly through said upper wall opening within said inlet pipe and then extends through an opening in the wall of said inlet pipe and curves laterally.

5. A swivel assembly as recited in claim 1, in which said hollow body comprises separately formed upper and lower sections attached together and forming said upper and lower walls respectively, said inlet pipe comprising a tubular gooseneck extending upwardly through said upper wall opening and then curving laterally, and said outlet pipe comprising a second tubular gooseneck which extends upwardly from beneath the body through both of said openings and the body and then through an opening in the wall of said inlet pipe and then curves laterally.

DONOVAN B. GRABLE.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,071,199	Andrews	Aug. 26, 1913
1,280,159	Carmichael	Oct. 1, 1918
1,547,461	Steele	July 28, 1925
1,703,390	Duffy	Feb. 26, 1929
1,909,075	Ricker et al.	May 16, 1933
2,054,859	Kitching	Sept. 22, 1936
2,120,132	Hawkins	June 7, 1938
2,373,323	Macready	Apr. 10, 1945
2,507,122	Smith	May 9, 1950
2,514,585	Natland	July 11, 1950
2,528,955	Hayward	Nov. 7, 1950
2,537,605	Sewell	Jan. 9, 1951

FOREIGN PATENTS

Number	Country	Date
407,051	France	Dec. 20, 1909