

Feb. 22, 1966

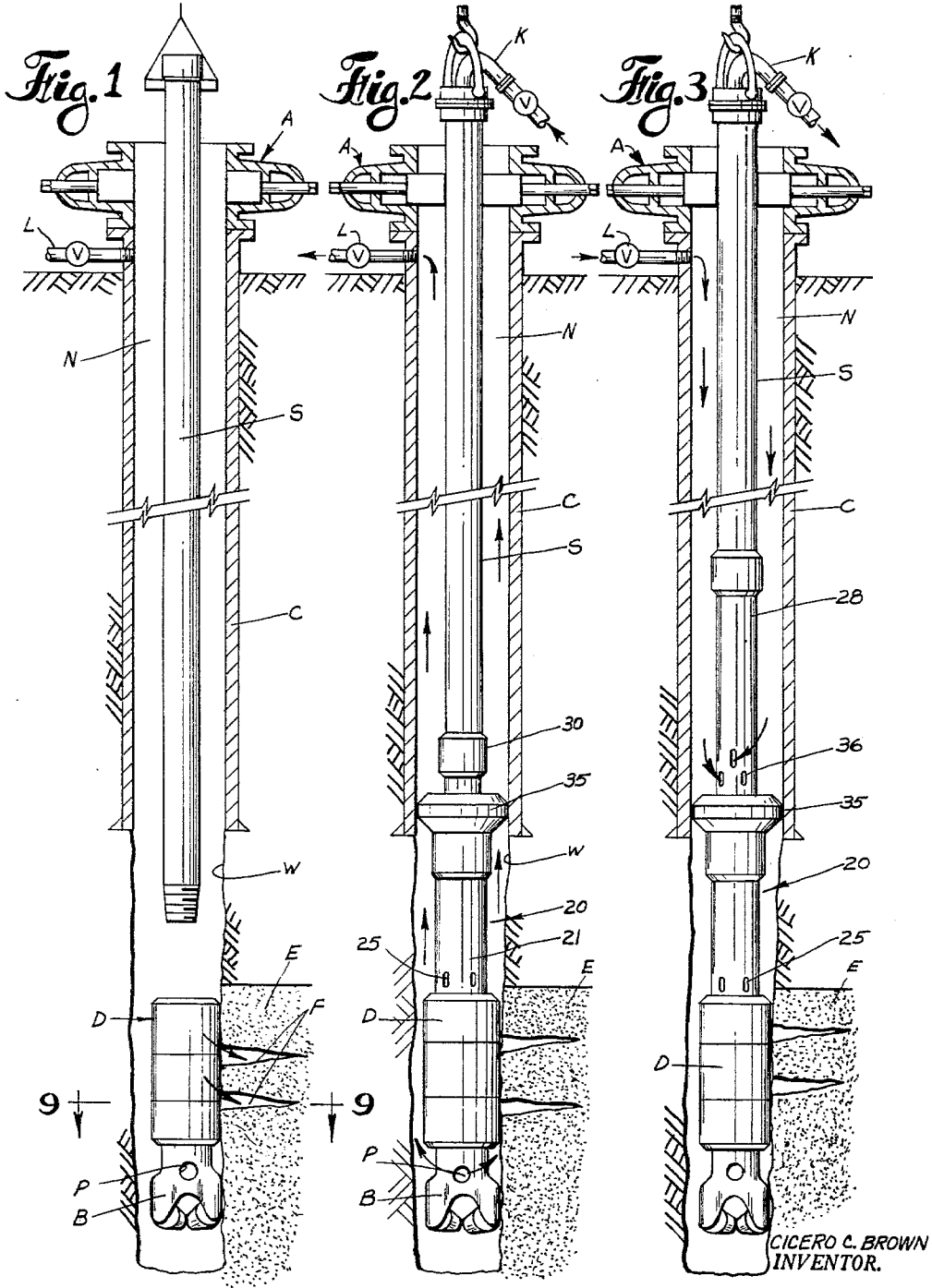
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METHOD AND APPARATUS FOR RELEASING WALL-STUCK PIPE

Filed Jan. 11, 1962

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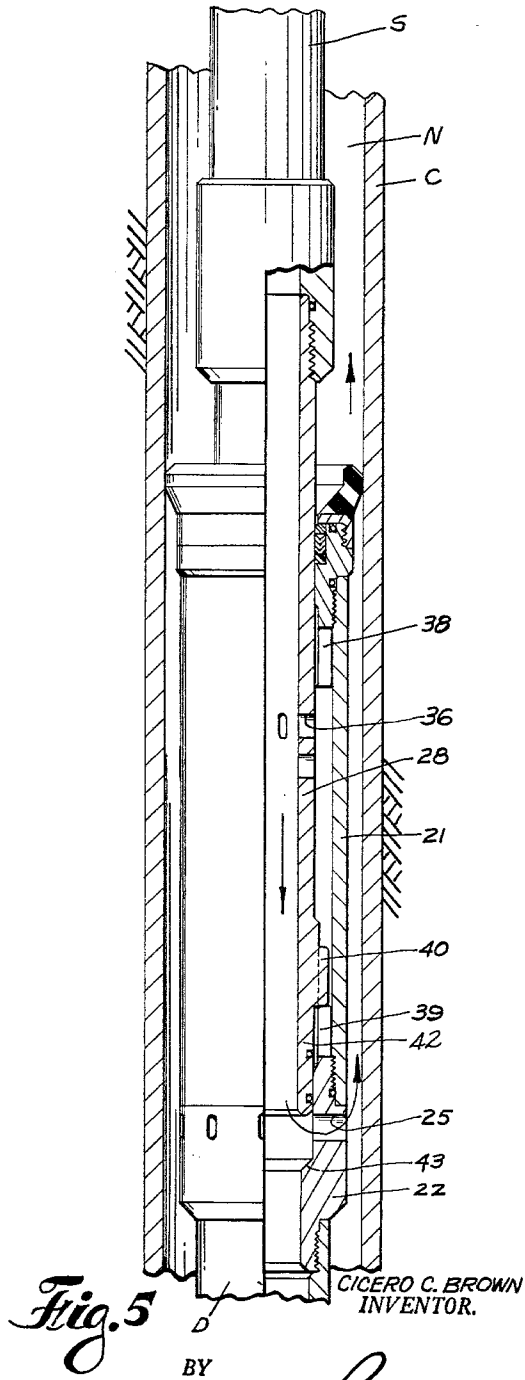
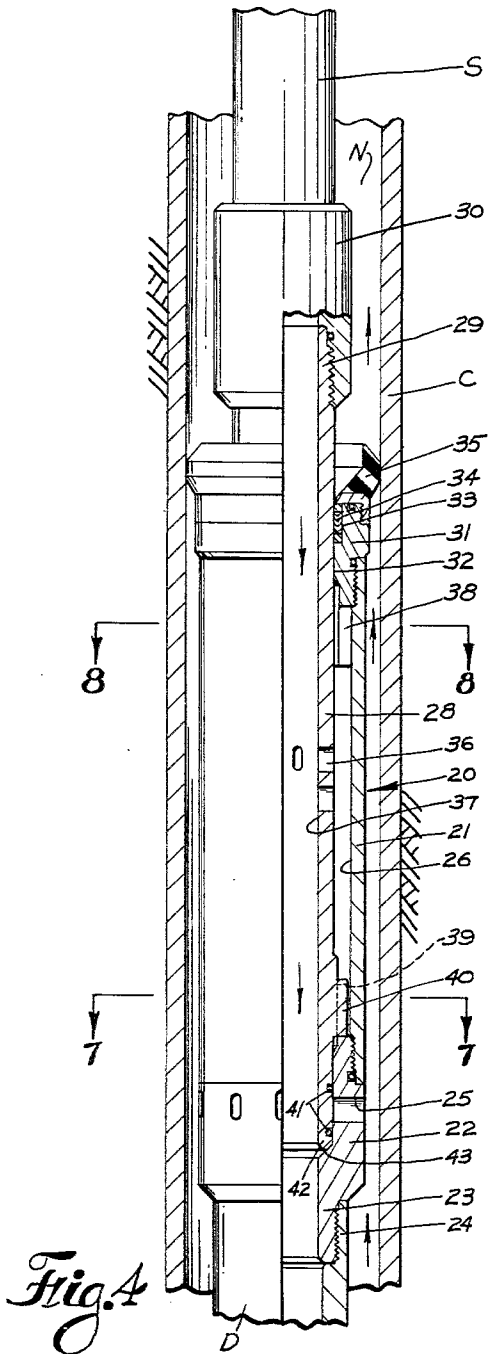
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METHOD AND APPARATUS FOR RELEASING WALL-STUCK PIPE

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5 Sheets-Sheet 2



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METHOD AND APPARATUS FOR RELEASING WALL-STUCK PIPE

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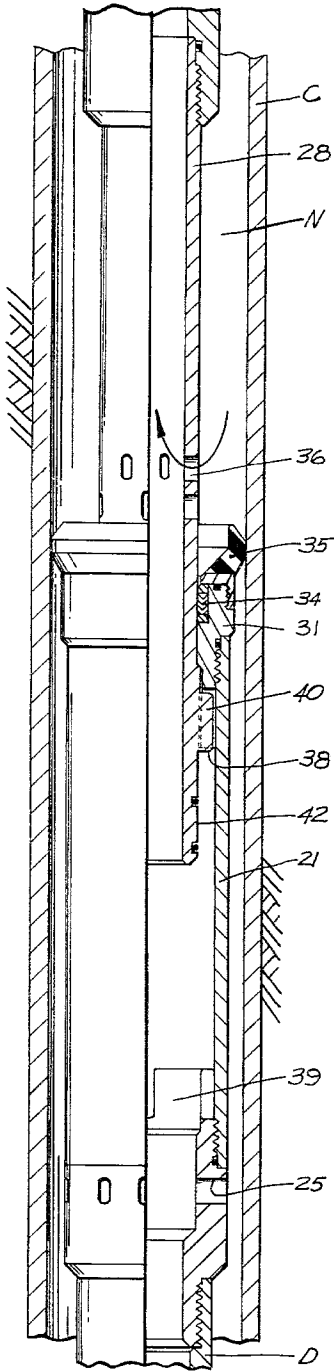


Fig. 6

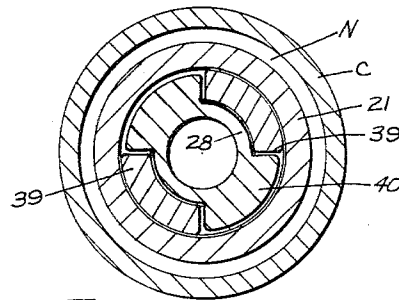


Fig. 7

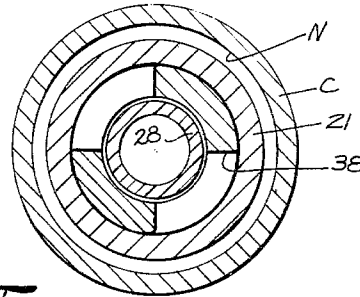


Fig. 8

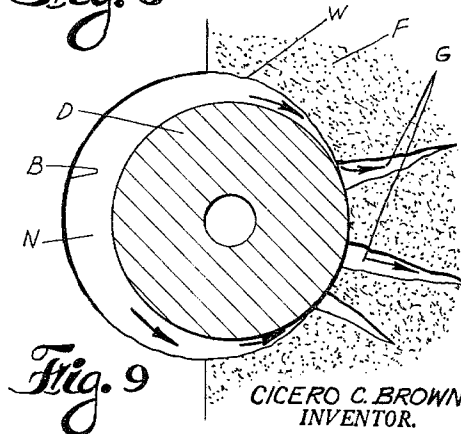


Fig. 9

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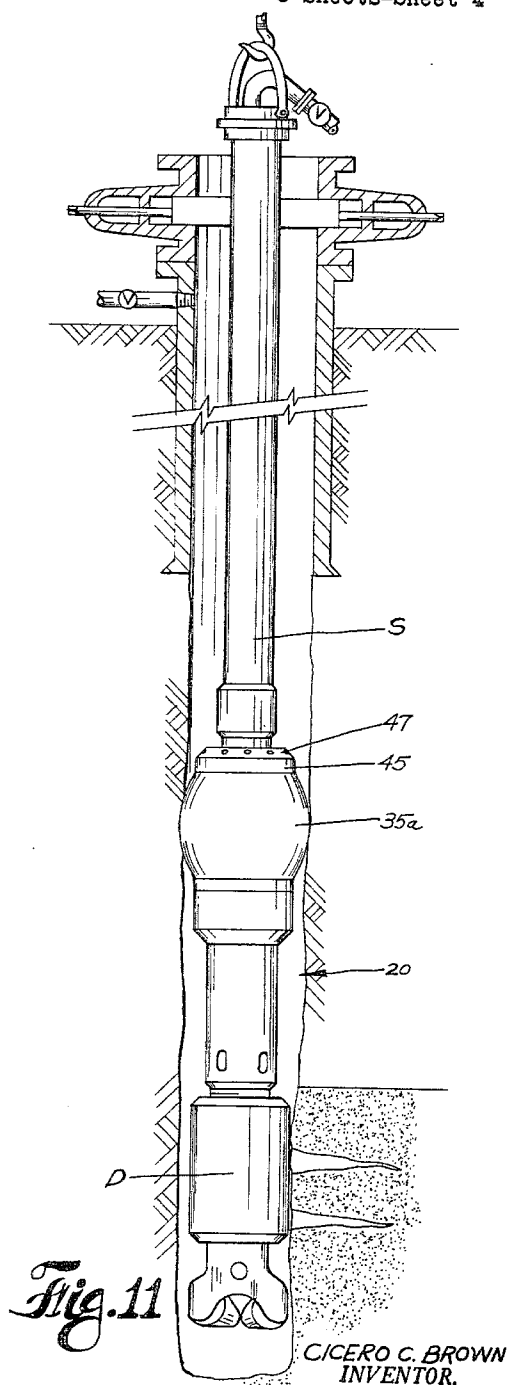
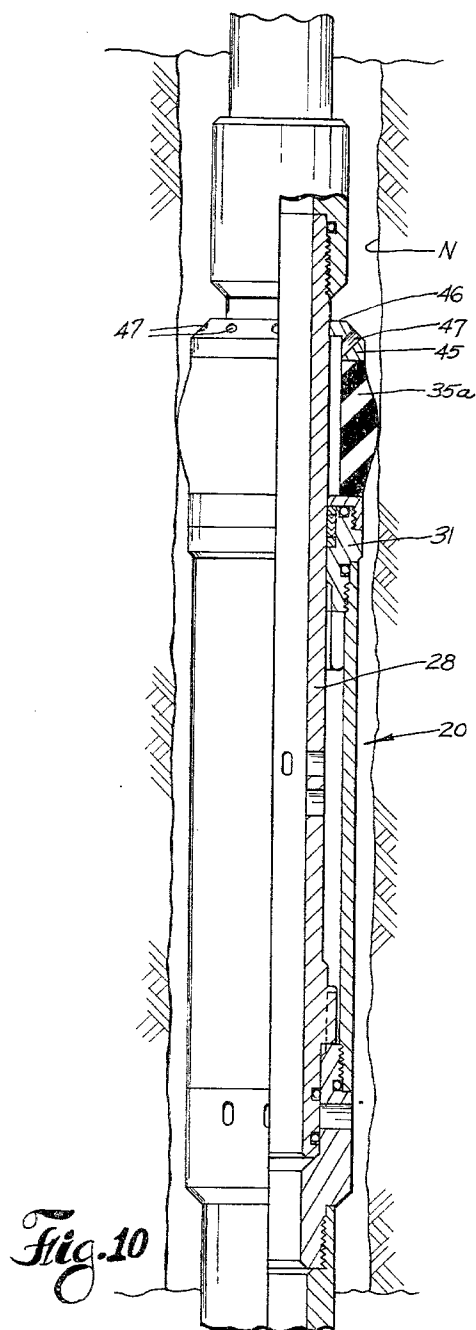
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METHOD AND APPARATUS FOR RELEASING WALL-STUCK PIPE

Filed Jan. 11, 1962

5 Sheets-Sheet 4



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METHOD AND APPARATUS FOR RELEASING WALL-STUCK PIPE

Filed Jan. 11, 1962

5 Sheets-Sheet 5

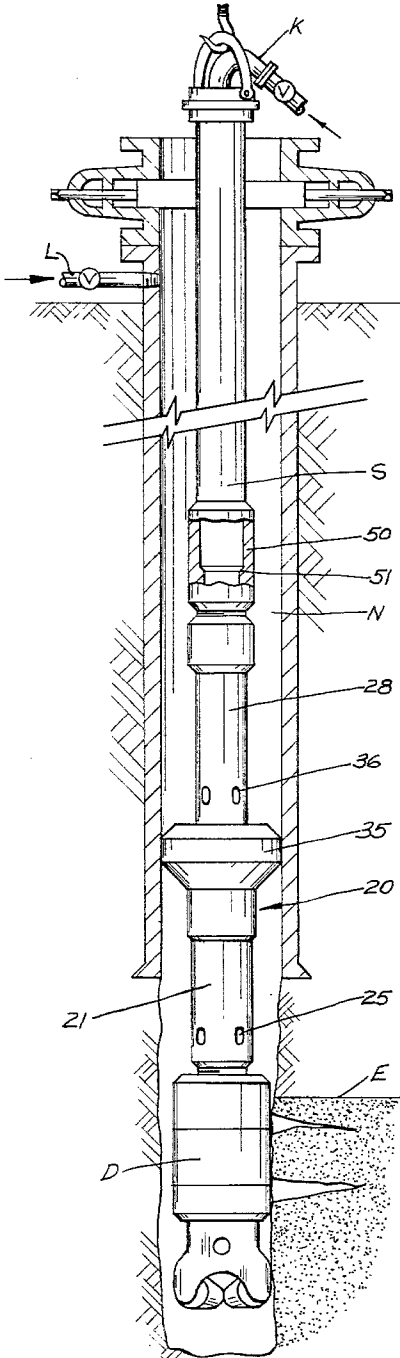


Fig. 12

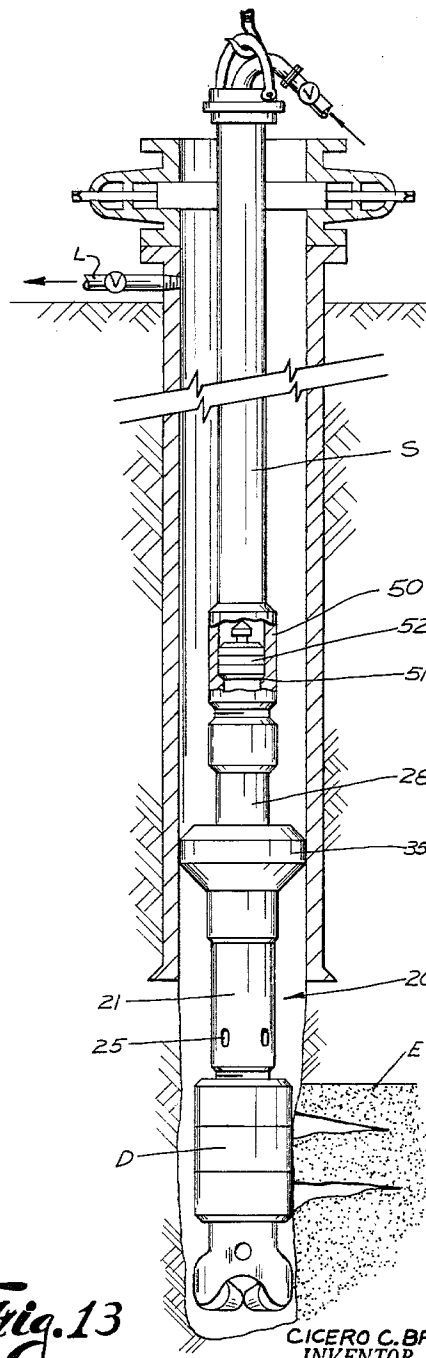


Fig. 13

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3,236,307 METHOD AND APPARATUS FOR RELEASING WALL-STUCK PIPE

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Filed Jan. 11, 1962, Ser. No. 165,596

13 Claims. (Cl. 166-43)

This invention relates to a method and apparatus for releasing wall-stuck pipe in a well.

"Wall-stuck" pipe is the term commonly used in the oil well drilling industry to describe a condition which is encountered during rotary drilling in which the differential in pressure between the hydrostatic head of the drilling mud in the well bore and the formation pressure in a permeable or porous formation along the bore hole forces the drill pipe against the face of the formation and holds it tightly in engagement with the face of the formation under the differential pressure so that the pipe string cannot be released either by rotation or by pulling, or even by conventional jarring in many cases. This condition occurs usually when the drill string, particularly the lower portion comprising the relatively larger diameter drill collars, has been held stationary for at least a short time opposite a permeable earth formation. Since the weight of the drilling fluid will normally be maintained so that the hydrostatic head of the drilling fluid exceeds the formation pressures in order to prevent blow-outs, the conditions for causing drill pipe to become wall-stuck will usually be present and will become effective, as indicated, when rotation of the drill string is stopped, particularly while the drill collars are opposite a permeable formation. Ordinarily, when wall sticking does occur in the manner described, circulation can still be maintained through the drill string in the normal manner, this being one of the usual indications that the drill string is wall-stuck, rather than that the sticking might be due to some other condition in the well, as by cavings about the bit or the like.

Heretofore, various methods and apparatus have been employed in effecting release of wall-stuck pipe. One of the more common methods is to back-off the portion of the pipe string above the point at which the pipe is stuck and attach to the end of the released pipe a string of tools, including conventional drill stem test tools. The thus equipped pipe is then run back into the well and connected to the stuck portion of the pipe string. Then by opening the valve in the drill stem tester, while sealing off the well bore above the stuck point, the pressure differential will be reduced sufficiently to often result in release of the stuck pipe. Neither this method nor any others heretofore employed have proven entirely successful in all instances.

The present invention, therefore, is directed to an improved method for effecting release of wall-stuck pipe and to several forms of apparatus which may be employed for performing the method in accomplishing the release.

In accordance with the present invention, the method involves a series of stages—(a) the interposing of a barrier or seal in the annulus between the drill string and the bore wall to thereby isolate the permeable formation from the hydrostatic head of fluid in the annulus; (b) displacing the heavier mud fluid in either the drill string or the annulus with water to thereby develop differential hydrostatic pressure between the two columns; (c) circulating the fluid in a direction to move the heavier column downwardly until it is moving at considerable velocity; and (d) suddenly blocking the circulation of the fluid. This sudden interruption in the movement of the fluid generates a great downward jarring force by reason of the inertia of the moving column of heavy fluid aided by the difference in weight between the two columns of fluid.

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This force will be transmitted to the stuck portion of the drill string and will usually be great enough to jar the stuck pipe loose from the face of the formation.

Additional objects of this invention are to provide several embodiments of apparatus particularly adapted for carrying out the method of this invention.

Other and more specific objects and advantages of this invention will become more readily apparent from the following detailed description when read in conjunction with the accompanying drawing illustrating the procedural steps of the method and several useful embodiments of apparatus for practicing the method.

In the drawing:

FIGS. 1, 2 and 3 are generally diagrammatic views showing several stages in the operation of the method and apparatus in a well bore;

FIGS. 4, 5 and 6 are longitudinal, partly sectional views of one form of apparatus in accordance with this invention, the parts of the apparatus being shown in different operating positions;

FIGS. 7 and 8 are cross-sectional views taken generally along lines 7-7 and 8-8, respectively, of FIG. 4;

FIG. 9 is a cross-sectional view taken along line 9-9 of FIG. 1;

FIG. 10 is a view similar to FIG. 4 illustrating another embodiment of this invention;

FIG. 11 is a generally diagrammatic view similar to FIG. 2, showing the embodiment of FIG. 10 installed in the drill string; and

FIGS. 12 and 13 are diagrammatic views generally similar to FIGS. 2 and 3, illustrating two stages in the operation of still another apparatus embodiment in accordance with this invention.

FIG. 1 is a generally diagrammatic view of a well W having its upper portion lined in the usual manner with a casing C, leaving a lower unlined portion which intersects a porous or permeable earth formation E shown as having a number of fissures F which, for purposes of illustration, are shown in greatly exaggerated scale, the fissures providing passages for the flow of drilling fluid into formation E when the hydrostatic pressure of the drilling fluid in the well bore exceeds the pressure in formation E.

As seen in FIG. 1, the lower portion of a drill string S, comprising the drill collars D, has been stuck to the wall of formation E by differential pressure between the fluid column in the bore hole and that in the formation E. The usual drill bit B is shown connected in the usual manner to the lower end of the string of drill collars D and fluid circulation ports P are shown in the bit through which drilling fluid will normally be discharged from the bit. The drill string S is shown as having been disconnected from the stuck portion of the string and is in process of being withdrawn from the well. The well head is shown equipped with conventional blowout preventors A, and a valved connection L is shown communicating with the annulus N between the drill string S and the wall of casing C. The arrows in FIGS. 1 and 9 indicate the direction of movement of fluid from the well bore into formation E, which is responsible for forcing the drill collars D against the face of the formation. Usually a filter cake will have built up on the face of the formation and it is into this cake that the drill collars or other portions of the pipe string will be embedded under the differential force exerted by the drilling fluid column. Ordinarily also, the sticking will occur when the bit is off bottom, as illustrated.

After the drill string has been released from the stuck drill collars, it will be withdrawn from the well and will have connected to its lower end an apparatus or tool, in accordance with this invention, designated generally by the numeral 20. Thereafter the drill string will be run

back into the well so that the lower end of the tool 20 may be reconnected to the drill collars D. This stage is illustrated in FIG. 2.

FIGS. 4, 5 and 6 illustrate the details of tool 20. This tool comprises a tubular body 21 into the lower end of which is threadedly inserted the upper end of a sub 22, the lower end of which carries an externally threaded pin 23 for threaded reception in a tool joint socket 24 provided at the upper end of drill collar D, thereby forming the means by which the apparatus may be connected to the drill collars. A number of radial ports 25 are provided through the wall of sub 22 for communicating the bore 26 of body 21 with the annulus N. The upper end of sub 22 extends interiorly of bore 26. A tubular mandrel 28 is slidably mounted in bore 26 of the body and projects through its upper end, being provided with an externally threaded pin 29 at its upper end for connection into a collar 30 by means of which mandrel 28 and the apparatus, as a whole, may be connected to drill string S. The external diameter of mandrel 28 is made substantially less than the diameter of bore 26, providing substantial clearance therebetween. A tubular bushing 31 is screwed into the upper end of body 21 and has a bore 32 having a sliding fit about the exterior of mandrel 28. Bushing 31 is counterbored from its upper end to provide a stuffing box 33 containing packing 34 for forming a fluid-tight slidable seal about mandrel 28 near the upper end of body 21. Secured to the upper end of bushing 31 and surrounding mandrel 28 is an upwardly opening cup-shaped packer or seal member 35 which is adapted to form a fluid-tight seal between the exterior of body 21 and the wall of casing C. The upwardly opening form of the cup-shaped seal member serves to seal the annulus against downward movement of fluid, while permitting upward flow of fluid through the annulus past the seal member. A plurality of radial ports 36 are provided through the wall of mandrel 28 to provide communication between the bore 37 of the mandrel and the exterior thereof, the ports 36 being disposed intermediate the ends of the mandrel. The lower end of bushing 31 is provided with longitudinal slots opening downwardly to form an annular clutch member 38 positioned in the space between mandrel 28 and body 21. A similar but upwardly facing clutch member 39 is formed on the upper end of sub 22. Carried on the exterior of mandrel 28, spaced a short distance above the lower end, is a series of angularly spaced, longitudinally extending splines 40 adapted to engage either of the clutch members 38 or 39, depending upon the position of the mandrel relative to body 20, whereby to clutch the mandrel and the connected portion of pipe string S to body 21 and thence to drill collars D. When the mandrel is at any position at which the splines are between the two clutch members, the drill string is free to rotate relative to body 21 and drill collars D. The lower end of mandrel 28 has seated in its exterior a pair of longitudinally spaced packing elements 41, such as conventional O-rings which are adapted, when the mandrel is in its lowermost position in body 21, to seal between the mandrel and sub 22 at points above and below the ports 25, the lower end portion of the mandrel thus defining a sleeve valve 42 for opening and closing ports 25. Sub 22 is provided with an internal upwardly facing shoulder 43 to limit downward movement of the mandrel so that when the lower end of the mandrel has engaged shoulder 43, seals 41 will be positioned above and below ports 25, closing off the latter.

FIG. 5 illustrates a position in which the mandrel 28 has been elevated just enough to raise the sleeve valve 42 above ports 25, thereby opening communication between the bore of the pipe string and the annulus.

FIG. 6 illustrates still another position of the apparatus in which the mandrel has been elevated to its maximum extent, wherein splines 40 are engaged in upper clutch member 38 at which position ports 36 will be elevated above seal member 35, placing the bore of the pipe string

in communication with annulus N at a point above seal member 35.

By providing the relatively movable connection between mandrel 28 and body 21, it is possible to circulate drilling or wash fluid at several points relative to the stuck portion. When the bit is clear, circulation can be carried through the bit ports P in the usual manner, mandrel 28 being in its fully retracted position closing ports 25 (FIG. 4). If the bit ports are plugged by cavings or the like, mandrel 28 may be elevated sufficiently to move sleeve valve 42 to a point opening ports 25 (FIG. 5), whereupon circulation may be established at a point above the bit. Finally, the mandrel may be pulled up to its fully extended position at which ports 36 will be positioned above seal member 35 and circulation established above the top of the drill collars.

In operation, the tool will be positioned to establish circulation at any of the one of three points as determined by the position of the mandrel, as previously described, and water will be pumped into drill string S through a suitable connection K at its upper end (FIG. 2) to displace the heavy mud fluid from the interior of the drill string into annulus N. As indicated by the arrows in FIG. 2, circulation in this example has been established through the bit ports P, the mandrel being in its fully retracted position as illustrated in FIG. 4. Only enough displacement of the heavy mud by water is effected to leave the drill string filled with water while retaining the heavier mud fluid in the annulus. The resulting difference in weight of the two fluid columns will exert a substantial downward force on seal member 35 and thereby upon body 21 and drill collars D. As indicated previously, the form of seal member 35 is such that upward flow of fluid in the annulus past the seal will occur but reverse flow cannot occur, the weight of the fluid column in annulus N being effective to urge the seal member into sealing engagement with the wall of casing C.

When the displacement of the heavy drilling fluid from drill string S has been completed, the string is elevated sufficiently to raise mandrel ports 36 above seal member 35, as seen in FIG. 3. Thereupon circulation is reversed, that is, the heavier drilling fluid will be pumped through valved connection L into annulus N and thence through ports 36 into drill string S and upwardly to the top of the well and out of connection K. This reverse circulation is continued until the column of fluid in the annulus is moving downwardly at a relatively high velocity. As soon as a suitable velocity has been attained, drill string S will be lowered to move ports 36 into the bore of body 21 below seal member 35 and packing 34. This movement, which is performed quickly, serves to suddenly and sharply interrupt or block the rapidly moving column of fluid. The resulting inertia of the moving column of heavy fluid, aided by the difference in weight between the heavier fluid in the annulus and the column of water in the drill string, produces a sudden tremendous downwardly directed jarring force on seal member 35 and thence on body 21 and the drill collars attached thereto. The tremendous jarring force thus applied will jar the drill collars loose from the wall of formation E. This action is also assisted by the isolation of the heavy column of fluid in the annulus from earth formation E by seal member 35, thereby tending to reduce the differential pressure responsible for the sticking of the drill pipe.

By repeating the previously described sequence of operations, repeated jarring blows may be struck on the stuck pipe should the first blow be ineffective to release the stuck pipe. The magnitude of the jarring force will depend upon the velocity of the downwardly moving column and the difference in the specific gravities of the two columns of fluid. Upon release of the drill collars, the entire pipe string will be withdrawn from the well, and apparatus 20 removed from the pipe string so that the latter may be re-constituted in its original form for continuing drilling.

As illustrated and described previously, the seal member is shown positioned inside casing C and where it is possible to locate the seal member in a metallic casing, the seal member may be of the simple cup-shaped form illustrated. However, since the point at which sticking occurs may be a long distance below any casing, thereby requiring the seating of the seal in an open hole, since the seal should be as near the stuck point as practicable, a modified form of seal member may be employed, as illustrated in FIGS. 10 and 11.

In this modification, all of the structure of tool 20 is identical with that previously described, except for the shape of seal member 35. In this modification, the seal member comprises a tubular sleeve 35a constructed of flexible resilient material and having its lower end connected to bushing 31 in the same manner as in the previously described embodiment. The upper end of sleeve member 35a, instead of being free to flex radially, as in the case of the lip on seal member 35, is secured to a metal ring 45 having an inwardly turned flange 46 which slidably engages the exterior of mandrel 28. A plurality of ports 47 extend through the wall of ring 45 providing communication between the interior of sleeve 35a and annulus N.

With this embodiment, when the tool is operated in an unlined portion of the bore hole, the fluid in the annulus will flow through ports 47 into the interior of sleeve member 35a and hydrostatic pressure exerted by this fluid on the inside of sleeve member 35a will expand the latter into tight sealing engagement with the wall of the well bore. The flexible character of the sleeve member will permit it to accommodate itself to the irregularities which are normally present in the wall of the unlined bore.

The operation of this modification is identical of that previously described since the form of the seal member represents the only difference in the construction of the device, FIG. 11 showing the device as positioned in the drill string during operation.

FIGS. 12 and 13 illustrate still another embodiment of the apparatus by means of which the jarring force may be generated and applied. In this embodiment, a tubular nipple 50 is interposed between drill string S and the upper end of tool 20, the nipple being provided internally with an annular plug seat 51 for the reception of a plug 52 which may be dropped or pumped through drill string S.

In this embodiment circulation of fluid will be conducted with the mandrel in the appropriate position as may be required to establish circulation in the manner previously described. Thereafter, the mandrel will be lifted to the position in FIG. 6 at which the ports 36 will be above seal member 35. This position is illustrated also in FIG. 12. Water will now be pumped through connection L into the annulus and thence through ports 36 into and up the interior of drill string S, that is, reverse circulation will be conducted to displace the heavier fluid from the annulus into the interior of the drill string, the column of heavy fluid being retained in the drill string. The pump is then connected to the top of the drill string through connection K and fluid pumped into the drill string to start the column therein moving downwardly until it attains a sufficient velocity. As this pumping is underway, plug 52 will be dropped into the drill string and pumped down with the fluid. When the plug lands on seat 51 (FIG. 13) the movement of the entire column of fluid in the drill string will be abruptly stopped and the inertia in this column, aided by the difference in weight between the internal and external columns of fluid, will generate and apply a heavy downward jarring force through mandrel 28 to the drill collars to jar them loose, as previously described.

As will be evident from the foregoing, the primary feature of this invention is the procedure by which the inertia of the moving column of fluid may be employed as a jarring mechanism by which wall-stuck pipe may be

released. This jarring action is made more effective by two additional features: (1) making the specific gravities of the two columns of fluid in the drill string and the annulus different; and (2) interposing a fluid-tight barrier between the formation responsible for the sticking and the column of fluid in the annulus which creates the pressure differential producing the sticking of the drill pipe.

It will be understood that various changes and modifications may be made in the illustrative embodiments of the method and apparatus herein described within the scope of the appended claims, but without departing from the spirit of this invention.

What I claim and desire to secure by Letters Patent is:

1. The method of releasing wall-stuck pipe in a well, comprising, removing the free portion of the pipe, placing means in the well bore to form and seal off an annulus therein above the stuck point, connecting said seal-forming means to the wall-stuck portion of the pipe, establishing circulation of a fluid between the interior of the stuck pipe and the well annulus above the stuck point to thereby establish separate upwardly and downwardly moving columns of said fluid, and abruptly interrupting the movement of the downwardly moving column of fluid whereby to generate a high energy downward jar directed against said pipe to release the same.

2. The method of releasing wall-stuck pipe in a well, comprising, removing the free portion of the pipe, placing means in the well bore to form and seal off an annulus above the stuck point and connecting the same to the stuck portion of the pipe string, establishing circulation of a hydraulic fluid between the interior of the stuck pipe and the well annulus to thereby establish separate upwardly and downwardly moving columns of said fluid, above the seal-forming means, introducing into one of said columns a hydraulic fluid of lower specific gravity than the original fluid to displace the latter from said one of said columns to the other, thereupon reversing the direction of flow between the well annulus and the interior of the pipe and causing the higher specific gravity column to flow downwardly at high velocity, and abruptly interrupting the movement of the downwardly moving column of fluid whereby to generate a high energy downward jar against said pipe to release the same.

3. The method according to claim 2 wherein said lower specific gravity fluid is introduced into the column in the interior of the pipe.

4. The method according to claim 2 wherein said lower specific gravity fluid is introduced into the column in said annulus.

5. Apparatus for use in releasing wall-stuck pipe in a well, comprising, relatively movable inner and outer tubular members forming a telescopic connection means, means carried by the outer connection member for connection to the wall-stuck portion of a pipe string, means carried by the inner connection member for attachment to the lower end of the free portion of the pipe string, between the adjacent ends of the wall-stuck portion of a pipe string and the free portion thereof, seal means carried by the outer member of said connection means for sealing off the annulus between the stuck portion of the pipe string and the well wall above the stuck point, passage means in said connection means providing fluid communication between the interior of the pipe string and the annulus, and closure means operably associated with the pipe string for closing said passage means.

6. Apparatus according to claim 5 wherein said seal means comprises an upwardly opening flexible cup seal.

7. Apparatus according to claim 5 wherein said passage means comprises ports in the wall of said inner tubular member movable therewith between positions above and below said seal means by longitudinal movement of the inner member relative to the outer member.

8. Apparatus according to claim 5 wherein said last-mentioned means comprises a plugging element insertable through the bore of said pipe string and a seat in the bore

of said inner tubular member to receive said plugging element to close the bore of said inner tubular member.

9. Apparatus for use in releasing wall-stuck pipe in a well, comprising, relatively movable inner and outer tubular members forming a telescopic connection means, means carried by the outer connection member for connection to the wall-stuck portion of a pipe string, means carried by the inner connection member for attachment to the lower end of the free portion of the pipe string, between the adjacent ends of the wall-stuck portion of a pipe string and the free portion thereof, cooperating clutch elements positioned on the respective members for releasably securing said members against relative rotation, seal means carried by the outer member of said connection means for sealing off the annulus between the stuck portion of the pipe string and the well wall above the stuck point, passage means in said connection means providing fluid communication between the interior of the pipe string and the annulus, and closure means operably associated with the pipe string for closing said passage means.

10. Apparatus for use in releasing wall-stuck pipe in a well, comprising, relatively movable inner and outer tubular members forming a telescopic connection means, means carried by the outer connection member for connection to the wall-stuck portion of a pipe string, means carried by the inner connection member for attachment to the lower end of the free portion of the pipe string, between the adjacent ends of the wall-stuck portion of a pipe string and the free portion thereof, cooperating clutch elements positioned on the respective tubular members for releasably securing said members against relative rotation, internal seal means mounted in the upper end portion of the outer tubular member to form a slidable seal between said tubular members, external seal means mounted on the outer tubular member for sealing off the annulus between the stuck portion of the pipe string and the well wall above the stuck point against downward flow of fluid through the annulus, passage means in said connection means providing fluid communication between the interior of the pipe string and the annulus, and closure means operably associated with the pipe string for closing said passage means.

11. Apparatus according to claim 10 wherein said external seal means comprises an upwardly opening flexible cup seal.

12. Apparatus according to claim 10 wherein said passage means comprises ports in the wall of said inner tubular member movable therewith between positions above and below said internal seal means by longitudinal movement of the inner member relative to the outer member.

13. Apparatus for use in releasing wall-stuck pipe in a well, comprising, relatively movable inner and outer tubular members forming a telescopic connection means between the adjacent ends of the wall-stuck portion of a pipe string and the free portion thereof, internal seal means mounted in the upper end portion of the outer tubular member to form a slidable seal between said tubular members, external seal means mounted on the outer tubular member for sealing off the well annulus above the stuck point against downward flow of fluid through the annulus, first passage means in the outer tubular member below the external seal means providing fluid communication between the interior and exterior of the outer tubular member, valve means positioned on the inner tubular member for movement between positions opening and closing said first passage means in response to relative longitudinal movement between said tubular members, second passage means through the wall of the inner tubular member above said valve means, said second passage means being movable with said inner tubular member between positions above and below said internal seal means by said longitudinal movement of the inner tubular member relative to the outer tubular member.

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