

Jan. 26, 1960

M. M. KINLEY

2,922,479

APPARATUS FOR CONTROLLING FLUID CIRCULATION

Filed May 28, 1956

3 Sheets-Sheet 1

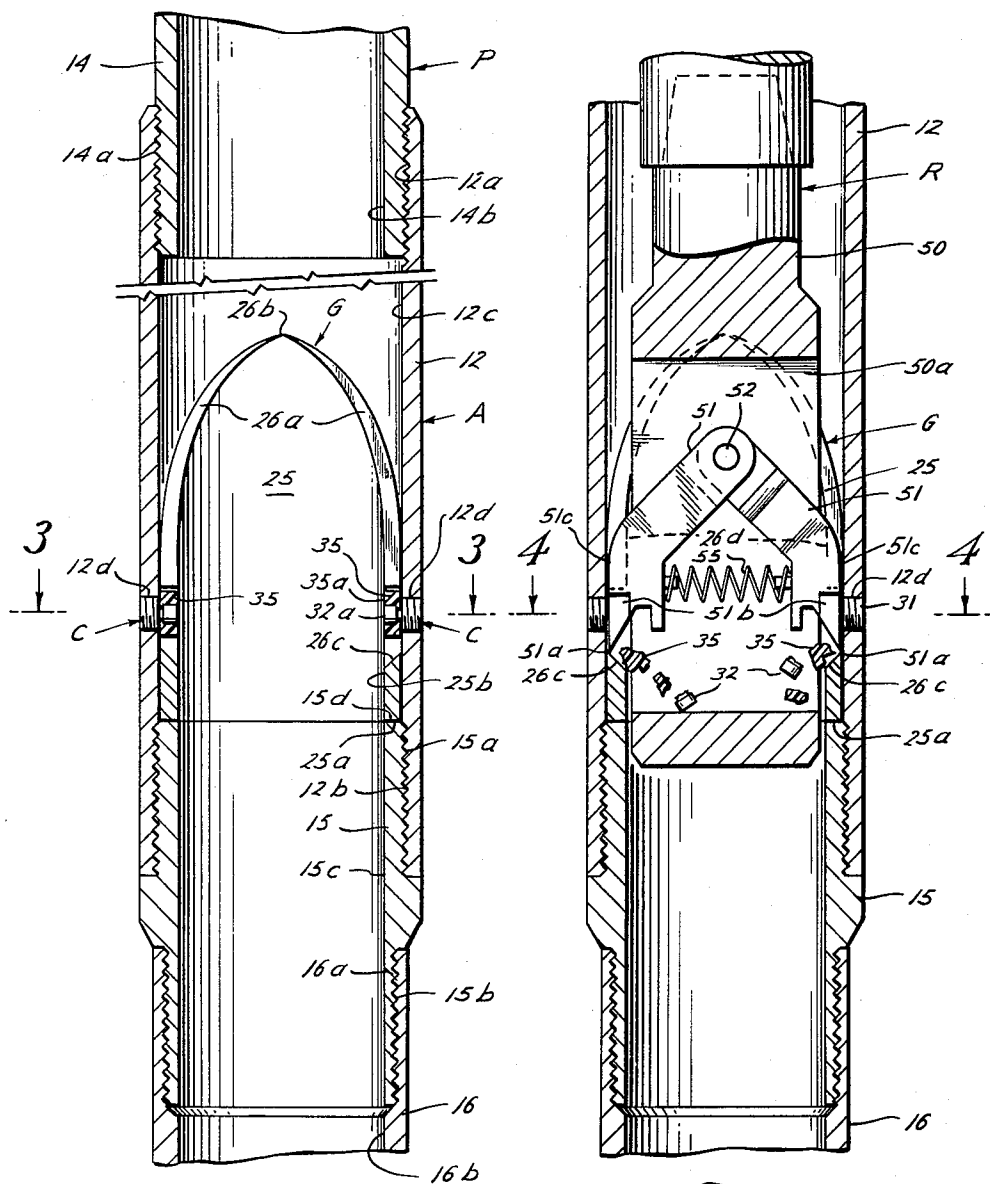


Fig. 1

Fig. 2

Myron M. Kinley

INVENTOR.

BY *Hayden & Pravel*

ATTORNEYS

Jan. 26, 1960

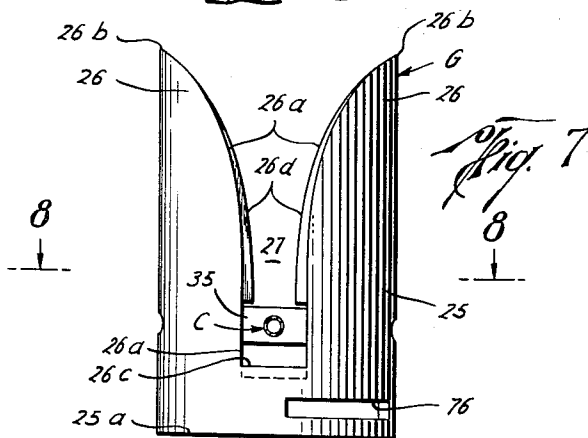
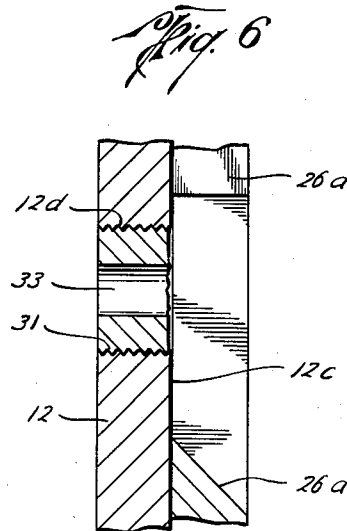
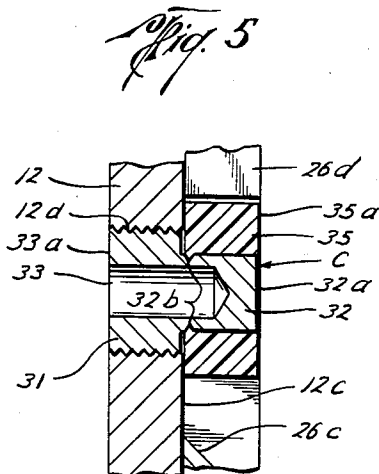
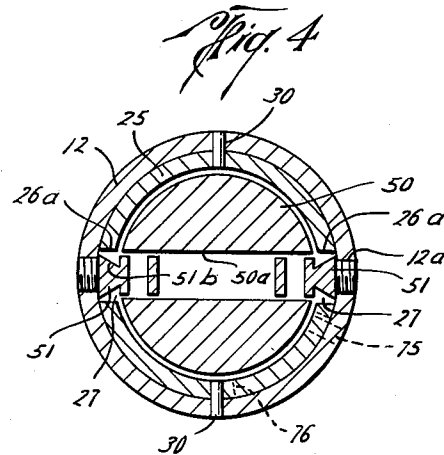
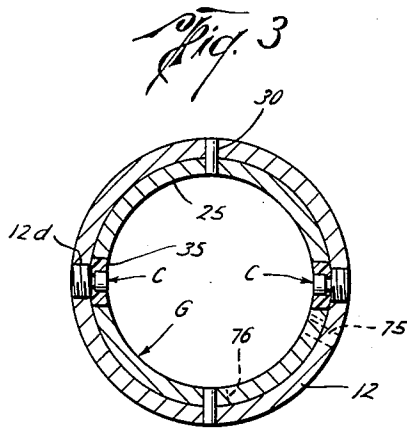
M. M. KINLEY

2,922,479

APPARATUS FOR CONTROLLING FLUID CIRCULATION

Filed May 28, 1956

3 Sheets-Sheet 2



Myron M. Kinley

INVENTOR.

BY *Hayden & Pravel*

ATTORNEYS

Jan. 26, 1960

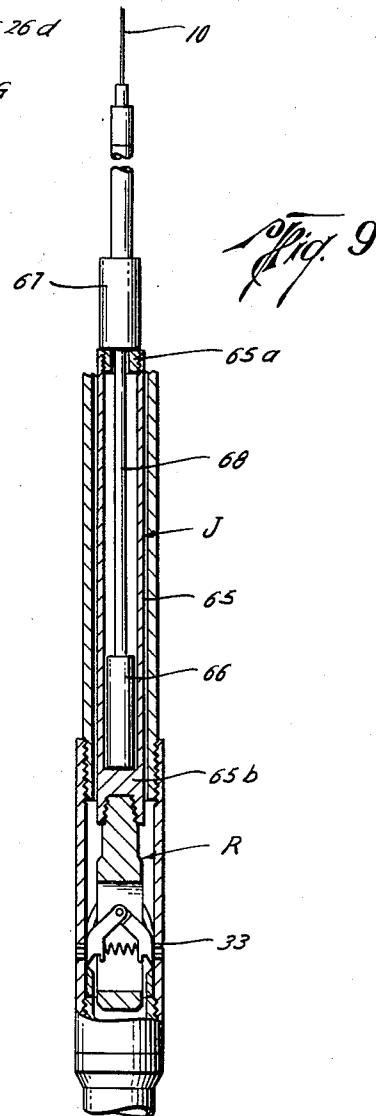
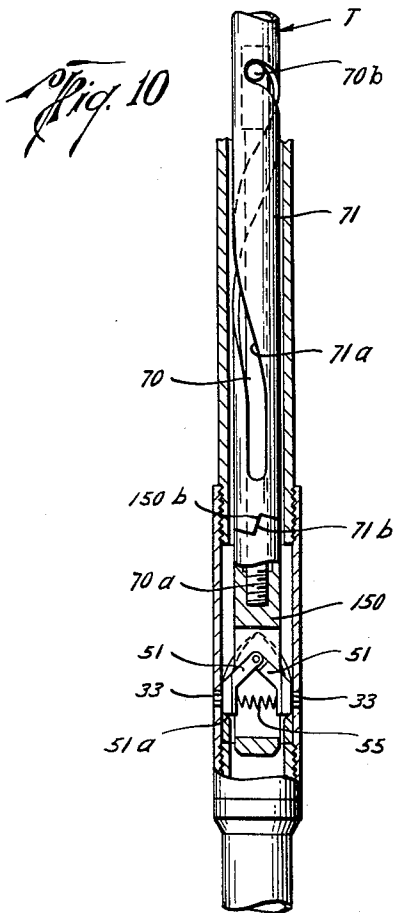
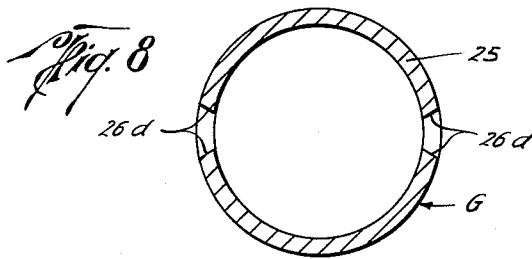
M. M. KINLEY

2,922,479

APPARATUS FOR CONTROLLING FLUID CIRCULATION

Filed May 28, 1956

3 Sheets-Sheet 3



Myron M. Kinley
INVENTOR.

BY *Hayden & Tranel*

ATTORNEYS

1

2

2,922,479

APPARATUS FOR CONTROLLING FLUID CIRCULATION

Myron Macy Kinley, Los Angeles, Calif.

Application May 28, 1956, Serial No. 587,878

14 Claims. (Cl. 166—224)

This invention relates to new and useful improvements in apparatus for controlling fluid circulation.

An object of this invention is to provide a new and improved apparatus for controlling fluid circulation, and particularly for controlling fluid circulation through a pipe string or tubing in a well, wherein a guide means is provided in the tubing for positively guiding an opening tool into contact with a closure member to open same for establishing fluid flow through the wall of the tubing.

An important object of this invention is to provide a new and improved apparatus for controlling fluid circulation in a pipe string wherein means are provided for the usual well tools to pass through the pipe string without establishing fluid communication between the interior and exterior of the pipe string, and wherein means are also provided for guiding an opening tool interiorly of the pipe string to effect an opening of a port in said pipe string for establishing such fluid communication.

Another object of this invention is to provide a new and improved apparatus which is operable by a wire line suspended opening tool to establish fluid communication between the interior and exterior of the pipe string.

A further object of this invention is to provide a new and improved apparatus wherein a wire line operated opening tool is manipulated to fracture or shear one or more closure members for one or more apertures in a pipe string whereby the aperture or apertures are opened to permit fluid circulation between the interior and the exterior of the pipe string.

Still another object of this invention is to provide a new and improved apparatus which has a tubular housing for connection in a tubing or pipe string, such housing having ports therethrough for establishing fluid communication between the interior and exterior of the housing, the port being closed with a closure member which is adapted to be fractured or sheared to open said port, and wherein the closure member is positioned in a recess which is normally inaccessible to well tools to prevent an inadvertent shearing or fracturing of said closure member but which is accessible to an opening or fracturing tool for effecting the shearing or fracturing of such member; the closure member being optionally protected by a frangible material thereabove to further prevent the premature release of the closure member.

An additional object of this invention is to provide a new and improved apparatus for controlling fluid circulation in a pipe string wherein one or more ports are provided in a pipe string which are closed by one or more closure plugs, such plugs being protected by a guide member against inadvertent release by the usual well tools passing through the pipe string; the guide means initially serving to guide an opening tool into engagement with the closure plugs to open said ports and to subsequently serve as a valve to close said ports by rotating same with a rotation-imparting tool.

The construction designed to carry out the invention

will be hereinafter described, together with other features thereof.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings forming a part thereof, wherein an example of the invention is shown, and wherein:

Fig. 1 is a view, partly in elevation and partly in section, illustrating the apparatus of this invention with the ports or openings thereof in the closed position;

Fig. 2 is a view similar to Fig. 1, but illustrating the apparatus of this invention during the opening of the port or ports in the tubular housing with a release tool;

Fig. 3 is a horizontal sectional view taken on line 3—3 of Fig. 1;

Fig. 4 is a horizontal sectional view taken on line 4—4 of Fig. 2;

Fig. 5 is an enlarged fragmentary sectional view, illustrating in detail the preferred type of closure means of the apparatus of this invention in its closed position;

Fig. 6 is a view, similar to Fig. 5, but illustrating the closure means after such means has been released to establish fluid communication between the interior and the exterior of the apparatus;

Fig. 7 is an elevation illustrating the preferred form of the guide means of this invention, with one of the closure members being illustrated in section;

Fig. 8 is a sectional view taken on line 8—8 of Fig. 7, and particularly illustrating the dovetail portion of the longitudinal recesses in the guide means;

Fig. 9 is an elevation, partly in section, of the apparatus of this invention with one type of release tool; and

Fig. 10 is an elevation, partly in section, illustrating the apparatus of this invention with one type of rotation-imparting tool for turning the guide member to control the opening and closing of the port or ports in the tubular housing subsequent to the release of the closure member or members with the release tool.

In the drawings, the letter A designates generally the apparatus of this invention which is adapted to be used initially with a release or opening tool R (Figs. 2 and 9) and subsequently with a rotation-imparting tool T (Fig. 10), as will be explained. The apparatus A is connected in a tubing string or pipe string P which ordinarily is positioned in a well (not shown) in a known manner. The release tool R is suspended or supported by a cable or flexible line 10 which extends to the surface of the well in which the pipe string P is located so that the release tool R is manipulated from the surface of the well. As will be explained in detail hereinafter, the release tool R is manipulated from the surface of the well, or from the upper end of the pipe string P to effect an opening of one or more ports in the pipe string P to establish fluid communication between the areas interiorly and exteriorly of the pipe string P, whereby fluid circulation is obtained in the well in which the pipe string P is located. Also, as will be explained, subsequent to the opening of such port or ports, the rotation-imparting tool T is used instead of the tool R so as to close or otherwise control the fluid communication.

Considering the invention in detail, and referring to Figs. 1 and 2 in particular, the apparatus A has a tubular housing or body 12 which has internal upper threads 12a in threaded engagement with external threads 14a on an upper tubing or pipe section 14. The tubular housing or body 12 also has lower internal threads 12b which are in threaded engagement with external threads 15a on an adapter 15 which may be considered the lower part of the tubular housing or body 12. The adapter 15 has lower external threads 15b which are in threaded engagement with upper internal threads 16a of a lower tubing or pipe section 16.

3

The internal diameter or bore 15c of the adapter 15 is of substantially the same size as the internal diameter or bore of the pipe string P. Therefore, as illustrated in Figs. 1 and 2, the bore 15c is of substantially the same diameter as the bores 14b and 16b.

The internal diameter or bore 12c of the tubular housing or body 12 is enlarged compared to the bores 14b, 15c and 16b, so that a shoulder 15d which is annular and extends laterally is provided. Such annular shoulder 15d serves as a support for a guide member G (Figs. 1, 2 and 7). The guide member G is preferably in the form of a tubular body 25 which has one or more upwardly extending guide sections 26 with longitudinal recesses 27 formed therebetween. Each of the guide sections 26 has corresponding downwardly curved surfaces 26a which terminate at the upper end in a point 26b. A pair of the adjacent downwardly curved surfaces 26a terminate in a lateral shoulder 26c at the lower end of each of the recesses 27. Each of the lateral surfaces 26c is downwardly inclined as best seen in Figs. 1 and 2 and each of the lateral surfaces 26a preferably has a dove-tailed portion 26d spaced above the lateral surfaces 26c (Figs. 7 and 8), for a purpose to be hereinafter explained.

The tubular body 25 preferably has its lower annular surface 25a resting upon the lateral annular shoulder 15d. Retaining screws or pins 30 (Figs. 3 and 4) extend through the tubular housing or body 12 and into the guide body 25 to normally retain same against rotation relative to the tubular housing 12. Also, such retaining screws or pins 30 may serve to support the guide means G within the tubular housing 12 in the event the lower surface 25a is not in contact with the shoulder 15d.

The guide means G is so positioned within the tubular housing or body 12 that the longitudinal recesses 27 are aligned with closure plugs C which are positioned in the lateral openings 12d. The closure plugs C may take numerous forms, but as shown in the drawings, the outer portion of each of the closure plugs C is threaded as indicated by the external threads 31 which engage with the threads which are provided in each of the openings 12d. The inner end 32 of each of the members or plugs C extends into one of the recesses 27, but it will be observed that inner surface 32a does not extend inwardly beyond the inner diameter or bore 25b of the guide body 25. Thus, since the bore 25b of the guide body 25 is at least as large in diameter as the bore of the pipe string P, neither the closure members C or the guide body 25 extends into the bore of the pipe string P to a greater extent than the internal diameter or bore of the pipe string P itself. Therefore, the guide means G and the closure member C do not offer any obstruction to the passage of the usual well tools through the pipe string P.

Also, the closure members or plugs C are protected against inadvertent or premature release by their confined position within the recesses 27, as is believed evident from the drawings. However, when it is desired to establish fluid communication between the interior and the exterior of the pipe string P, the closure members or plugs C are released or fractured by a release tool R, the details of which will be explained. To this end, the closure members or plugs C are each provided with an internal hollow bore 33 which is open at the outer end 33a, but which is closed by the closed head or end 32. The bore 33 extends inwardly beyond the inner bore or surface 12c of the tubular housing or body 12 so that when the closure members or plugs C are released or fractured, the full opening of the bore 33 is provided for the fluid communication therethrough. An annular groove or scored ring 32b is provided at the closed end 32 at a point outwardly of the inner end of the bore 33 to facilitate the fracturing of each of the closure members or plugs C at that point, so as to assure the opening of the bore 33 for the fluid flow therethrough.

For further preventing the premature release or fracture of the closure members C, a frangible material 35

4

such as cement, synthetic resin or any other material which is adapted to be cracked with the application of an impact thereto, is moulded or otherwise formed at the lower end of each of the recesses 27 immediately above the plugs C, and also preferably extending slightly below the plugs C. The inner surface 35a of the material 35 does not project inwardly beyond the inner diameter or bore 25b of the guide body 25, but it does project inwardly at least as far as the inner end 32a of each of the closure plugs C.

One type of release tool which can be used for releasing or fracturing the frangible material 35 and the closure members or plugs C is shown in Figs. 2 and 9, wherein the release tool R is shown as suspended from a cable or flexible line 10 from the surface of the well in which the pipe P is located. Of course, the release tool R may, in some instances, be lowered on relatively stiff pipe, but such is not necessary with the release tool R illustrated. A jarring device J which may be of conventional construction is connected between the flexible line 10 and the release tool R for applying a jarring force to the release tool R when desired. As illustrated, the jarring device J includes a jar sleeve 65 and two jarring heads 66 and 67 which are slidable longitudinally relative to the sleeve 65. The heads 66 and 67 are connected by a rigid rod 68, with the lower head 66 contacting the upper end 65a of the sleeve 65 upon a lifting of the cable 10 for an upward jar. The head 66 hits the lower end 65b and the head 67 may also hit the upper end 65a to jar downwardly on the sleeve 65 and the release tool R connected therebelow.

The release tool R has a body 50 which is formed with a longitudinal slot 50a for receiving a pair of shearing arms 51. Such arms 51 are pivoted together at pivot pin 52 which extends through both of the arms 51 and into the body 50. A coil spring 55 or other similar resilient means urges the arms 51 outwardly into constant engagement with the inside surface of the pipe string P and also the inside surface or bore 12c of the tubular housing 12. The substantially vertical external surface 51c of each arm 51 is preferably of a greater length from the pointed end 51a upwardly than the normal distance between the ends of pipe sections at a coupling to prevent the ends 51a from engaging the pipe ends at the coupling as the tool R is lowered in the pipe.

The arms 51 serve as shearing arms, and to facilitate the shearing or fracturing of the frangible material 35 and the closure members or plugs C, the lower ends 51a of the jarring arms 51 are preferably pointed as shown in the drawings so that such pointed ends 51a engage the frangible material 35 initially and, after cracking or fracturing same, they ultimately engage the scored ring 32b of each of the plugs C. It should be pointed out that the weight of the release tool R and the jarring device J and other equipment connected therewith is sufficient to cause the pointed ends 51a of the arms 51 to contract in opposition to the spring force from the spring 55 when the arms 51 are guided downwardly and inwardly along the inclined lateral surfaces 26c, whereby the arms 51 are retracted and such retraction permits the release tool R to drop below the lateral inclined surfaces 26c whereby the weight of the release tool R and all of the equipment connected therewith is suspended from the cable 10 to indicate to the operator at the surface of the well that the plugs C have been sheared or fractured to open the hollow bores 33 for establishing the fluid communication between the interior and the exterior of the pipe string P.

It should be noted that the arms 51 have converging sides 51b (Fig. 4) which form a dove-tail for fitting into the dove-tail portions 26d (Figs. 7 and 8) of the guide body 25. The lower ends of the dove-tail portions 26d terminate above the plugs C so that the dove-tail sides 51b interfit in the dove-tail groove portions 26d only while the tool R is positioned with the pointed ends 51a above

the plugs C. Such interfitting prevents the arms 51 from being urged inwardly when a downward jarring force is applied thereto with the jar J.

However, after the plugs C have been sheared, the dove-tail or converging sides 51b move below the dove-tail portions 26d where the surface 26a is again straight (Fig. 4) so that the arms 51 can then move inwardly towards each other for sliding along the inclined surface 26c as previously explained. Thus, although the lengths of the dove-tail portions 26d and the straight part of the guide surfaces 26a therebelow are preferably about as shown in the drawings, they may be varied so long as the arms 51 are held against inward movement during the shearing of the plugs C and then are permitted to move inwardly when they drop below the plugs C after shearing the plugs C.

In operation or use of the apparatus of this invention, the apparatus A is connected in a pipe string P as particularly indicated in Fig. 1. Under such conditions, there is no fluid communication through the openings 12d of the tubular housing 12 since the closure members C have the closed ends 32 which close off the hollow bores 33 of the plugs C (Fig. 5). Well tools of the usual type may be raised and lowered through the pipe string P without interference or obstruction by the apparatus A since the internal diameter thereof does not exceed the internal diameter of the sections of the tubing or pipe string P. Also, the closure members or plug C do not extend into the bore beyond the internal diameter or bore of the pipe string P. Therefore, the usual well operations can be conducted without establishing any fluid circulation between the interior of the pipe string P and the exterior thereof. Since the pipe string P is ordinarily positioned in a well, the area on the inside or interior of the pipe string is isolated from the area exteriorly thereof so that separate fluids may be handled during their usual well operations, and production, without a commingling of the fluids.

However, when it is desired to establish fluid circulation in the well, then fluid communication can be obtained between the area interiorly of the pipe string P and the area exteriorly thereof by lowering the release tool R downwardly within the inside of the pipe string P. The spring 55 expands the arms 51 outwardly in the enlarged housing 12 and the arms 51 are guided along the guide surfaces 26a of the guide member G to guide the arms 51 into the longitudinal recesses 27 so that the pointed ends 51a of the arms 51 are guided into engagement with the frangible material 35 if same is included. Jarring device J is then manipulated to cause the arms 51 to hit the frangible material 35 with a jarring impact for cracking or fracturing same. Upon a cracking of the material 35, the arms 51 move downwardly with the pointed ends 51a in engagement with the scored rings 32b on the closure members or plugs C and then a jarring impact is applied to them with the jar J which is sufficient to shear or fracture such plugs C along the scored rings 32b. If necessary, the release tool R may be raised and lowered by manipulating the cable or flexible line 10 to apply several jarring impacts to the frangible material 35 and to the closure members or plugs C. Of course, if the frangible material 35 is not included, the jarring arms 51 will contact the closure plugs C only upon their being guided into the longitudinal recesses 27.

It should be pointed out that the spring 55 constantly urges the jarring arms 51 outwardly about the pivot pin 52 so that the jarring arms 51 are in engagement with the internal surface or bore 12c of the tubular housing 12 as they are guided in the recesses 27. Such spring 55 thus urges the pointed ends 51a outwardly to engage the closure member C at the scored rings 32b. The co-action between the dove-tail portions 26d and the dove-tail sides 51b prevents inward movement of the arms 51 during the shearing of the plugs C, as previously explained. Of

course, even if the scored rings 32b are not employed, the closure member C can be fractured or sheared to open the hollow bores 33, but the scored rings 32b do facilitate the shearing or fracturing at the indicated areas formed by the scored rings.

As soon as the closure plugs C are fractured or sheared so as to release the closed ends 32 thereof, the hollow bores 33 are opened to permit fluid flow therethrough. Fluid communication or circulation is thus established between the interior and exterior of the pipe string P.

After the plugs C and the material 35 are sheared loose, the pointed ends 51a of the jarring arms 51 are guided downwardly and inwardly along the downwardly and inwardly inclined lateral surfaces 26c so that the release tool R moves below the closure members or plugs C and remains suspended from the cable 10 so that the operator at the surface of the well can determine that the full weight of the release tool R and the other equipment connected therewith is being supported. When such condition occurs, the operator knows that the closure members or plugs C have been fractured or released and, therefore, that fluid communication between the interior and exterior of the pipe string P has been established. When the operator has thus determined that the plugs C are fractured or released, the release tool R is removed from the pipe string P by lifting upwardly on the cable or other support line 10.

Although the closure members or plugs C are preferably formed of a brittle metal, it will be appreciated by those skilled in the art that various brittle materials such as synthetic resins can also be employed. The scored ring 32b is not essential and could be eliminated. Likewise, as previously pointed out, the frangible material 35 may be entirely eliminated and in most instances, it would not extend below the plugs C. It is also believed evident that other types of release tools than the release tool R may be utilized so long as arms such as the jarring arms 51 are provided of a width which is sufficiently small to enter the recesses 27 for imparting a jarring force to the frangible material 35 and the closure members or plugs C. Also the guide means G may be formed with one or more guide sections 26 and one or more of the recesses 27.

In some cases, it may be desirable to impart rotation to the guide member G to turn same so that the guide sections 26 cover the openings or ports 33 to close same. For this purpose, the tool T is used.

The rotation imparting tool T is similar to the release tool R in that it has the arms 51 which are pivoted at pivot pin 52 to a body 150 which is substantially the same as the body 50 of the tool R. The spring 55 urges the arms 51 outwardly into the recesses 27 in the same manner as with the tool R. The ends 51a of the arms are not generally pointed and the dove-tail sides 51b are not ordinarily used with the tool T.

The body 150 is connected with an inner rod 70 at threads 70a. The rod 70 fits within a tubular sleeve 71 which is longitudinally movable relative thereto and which is supported from the surface of the well by a cable or other flexible line (not shown). The sleeve 71 has a guide slot 71a into which pin 70b extends so that as the sleeve falls by gravity relative to the rod 70, the sleeve 71 is rotated relative to the rod 70. Such rotation of the sleeve 71 is imparted to the body 150 with a rotary jarring impact by the engagement of the hammer surface 71b on the sleeve 71 with the anvil surface 150b on the body 150. Such rotary jarring impact is transmitted to the arms 51 and thus to the guide member G to rotate same. The initial rotational impact imparted to the guide member G results in a shearing of the shear pins 30 if such pins are utilized. The sleeve 71 is raised by the flexible line and is permitted to fall by gravity as explained for a sufficient number of times to be certain that the guide sections 26 have been turned sufficiently to cover the ports provided through the bores 33

to thereby close off fluid communication therethrough. To be certain that the sleeve 25 stops its rotational movement when the sections 26 are covering such ports through the bores 33, a stop pin 75 extends into a slot 76 (Figs. 3, 4 and 7) to limit the rotational movement of the sleeve 25. Other suitable stop means could of course be provided.

In some instances, the contact between the outer surface of the sleeve 25 and inner surface of the body 12 may not be sufficiently close and uniform to seal off fluid flow through the openings of the bores 33 even though the sleeve 25 has been rotated to move the guide sections 26 to cover the bores 33. Therefore, cement or similar frangible sealing material may be pumped down the well to fill all open areas in the vicinity of the guide member G. After such cement or other material hardens, it can be knocked out of the bore of the sleeve 25 so as to leave the cement between the sleeve 25 and the interior of the body 12 to seal off any leakage through the bores 33 while providing the full longitudinal bore through the sleeve 25 for the passage of the usual well tools there-through without obstruction. Since the seal between the exterior of the sleeve 25 and the interior of the body 12 can be fractured upon rotation of the sleeve 25, such seal does not interfere with subsequent rotation to again establish fluid flow through the bores 33, if so desired.

If it is desired to open the ports or bores 33 again, the guide member G can be turned so as to again align the recesses 27 with such ports or bores 33. Such turning can be effected with a tool which is similar to the rotation-imparting tool T, but which is adapted to impart rotation in an opposite direction such as disclosed in my copending patent application Serial No. 436,647, filed June 14, 1954.

Also, a locking means such as disclosed in said application Serial No. 436,647 may be utilized with either the release tool R or the rotation-imparting tool T if it is desired to retain the arms 51 inactive during lowering into the pipe string P.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction, may be made within the scope of the appended claims without departing from the spirit of the invention.

What is claimed is:

1. An apparatus for controlling fluid communication between the interior of a pipe string and the exterior thereof, including a tubular guide member having a longitudinal recess therein with the open end of said recess being at the upper end of said guide member, and a closure plug mounted in the wall of said pipe string and extending laterally inwardly into said recess, said closure plug having a hollow bore which is open at its outer end and which extends inwardly of the bore of the pipe string with a closed inner end whereby fracturing of said plug at a point outwardly of said closed inner end opens said hollow bore for fluid flow therethrough.

2. The structure set forth in claim 1, including a closure plug opening tool, and wherein the lower end of said recess is inclined downwardly and inwardly, said closure plug being disposed above said lower end whereby upon fracturing said plug with the opening tool, the tool is guided downwardly and inwardly out of the recess for indicating to the operator of the opening tool that the bore of said plug has been opened.

3. The structure set forth in claim 1, including frangible material in said recess above said plug and having its inner surface extending inwardly at least as far as the inner end of said plug to prevent contact of the upper side of said plug prior to the removal of the frangible material from the area above said plug.

4. The structure set forth in claim 1, including means

for fracturing said closure plug to permit flow through its hollow bore, and a rotation-imparting tool for operably engaging said guide member to turn same a sufficient amount to effect a closing of said hollow bore after said closure plug has been fractured whereby fluid flow there-through is prevented.

5. In combination with an opening tool and a rotation-imparting tool, an apparatus for controlling fluid circulation in a pipe string, comprising a tubular housing having a port, a closure means for said port, guide means for guiding the opening tool longitudinally in said pipe string to open said closure means, means rotatably supporting said guide means in said housing, and said guide means being rotatable by the rotation-imparting tool for closing said port after said closure means has been opened.

6. An apparatus for use with an opening tool to establish fluid circulation between the interior and the exterior of a pipe string, including a tubular housing adapted to be connected in the pipe string, said housing having a port through the wall thereof for establishing fluid communication between the interior and the exterior thereof, a closure member for said port to prevent said fluid communication, guide means including a longitudinal guide slot within said housing aligned with said closure member and extending from a point above said closure member to said closure member for guiding the opening tool into engagement with said closure member for effecting an opening of said port whereby said fluid communication is established, said guide means including a sleeve having an inner longitudinal bore of a diameter at least as large as the diameter of said pipe string whereby well tools other than said opening tool can move longitudinally through said housing without interference from said guide means, and means on the housing for supporting said sleeve.

7. An apparatus for use with an opening tool to establish fluid circulation between the interior and the exterior of a pipe string, including a tubular housing adapted to be connected in the pipe string, said housing having a port through the wall thereof for establishing fluid communication between the interior and the exterior thereof, a closure member for said port to prevent said fluid communication, guide means including a longitudinal guide slot within said housing aligned with said closure member and extending from a point above said closure member to said closure member for guiding the opening tool into engagement with said closure member for effecting an opening of said port whereby said fluid communication is established, said opening tool being suspended from a flexible line, and means for guiding said opening tool through said guide means after said closure means is fractured to impose the weight of said tool on said flexible line to thereby indicate to the operator of the opening tool that the closure member has been fractured and the port has been opened.

8. An apparatus for use with an opening tool to establish fluid circulation between the interior and the exterior of a pipe string, including a tubular housing adapted to be connected in the pipe string, said housing having a port through the wall thereof for establishing fluid communication between the interior and the exterior thereof, a closure member for said port to prevent said fluid communication, guide means including a longitudinal guide slot within said housing aligned with said closure member and extending from a point above said closure member to said closure member for guiding the opening tool into engagement with said closure member for effecting an opening of said port whereby said fluid communication is established, and frangible material above said closure member for protecting said member against premature opening by preventing fracturing thereof prior to the removal of a sufficient amount of said frangible material to expose the closure member to said opening tool.

9. An apparatus for use with an opening tool to establish fluid circulation between the interior and the exterior of a pipe string, including a tubular housing adapted to be connected in the pipe string, said housing having a port through the wall thereof for establishing fluid communication between the interior and the exterior thereof, a closure member for said port to prevent said fluid communication, guide means including a longitudinal guide slot within said housing aligned with said closure member and extending from a point above said closure member to said closure member for guiding the opening tool into engagement with said closure member for effecting an opening of said port whereby said fluid communication is established, an opening tool having a shearing arm, said guide means including a sleeve having said longitudinal guide slot into which said shearing arm is guided, and said closure member extending laterally into said slot but terminating inwardly of the bore of said sleeve so that said closure member is prevented from being engaged by the usual well tools passing through the bore of said sleeve.

10. An apparatus for use with an opening tool to establish fluid circulation between the interior and the exterior of a pipe string, including a tubular housing adapted to be connected in the pipe string, said housing having a port through the wall thereof for establishing fluid communication between the interior and the exterior thereof, a closure member for said port to prevent said fluid communication, guide means including a longitudinal guide slot within said housing aligned with said closure member and extending from a point above said closure member to said closure member for guiding the opening tool into engagement with said closure member for effecting an opening of said port whereby said fluid communication is established, an opening tool having a shearing arm, said guide means including a sleeve having said longitudinal guide slot into which said shearing arm is guided, said closure member extending laterally into said slot but terminating inwardly of the bore of said slot so that said closure member is prevented from being engaged by the usual well tools passing through the bore of said sleeve, and frangible material in said recess which is engaged and fractured by said opening tool prior to the engagement of said closure member by said tool to thereby assist in preventing a premature fracturing and opening of said closure member.

11. In combination with an opening tool having a flexible line therewith for lowering said tool into a pipe string, said opening tool having a laterally extending arm, an apparatus for opening fluid circulation between the interior and the exterior of the pipe string, comprising a tubular body connected in the pipe string and having a portion with an enlarged inner diameter as compared to the inner diameter of the bore of the pipe string, said body having a lateral opening therethrough for establishing fluid communication between the area exteriorly of the pipe string and the area interiorly of the body and the rest of the pipe string, plug means for closing said lateral opening to prevent said fluid communication, a guide member in the enlarged portion of said body for guiding said opening tool into contact with said plug means, the inner wall of said guide member terminating inwardly of the bore of said pipe string so that such guide member does not interfere with the movement of the usual well tools through said pipe string, said guide member including a longitudinal guide slot disposed above said plug means, and a curved guide surface on said guide member for guiding said arm on said opening tool into said slot when said opening tool is lowered in the pipe string for contacting said plug means with sufficient force to open same.

12. In combination with an opening tool having a flexible line therewith for lowering said tool into a pipe string, said opening tool having a laterally extending arm, an apparatus for opening fluid circulation between

the interior and the exterior of the pipe string, comprising a tubular body connected in the pipe string and having a portion with an enlarged inner diameter as compared to the inner diameter of the pipe string, said body having a lateral opening therethrough for establishing fluid communication between the area exteriorly of the pipe string and the area interiorly of the body and the rest of the pipe string, plug means for closing said lateral opening to prevent said fluid communication, a guide member in the enlarged portion of said body for guiding said opening tool into contact with said plug means, said guide member including a longitudinal guide slot disposed above said plug means, a guide surface on said guide member for guiding said arm on said opening tool into said slot when said opening tool is lowered in the pipe string for contacting said plug means with sufficient force to open same, and said guide member in said tubular body extending inwardly into the bore thereof at least as far as said plug means extends to protect the plug means from being released by the usual well tools passing longitudinally through the tubular body and the pipe string.

13. In combination with an opening tool having a flexible line therewith for lowering said tool into a pipe string, said opening tool having a laterally extending arm, an apparatus for opening fluid circulation between the interior and the exterior of the pipe string, comprising a tubular body connected in the pipe string and having a portion with an enlarged inner diameter as compared to the inner diameter of the pipe string, said body having a lateral opening therethrough for establishing fluid communication between the area exteriorly of the pipe string and the area interiorly of the body and the rest of the pipe string, plug means for closing said lateral opening to prevent said fluid communication, a guide member in the enlarged portion of said body for guiding said opening tool into contact with said plug means for opening same, said guide member including a longitudinal guide slot disposed above said plug means, a guide surface on said guide member for guiding said arm on said opening tool into said slot when said opening tool is lowered in the pipe string for contacting said plug means with sufficient force to open same, said guide member in said tubular body extending inwardly into the bore thereof at least as far as said plug means extends to protect the plug means from being released by the usual well tools passing longitudinally through the tubular body and the pipe string, and said guide member being tubular and having an internal diameter which is at least as large as the internal diameter of the pipe string.

14. In combination with an opening tool having a flexible line therewith for lowering said tool into a pipe string, said opening tool having a laterally extending arm, an apparatus for opening fluid circulation between the interior and the exterior of the pipe string, comprising a tubular body connected in the pipe string and having a portion with an enlarged inner diameter as compared to the inner diameter of the pipe string, said body having a lateral opening therethrough for establishing fluid communication between the area exteriorly of the pipe string and the area interiorly of the body and the rest of the pipe string, plug means for closing said lateral opening to prevent said fluid communication, a guide member in the enlarged portion of said body for guiding said opening tool into contact with said plug means for opening same, said guide member including a longitudinal guide slot disposed above said plug means, a guide surface on said guide member for guiding said arm on said opening tool into said slot when said opening tool is lowered in the pipe string for contacting said plug means with sufficient force to open same, said opening tool being suspended from a flexible line, and means for guiding said opening tool through said guide member after said plug means is fractured to impose the weight of said tool on said flexible line for indicating at the surface of the well

11

in which said pipe string is located that said plug means has been opened and therefore than said opening is open for fluid communication therethrough.

References Cited in the file of this patent

UNITED STATES PATENTS

1,854,477 McKissick ----- Apr. 19, 1932

2,208,604

2,379,079

2,506,795

2,568,087

2,710,655

2,723,677

12

Scaramucci ----- July 23, 1940

Hayward ----- June 26, 1945

Koeln ----- May 9, 1950

Page ----- Sept. 18, 1951

Collett ----- June 14, 1955

Middleton et al. ----- Nov. 15, 1955