This invention relates to new and useful improvements in circulation port assemblies for tubing or well pipe. In the producing of oil, gas and the like from wells, well packers are frequently positioned in the well casing to seal off the annulus between the tubing and the casing above the well formation being produced through the tubing. Under present day practice, fluid such as drilling mud is left in the annulus above the packer during production through the tubing and if it is desired to obtain circulation from the casing to the tubing and the area below the packer to "kill" the well or for any other reason, the tubing is perforated above the packer by lowering special perforating or punching tools into the tubing. Such perforating or punching procedure does permit the circulation of the fluid from the casing annulus to the inside of the tubing to "kill" the well or for any other reason but it is very costly and is therefore undesirable. In other instances, instead of perforating or punching the tubing, the packer is released which generally requires lifting the tubing with hoisting equipment while the well is under pressure which is of course an extremely dangerous operation.

It is therefore an object of this invention to provide a new and improved circulation port assembly for tubing or well pipe which has circulation ports capable of being easily and inexpensively opened for the circulation of fluid from the casing to the annulus.

An important object of this invention is to provide a new and improved circulation port assembly for tubing or well pipe which has ports that are normally sealed but which are adapted to be opened by an open tool which is either dropped or lowered in the tubing when it is desired to establish fluid communication between the casing annulus and the tubing.

Another object of this invention is to provide a new and improved circulation port assembly for tubing or well pipe for establishing fluid communication between the casing annulus and the tubing, wherein said assembly has an open unrestricted axial bore which is substantially the same size as the bore of the tubing or well pipe whereby the movement of well swabs and similar well tools through the tubing does not inadvertently open the circulation port assembly.

A further object of this invention is to provide a new and improved circulation port assembly having ports which are normally closed by sealing plugs held in sealing position by a frangible member adapted to be cracked or broken for permitting the release of the sealing plugs from their sealing position by pressure fluid exteriorly of the assembly.

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 where-in:

Figure 1 is a vertical sectional view illustrating one form of the circulation port assembly of this invention connected in a tubing or well pipe. Figure 2 is a horizontal sectional view taken on line 2—2 of Figure 1.

Figure 3 is a sectional view showing a portion of the assembly shown in Figure 1 to illustrate the opening of the port or ports in said assembly.

Figure 4 is a sectional view illustrating the circulation port assembly of Figure 1 with an opening tool for effecting the opening of the port or ports of said assembly.

Figure 5 is a view similar to Figure 4, but illustrating a modification of the circulation port assembly and the opening tool of Figure 4.

Figure 5A is a cross-sectional view taken on line 5A—5A of Figure 5.

In the drawings, the letter A designates generally the circulation port assembly of this invention which is disposed in a tubing or well pipe T, between an upper section 10 thereof and a lower section 11 thereof. As will be explained more in detail, the circulation port assembly A is adapted to be lowered into a casing or well bore C on the tubing or well pipe T, and ordinarily, such assembly A is positioned above and in the vicinity of a well packer P which is schematically shown and which can be of any conventional construction. As will be more evident hereinafter, the circulation port assembly A is normally closed so that there is no communication therebetween through the annulus X and the bore of the tubing or well pipe T. However, when it is desired to establish communication between such annulus X and the interior of the tubing T for "killing" the well or for any other reason, an opening tool K (Figure 4) is lowered or dropped through the tubing T for effecting an opening of one or more ports 12 in the circulation port assembly A, thereby establishing fluid communication between the annulus X and the interior of the tubing or well pipe T. Under ordinary conditions, the annulus X above the packer P is filled with fluid such as drilling mud and therefore when fluid communication between the annulus X and the interior of the tubing T is established, the fluid in the annulus X flows through the open ports 12 and into the interior of the tubing T for circulating to the well formation below the packer P (not shown). Also in some cases, the fluid can be pumped from the annulus into the interior of the tubing T for such circulation to the well formation (not shown), and to fill the tubing T to the well surface.

Referring to the invention more in detail, and to Figures 1—4 in particular, the circulation port assembly A includes a tubular body 15 which has an axial bore 15a which is enlarged as compared to the bore of the tubing or well pipe T. The upper end of the body 15 is provided with internal threads 15b which are engaged with the usual threads 10a at the lower end of the tubing section 10 of the tubing string T. The lower end of the body 15 is provided with internal threads 15c which are in threaded engagement with external thread 17a on an adapter ring 17. The adapter ring 17 has additional internal lower threads 17b which are in threaded engagement with external threads 11a on the lower tubing section 11, whereby the body 15 is connected to the lower tubing section 11 through the adapter 17. It will be appreciated of course that the adapter 17 could be formed integrally or could be welded or otherwise affixed to the body 15, so that in effect, the body 15 is connected at each end to the upper tubing section 10 and the lower tubing section 11 in a tubing string or section of well pipe T. The adapter ring 17 does have an upper laterally extending annular shoulder 17c, the purpose of which will be more evident hereinafter.
As previously mentioned, the circulation port assembly A is provided with one or more lateral or radial ports 12, preferably three in number, which when opened establish fluid communication between the casing annulus X and the interior of the body 15 and the interior of the tubing or well pipe P. The ports 12 are formed in the body 15 and are provided with a reduced diameter portion 12a so as to form an internal shoulder 12b. Each of the ports 12 has a closure member or plug 20 positioned therein with its outer surface 20a in engagement with the shoulder 12b so that such plugs 20 are limited in their outward movement. Each of the plugs 20 is generally cylindrical in shape and each preferably is provided with a sealing means such as O-ring 21, formed of rubber or other elastic resilient material which provides a seal between the external surface of the plug 20 and the inner wall 12c of each port 12. Thus, when the plugs 20 are positioned in ports 12, the rings 21 or any other suitable sealing means prevent the passage of fluid around the plugs 20, thereby closing fluid flow through the ports 12. For maintaining the plugs 20 in their sealing or closed position (Figure 1), a retainer ring 25 is provided, such ring having a central opening or bore 25a which is of substantially the same diameter as the diameter of the bore of the tubing or well pipe T, whereby swells or other well tools are adapted to pass through the central opening of the body 15 without contact with the ring 25. The outer edge 25b of the ring 25 engages each of the plugs 20 at substantially their mid-portions to prevent any inward movement of such plugs 20. Therefore, so long as the retainer ring 25 is in position (Figure 1) the plugs 20 remain in their closed or sealing position.

The retainer ring 25 is held in its position with its outer edge 25b in contact with the plugs 20 by means of a support ring 30 which has a plurality of pointed longitudinal projections 30a formed along its upper edge so as to support the retainer ring 25 at a plurality of points. As illustrated in Figure 1, each projection 30a on the support ring 30 is triangular in shape and has a sharp or pointed upper end in engagement with the lower side of the retainer ring 25 for a purpose to be hereinafter explained. The ring 30 rests upon the shoulder 17c of the adapter 17. To prevent the upward displacement of the retainer ring 25, a plurality of pins or bars 35 are attached to the body 15 and project inwardly at predetermined points above the ring 25 for engagement with its upper surface. Ordinarily such pins 35 are positioned directly above the vertical projections 30a of the support ring 30.

In the form of invention shown in Figures 1–4, the ring 25 is preferably formed of a relatively brittle frangible material so that it can be cracked upon the application of a predetermined force thereto. However, such ring 25 must be sufficiently strong to resist a fracture under normal fluid flow through the tubing string T. Preferably the ring 25 is formed of plastic, particularly since such plastic would be non-corrosive and would therefore be substantially unaffected over long periods of time. It should also be pointed out in this connection that the plugs 20 are preferably formed of a light non-corrosive metal such as aluminum because the circulation port assembly A is often left in the well for considerable periods of time and is subjected to corrosive fluids. It will be appreciated that when it is desired to open the ports 12 it is important for the plugs 20 to be freely movable inwardly and out of the ports 12 as will be explained hereinafter.

To facilitate the fracture or cracking of the ring 25 indentations or grooves 25c are provided on the upper and lower surfaces of the ring 25. Such indentations or grooves 25 are crack initiation grooves and preferably one or more of the grooves 25c is positioned above one or more of the projections 30a because upon the application of a downward force to the ring 25, the cracking of the ring 25 more readily occurs with a groove 25c above the projection 30a. Various tools can be employed for applying the necessary predetermined force to the retainer ring 25 for fracturing or cracking same to displace it from in front of the support ring 30. Among such tools is a frangible Y used in Figure 4 as the opening tool K. Such tool K is formed with a body 50 which is relatively heavy and which is provided with one or more recesses or slots 50a, each of which is adapted to receive an arm 51. Each arm 51 is pivotally connected to the body 50 by a pivot pin 52 (Figure 4) so that each arm 51 is adapted to swing or pivot into and out of its recess 50a. A spring 53 or other resilient means is provided on the inner surface of each of the arms 51 for urging same outwardly from the recess 50a to lateral extended position. Each arm 51 is limited in its pivoting upwardly by the stop surface 50b. Thus, as the opening tool K is lowered or dropped through the tubing or well pipe T it is in engagement with the inner surface or wall of the tubing T and when the opening tool K reaches the enlarged bore 15a of the tubular body 15, the spring 53 swings or pivots the arm 51 outwardly to a substantially lateral extended position. When in such lateral extended position, the arms 51 engage the upper surface of the retainer ring 25 and due to the downward movement of the opening tool K, a downward force is applied to the ring 25 to fracture or crack same.

The body 50 is ordinarily provided with a fishing neck 55 of conventional construction so that a fishing tool can be lowered downwardly through the tubing string T and connected thereto for raising the opening tool 55 out of the well when desired. In some cases, instead of merely dropping the opening tool K, a wire line or cable is connected to the upper end of the body 50 and in such case, the fishing neck 55 would of course not be necessary.

In the operation or use of the form of the invention shown in Figures 1–4, the circulation port assembly A connected in the tubing or well pipe T as indicated in Figure 1 is positioned in the well casing or well bore C above the well packer P. As previously mentioned, the well packer P is of conventional construction and it seals off the annulus between the tubing T and the casing C in the ordinary instance to direct fluid which is produced from a well formation (not shown) through the inside of the tubing string T to the surface of the well. The normal well operations result in withdrawal of oil or gas or other fluid from the well formation which is carried out with the circulation port assembly A having its plug or plugs 20 in their sealing or closed position (Figure 1). It may never be necessary to open the port or ports 12, and as previously explained, because the central opening 25a of the ring 25 is of substantially the same size as the bore of the tubing string T, the circulation port assembly A does not in any way interfere with the normal well operations such as the lowering of well swabs or other well tools in and through the tubing string T and the assembly A.

However, should it be necessary or desirable to circulate from the casing annulus X to the interior of the tubing string T for any reason such as for killing the well by applying the weight of fluid from the casing to the well formation below the packer P, the opening tool K is lowered into the tubing T. The opening tool K is either lowered on a wire line or it is simply dropped without having any wire line or cable connected thereto. As the opening tool K passes downwardly through the tubing T, the arm 51 or arms 51 are urged into engagement with the inside of the tubing T as indicated by the illustration of the tool K in the Figure 4. When the tool K reaches the tubular body 15, it urges the arms 51 to their laterally extended position and then such arms 51 engage the upper surface of the frangible ring 25 with a predetermined force which is sufficient to fracture or crack such ring 25 as indicated in Figure 3. Such cracking or fracture of the ring 25...
causes it to be displaced from its position inside of the plug or plugs 20. Thereafter, pressure fluid from the fluid in the casing annulus X forces the plug or plugs 20 inwardly out of the openings 12 whereby fluid communication between the annulus X and the interior of the tubing T is effected. The fluid in the annulus X can thus flow through the tubing T to the area below the packer P for applying sufficient fluid pressure to the formation F to prevent its flowing, or in other words, to kill such well. Circulation can also be maintained for any other purpose as will be evident. Also fluid can be pumped through the annulus X instead of merely relying upon the flow of the fluid from the annulus X. After the plugs 20 are moved inwardly to open the ports 12, the opening tool K can be removed by the engagement of a fishing tool with the fishing neck 55, such fishing tools being well known in the art; or the tool K can be pulled from the well with the tubing.

In Figure 5, a modification of the circulation port assembly A is illustrated and is identified by the letter K'. Also, a modified opening tool K' is illustrated. The parts of the assembly A' which are identical with the assembly A of Figures 1-4 have like numerals. Thus, the tubular body 15 is the same in both forms of the invention and also the lateral ports 12. The plugs 120 for sealing or closing same are each modified to provide a flange 120b which engages the interior of the body 15 so that the size or diameter of each lateral port 12 may be as large as the external size or diameter of each plug 120. A modified retainer plate 125 is utilized which has a central opening or bore 125a which is of a smaller diameter than the diameter of the bore of the tubing or well pipe T.

The opening tool K does not employ arms 51 such as on the opening tool K, but instead the tool K' is of substantially the same diameter as the diameter of the bore of the tubing T. The body 150 of the tool K' has head sections 150a and 150b, each of which has lateral projections or ribs 151. The projections 151 on the head 150b are preferably pointed at the bottom as indicated by the numeral 15la to facilitate the breaking of the flange ring 125 upon contact therewith. Because of the open areas between the lateral projections 151, fluid flows around the tool K' as it is lowered in the pipe T so that the opening tool K' can be dropped through tubing T without being retarded by any tendency to float in the fluid inside of such tubing T. The upper end 155 of the tool K' is formed with a fishing neck 155a of conventional construction, if such tool is not lowered on a wire line or cable initially. It will be observed that the central opening 125a is of a smaller diameter than the maximum diameter of the projections or ribs 151 of the lower head section 150b whereby the retainer ring 125 is adapted to be engaged or jarred by the contact of the lower head section 150b with the upper surface of the ring 125 when it is desired to open the port or ports 12.

In the operation or use of the modified construction shown in Figure 5, the assembly A' is used with the tubing T in a sealing or closed position illustrated in Figure 5 and preferably above a packer P such as shown in Figure 1. When it is desired to open the port or ports 12 to effect the circulation between the annulus or area exteriorly of the tubular body 15 and the area interiorly thereof, the opening tool K' is dropped or lowered through tubing T. It contacts the retainer ring 125 and imparts a sufficient force or jar thereto to fracture or break the ring 125 so as to move away from the position inside of the plug or plugs 20. The plug or plugs 20 are thereafter free to move inwardly by the force of the pressure fluid in the annulus or area exteriorly of the tubular body 15.

It is believed evident that the opening tool K' could be utilized in the form of the invention shown in Figure 5 instead of the opening tool K', if desired.

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. A circulation port assembly for a well pipe, comprising a tubular body connected in the well pipe and having a substantially axial bore in fluid communication with the bore of the well pipe, said body having a substantially lateral port for establishing fluid communication between the area exteriorly of said body and said axial bore of said body, closure means for normally closing said lateral port but being adapted to be moved out of said port to open same, and an annular ring formed of a frangible material in said body for normally preventing said closure means from moving out of said port, whereby said lateral port is maintained closed until said annular ring is displaced by cracking same to permit the movement of said closure means out of said lateral port.

2. The structure set forth in claim 1, wherein said annular ring has a central opening of substantially the same size as the axial bore of said well pipe whereby well tools may be lowered therethrough without any contact therewith.

3. The structure set forth in claim 1, wherein said closure means is a plug positioned in said lateral opening, and wherein said annular ring is disposed inwardly of said plug.

4. The structure set forth in claim 1, wherein a support ring is provided for preventing longitudinal displacement of said annular ring until a predetermined longitudinal force is applied thereto for moving said annular ring longitudinally away from said closure means by cracking same, whereby said closure means can be moved inwardly to establish fluid communication between the area exteriorly of said body and the interior thereof.

5. A circulation port assembly for a well pipe, comprising a tubular body connected in the well pipe with its axial bore in fluid communication with the bore of the well pipe, said body having a lateral port for establishing fluid communication between the area exteriorly of said body and said axial bore of said body, closure means for normally closing said lateral port, but being adapted to be moved inwardly of said body to open same, an annular ring formed of a frangible material in said body for normally preventing said closure means from moving out of said port, and an opening tool adapted to be lowered through the well pipe into engagement with said annular ring for displacing said same away from said closure means by cracking same for thereafter permitting said closure means to move inwardly to establish said fluid communication between the areas exteriorly and interiorly of said body.

6. The structure set forth in claim 5, wherein said body has an enlarged axial bore of greater size than the bore of said well pipe, and wherein said opening tool has an arm engageable with the inside wall of the well pipe as it moves therethrough, and means for urging said arm laterally outwardly as it enters the enlarged axial bore of said body for subsequent contact with said annular ring to effect the displacement thereof by cracking same.

7. The structure set forth in claim 5, wherein said closure means is a cylindrical plug disposed in said port, and wherein said ring has its edge substantially at the mid-portion of said plug when holding same against inward movement.

8. The structure set forth in claim 5, wherein said closure means is a cylindrical plug disposed in said port, and wherein said port has an annular shoulder to prevent outward displacement of said plug from said body.

9. The structure set forth in claim 5, wherein said closure means is a plug having a lateral flange thereon engageable with the interior of said body to prevent out-
ward movement of said plug through said lateral port, whereby said port has a size at least as large as the external size of said plug.

10. The structure set forth in claim 5, wherein said annular ring has a bore of lesser size than the bore of said well pipe, and wherein said opening tool is larger than the bore of said annular ring, whereby said opening tool may contact said annular ring to effect displacement thereof by cracking same.

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