

Sept. 6, 1955

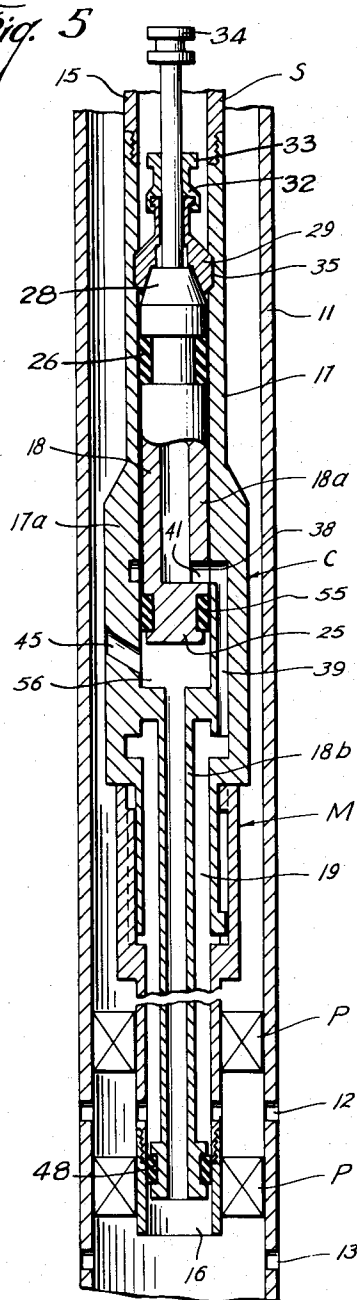
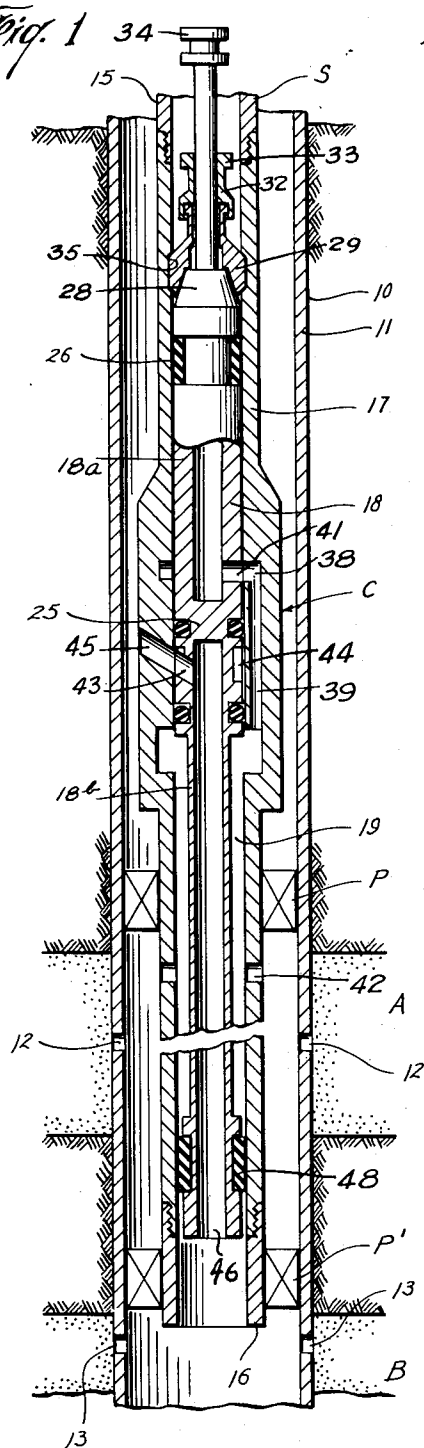
C. C. BROWN

2,717,041

CROSSOVER APPARATUS FOR DUAL PRODUCTION IN OIL WELLS

Filed Oct. 16, 1952

4 Sheets-Sheet 1



Cicero C. Brown
INVENTOR.

BY *J. Vincent Martin*
Joe E. Edwards
B. R. Pravel
ATTORNEYS.

Sept. 6, 1955

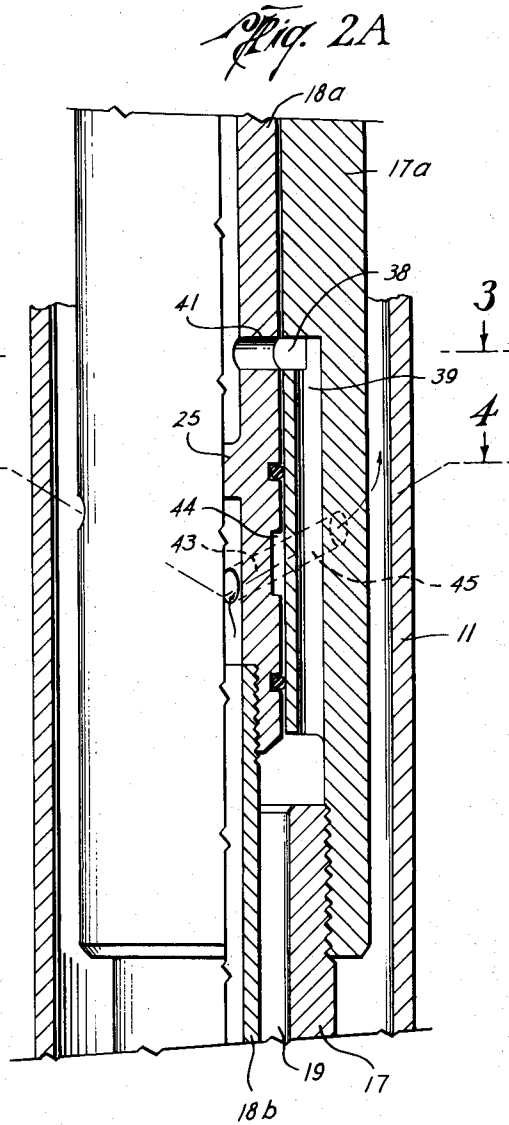
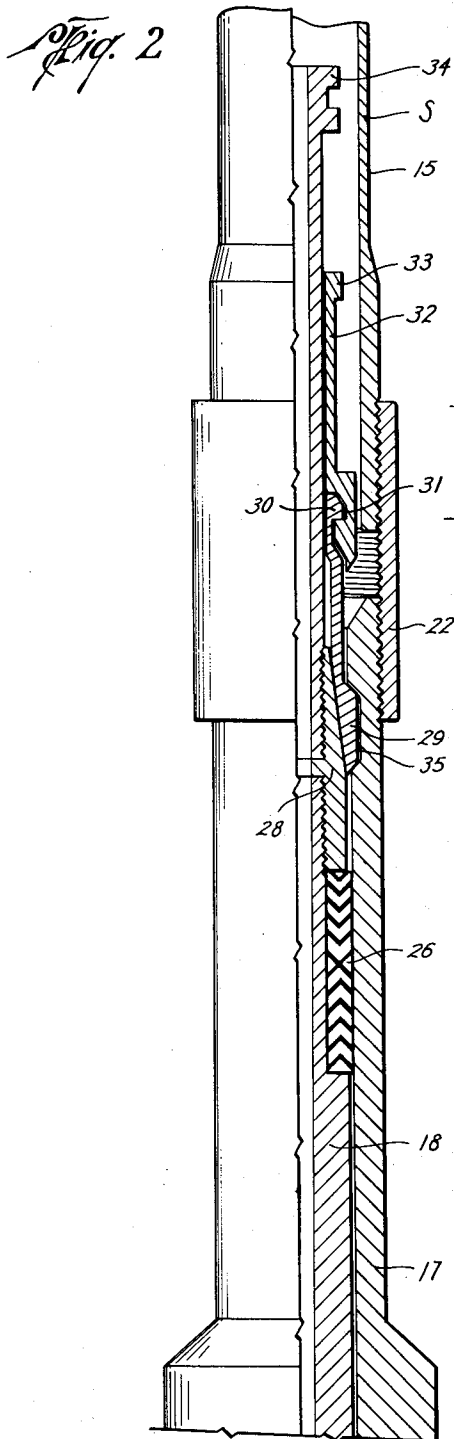
C. C. BROWN

2,717,041

CROSSOVER APPARATUS FOR DUAL PRODUCTION IN OIL WELLS

Filed Oct. 16, 1952

4 Sheets-Sheet 2



Cicero C. Brown
INVENTOR.

BY *J. Vincent Martin*
Joe E. Edwards
B. R. Favel
ATTORNEYS

Sept. 6, 1955

C. C. BROWN

2,717,041

CROSSOVER APPARATUS FOR DUAL PRODUCTION IN OIL WELLS

Filed Oct. 16, 1952

4 Sheets-Sheet 3

Fig. 2B

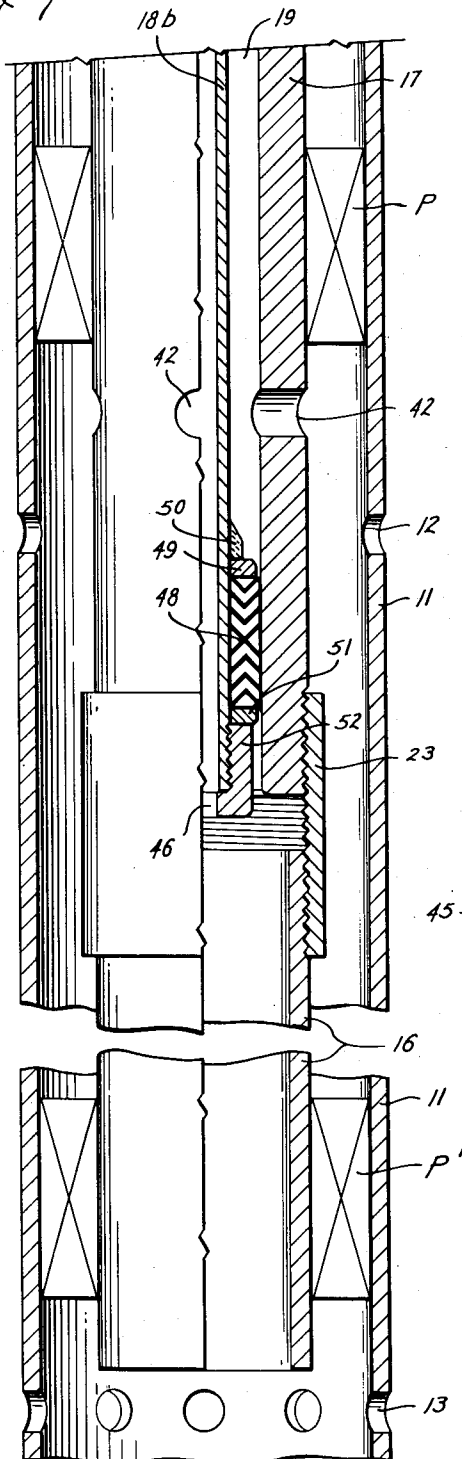


Fig. 3

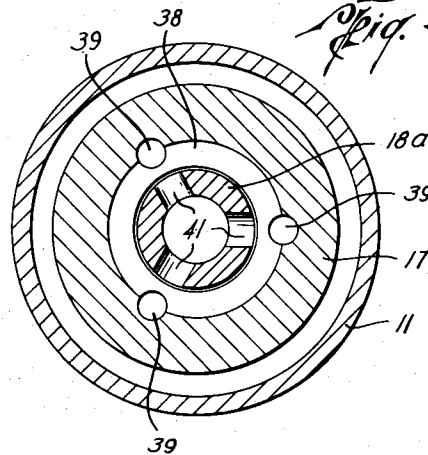
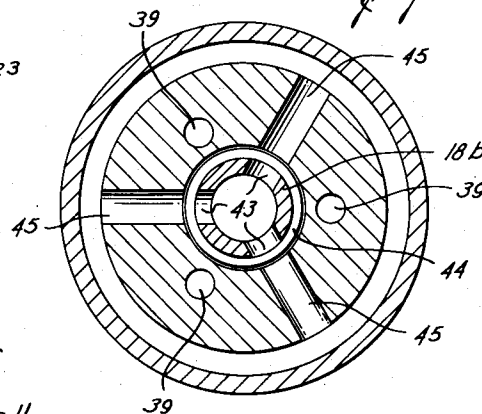


Fig. 4



Cicero C. Brown
INVENTOR.

BY *J. Vincent Martin*
Joe E. Edwards
B. R. Pravel
ATTORNEYS

Sept. 6, 1955

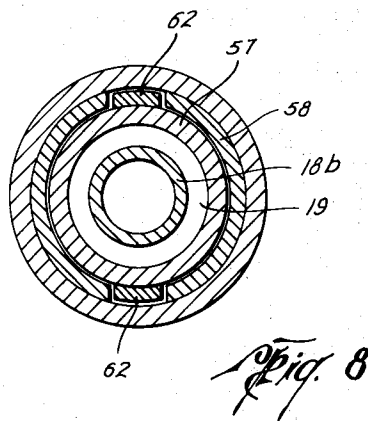
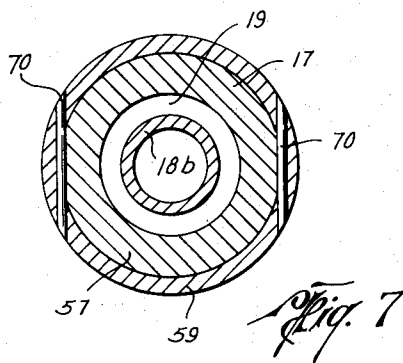
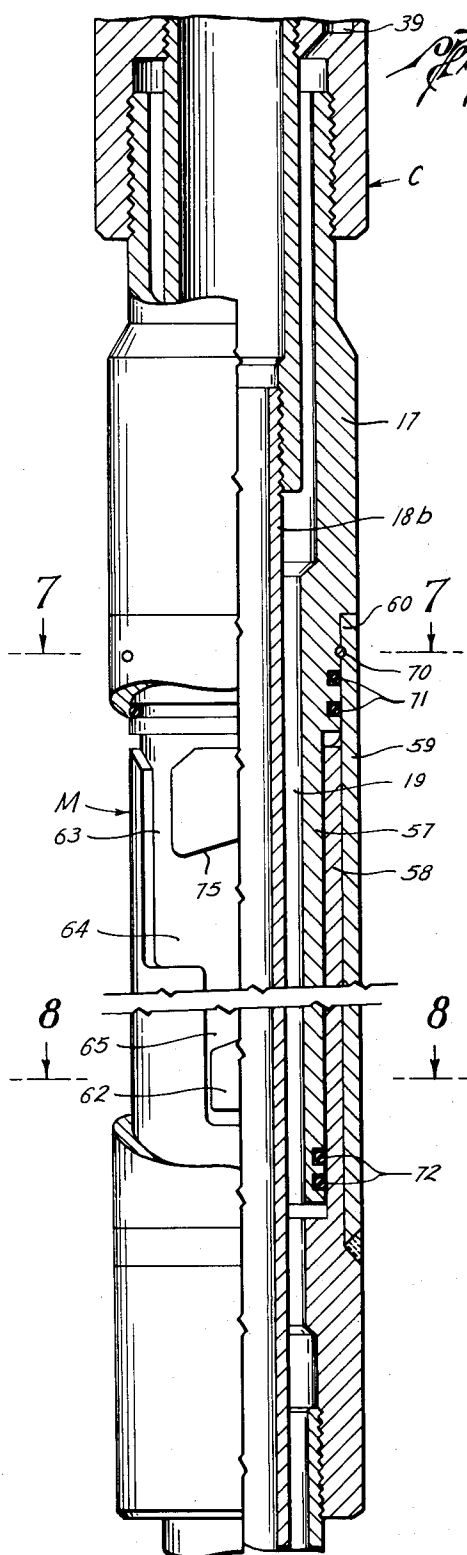
C. C. BROWN

2,717,041

CROSSOVER APPARATUS FOR DUAL PRODUCTION IN OIL WELLS

Filed Oct. 16, 1952

4 Sheets-Sheet 4



Cicero C. Brown
INVENTOR.

BY J. Vincent Martin
Joe E. Edwards
B. R. Pravel
ATTORNEYS

1

2,717,041

CROSSOVER APPARATUS FOR DUAL PRODUCTION IN OIL WELLS

Cicero C. Brown, Houston, Tex.

Application October 16, 1952, Serial No. 315,161

13 Claims. (Cl. 166—186)

This invention relates to new and useful improvements in crossover apparatus for dual production in oil wells and the like.

Crossover apparatus for the production of oil from several formations at the same time is well known, wherein such apparatus includes a tubing or pipe string, an inner conductor extending axially therein with an annular space between the pipe string and the conductor, and suitable ports connecting the inner conductor with the exterior of the pipe string and the annular space with the interior of the pipe string, whereby oil from one formation may flow into the annular space and upwardly through the pipe string while oil from a second formation may flow into the inner conductor and pass upwardly and outwardly to the area exterior of the pipe string. Of course, the usual types of well packers are used between the pipe string and the well casing to separate the producing formations from each other. Such previously known crossover apparatus has the disadvantage that the full open bore of the pipe string cannot be obtained for well operations therethrough without removing the entire pipe string from the well casing.

Thus, with the prior crossover apparatus, in order to obtain the full open bore of the pipe string apparatus, it is necessary to unset the packers, pull the tubing or pipe string, remove the crossover structure therefrom, reconnect the adjacent sections of pipe in the string, and lower the string into the well casing. When it is again desired to use the crossover apparatus, the pipe string must be again withdrawn from the casing, the crossover apparatus connected into the string, and then lowered to the desired position in the casing where the packers are again set. Such a procedure is obviously costly and undesirable.

It is therefore an object of this invention to provide a crossover apparatus wherein the full open bore of the tubing or pipe string can be made available for performing well operations therethrough without the necessity of pulling the entire pipe string from the well.

An important object of this invention is to provide a crossover apparatus having an inner conductor in a pipe string, wherein the full open bore of the tubing or pipe string can be made available for performing well operations therethrough by the removal of the inner conductor from the pipe string without disturbing the packers disposed in the annular space between the well casing and said pipe string or requiring removal of the entire pipe string from the well.

Another object of this invention is to provide a crossover apparatus for dual production in oil wells and the like, in which said apparatus has a tubular full-opening housing or adapter connected in a pipe string with an inner conductor extending through said housing, said conductor having a releasable connection with said housing whereby the conductor may be removed from said pipe string to provide a full open bore in the string without removing the string from the well.

Still another object of this invention is to provide a

2

crossover apparatus for dual production in oil wells and the like, in which said apparatus has a tubular adapter connected in a tubing or pipe string with an inner conductor disposed in said string, and a releasable connection between said adapter and the portion of the pipe string therebelow, whereby the full open bore of the pipe string below the adapter may be made available by releasing said connection and removing said crossover apparatus without the necessity for unsettling the packers disposed about said portion of the pipe string below the adapter.

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 specifications and by reference to the accompanying drawing forming a part thereof, wherein an example of the invention is shown, and wherein:

Figure 1 is a vertical sectional view of one form of the crossover apparatus of this invention, illustrating somewhat diagrammatically its relationship to the packers and other structure when positioned in a well casing.

Figures 2, 2A, and 2B are views which, together, illustrate the details of the complete crossover apparatus of this invention, such views being partly in section and partly in elevation, with Figure 2 illustrating the upper portion, Figure 2A illustrating the intermediate portion, and Figure 2B illustrating the lower portion.

Figure 3 is a horizontal sectional view taken on line 3—3 of Figure 2A.

Figure 4 is a horizontal sectional view taken on line 4—4 of Figure 2A.

Figure 5 is a view similar to Figure 1, but illustrating another form of the crossover apparatus of this invention in its position in the well casing.

Figure 6 is a detailed view, partly in elevation and partly in section, of a portion of the crossover apparatus illustrated in Figure 5, and particularly illustrating the releasable connection for permitting the release and removal of the inner conductor from the tubing or pipe string.

Figure 7 is a horizontal sectional view taken on line 7—7 of Figure 6.

Figure 8 is a horizontal sectional view taken on line 8—8 of Figure 6.

In the drawings, the numeral 10 designates a well bore which traverses an upper producing formation A and a lower producing formation B. The usual well casing 11 extends through the well bore and has perforations or inlets 12 opposite the formation A, with similar inlets 13 opposite the formation B.

The crossover apparatus of this invention is generally indicated in the drawings by the letter C, and such apparatus C is connected in a tubing or pipe string S of the usual type for the lowering of the crossover apparatus into the well casing 11. The upper tubing section 15 of the tubing S extends to the surface (not shown) of the well bore 10; while the lower tubing section 16 is connected to the lower end of the crossover apparatus C. The crossover apparatus C has a tubular adapter 17 which has its upper end connected to the lower end of the upper tubing section 15 of the tubing string S and its lower end connected to the upper end of the lower tubing section 16 of the tubing string, so that the adapter 17 in effect forms a continuation of the tubing and has substantially the same internal diameter or bore as the tubing string S. The tubular adapter 17 has extending therein an inner conductor 18 which is formed with a portion thereof of a lesser diameter than the bore of the tubular adapter 17 whereby an annular space 19 is formed between the inner conductor 18 and the tubular adapter 17. Disposed ex-

3

teriorally of the tubing or pipe string S are a pair of spaced packers P and P', such packers serving to seal off the annular space between the well casing 11 and the tubing string S. The upper packer P is disposed above the perforations or inlets 12 and the lower packer P' is located between the inlets 12 and 13 whereby fluids from the formation A enter the inlets 12 into the annular space between the packers P and P'. The fluid flowing from the formation B enters through the inlets 13 and is confined below the lower packer P'. As will be explained in detail hereinafter, the crossover apparatus C of this invention has suitable ports or passages whereby fluid entering from the formation A passes through the annular space 19 in the crossover apparatus and thence upwardly into the interior of the tubing string S to the surface. The fluids from the formation B pass upwardly through the interior of the inner conductor 18 and then pass into the area exterior of the tubular adapter 17 and above the upper well packer P for flow into the casing upwardly to the surface of the well. Thus, dual production, that is, production of oil from several formations at the same time, is effected with the oil from the upper formation passing upwardly through the tubing while the oil from the lower formation passes upwardly through the casing.

One form of the crossover apparatus C of this invention is shown in detail in Figures 2-4. The upper end 15 of the tubing is connected to the tubular adapter 17 by a threaded coupling 22 and the lower end 16 of the tubing is connected to the tubular adapter 17 by a threaded coupling 23. It will be appreciated, of course, that other types of connections, such as welding or tool joints, could be utilized instead of the couplings 22 and 23. As was pointed out above, the tubular adapter 17 has an inner conductor 18 therein. In this form of the invention shown in Figures 2-4, the conductor 18 is a unitary member with an upper section 18a and a lower section 18b formed by a plug or lateral portion 25 which blocks off the bore of the upper section 18a from the lower section 18b. The upper section 18a is provided with a seal 26 which is adapted to contact the bore of the tubular adapter 17 and to provide a seal between the inner conductor 18 and the tubular adapter 17. The lower section 18b of the inner conductor 18 is of a lesser diameter than the bore of the tubular adapter 17 so that an annular space 19 is formed therebetween.

The upper end of the inner conductor 18 is formed with a releasable connection between the inner conductor 18 and the adapter 17. Since the adapter 17 is, in effect, a continuation of the tubing string S, the inner conductor 18 is, in effect, connected to the tubing string. This releasable type of connection, which is shown in Figure 2 particularly, is of the type disclosed in U. S. Patent No. 2,246,811, and includes a cone 28 connected to the outer surface of the inner conductor 18. Slidably mounted on the inner conductor 18 above the cone 28 are locking dogs 29 which have their upper ends formed in the shape of hooks 30 which fit loosely within a recess 31 in a collar or ring 32 disposed above the dogs 29. The loose fit between the hooks 30 and the recess 31 permits a slight radial movement of the dogs 29, the purpose of which will be explained hereinafter. The upper end of the collar 32 has a radial flange 33 which permits the collar 32 to be grabbed or attached to a suitable tool extending down through the tubing S. Above the collar 32, the conductor 18 has a radial flange 34 which limits the upward movement of the collar 32 with respect to the conductor 18 and also serves as a means to grab the conductor with a wire line or similar gripping device extended downwardly through the tubing S.

It will be observed in Figure 2 that the tubular adapter 17 has an annular recess 35 therein for the reception of the locking dogs 29 when in their expanded or gripping position, whereby the conductor 18 is held in a fixed position relative to the pipe string S. Below the recess 35

4

provided for the locking dogs 29, the tubular adapter 17 has an enlarged outer diameter or a thickened portion to facilitate the provision of the crossover ports.

This thickened or enlarged portion 17a has an annular recess or opening 38 on the inner surface thereof which communicates with a vertical passage 39, which, in turn, communicates with the annular space 19 between the lower portion 18b of the conductor 18 and the tubular adapter 17. As best seen in Figures 2A and 3, the annular recess 38 communicates with the bore of the upper portion 18a of the conductor 18 by the ports or passages 41. It will be observed that this group of ports 41 are above the plug 25. Below the packer P there is disposed in the tubular adapter 17 a plurality of ports or passages 42 whereby communication with the producing formation A is established through the inlets 12 in the casing 11. Thus, fluid from the producing formation A may pass through the perforations or inlets 12 into the annular space between the casing 11 and the tubular adapter 17 where it is confined between the packer P and the packer P'. Thence, the fluid enters the annular space 19 through the ports 42 and passes upwardly through the vertical passage 39 and into the bore of the upper portion 18a of the inner conductor 18 through the communication of the annular recess 38 and the ports 41. The fluid then passes upwardly through the tubing string S to the surface of the well, so that it can be seen that the fluid, such as oil from the producing formation A, enters the crossover apparatus and is passed to the surface of the well through the interior of the tubing string S.

Near the upper end of the lower portion 18b of the conductor 18, but below the plug 25, there are provided a plurality of ports 43 which communicate with the interior of the lower portion 18b of the conductor and also communicate with an annular recess or opening 44 on the exterior of the lower portion 18b. This annular opening 44 in turn communicates with a plurality of ports 45 in the tubular adapter 17, which ports 45 extend radially through the adapter 17 and establish communication with the annular space between the adapter and the casing 11. Since the lower end of the lower section 18b of the conductor is open at 46, fluid from the formation B may flow inwardly through the perforations 13 and pass upwardly through the lower end 16 of the tubing string S and enter the interior of the lower section 18b. Thereafter, the fluid passes through the ports 43, the annular opening 44, and the ports 45 into the casing, where it is conducted to the surface of the well. It will be observed that the lower packing P' serves to prevent the fluid from the formation B which enters through the perforations 13 from passing upwardly in the annular space between the casing 11 and the pipe string, while a sealing element 48 on the exterior and lower end of the lower section 18b of the conductor prevents the fluid from passing into the annular space 19. Therefore, there is no intermingling of the fluids from the formations A and B in their passage upwardly. The sealing element 48 may take numerous forms but preferably it is of the chevron type with an annular ring 49 thereabove fixed to the outer surface of the conductor 18 by a weld 50 and a lower metallic ring 51 held in position by a locking collar 52 threaded to the lower end of the conductor 18.

In the operation or use of the crossover apparatus illustrated in Figures 2-4, the radial flange 34 on the upper end of the conductor 18 is connected to a wire line or similar gripping tool whereby the conductor may be lowered into the tubing string S. The conductor will be lowered into such tubing string S after the tubing string has been placed in the well casing and the packers P and P' set in gripping position therewith. As the conductor 18 is lowered into the tubing string, the dogs 29 will ride loosely above the cone 28. The conductor 18 is lowered until the cone 28 has passed below the recess 35. Then the conductor 18 is raised so that the cone 28 urges the locking dogs 29 radially outwardly whereby such dogs enter

the recess 35 and thereafter the fluid pressure from below the apparatus tends to urge the inner conductor upwardly to maintain the locking dogs 29 in the recess 35 by the action of the cone 28. If desired, the cone 28 may be held in its expanding position illustrated in Figure 2 by an upward pull on the inner conductor 18 through the wire line previously mentioned.

With the crossover apparatus shown in Figures 1-4, the formation A can then be produced by a flow of the oil through the inlet 12 and ports 42 into the annular space 19 which directs the flow of the oil upwardly through the vertical passage 39, the annular opening 38, and the ports 41, whereby the oil passes into the bore of the upper section 18a for flow to the surface through the tubing. At the same time, the oil flows from the formation B through the inlet 13 and enters the interior of the lower section 18b of the conductor, whereby it is directed upwardly through the ports 43, annular opening 44, and ports 45 to the casing above the upper packer P, so that the oil can flow to the surface through the casing 11.

When it becomes necessary to perform a well operation through the tubing string S, the inner conductor 18 can be removed in its entirety so that the full open bore of the tubing string S is made available for such a well operation. The removal of the inner conductor 18 can be accomplished in several ways, but preferably the radial shoulder 33 on the collar 32 is engaged by a tool extending through the tube string and the shoulder 34 is forced downwardly with respect to such collar 32 and locking dogs 29 so that the cone 28 is forced downwardly below the locking dogs 29. Thereafter, the shoulder 33, and therefore the dogs 29, are raised upwardly to remove the dogs 29 from the recess 35.

Once the dogs 29 have been raised upwardly above the recess 35, then an upward movement of the conductor 18 will carry the dogs 29 upwardly so that such dogs are removed with the conductor. Since the bore of the tubular adapter 17 is of substantially the same internal diameter as the internal diameter or bore of the usual well string S, this provides the full open bore of the tubing string for the well operations which are conducted therethrough. When it is desired to again provide the dual production from the two formations, the inner conductor 18 may again be lowered into the tubing string and fixed in position as above explained.

In Figure 5 a modified form of the crossover apparatus of this invention is illustrated. This crossover apparatus of Figure 5 is similar to that shown in Figure 1, except that the inner conductor 18 is not a unitary member, but instead the lower section 18b is integral or directly connected with the tubular adapter 17 and the upper section 18a is the only portion of the conductor 18 which is connected with the locking arrangement including the locking dogs 29 which engage in the recess 35. Also, in the form shown in Figure 5, the release of the conductor 18 from the pipe string is effected by a releasable connection M, illustrated in detail in Figure 6.

Due to the construction of the crossover apparatus of Figure 5, with the upper section 18a separate from the lower section 18b, the plug 25 is formed as the bottom or lower end of the upper section 18a in Figure 5 and the suitable packing element 55 is disposed on the exterior of the lower end of the section 18a for sealing with the bore of the adapter 17. Communication of the bore of the upper section 18a with the annular space 19 is provided through the same type of vertical passage 39, annular opening 38, and ports 41, as in Figure 1. In Figure 5, there is no necessity for the ports 43 and the annular opening 44, as in Figure 1, since the space 56 serves the same purpose as it communicates with the interior or the bore of the lower section 18b and the radial ports 45 in the adapter 17. Thus, fluid flow from the lower formation B is directed in the same way as in the form of the device shown in Figure 1, so

that the oil from such formation passes upwardly through the lower section 18b and outwardly into the casing 11 through the ports 45 in the tubular adapter 17.

The releasable connection M is shown in detail in Figure 6 and serves to permit the removal of the lower conductor 18b, along with the upper conductor 18a, so that the full open bore of the pipe string may be obtained without the unsetting of the packers or without removing the entire pipe string from the well casing. The releasable connection M is shown in Figure 6 in its connected position and as can be seen therein, the tubular adapter has its lower portion 57 of a reduced outer diameter, whereby such portion 57 may telescope within an annular sleeve 58 connected to the lower end of the pipe string. The sleeve 58 is provided with a cylinder 59 surrounding same and extending upwardly beyond the upper end of the sleeve 58 into a recess 60 in the exterior of the tubular adapter 17. This cylinder 59 is shown as being welded to the sleeve 58 but it will be appreciated that such parts may be integral or otherwise formed.

The reduced diameter portion 57 of the adapter 17 has thereon lugs or pins 62 which are adapted to slide in a slot formed in the sleeve 58. This slot includes an upper vertical portion 63, a lateral portion 64, and a lower vertical portion 65. When the releasable connection M is assembled as shown in Figure 6 the lugs or pins 62 will be near the lower end of the lower vertical slot portion 65, as shown in Figure 6.

To assist in maintaining the pins 62 in the lower position during the lowering of the crossover apparatus into the casing 11, shear pins 70 may be provided to lock the cylinder 59 to the tubular adapter portion 57. It will be appreciated that such pins 70 can be sheared by an upward movement of the tubular adapter 17 to move the reduced diameter portion 57 upwardly relative to the sleeve 58 and the cylinder 59. Suitable seal rings 71 are preferably provided between the portion 57 and the cylinder 59 and additional seal rings 72 are provided at the lower end of the reduced diameter portion 57, to seal between such portion and the interior of the sleeve 58.

In the operation of the form of the crossover apparatus shown in Figures 5-8, the pipe string S is first set in position with the packers P and P', engaging with the well casing 11. That is, of course, carried out with the releasable connection M in the position shown in Figure 6, and the shear pins 70 prevent the release of the connection while setting the packers therebelow. Thereafter, the upper section 18a of the inner conductor is set in gripping contact with the tubular adapter 17 by setting the dogs 29 in the recess 35 in the same manner as described in connection with Figure 1. Thus, with the upper section 18a in position dual production is effected in the manner above described in connection with Figure 1. When it is desired to release the connection M, an upward pull is exerted on the tubing string S. Since the packers P and P' are set in the well casing, the lower portion of the pipe string will be held against longitudinal movement, thereby holding the sleeve 58 and the cylinder 59 against longitudinal movement, while the lower portion 57 of the adapter 17 is moved upwardly. Such upward movement carries with it the pins 62 until such pins contact the guide surface 75 on the sleeve 58, at which time rotation in a clock-wise direction, as viewed from Figure 8, will move the pins 62 in line with the vertical slot 63 so that continuous upward movement of the lugs 62 will permit the separation of the lower end 57 from the sleeve 58 and the cylinder 59, as well as the lower portion of the pipe string to which such parts are connected. It will be appreciated, of course, that the first initial upward movement will shear the pins 70. Since the lower section 18b of the conductor is connected directly to the tubular adapter 17, upon the removal of the upper portion

of the pipe string with the tubular adapter 17, the lower section 18b is likewise removed so that the full open bore of the pipe string which remains in the casing is provided for well operations therethrough. After such operations have been completed, the portion of the pipe string with the tubular adapter may again be lowered into the well and the pins 62 rotated into the slot provided by the portions 63, 64, and 65 so that the connection M is again made.

It will be appreciated that any type of the usual packers may be used in this invention and for that reason the packers P and P' have been shown schematically. Also, it will be evident that other forms of the releasable connection M, shown in Figure 6, could be utilized in place of the particular connection illustrated.

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 crossover apparatus adapted to be lowered into a well casing on a pipe string having spaced well packers thereon adapted to seal with the casing for dual production in oil wells and the like from a first production zone between said packers and a second production zone below said packers, comprising a tubular housing connected in said pipe string, an inner conductor in said housing with an annular space formed between said housing and said inner conductor, said conductor having a plug for forming an upper conductor section and a lower conductor section, a releasable connection between said conductor and said pipe string, said pipe string having means for establishing fluid communication between said first production zone and said annular space, said housing and said conductor having means establishing fluid communication between said annular space and the interior of said upper conductor section, said pipe string having means for establishing fluid communication between said second production zone and the lower conductor section, said housing and said conductor having an additional means establishing fluid communication between the interior of said lower conductor section and the area above said packers and exterior of said housing, said conductor constituting the only obstruction in the bore of said pipe string, and means for releasing said connection between said conductor and said pipe string whereby said conductor may be removed to provide the full open bore of the pipe string for well operations without removing the entire pipe string from the well casing.

2. The apparatus set forth in claim 1, wherein said conductor is a unitary member having said upper section and said lower section, and wherein said plug blocking off fluid flow between said sections is formed in the bore of said conductor.

3. The apparatus set forth in claim 1, wherein said sections are movable longitudinally relative to each other.

4. A crossover apparatus adapted to be positioned in a well casing on a pipe string having spaced well packers thereon adapted to seal with the casing for dual production in a well from a first production zone between the packers and a second production zone below the packers, including an inner conductor connected in said pipe string with an annular space formed therebetween, plug means in said conductor blocking off flow therethrough, said string and conductor having means for establishing fluid communication between said annular space and the first production zone between said packers in said well casing and between said annular space and the interior of said conductor above said plug means, said string and conductor having an additional means for establishing communication between the second production zone and the interior of said conductor below said plug means and between said interior of said conductor below said plug

means and the exterior of said string above said packers, said conductor constituting the only obstruction in the bore of said pipe string, and a releasable connection between said conductor and said string whereby the removal of said conductor from the well provides the full open bore of said string for performing well operations therethrough without unsettling said packer.

5. The apparatus set forth in claim 4, wherein said releasable connection includes locking dogs engageable with said pipe string.

6. The apparatus set forth in claim 4, wherein said releasable connection is on adjacent sections of said pipe string, and said conductor is directly connected to only one of said sections, whereby the release of said connection permits the removal of said conductor and the section having connection therewith from the other section.

7. The apparatus set forth in claim 4, wherein said conductor is a unitary member having an upper section formed above said plug means and a lower section formed below said plug means, and wherein said plug means blocking off fluid flow between said sections is integral with the walls of said conductor.

8. In combination with a tubing string having a pair of spaced well packers thereon adapted to seal with a well casing for dual production in a well from a first production zone between said packers and a second production zone below said packers, of a crossover apparatus including an inner conductor disposed in said tubing string, crossover means for permitting simultaneous flow of oil from said first production zone through the tubing string and from said second production zone through the well casing, said conductor constituting the only obstruction in the bore of said pipe string, and means for releasing said conductor from said tubing string to provide the full open bore of said tubing string without removing the entire string from the well casing.

9. The apparatus set forth in claim 8, wherein flow from said first production zone is conducted through a lower section of said conductor to an area exterior of the tubing string above said packers and flow from said second production zone is conducted through into an upper section of said conductor, and wherein said conductor has a plug between said sections to prevent intermingling of the fluids from the two production zones.

10. In combination with a tubing string having a pair of spaced well packers thereon adapted to seal with a well casing for separating two well formations from each other for dual production from a well, a crossover apparatus including an inner conductor disposed in said tubing string, crossover means for permitting simultaneous flow of well fluid from one well formation through the tubing string and from another well formation through the well casing, said conductor constituting the only obstruction in the bore of said pipe string, and means for releasing said conductor from said tubing string to provide the full open bore of said tubing string without removing the portion of the string carried by the packers, whereby the conductor may be removed without disturbing the packers.

11. A crossover apparatus adapted to be lowered into a well casing on a pipe string having spaced well packers thereon, which packers seal with the casing to separate the fluid production from a first producing zone between the packers and a second producing zone below the packers, said apparatus including, a tubular housing connected in said pipe string and having a bore of substantially the same diameter as the bore of the pipe string, an inner conductor in said housing having a transversely extending member therein for blocking straight-through flow through the conductor and for dividing the conductor into an upper conductor section and a lower conductor section, a releasable connection between said conductor and said pipe string, the pipe string above the inner conductor forming one flow conduit extending to the well surface and the well casing above the packers forming a second flow conduit extending to the surface,

9

means establishing communication between one of the producing zones and the upper conductor section and additional means establishing communication between said upper conductor section and the flow conduit formed by the pipe string, means establishing communication between the other producing zone and the lower conductor section with additional means establishing communication between the lower conductor section and the second flow conduit formed by the well casing, and means for releasing the releasable connection between the conductor and said pipe string, whereby said conductor may be removed to provide the substantially full open bore of the pipe string for well operations without removing the entire pipe string from the well bore.

12. In combination with a tubing string having a pair of spaced well packers thereon adapted to seal with a well casing for separating two fluid producing zones from each other for dual production from a well, a crossover apparatus including, a tubular housing connected in the tubing string and having a bore of substantially the same diameter as said tubing string, an inner conductor releasably mounted in said housing, crossover

10

means for permitting simultaneous flow of fluid from one producing zone through the tubing string and from the other producing zone through the well casing, said inner conductor constituting the only obstruction in the bore of the tubing string, and means for releasing and removing said conductor from said tubing string to provide the substantially full open bore of the tubing string without removing that portion of the tubing string on which the packers are mounted.

13. The combination set forth in claim 10, wherein the releasing means is actuated by means of a flexible line whereby said inner conductor may be disposed within and removed from the tubing string by means of said flexible line.

References Cited in the file of this patent

UNITED STATES PATENTS

2,368,428	Saurenman	Jan. 30, 1945
2,433,942	Works	Jan. 6, 1948
2,488,931	Penick	Nov. 22, 1949