

May 17, 1960

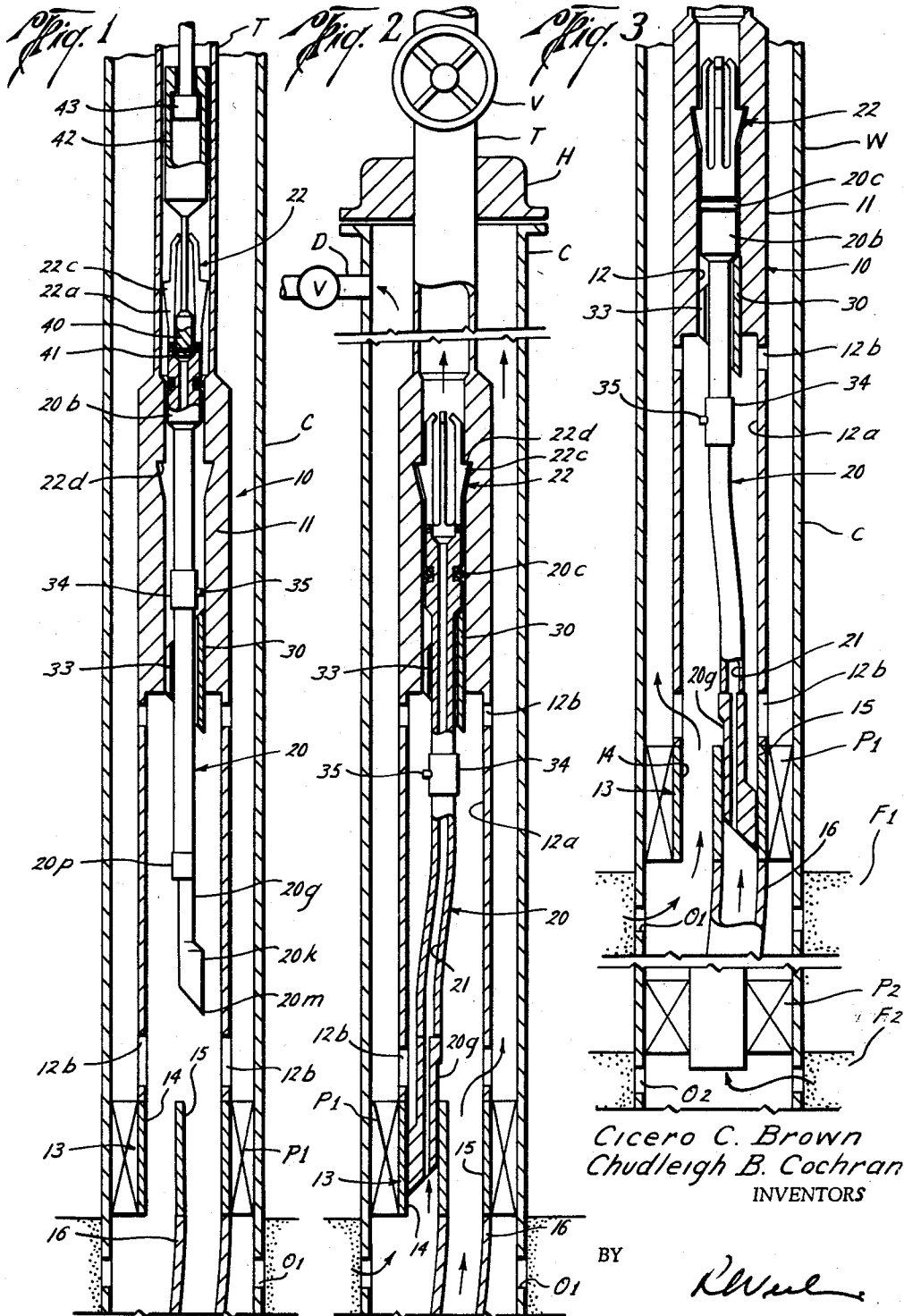
C. C. BROWN ET AL

2,936,832

CROSSOVER APPARATUS FOR DUAL PRODUCTION WELL STRINGS

Filed March 27, 1957

4 Sheets-Sheet 1



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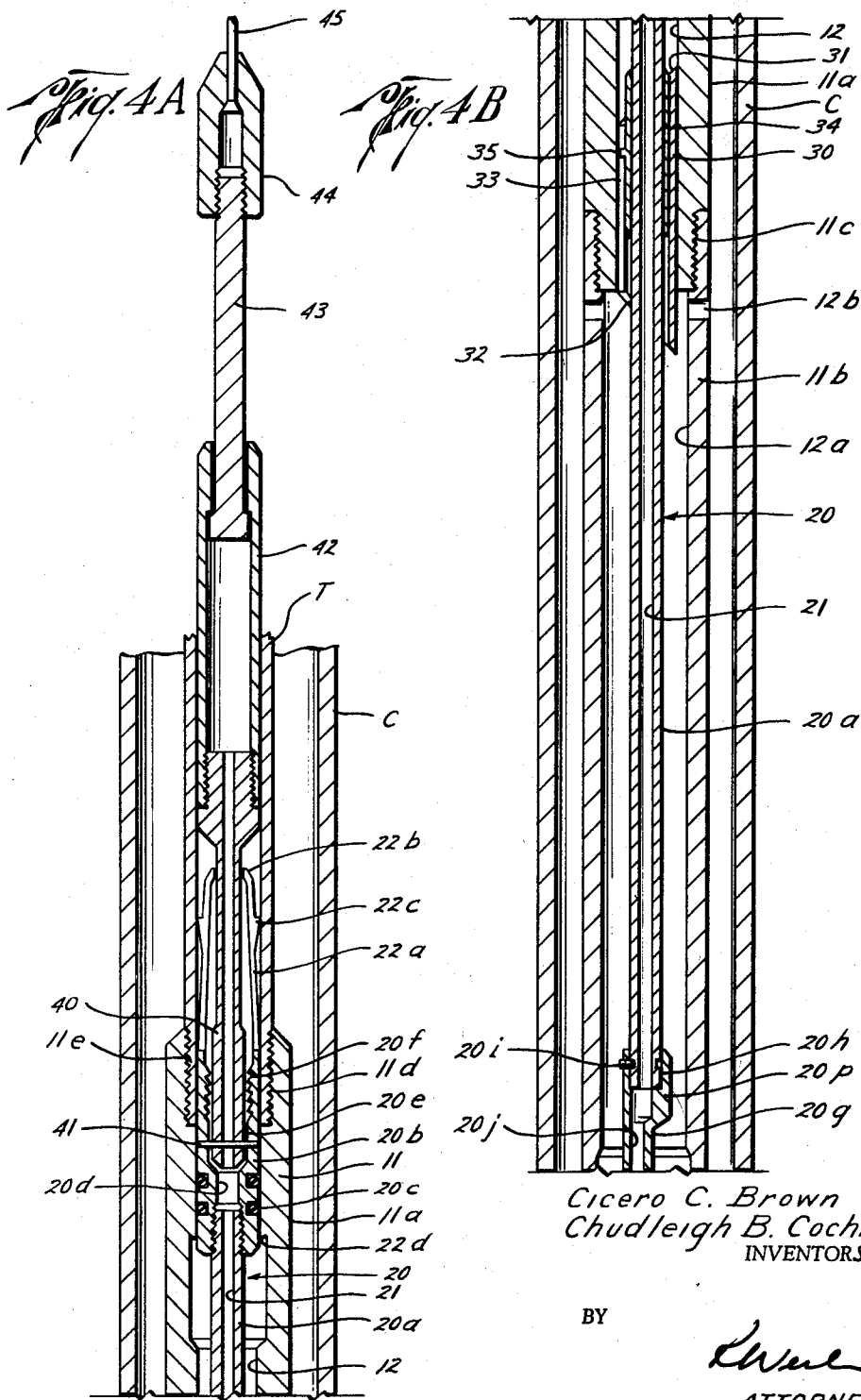
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CROSSOVER APPARATUS FOR DUAL PRODUCTION WELL STRINGS

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4 Sheets-Sheet 2



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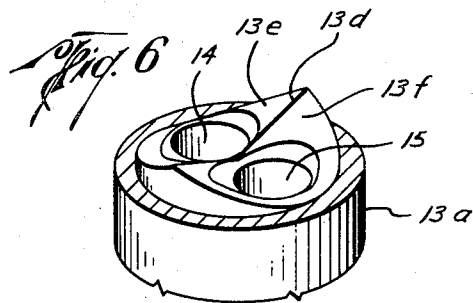
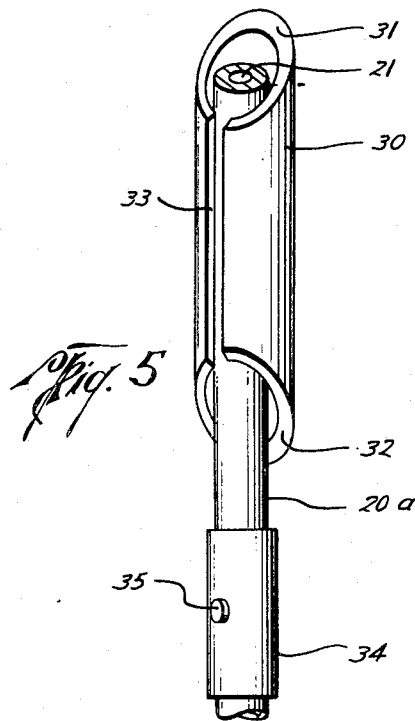
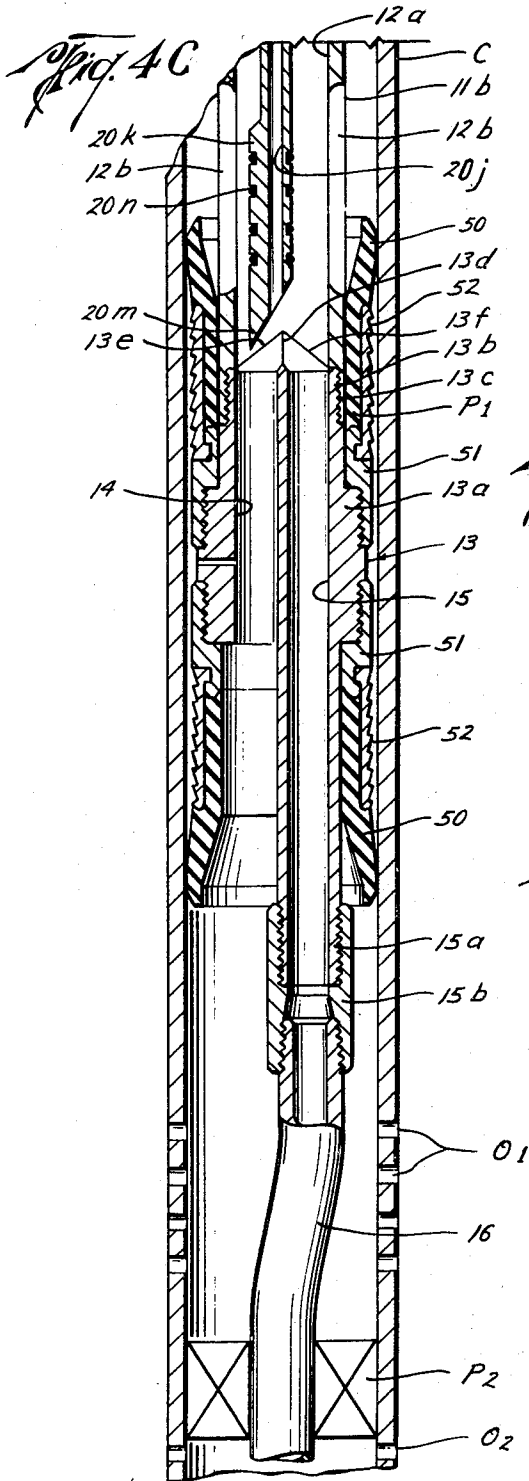
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CROSSOVER APPARATUS FOR DUAL PRODUCTION WELL STRINGS

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4 Sheets-Sheet 3



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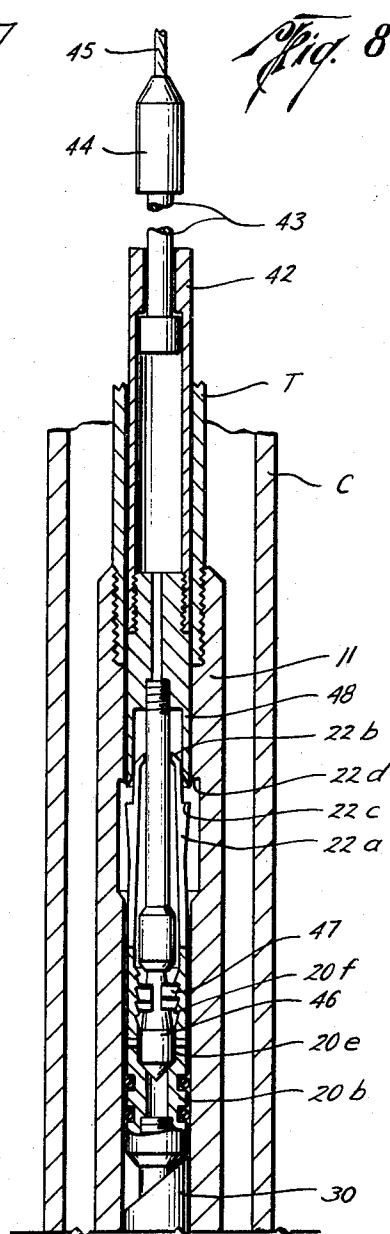
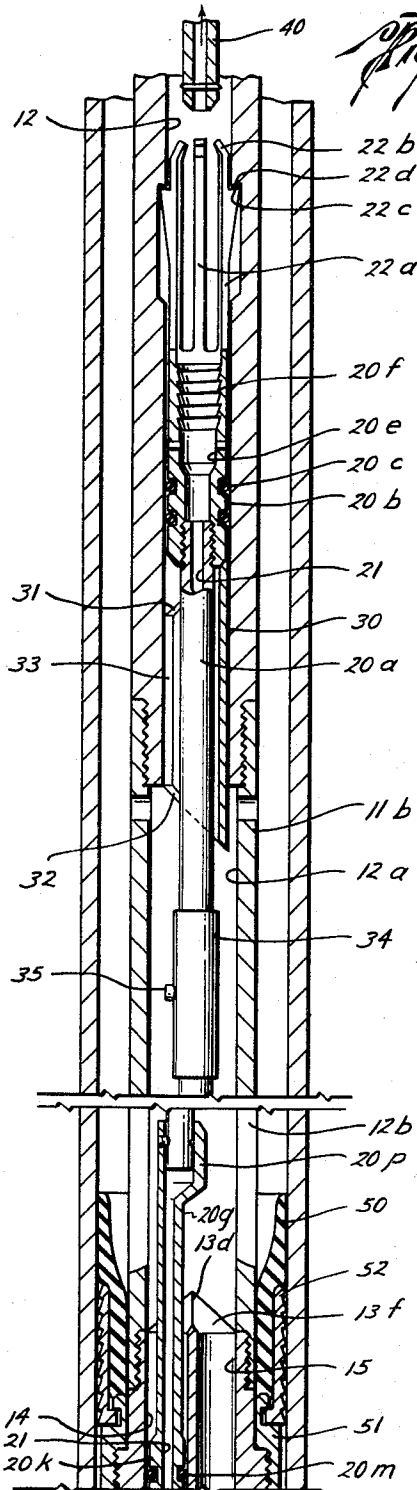
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CROSSOVER APPARATUS FOR DUAL PRODUCTION WELL STRINGS

Filed March 27, 1957

4 Sheets-Sheet 4



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2,936,832

CROSSOVER APPARATUS FOR DUAL PRODUCTION WELL STRINGS

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Application March 27, 1957, Serial No. 648,862

17 Claims. (Cl. 166—115)

This invention relates to well production equipment and particularly to apparatus useful in the dual production in oil wells, and the like.

In many oil wells production is obtained from several producing zones at different elevations in the well, and which ordinarily contain fluids at different formation pressures. In many such wells equipment is employed for the simultaneous production of well fluids from two separate formations. These are commonly referred to as "dual-completion" wells and involve well equipment by which production from each of the two producing formations is separately delivered to the surface.

In general, such equipment includes an inner well pipe string, such as a tubing string, on which are mounted vertically spaced packers, the upper one of which is usually set above the upper producing formation, and the lower one being set between the two producing formations. By means of a structure commonly referred to as a "crossover" apparatus, fluid from one formation will be caused to flow through the inner pipe string, or tubing string, while fluid from the other formation will be caused to flow through the annulus between the tubing and outer well pipe string or casing.

Crossover structures heretofore employed are generally relatively complicated in form, and particularly involve the use of conduit arrangements disposed in the relatively small diameter tubing strings which require sharp turns and relatively small passages to lead the different fluids separately into the production pipe strings. The resulting restricted passages are subject to severe erosion by the flow of high pressure fluids and may become plugged with detritus carried by the fluids or otherwise become inefficient or inoperative, particularly by reason of the tortuous path which the well fluids are required to traverse in such crossover devices.

The present invention has for its primary object the provision of a crossover apparatus, which may be termed "straight-flow" crossover apparatus, in providing a structure by which the streams of fluid from both well formations will be caused to travel substantially straight parallel paths in flowing from the respective formations to the connected pipe strings, that is, with minimum deflection in the paths of flow, and thereby obviate the difficulties encountered with more conventional devices.

Frequently, after a dually-producing well has been in operation for some time, conditions occurring in the separate formations may make it desirable to reverse the flow paths of the separate formation fluids. That is, it may be desirable to switch the flow of one fluid from the inner or tubing string to the outer or casing string and, at the same time, switch the other fluid from the casing string to the tubing string. Conventional crossover devices are ordinarily incapable of accomplishing this switching or can effect it only by a relatively difficult re-arrangement of the cross-over device.

Accordingly, it is another important object of this invention to provide a straight-flow crossover device which may be readily switched to transfer or reverse the flows

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of the separate fluids from one to the other of the pipe string, as may be required, with a minimum of manipulation and without modification of the crossover structure.

In accordance with the illustrative embodiment of the present invention, the crossover structure includes a tubular body forming a part of the inner pipe string and having a crossover section carrying a pair of parallel, longitudinal passages positioned to extend through the upper packer in a dual-production arrangement, one of the passages communicating at its lower end with the space between the two packers, that is with the upper one of the producing formations, and the other passage forming an extension of the inner pipe string and extending through the lower packer into communication with earth formations therebelow. A hollow mandrel or plunger means, termed herein the "crossover plunger means" is slidably mounted in the body and is arranged so that it may be longitudinally guided into a selected one of the passages, thereby connecting the flow through that passage with the interior of the inner pipe string, the flow through the other passage being thereby caused to pass through openings provided in the wall of the housing above the upper packer into the annular space between the inner and outer pipe strings. Spaced seals are arranged between the portion of the plunger means and the inner pipe string above the openings in the body and between the portion of the plunger means which is inserted in a passage and the wall of that passage at a point below the body openings to thereby assure effective separation of the fluids flowing through the crossover structure. Means operable by relative downward movement of the plunger means in the body are provided for effectively guiding the plunger means into the selected passage, and means are also provided for releasably latching or locking the plunger means in position in the selected passage when it has been inserted therein.

The plunger means, in accordance with the present invention, is run into the inner pipe string from the surface, preferably on a wire line, using generally conventional running and retrieving tools, but may be pumped into place by fluid pressure applied at the surface to a suitable hydraulically propelled running tool.

A principal object of the invention, therefore, is to provide a crossover apparatus by which two separate producing formations in a well may be separately produced, the separate flows from the formations being selectively directed either to the inner or the outer pipe strings as may be desired.

A further object is the provision of a straight flow crossover apparatus for dual-completion wells which is comparatively simple in construction and easy to manipulate.

An additional object is the provision of novel guide means for constraining entrance of the plunger means into a selected one of the production passages in the crossover structure.

Other and more specific objects and advantages of this invention will become more readily apparent from the following detailed description when read in conjunction with the accompanying drawing which illustrates a useful embodiment of this invention.

In the drawing,

Fig. 1 is a longitudinal, partly sectional view of the crossover apparatus in accordance with this invention, shown in somewhat diagrammatic form in a well, the parts being shown in the position occupied by the crossover plunger means as it is being lowered into the inner pipe string;

Fig. 2 is a view similar to Fig. 1, showing the upper end of the well, and the crossover plunger means installed in operative position for connecting the upper

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producing formation with the inner string, and the lower producing formation with the outer pipe string;

Fig. 3 is a view similar to Fig. 2, showing the crossover plunger means in the position reversed from that of Fig. 2, that is, in which the lower producing formation is connected to the inner pipe string and the upper formation to the outer pipe string;

Figs. 4A, 4B, and 4C are longitudinal sectional views, respectively, of the upper, intermediate, and lower portions, which, together, comprise the complete crossover structure, the plunger element being shown as it is being lowered through the inner pipe string on a wire line-supporting running tool;

Fig. 5 is a fragmentary elevational view, in perspective, of details of guide elements employed in the structure for guiding the plunger means therein;

Fig. 6 is a perspective elevational view of the upper end portion of the crossover section of the tool, showing additional guide elements thereon about the upper ends of the flow passages;

Fig. 7 is a view illustrating the position of the parts with the crossover plunger in place and locked to the tool body, and showing the lower end of the running tool being withdrawn; and

Fig. 8 illustrates the upper portion of the structure connected to a wire line retrieving tool preparatory to withdrawing the crossover plunger means from the body.

Referring first to Figs. 1, 2 and 3, there is shown a well bore W in which is installed the usual outer well pipe string or casing C, which extends through vertically spaced upper and lower producing formations F₁ and F₂, respectively, the casing being provided with openings or perforations O₁ and O₂ communicating with the respective formations F₁ and F₂, through which fluids from these formations may enter the casing. An inner well pipe string or tubing string T extends from the surface through the bore of casing C in the usual manner to a point opposite the lower formation. Tubing T will be equipped with a control valve V at the surface, and the upper end of casing C will be closed about tubing T by a conventional well head H (Fig. 2), and a valved outlet D is connected to communicate with the interior of casing C near its upper end. Upper and lower packers P₁ and P₂ are mounted on the exterior of the inner pipe string to seal between the inner and outer pipe strings at points, respectively, above upper formation F₁ and between formations F₁ and F₂ (Fig. 3). It will be understood that packers P₁ and P₂ may be of any generally conventional and well-known form adapted to effectively separate the producing formations from one another.

The crossover device, in accordance with the present invention, is designated generally by the numeral 10 and includes a generally tubular body 11 which has an axial bore 12 and is connected to form a part of inner pipe string T. The lower portion of body 11 has the enlarged bore 12a which is provided, adjacent its lower end, with a crossover section or head, designated generally by the numeral 13, which is ordinarily arranged to carry the upper packer P₁ and is provided with a pair of parallel passages 14 and 15, equal in diameter, which extend entirely through the crossover section and through packer P₁, passage 14 providing communication with the space between the packers P₁ and P₂. Passage 15 is connected by means of a pipe 16, which forms an extension of the inner pipe string T and extends through the lower packer P₂, into communication with the space below the lower packer, thus placing pipe 16 in communication with the fluids entering the casing from lower formation F₂, while passage 14 is in communication with the fluids entering the casing from formation F₁. The upper ends of passages 14 and 15 communicate with enlarged bore 12a above upper packer P₁. Openings 12b are provided in the wall of body 11 at points above

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crossover section 13 to provide communication with the interior of casing C.

A tubular mandrel or plunger means, designated generally by the numeral 20 and having a straight bore 21 extending entirely therethrough, is slidably disposed in the bore of body 11 and is adapted to have its lower end inserted into one or the other of the passages 14 and 15, as will be subsequently described, whereby to direct fluid entering the passage into which it is inserted, through bore 21 and into bore 12 of the body, and thence into the communicating bore of inner pipe string T to which the body is connected. Latch means, designated generally by the numeral 22, is provided on the upper end portion of the plunger means for releasably latching the plunger means to the body as will be subsequently described.

Referring now to Figs. 4A, 4B and 4C which illustrate the crossover structure in greater detail, it will be seen that body 11 includes upper and lower sections 11a and 11b, bore 12 being in section 11a, and bore 12a being in section 11b. These sections are connected by a threaded connection shown at 11c. Upper section 11a has an internally threaded socket 11d adapted to receive the threaded pin 11e on tubing T. Crossover section 13 comprises the body 13a provided at its upper end with a threaded pin 13b which is receivable in a threaded socket 13c provided at the lower end of body section 11b. Body 13a of the crossover section extends through the bore of upper packer P₁ and may, as shown, form the core or supporting body of the packer. The arrangement shown is one which is convenient for attaching the packer to the crossover section, but it will be understood that other types of packers may be employed and the connections to the crossover section may be widely varied from that shown. Packer P₁, as illustrated, is of the self-anchoring, differential pressure-actuated type, but, as noted, other forms of packers may be employed.

As shown in Fig. 4C, for purposes of illustration, body 13a has mounted on its opposite ends oppositely facing resilient cup seals 50—50, which are identical in construction, and are secured to body 13a by threaded collars 51—51. Each of the cup seals has a plurality of circumferentially arranged toothed slip segments 52 secured to its outer surface which grip the wall of casing C (Fig. 7) when the cup seal is expanded by fluid pressure acting on the interior of the cup seal, as well understood in this art. Packer P₂ may be of the same form as packer P₁ or may be of different construction than that shown, there being numerous conventional forms of packers which may be employed for the purposes indicated.

The portion of body 13a, which defines passage 15, is lengthened downwardly relative to the portion defining passage 14 and is provided at its lower end with the threaded pin 15a to which extension pipe 16 may be coupled by means of a collar 15b, or by other suitable connection means. The upper end of crossover body 13a, as best seen in Fig. 6, is machined to provide an upwardly projecting deflector wall 13d extending transversely thereof between the upper ends of passages 14 and 15. Deflector wall 13d has oppositely extending downwardly curved side surfaces 13e and 13f forming cam surfaces which lead downwardly from the upper end of wall 13d toward the mouths of passages 14 and 15, respectively. These cam surfaces provide a useful guiding function in connection with constraining movement of the plunger means into a selected one of the passages, as will be more fully described hereinafter.

Crossover plunger means 20 comprises the elongate tubular barrel 20a threadedly connected at its upper end to a larger diameter head 20b which is dimensioned to have a sliding fit in bore 12 and is provided with a circumferential seal packing 20c to form a slidable fluid-tight seal between the upper end of the plunger means

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and the bore wall of body 11. Head 20b has an axial bore 20d which is in communication with a socket 20e formed on the upper end of head 20b, the socket being in co-axial communication with the bore of tubing T. The inner wall of socket 20e is provided with a plurality of downwardly facing buttress teeth 20f, for purposes to be subsequently described.

Head 20b also carries the latch mechanism 22, which comprises a plurality of angularly spaced circumferentially arranged resilient fingers 22a projecting upwardly from the upper end of head 20b and integrally connected thereto. The upper ends of fingers 22a have inwardly turned tips 22b forming upwardly tapering guiding surfaces. Each of the fingers 22a carries a radially outwardly projecting latching prong 22c which is designed to be engaged beneath a latching shoulder 22d formed in the wall of upper body portion 11a at a point just below the upper end of portion 11a. Figs. 2, 3 and 7 show the prongs 22c engaged with shoulder 22d. As shown in Fig. 4A, the latching means is shown at a point above the latching shoulder in process of being lowered into bore 12.

The lower end of barrel 20a carries a plug member 20g, having at its upper end a slip socket 24h adapted to receive the lower end of barrel 20a which is secured in slip socket 24h by means of a set screw 20i. Plug member 20g has the through-bore 20j which communicates with bore 21, and the wall of plug member 20g adjacent its lower end is thickened at one side to form the enlarged head 20k to a diameter to provide a sliding fit in the passages 14 and 15. The lower end of plug head 20k is cut or machined at a steeply sloping angle to provide a nose 20m off-set to one side of the longitudinal axis of the plunger means. The exterior of head 20k is provided with a plurality of longitudinally spaced seal rings 20n which, when the plug member is inserted in either of the passages 14 or 15, will form fluid-tight seals between the plug member and the passages at points below openings 12b. Plug member 20g carries at its upper end an eccentric enlargement 20p disposed diametrically opposite nose 20m which is adapted to engage the wall of bore 12a to limit lateral movement of the plug member to the side whereby to maintain nose 20m on the opposite side of the longitudinal axis of bore 12a. By this opposing arrangement of cam 20p and nose 20m, it will be seen that nose 20m will always be constrained to a position on one side or the other of deflector wall 13d, depending upon the orientation of the plug member in the crossover body.

Indexing means for aligning plug member 20g with one or the other of passages 14 and 15, are provided on barrel 20a and on body 11. As best seen in Figs. 4B and 5, this indexing means comprises a tubular sleeve 30 which is secured to the wall of bore 12 adjacent the lower end of body portion 11a. The upper end of sleeve 30 is cut or machined at a steep angle to provide the downwardly sloping cam surface 31, and the lower end of sleeve 30 is similarly cut to provide the upwardly tapering cam surface 32, the cam surfaces 31 and 32 tapering toward each other. A longitudinal indexing slot 33 is cut in the wall of sleeve 30 at its shortest point. Mounted on the exterior of barrel 20a, at an intermediate point thereof, is a collar 34 which is adapted to slide through the bore of sleeve 30. Collar 34 carries a radially projecting lug 35 which functions as an indexing cam in co-operation with sleeve 30. These indexing cams are employed to align plug member 20g with the selected one of the passages 14 and 15 and for this purpose nose 20m of the plug member will be oriented about barrel 20a to be in alignment with lug 35. Sleeve 30 will be positioned in bore 12 of the body, so as to place indexing slot 33 in a plane substantially normal to the plane of deflector wall 13d.

By the described relative positions of the indexing cams and the guide elements formed by nose 20m and the

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surfaces 13e and 13f on the crossover section, plug member 20g may be selectively guided into either of the passages 14 and 15, as will be more fully described hereinafter.

In operation of the above-described device, body 11 will be connected into the tubing string T and will have mounted thereon packers P₁ and P₂ at the proper points to provide the desired seals above formation F₁ and between formations F₁ and F₂. Running in of this tubing string and setting of the packers will be accomplished in any conventional manner as is well understood in the art. With the tubing string and the crossover body in position, the plunger means will then be run into the tubing string. This is accomplished by means of a suitable running tool, one form of which is illustrated in Figs. 1 and 4A. This tool comprises a cylindrical plug 40 which is adapted to be inserted into socket 20e and secured therein by means of a shear pin 41 which extends transversely through suitable registering openings in the wall of socket 20e and plug 40. The upper end of plug 40 is secured to the outer member 42 of a conventional wire line jar, the inner member 43 of which is secured by a rope socket 44 to the usual wire line or cable 45 by which the tool is run into and out of the well. With the plunger means thus secured to the lowering tool, the structure is inserted in tubing T and lowered through the bore thereof, as best seen in Figs. 1 and 4A. The resilience of fingers 22a will permit them to be compressed sufficiently to enter the bore of tubing T and slide downwardly as the device is lowered through the tubing. The crossover plunger means will be lowered through indexing sleeve 30 until lug 35 strikes upper cam surface 31. Even though, as shown in Fig. 1, the point of contact is at a high point on surface 31, the slope of surface 31 will cause lugs 35 to slide down around this surface into indexing slot 33 whereby the plunger means will be oriented to align nose 20m on the lower end of the plunger means with passage 14 (Figs. 2 and 4C). This will result because, as illustrated in Figs. 2, 4B, 4C and 7, indexing slot 33 is shown as oriented to the side of the tool which carries passage 14. With plug member 20g thus oriented to align with the upper end of passage 14, as the plunger means continues downwardly, nose 20m will be off-set to the lefthand side of bore 12 (Figs. 2 and 4C) and deflector wall 13d and the pointed sloping face of nose 20m will engage surface 13e and the resulting cam action between these surfaces will necessarily constrain plug 20g to enter passage 14. Downward progress of the plug into passage 14 will continue until arrested by engagement of the lower end of head 20b with the upper edge of indexing sleeve 30, as best seen in Fig. 7. At this point latching prongs 22c carried by fingers 22a will have descended below latching shoulder 22d and will expand in position to engage beneath the shoulder, as seen in Figs. 2, 3 and 7. The running tool may now be withdrawn by applying jarring blows to the jar elements of the running tool which will act to break shear pin 41 and allow the running tool to be withdrawn from socket 20e and from the plunger means (Fig. 7). The crossover plunger will now be secured in place in passage 14 by latching of prongs 22c under shoulder 22d and will form a conduit connecting passage 14 to the bore of tubing string T. Thus, well fluid entering casing C through openings O₁ between packers P₁ and P₂ will flow upwardly through the lower end of passage 14 into bore 21 of the crossover plunger, and thence through bore 12 into the bore of tubing string T and thence to the surface. At the same time, fluid flowing into the casing through openings O₂ from formation F₂ will flow upwardly through pipe 16 and passage 15 into the interior of body portion 11b whence it will pass through openings 12b into the interior of casing C and flow upwardly therein to the surface. Seals 20c and 20n, which seal, respectively, at points above and below openings 20b between the crossover plunger and the crossover body, will pre-

vent intermixing of fluid from the two producing formations.

With this arrangement, it will be seen that the paths of flow of the fluids from the separate producing formations will travel separate, substantially straight longitudinal paths in moving from their respective formations into the pipe strings which will carry them separately to the surface. Thus, minimum resistance to the fluid flows will occur; minimum erosive action will occur on the parts of the crossover structure; and the possibility of plugging of the crossover passages will be minimized.

When conditions in the operation of the well make it desirable to switch the flows from the two formations to the opposite conductor pipes, the crossover or reversing of the fluid flows can be effected very simply. The wire line running tool, previously described, will be equipped with a spear 46 (Fig. 8) in place of the plug 40 employed in lowering the crossover plunger, and the running tool will be run back into tubing T and spear 46, which is of conventional construction for this type of tool, will be run into socket 20e. Toothed slip members 47, carried on the spear 46, will engage teeth 20f inside socket 20e and will thereby lock the spear to the plunger means. The spear also carries, adjacent its upper end and concentric with the spear stem, an overshot sleeve 48 which is dimensioned to slide over inwardly curved tips 22b of the fingers 22a to compress the fingers inwardly so as to retract prongs 22c inwardly away from latching shoulder 22d. The retraction of prongs 22c and the engagement of slips 47 with teeth 20f will occur simultaneously by reason of the pre-determined spacing between the overshot sleeve 48 and the slip-carrying portion of spear 46. With the latching prongs 22c thus retracted, a pull applied to the wire line will permit the entire crossover plunger means to be drawn upwardly through body 11 pulling plug 20g out of passage 14. Lug 35, which will have descended below the lower end of indexing sleeve in the previous running-in operation, will pass upwardly through indexing slot 33, being guided thereto by lower cam surface 32, and the crossover plunger means may thus be withdrawn from the well through body 11 and tubing string T.

Plug member 20g may now be turned on barrel 20a through 180° by loosening set screw 20i and resetting it after completing the desired rotation, or lug collar 34 may be turned 180° relative to plug 20g. Thereupon, the running-in tool will be re-attached to the upper end of the crossover plunger means, as previously described, and the plunger means run back into the tubing. In this case, since nose 20m on the end of the plug member will be rotated 180° with respect to the position of lug 35 from its previous position, the result will be that when lug 35 again passes into and through indexing slot 33, nose 20m will be on the opposite side of deflector wall 13d from that occupied in the previously described operation, and the plug member will thus now be aligned with passage 15 and constrained to enter same by engagement of nose 20m with cam surface 13f. When the plunger member has been thus inserted in passage 15 and locked in place by re-engagement of latching prongs 22c with shoulder 22d (see Fig. 3), it will be seen that the production from the lower formation F₂, which will flow upwardly through pipe 16, will now flow through bore 21 of the plunger means into and through the bore of tubing string T, while the production from upper formation F₁ will pass through passage 14 and thence through openings 12b into the interior of the casing and will flow therein to the surface. Again, the fluids from both formations will traverse relatively straight non-tortuous paths with the advantages pointed out previously.

It will be obvious that various types of running-in and retrieving tools may be employed for running-in and withdrawing the crossover plunger means. Also, other types of latching means, indexing and guide means may be employed in place of those in the illustrative embodi-

ment to perform the functions of these elements of the illustrative embodiment.

Once a connection between a producing formation and one of the pipe strings has been made, as previously described, this connection will usually be maintained for a considerable period of time until production conditions become such as may make a switch in connections desirable. It will usually, therefore, be found desirable to withdraw the crossover plunger means completely from the well so that the seal packings may be replaced, as this will usually be found necessary after having been in place in the well for a long period of time. Hence, the illustrative embodiment employs an arrangement for rotating plug member 20g about plunger barrel 20a which is designed to be effected externally of the well. However, it will be obvious to those skilled in the art that a suitable form of connection may be made between plug member 20g and barrel 20a, or between indexing lug 35 and barrel 20a which can be manipulated from the surface to effect the desired relative rotation between these members without withdrawing the plunger means from the well.

Accordingly, it will be understood that numerous modifications and variations may be made in the details of the illustrative embodiment within the scope of the appended claims, but without departing from the spirit of this invention.

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

1. In combination with an inner well pipe string having a pair of spaced well packers thereon adapted to seal with an outer well pipe string for separating two well formations from each other for dual production from a well, a straight-flow crossover apparatus, comprising, a generally tubular body forming a part of the inner well pipe string, said body including a section having a pair of parallel passages extending longitudinally through the upper one of said packers, one of said passages being adapted to communicate with the space between said packers and the other passage being adapted to communicate into communication through the lower packer with the portion of the well therebelow, openings in the wall of said body above the upper packer communicating with the interior of the outer pipe string, plunger means having a straight through-bore slidably disposed in the bore of said body and adapted for insertion into said passages, cooperable guide means on the plunger means and the body operable by relative downward movement of the plunger means in the body to guide the plunger means into a selected one of said passages, whereby to conduct well fluid entering said selected passage into said inner pipe string, while well fluid entering the other of said passages is directed through said openings into the outer pipe string, means releasably securing the plunger to the body in its passage-inserted position, and spaced seal means sealing between the plunger means and the body above said openings and between the selected passage and the portion of the plunger means inserted therein.

2. In combination with an inner well pipe string having a pair of spaced well packers thereon adapted to seal with an outer well pipe string for separating two well formations from each other for dual production from a well, a straight-flow crossover apparatus, comprising, a generally tubular body forming a part of the inner well pipe string, said body including a section having a pair of parallel passages extending longitudinally through the upper one of said packers, one of said passages being adapted to communicate with the space between said packers and the other passage being adapted to communicate with conduit means leading through the lower packer into communication with the portion of the well therebelow, openings in the wall of said body above the upper packer communicating with the interior of the outer pipe string, plunger means having a straight through-bore slidably disposed in the bore of said body and

adapted for insertion into said passages, and cooperable guide means on the plunger means and the body operable by relative downward movement of the plunger means in the body to guide the plunger means into a selected one of said passages whereby to conduct well fluid entering said selected passage into said inner pipe string, while well fluid entering the other of said passages is directed through said openings into the outer pipe string.

3. In combination with an inner well pipe string having a pair of spaced well packers thereon adapted to seal with an outer well pipe string for separating two well formations from each other for dual production from a well, a straight-flow crossover apparatus, comprising, a generally tubular body forming a part of the inner well pipe string, said body including a section having a pair of parallel passages extending longitudinally through the upper one of said packers, one of said passages being adapted to communicate with the space between said packers and the other passage being adapted to communicate with conduit means leading through the lower packer into communication with the portion of the well therebelow, openings in the wall of said body above the upper packer communicating with the interior of the outer pipe string, plunger means having a straight through-bore slidably disposed in the bore of said body and adapted for insertion into said passages, cooperable guide means on the plunger means and the body operable by relative downward movement of the plunger means in the body to guide the plunger means into a selected one of said passages whereby to conduct well fluid entering said selected passage into said inner pipe string, while well fluid entering the other of said passages is directed through said openings into the outer pipe string, and spaced seal means sealing between the plunger means and the body above said openings and between the selected passage and the portion of the plunger means inserted therein.

4. In combination with an inner well pipe string having a pair of spaced well packers thereon adapted to seal with an outer well pipe string for separating two well formations from each other for dual production from a well, a straight-flow crossover apparatus, comprising, a generally tubular body forming a part of the inner well pipe string, said body including a section having a pair of parallel passages extending longitudinally through the upper one of said packers, one of said passages being adapted to communicate with the space between said packers and the other passage being adapted to communicate with conduit means leading through the lower packer into communication with the portion of the well therebelow, openings in the wall of said body above the upper packer communicating with the interior of the outer pipe string, plunger means having a straight through-bore slidably disposed in the bore of said body and adapted for insertion into said passages, and cooperable guide means on the plunger means and the body operable by relative downward movement of the plunger means in the body to guide the plunger means into a selected one of said passages whereby to conduct well fluid entering said selected passage into said inner pipe string, while well fluid entering the other of said passages is directed through said openings into the outer pipe string, said guide means including indexing cams arranged to align the plunger means with the selected passage.

5. In combination with an inner well pipe string having a pair of spaced well packers thereon adapted to seal with an outer well pipe string for separating two well formations from each other for dual production from a well, a straight-flow crossover apparatus, comprising, a generally tubular body forming a part of the inner well pipe string, said body including a section having a pair of parallel passages extending longitudinally through the upper one of said packers, one of said passages being adapted to communicate with the space between said

packers and the other passage being adapted to communicate with conduit means leading through the lower packer into communication with the portion of the well therebelow, openings in the wall of said body above the upper packer communicating with the interior of the outer pipe string, plunger means having a straight through-bore slidably disposed in the bore of said body and adapted for insertion into said passages, cooperable guide means on the plunger means and the body operable by relative downward movement of the plunger means in the body to guide the plunger means into a selected one of said passages whereby to conduct well fluid entering said selected passage into said inner pipe string, while well fluid entering the other of said passages is directed through said openings into the outer pipe string, said guide means including indexing cams arranged to align the plunger means with the selected passage, and spaced seal means sealing between the plunger means and the body above said openings and between the selected passage and the portion of the plunger means inserted therein.

6. In combination with an inner well pipe string having a pair of spaced well packers thereon adapted to seal with an outer well pipe string for separating two well formations from each other for dual production from a well, a straight-flow crossover apparatus, comprising, a generally tubular body forming a part of the inner well pipe string, said body including a section having a pair of parallel passages extending longitudinally through the upper one of said packers, one of said passages being adapted to communicate with the space between said packers and the other passage being adapted to communicate with conduit means leading through the lower packer into communication with the portion of the well therebelow, openings in the wall of said body above the upper packer communicating with the interior of the outer pipe string, plunger means having a straight through-bore slidably disposed in the bore of said body and adapted for insertion into said passages, cooperable guide means on the plunger means and the body operable in response to relative downward movement of the plunger means in the body to guide said plunger means into a selected one of said passages whereby to conduct well fluid entering said selected passage into said inner pipe string, while well fluid entering the other of said passages is directed through said openings into the outer pipe string, and means releasably securing the plunger means to the body in its passage-inserted position.

7. In combination with an inner well pipe string having a pair of spaced well packers thereon adapted to seal with an outer well pipe string for separating two well formations from each other for dual production from a well, a straight-flow crossover apparatus, comprising, a generally tubular body forming a part of the inner well pipe string, said body including a section having a pair of parallel passages extending longitudinally through the upper one of said packers, one of said passages being adapted to communicate with the space between said packers and the other passage being adapted to communicate with conduit means leading through the lower packer into communication with the portion of the well therebelow, openings in the wall of said body above the upper packer communicating with the interior of the outer pipe string, plunger means having a straight through-bore slidably disposed in the bore of said body and adapted for insertion into said passage, cooperable guide means on the plunger means and the body operable in response to relative downward movement of the plunger means in the body to guide said plunger means into a selected one of said passages whereby to conduct well fluid entering said selected passage into said inner pipe string, while well fluid entering the other of said passages is directed through said openings into the outer pipe string, and means releasably securing the plunger means to the body in its passage-inserted position, said guide means including indexing cams arranged to align

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the plunger means with the selected passage and additional guide members on the lower end of the plunger means and on said section cooperable to constrain entrance of said plunger means into said selected passage.

8. In combination with an inner well pipe string having a pair of spaced well packers thereon adapted to seal with an outer well pipe string for separating two well formations from each other for dual production from a well, a straight-flow crossover apparatus, comprising, a generally tubular body forming a part of the inner well pipe string, said body including a section having a pair of parallel passages extending longitudinally through the upper one of said packers, one of said passages being adapted to communicate with the space between said packers and the other passage being adapted to communicate with conduit means leading through the lower packer into communication with the portion of the well therebelow, openings in the wall of said body above the upper packer communicating with the interior of the outer pipe string, plunger means having a straight through-bore slidably disposed in the bore of said body and adapted for insertion into said passages, cooperable guide means on the plunger means and the body operable in response to relative downward movement of the plunger means in the body to guide said plunger means into a selected one of said passages whereby to conduct well fluid entering said selected passage into said inner pipe string, while well fluid entering the other of said passages is directed through said openings into the outer pipe string, seal means sealing between the plunger means and the body above said openings and between the selected passage and the portion of the plunger means inserted therein, and means releasably securing the plunger means to the body in its passage-inserted position, said guide means including indexing cams arranged to align the plunger means with the selected passage and additional guide members on the lower end of said plunger means and on said section cooperable to constrain entrance of said plunger means into said selected passage.

9. In a crossover apparatus for dual-completion well strings, a tubular body adapted to form part of an inner well pipe string, a crossover head carried by a lower section of the body and having a pair of longitudinal parallel passages therethrough communicating at their upper ends with the bore of said body, openings in the wall of the body above the crossover head, plunger means having a straight through-bore slidably disposed in the bore of said body above the head and adapted for insertion into said passages, cooperable guide means on the plunger means and the body operable by relative downward movement of the plunger means in the body to guide the plunger means into a selected one of said passages, and spaced seal means sealing between the plunger means and the body above said openings and between the plunger means and the selected one of said passages below said openings.

10. In a crossover apparatus for dual-completion well strings, a tubular body adapted to form a part of an inner well pipe string, a crossover head carried by a lower section of the body and having a pair of longitudinal parallel passages therethrough communicating at their upper ends with the bore of said body, openings in the wall of the body above the crossover head, plunger means having a straight through-bore slidably disposed in the bore of said body above the head and adapted for insertion into said passages, cooperable guide means on the plunger means and the body operable by relative downward movement of the plunger means in the body to guide the plunger means into a selected one of said passages, spaced seal means sealing between the plunger means and the body above said openings and between the plunger means and the selected one of said passages below said openings, and means releasably securing said plunger means to the body when the plunger means has been inserted in the selected passage.

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11. In a crossover apparatus for dual-completion well strings, a tubular body adapted to form part of an inner well pipe string, a crossover head carried by a lower section of the body and having a pair of longitudinal parallel passages therethrough communicating at their upper ends with the bore of said body, openings in the wall of the body above the crossover head, plunger means having a straight through-bore slidably disposed in the bore of said body above the head and adapted for insertion into said passages, cooperable guide means on the plunger means and the body operable by relative downward movement of the plunger means in the body to guide the plunger means into a selected one of said passages, and spaced seal means sealing between the plunger means and the body above said openings and between the plunger means and the selected one of said passages below said openings, said guide means including indexing cams arranged to align the plunger means with the selected passage.

12. In a crossover apparatus according to claim 11, wherein said indexing cams include a sleeve secured to the bore wall of said body above the crossover head and having a longitudinal slot aligned with one of said passages, and a radially projecting lug on the plunger means receivable in said slot.

13. In a crossover apparatus for dual-completion well strings, a tubular body adapted to form part of an inner well pipe string, a crossover head carried by a lower section of the body and having a pair of longitudinal parallel passages therethrough communicating at their upper ends with the bore of said body, openings in the wall of the body above the crossover head, plunger means having a straight through-bore slidably disposed in the bore of said body above the head and carrying a plug member at its lower end adapted for insertion into said passages, cooperable guide means on the plunger means and the body operable by relative downward movement of the plunger means in the body to guide the plug member into a selected one of said passages, means sealing between the plunger means and the body above said openings, and means sealing between the plug member and the selected one of said passages below said openings.

14. In a crossover apparatus for dual-completion well strings, a tubular body adapted to form part of an inner well pipe string, a crossover head carried by a lower section of the body and having a pair of longitudinal parallel passages therethrough communicating at their upper ends with the bore of said body, openings in the wall of the body above the crossover head, plunger means having a straight through-bore slidably disposed in the bore of the body above the head and carrying a plug member at its lower end adapted for insertion into said passages, cooperable guide means on the plunger means and the body operable by relative downward movement of the plunger means in the body to guide the plug member into a selected one of said passages, means sealing between the plunger means and the body above said openings, means sealing between the plug member and the selected one of said passages below said openings, said guide means including indexing cams arranged to align the plug member with the selected passage, and additional guide members on the lower end of the plug member and on the crossover head cooperable to constrain entrance of said plug member into said selected passage.

15. A crossover apparatus for dual-completion well strings, comprising, a generally tubular body adapted to form part of an inner well pipe string and having openings in the wall thereof adapted to communicate with an outer well pipe string, said body including a section having a pair of longitudinal parallel passages therethrough communicating at their upper ends with the bore of the body below said openings, said passages opening to the lower end of the body, hollow plunger means longitudinally movable in the bore of the body, and cooperable means including indexing cams on the plunger means and the body adapted to selectively guide said plunger

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means into one of said passages whereby to connect said one of said passages into communication with the inner well pipe string.

16. A crossover apparatus for dual-completion well strings, comprising, a generally tubular body adapted to form a part of an inner well pipe string and having openings in the wall thereof adapted to communicate with an outer well pipe string, said body including a section having a pair of longitudinal parallel passages therethrough communicating at their upper ends with the bore of the body below said openings, said passages opening to the lower end of the body, hollow plunger means longitudinally movable in the bore of the body, and cooperable means on the plunger means and the body for guiding the plunger means into a selected one of said passages whereby to connect the selected passage into communication with the inner well pipe string.

17. A crossover apparatus for dual-completion well strings, comprising a generally tubular body adapted to form a part of an inner well pipe string and having openings in the wall thereof adapted to communicate with an outer pipe string, said body including a section having a

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pair of longitudinal parallel passages therethrough communicating at their upper ends with the bore of the body below said openings, said passages opening to the lower end of the body, hollow plunger means longitudinally movable in the bore of the body, cooperable means on the plunger means and the body for guiding said plunger means into a selected one of said passages whereby to connect the selected passage into communication with the inner well pipe string, and means for releasably securing the plunger means in place in the selected passage.

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