

March 21, 1961

J. R. BROWN

2,975,836

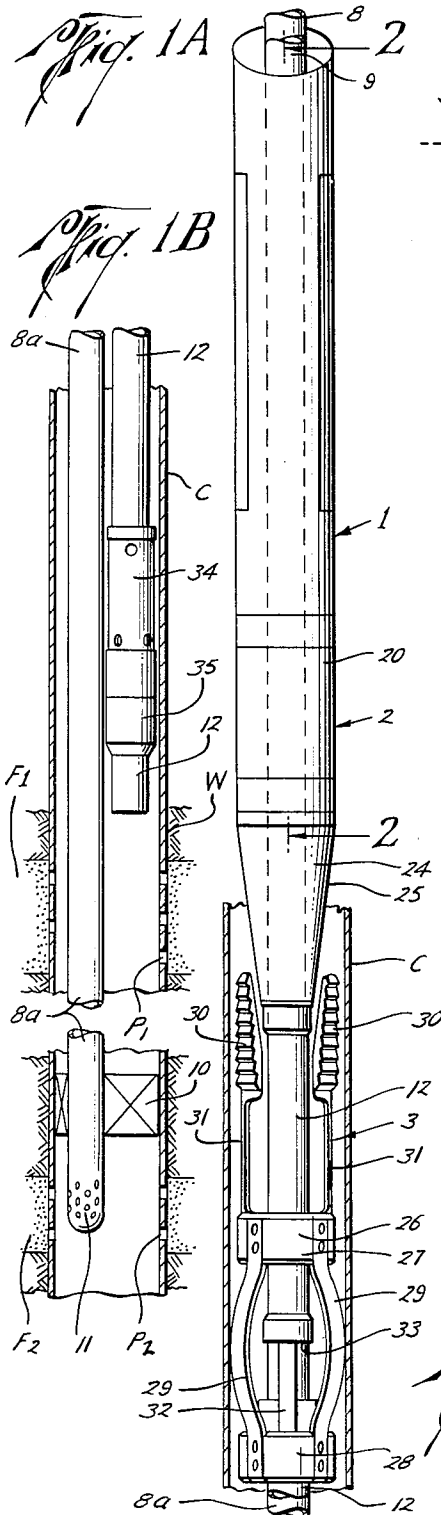
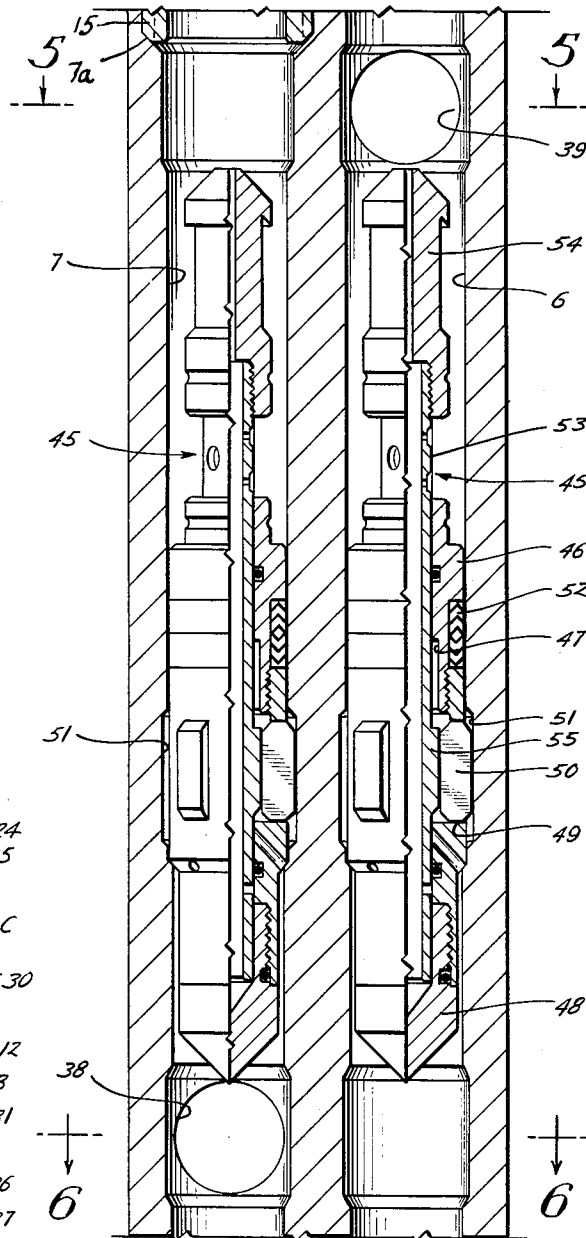
DUAL STRING CROSS-OVER TOOL

Filed June 11, 1958

3 Sheets-Sheet 1

Fig. 1A

Fig. 1B



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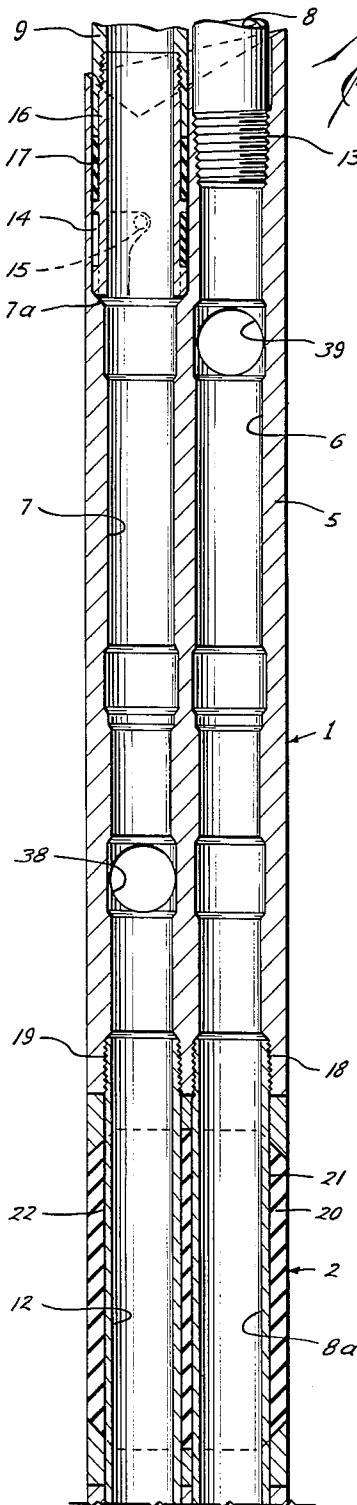
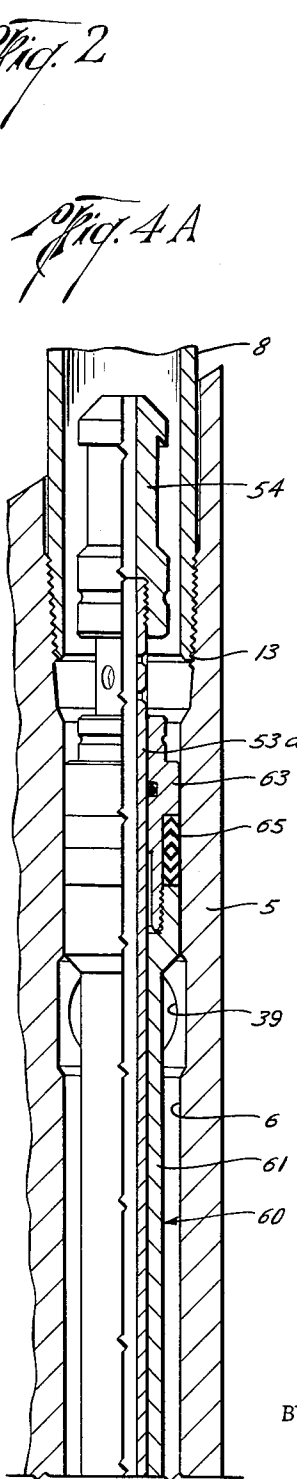
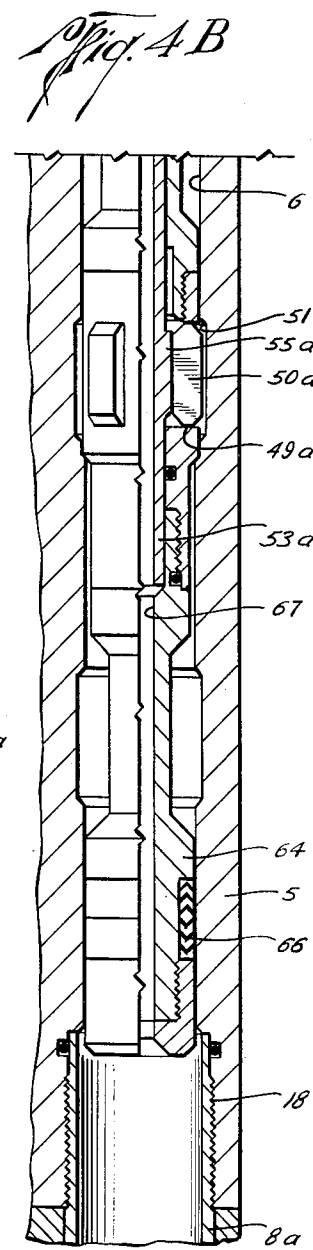
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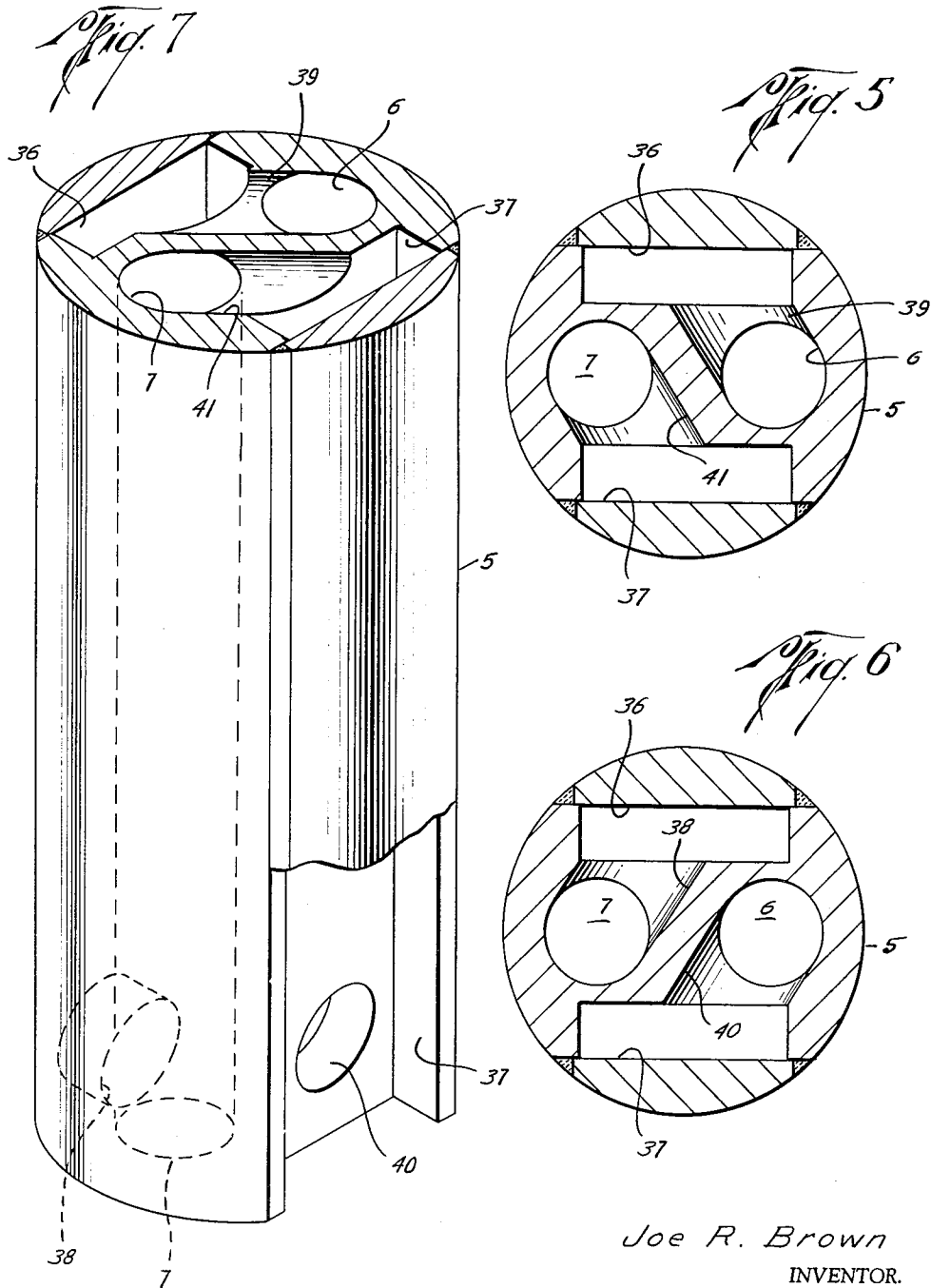
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DUAL STRING CROSS-OVER TOOL

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7 Claims. (Cl. 166—189)

This invention relates to cross-over devices for use with dual pipe strings in wells.

In dual completion wells wherein two producing formations are equipped to produce simultaneously, the formations will be packed-off from one another, one being placed in communication with the well casing and the other with the well tubing. Ordinarily, the tubing will be in communication with the lower of the two formations. So-called "conventional" or "normal" flow is that in which the lower formation will produce through the tubing and the upper formation through the casing; that is, through the annulus between the portions of the casing and the tubing above the separating packer.

It is often desirable, for various reasons, to "cross-over" these flows, that is, to flow the lower formation through the tubing until it passes the packer and thence into the casing, and to cross the flow from the upper formation into the portion of the tubing above the packer. Various types of cross-over devices or cross-over packers have been devised for accomplishing this crossing of the flows, some of these devices including means for selectively flowing the wells either conventionally or in the cross-over manner.

In recent years dual completions have been effected by means of parallel strings of pipe, both run inside the usual casing, in combination with a suitably constructed dual-string packer, for flowing fluids from two separate formations. The purpose of such dual pipe string completions is to avoid producing high pressure formation fluids through the casing which is relatively weaker than the tubing strings and more subject to leakage under high pressure conditions.

The present invention has for its principal object the provision of a cross-over device for use in wells completed by the dual-string method.

A primary object is to provide a cross-over device for use with dual-string packers.

An important object is to provide a cross-over device for use with dual-string packers which will permit selectively switching the flow from one pipe string to the other whereby to selectively produce the well in either parallel flow, corresponding to the "conventional" flow, or in cross-over flow.

A further object is to provide, in combination with packer means adapted to pack-off between formations communicating with a pair of parallel flow strings, a cross-over tool connected into the pair of pipe strings and employed with means adapted to selectively effect parallel or cross-over flow through the pipe strings.

An additional object is to provide a cross-over head for cross-over packers, said head having a pair of longitudinally extending parallel passages for co-axial connection with a pair of parallel pipe strings, cross-over connections between opposite ends of said passages, and means removably insertable in said passages to selectively direct fluids in said pipe string into parallel or cross-over flow.

Other and more specific objects and advantages of this

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invention will become apparent from the following detailed description when read in conjunction with the accompanying drawing which illustrates a useful embodiment in accordance with this invention.

5 In the drawing:

Figs. 1A and 1B, together, constitute a generally schematic view of a well completed by the dual string method and employing a cross-over device generally in accordance with this invention, Fig. 1B constituting the lower portion of the structure, being shown, for purposes of better illustration, turned at right angles to the upper portion of the structure shown in Fig. 1A;

Fig. 2 is a longitudinal sectional view taken generally along line 2—2 of Fig. 1A;

Fig. 3 is a view generally similar to Fig. 2, but showing the cross-over head portion in larger scale and showing flow-directing elements in the parallel passages thereof for directing cross-over flow through the device;

Figs. 4A and 4B, together, constitute a longitudinal sectional view of one-half of the cross-over head portion showing a modified form of flow-directing element positioned in one of the parallel passages of the head portion for directing parallel flow through the device;

Figs. 5 and 6 are cross-sectional views taken along lines 5—5 and 6—6, respectively, of Fig. 3; and

Fig. 7 is a perspective view, partly in section, of the cross-over head portion of the device.

Referring to Figs. 1A and 1B, the device is shown installed in a well W having spaced producing formations F_1 and F_2 . The well bore is lined with a casing C having perforations P_1 and P_2 opposite the respective producing formations F_1 and F_2 . The cross-over tool comprises the cross-over head section, designated generally by the numeral 1, a seal or packer section, designated generally by the numeral 2, and an anchor section, designated generally by the numeral 3. As best seen in Figs. 2 and 3, cross-over head section 1 comprises a generally cylindrical body 5 having a pair of parallel flow passages 6 and 7 extending longitudinally there-through. Passages 6 and 7 are arranged to be connected into two tubing strings 8 and 9, respectively, which extend to the top of the well and which have portions communicating with the respective formations F_1 and F_2 . Tubing string 8 includes a lower section 8a which extends below anchor section 3 to a point opposite lower formation F_2 and carries a packer 10 of any conventional form adapted to seal between tubing string section 8a and casing C at a point intermediate formations F_1 and F_2 in order to seal-off these formations from communication with each other through casing C. The lower end of tubing string section 8a may have a screen or slotted pipe section 11 through which fluids flowing from formation F_2 may enter the bore of tubing string section 8a and thence pass through tubing string 8 to the surface. Tubing string 9 includes a relatively short nipple 12 which extends below the lower end of anchor section 3 to any suitable point above packer 10 whereby fluids from upper formation F_1 may enter tubing string 9 for passage toward the surface.

At its upper end passage 6 is internally threaded at 13 to form a socket adapted to receive the threaded end of a section of tubing string 8 to which the device is connected. The upper end of passage 7 is provided with inwardly extending lugs 15 adapted to be received in J-slots 14 provided on the exterior of the lower end of a seal nipple 16 which is threadedly connected to the lower end of tubing string 9. It will be understood that tubing string 9, fitted with the seal nipple 16, will be inserted into the upper end of passage 7 and locked thereto by suitable rotation relative to lug 15. Packing means 17 is carried by seal nipple 16 to form a fluid-tight seal between the inserted end of tubing string 9 and the wall of passage

7. At their lower ends passages 6 and 7 are provided with internally threaded boxes 18 and 19, respectively, to receive the externally threaded upper ends of nipples 8a and 12, respectively.

Seal section 2 comprises a flexible resilient cylindrical body 20 having a pair of parallel passages 21 and 22 extending longitudinally therethrough and adapted to register with passages 6 and 7, respectively, of the cross-over head section. Nipples 8a and 12 extend slidably through passages 21 and 22, respectively, and through registering passages in a mandrel 24 secured to the lower end of seal section 2 and forming a part of anchor section 3. The latter includes the mandrel 24 which is provided with downwardly and inwardly tapering surfaces 25 and a slip cage 26 comprising the spaced collars 27 and 28, respectively, slidably mounted about both sections 8a and 12 of tubing strings 8 and 9, respectively. Outwardly bowed drag springs 29 extend between collars 27 and 28 to frictionally engage the wall of casing C. Upper collar 27 carries a pair of toothed slips 30 mounted on resilient arms 31 extending upwardly from collar 27 on opposite sides of mandrel 24. The slips are positioned to be radially expanded by engagement with tapered surfaces 25 into gripping engagement with the wall of casing C upon relative movement between the slip cage and mandrel 24. Slip cage 26 is releasably held against upward movement relative to nipple 12 by means of upwardly projecting inwardly biased spring fingers 32 (one shown) carried by lower collar 28, the free ends of fingers 32 being adapted to engage beneath an external downwardly facing shoulder 33 formed on nipple 12 in order to hold the slips out of engagement with mandrel 24. The fingers 32 are adapted to be spread apart sufficiently to pass by shoulder 33 by means of a releasing sleeve 34 slidably mounted on nipple 12 below the slip cage. A collar 35, carried by the lower end of nipple 12, serves to prevent the sleeve 34 from falling off of the nipple.

The anchor elements comprising anchor section 3 and their operation are entirely conventional, this anchor structure being of the general type designed to be set and released entirely by longitudinal movements of the supporting body relative to the anchoring elements. Anchors of this general type are well-known and an example of such anchors is disclosed in U.S. Patent No. 764,769, issued July 12, 1904, to Robinson et al.

As best seen in Figs. 5, 6 and 7, cross-over head section 1 includes a pair of by-pass channels 36 and 37 extending longitudinally of body 5 along opposite sides thereof. One of these by-pass channels, for example, channel 36, communicates at its lower end with the lower end of passage 7 by means of a cross-over passage 38, and communicates at its upper end with the upper end of passage 6 by means of a cross-over passage 39. The other by-pass channel, such as channel 37, communicates at its lower end with the lower end of passage 6 by means of a cross-over passage 40, and at its upper end with the upper end of passage 7 by means of a cross-over passage 41. It will be understood that passages 6 and 7 are substantially identical in their dimensions and form. The same condition applies generally to by-pass channels 36 and 37 and to cross-over passages 38, 39, 40 and 41.

To install the cross-over packer in the dual pipe string well equipment, body 5 will be connected into pipe string 8 by connecting the latter into socket 13. Lower section 8a will be inserted through anchor section 3 and seal section 2 and connected into socket 18, while nipple 12 will likewise be inserted through anchor section 3 and seal section 2 and connected into socket 19. Packer 10 will, of course, be positioned on pipe string section 8a and this assembled structure will be lowered into the well to position packer 10 between formations F₁ and F₂, whereupon packer 10 will be set by well-known and generally conventional procedures, while still allowing a

limited amount of longitudinal movement of pipe string section 8a relative to packer 10 by an arrangement well understood in this art.

Thereafter, by limited longitudinal movements of pipe string 8, slips 30 will be anchored to the wall of casing C to prevent downward movement of mandrel 24, while still, of course, permitting sliding movement of nipple 12 and pipe section 8a through the mandrel and seal element 20. When the anchor section has thus been set, pipe string 9, carrying seal nipple 16, will be run into the well and inserted into the upper end of passage 7 and seated against a shoulder 7a therein. When the weight of pipe string 9 is then brought to bear on cross-over body 5, seal member 20 will be compressed against the upper end of mandrel 24 and thereby expanded into sealing engagement with the wall of casing C, thereby closing off the casing annulus at a point above formation F₁. When this is accomplished, fluid from formation F₁ will be forced to flow into the lower end of nipple 12, while fluid from formation F₂ will be forced to flow through slotted pipe 11 into section 8a of pipe string 8.

To selectively direct fluids flowing through pipe strings 8 and 9 to flow in either the conventional or cross-over arrangement, additional devices are inserted in one or both of the passages 6 and 7 in the cross-over head, depending upon which type of flow is desired.

In order to direct the cross-over flow from pipe string 8 to pipe string 9, the bores of both passages 6 and 7 are sealed intermediate the ends thereof by appropriate plugging devices, as will be subsequently described. By closing off the bores of these passages, as noted, fluid flowing in pipe string 8 will be forced to pass through cross-over passage 40, thence upwardly through by-pass channel 37 and cross-over passage 41 into passage 7, and thence upwardly through pipe string 9. Similarly, fluid flowing upwardly through nipple 12 and pipe string 9 will be forced to pass through cross-over passage 38 into by-pass channel 36, thence upwardly through cross-over channel 39 into passage 6, and thence upwardly through pipe string 8 to the surface, thereby completing the cross-over flow of the two streams of fluid from formations F₁ and F₂.

These plugging devices comprise seal plugs, designated generally by the numerals 45—45, which may be run into passages 6 and 7 by conventional wire line operations. These plugs are releasable and are of the general construction disclosed in my U.S. application Serial No. 526,994, filed August 8, 1955. As plugs 45 are identical in construction, and as passages 6 and 7 are likewise identical in dimensions and arrangement, only one plug and its application to passage 6 will be described in detail, it being understood that the description will apply as well to the plug installed in passage 7. Each of these plugs comprises a generally tubular body 46 having a bore 47 closed at its lower end by a cap 48. At an intermediate point, body 46 is provided with a plurality of angularly spaced radial openings or windows 49 in which are mounted radially movable latch slips 50 which are adapted to be moved outwardly into an annular latching groove 51 formed in the wall of each of the passages 6 and 7 at points intermediate the cross-over passages communicating with the opposite ends of these passages. Seal packing 52 is mounted about the exterior of the plug body at a point above the windows 51, and is adapted to form a fluid-tight seal between the plug body and the wall of passage 6. Slidably disposed in bore 47 is a tubular mandrel 53, to the upper end of which is connected a conventional fishing head 54 by which the plug may be secured to conventional wire line fishing tools. An annular enlargement 55 is formed on mandrel 53 at an intermediate point thereof which will be opposite the slips 50 when the mandrel is fully inserted in bore 47; that is, when the inner end of the mandrel comes up against cap 48, which limits its inward movement. In this position, as seen in Fig. 3, enlargement 55

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will urge slips 50 outwardly into groove 51 to thereby lock the seal plug 45 in place in passage 6.

It will be understood that when the plugging device is initially introduced into passage 6, mandrel 53 will be in an upwardly retracted position and slips 50 will be forced inwardly of windows 49 by engagement with the smaller diameter of the bore wall of passage 6, so that the inner upper edges of the slips will be disposed beneath enlargement 55 which will prevent the latter from moving downwardly behind the slips until the latter are positioned opposite groove 51, at which point the slips are freed to move outwardly and the mandrel can move downwardly behind the slips to move the slips into the latched position in passage 6.

When it is desired to withdraw plugs 45, a wire line fishing tool of conventional form is run through the pipe strings to grasp fishing head 54 and by tension thereon mandrel 53 will be pulled upwardly in body 46 to pull enlargement 55 above the slips, thereby releasing slips 50 which are then moved inwardly from groove 51, and allow the plugs to be withdrawn from passages 6 and 7.

In order to establish parallel flow, a modified form of plugging device, designated generally by the numeral 60 and illustrated in Figs. 4A and 4B, will be run into one of the passages 6 or 7 of the cross-over head. This form of modified plugging device has a relatively elongated body 61 provided at its upper and lower ends with enlargements 63 and 64, respectively, the length of body 61 being such that the enlargements 63 and 64 will be disposed above and below the points of communication of the cross-over passages with the opposite ends of the flow passage into which device 60 is inserted. The enlargements 63 and 64 carry packing means 65 and 66, respectively, about their exteriors, adapted to form fluid-tight seals with the adjacent portions of the wall of the flow passage. Body 61 is provided, at an intermediate point thereon, with windows 49a and latching slips 50a adapted to be engaged in latching grooves 51. Body 61 has an axial bore 67 extending entirely therethrough and has slidably mounted in bore 67 a tubular mandrel 53a which is substantially identical with mandrel 53, having formed thereon an annular enlargement 55a which functions in the same manner, with respect to latching slips 50a, as enlargement 55 in the case of the sealing plugs, as previously described. The upper end of mandrel 53a carries a fishing head 54. Modified plugging device 60 is inserted into the bore of one of the passages 6 or 7 in the same manner as the other plugging devices previously described, and when locked into a groove 51, the packings 65 and 66 being above and below the cross-over passages at the opposite ends of the flow passage, will prevent any cross-over flow from pipe string 8 to pipe string 9. Instead, fluid flowed upwardly through the pipe string in which device 60 is installed, will be constrained to flow through the bore 67 of body 61 and through the bore of mandrel 53a into the upper section of that pipe string, and fluid flowing through the other pipe string will also be forced to continue its flow upwardly to the surface, since it cannot cross over into the pipe string containing device 60, whereby it will be seen that by the use of the modified plugging device 60, parallel flow will be accomplished. Parallel flow device 60 is illustrated as positioned in passage 6 of pipe string 8, but it will be understood that it may be installed in either pipe string to effect parallel flow.

Ordinarily, the dual strings will be run with modified plugging device 60 in place in passage 6 in order to secure parallel or conventional flow of fluids from formations F₁ and F₂. When cross-over flow is desired, plug 60 will be withdrawn and plugs 45 run into both passages 6 and 7 in the cross-over head.

If at any time it should be found desirable to produce from only one formation, parallel flow device 60 may be run into the flow passage in the cross-over head com-

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municating with the formation to be produced while one of the plugs 45 will be seated in the other flow passage in the cross-over head, thereby blocking flow from the formation to be shut in.

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

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

1. In dual-string well completions employing a pair of parallel pipe strings extending into a well and carrying means cooperating with the well wall to direct fluids from spaced earth formations separately into the respective pipe strings, a cross-over device, comprising, a body member connectible into both pipe strings and having a pair of parallel longitudinal passages therethrough each adapted to communicate with one of said pipe strings, a pair of cross-over channels in said body member arranged to provide cross-communication between longitudinally spaced points in the respective passages, each of said channels connecting the upper one of said points in one passage to the lower one of said points in the other passage, first flow-directing means removably insertable in both said passages to positions therein relative to said spaced points to direct fluid from said formations through said body member in cross-over flow, and a second flow-directing means removably insertable in one of said passages to a position relative to said spaced points to direct fluids from said formations through said body member in parallel flow, and means for releasably securing the respective flow-directing means in said passages, said first and second flow-directing means being alternatively employable for selectively directing cross-over or parallel flow through said body.

2. In dual-string well completions employing a pair of parallel pipe strings extending into a well and carrying means cooperating with the well wall to direct fluids from spaced earth formations separately into the respective pipe strings, a cross-over device, comprising, a body member connectible into both pipe strings and having a pair of parallel longitudinal passages therethrough each adapted to communicate with one of said pipe strings, a pair of cross-over channels in said body member arranged to provide cross-communication between longitudinally spaced points in the respective passages, each of said channels connecting the upper one of said points in one passage to the lower one of said points in the other passage, and flow-directing means comprising a pair of plug members removably insertable in both said passages adapted to form fluid-tight seals therein between said longitudinally spaced points whereby to direct fluids from said formations into cross-over flow through said body member, and means for releasably securing said plug members in said passages.

3. In dual-string well completions employing a pair of parallel pipe strings extending into a well and carrying means cooperating with the well wall to direct fluids from vertically spaced earth formations separately into the respective pipe strings, a cross-over device, comprising, a body member connectible into both pipe strings and having a pair of parallel longitudinal passages therethrough each adapted to communicate with one of said pipe strings, a pair of cross-over channels in said body member arranged to provide cross-communication between longitudinally spaced points in the respective passages, each of said channels connecting the upper one of said points in one passage to the lower one of said points in the other passage, and flow-directing means comprising a tubular seal member removably insertable in one of said passages, said seal member having an axial through bore and having longitudinally spaced seal packings positioned thereon to seal with said one passage above and below said spaced points, whereby to direct fluids into parallel flow through said body member, and

means for releasably securing said seal member in said one of said passages.

4. In dual-string well completions employing a pair of parallel pipe strings extending into a well and carrying means cooperating with the well wall to direct fluids from spaced earth formations separately into the respective pipe strings, a cross-over device, comprising, a body member connectible into both pipe strings and having a pair of parallel longitudinal passages therethrough each communicating with one of said pipe strings, said means cooperating with the well wall including a resilient seal element mounted on the body to seal between both said pipe strings and the well wall at a point above the uppermost one of said earth formations, a pair of cross-over channels in said body member arranged to provide cross-communication between longitudinally spaced points in the respective passages, each of said channels connecting the upper one of said points in one passage to the lower one of said points in the other passage, first flow-directing means removably insertable in both said passages to positions therein relative to said spaced points to direct fluid from said formations through said body member in cross-over flow, and a second flow-directing means removably insertable in one of said passages to a position relative to said spaced points to direct fluids from said formations through said body member in parallel flow, and means for releasably securing the respective flow-directing means in said passages, said first and second flow-directing means being alternatively employable for selectively directing cross-over or parallel flow through said body.

5. In dual-string well completions employing a pair of parallel pipe strings extending into a well and carrying means cooperating with the well wall to direct fluids from spaced earth formations separately into the respective pipe strings, a cross-over device, comprising, a body member connectible into both pipe strings and having a pair of parallel longitudinal passages therethrough each adapted to communicate with one of said pipe strings, said means cooperating with the well wall including a resilient seal element mounted on the body member to seal between both said pipe strings and the well wall at a point above the uppermost one of said earth formations, a pair of cross-over channels in said body member arranged to provide cross-communication between longitudinally spaced points in the respective passages, each of said channels connecting the upper one of said points in one passage to the lower one of said points in the other passage, and flow-directing means comprising a pair of plug members removably insertable in both said passages to seal each of said passages between said longitudinally spaced points, whereby to direct fluids from said formations into cross-over flow through said body member, and means for releasably securing said plug members in said passages.

6. In dual-string well completions employing a pair of parallel pipe strings extending into a well and carrying means cooperating with the well wall to direct fluids from spaced earth formations separately into the respective pipe strings, a cross-over device, comprising, a body member connectible into both pipe strings and having a pair of parallel longitudinal passages therethrough each adapted to communicate with one of said pipe strings,

said means cooperating with the well wall including a resilient seal element mounted on the body member to seal between both said pipe strings and the well wall at a point above the uppermost one of said earth formations, a pair of cross-over channels in said body member arranged to provide cross-communication between longitudinally spaced points in the respective passages, each of said channels connecting the upper one of said points in one passage to the lower one of said points in the other passage, and flow-directing means comprising a tubular seal member removably insertable in one of said passages, said seal member having an axial through bore and having longitudinally spaced seal packings positioned thereon to seal with said one passage above and below said spaced points, whereby to selectively direct fluids from said formations into parallel flow through said body member, and means for releasably securing said seal member in said one of said passages.

7. In dual-string well completions employing a pair of parallel pipe strings extending into a well and carrying means cooperating with the well wall to direct fluids from spaced earth formations separately into the respective pipe strings, a cross-over device, comprising, a body member connectible into both pipe strings and having a pair of parallel longitudinal passages therethrough each communicating with one of said pipe strings, said means cooperating with the well wall including a resilient seal element mounted on the lower end of the body member adapted by axial compression of the body member to seal between both said pipe strings and the well wall at a point above the uppermost one of said earth formations, an anchor assembly supported on the pipe strings below the seal element for anchoring engagement with the well wall to form a base against which said seal element is axially compressible, a pair of cross-over channels in said body member arranged to provide cross-communication between longitudinally spaced points in the respective passages, each of said channels connecting the upper one of said points in one passage to the lower one of said points in the other passage, and first and second flow-directing means alternatively removably insertable respectively in one or both said passages to selectively direct fluids from said formations through said body member respectively in either parallel or cross-over flow, said first flow-directing means comprising a pair of plug members adapted to form fluid-tight seals in both said passages between said spaced points therein, and said second flow-directing means comprising a tubular seal member having a through-bore and having longitudinally spaced external seal packings positioned to seal with said one passage at points above and below said longitudinally spaced points therein, and means for releasably securing the respective flow-directing means in said passages.

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