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MULTIPLE ZONE SELECTIVE FLOW CONTROL APPARATUS

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FIG. 2a.

FIG. 2b.

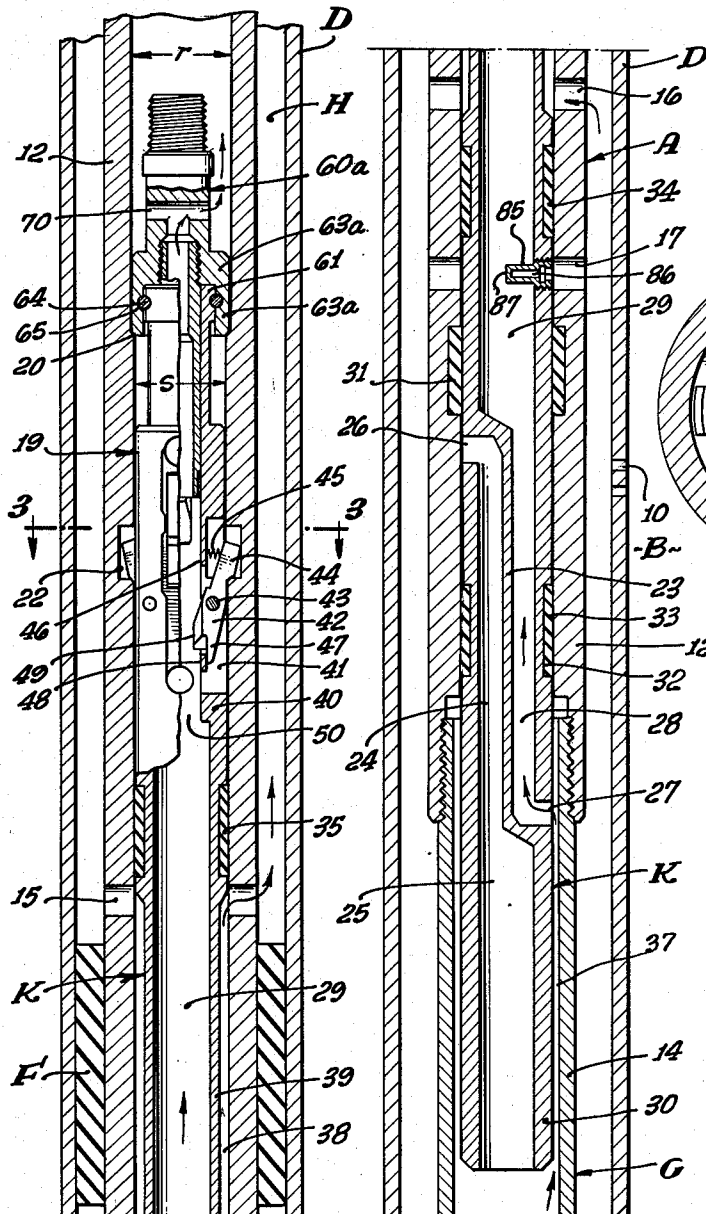
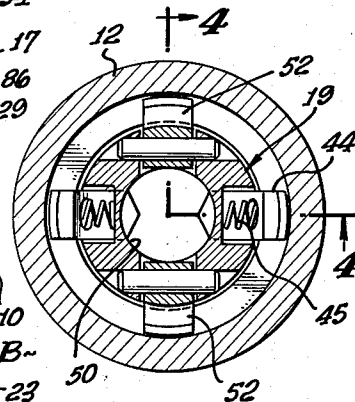


FIG. 3.



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MULTIPLE ZONE SELECTIVE FLOW CONTROL APPARATUS

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15 Claims. (Cl. 166-145)

The present invention relates to subsurface well bore apparatus, and more particularly to apparatus for controlling the flow of fluid between a plurality of formation zones in a well bore and the top of the well bore.

In a well bore having a plurality of producing zones, it is desired to conduct the fluid from each zone separately to the top of the well bore. Packer apparatus may be set in the well bore to isolate the producing zones from one another. Well production from the first zone may be conducted through a tubing string to the top of the well bore, production from a second zone being conducted through a region externally of the tubing string, such as the annulus around the tubing string, to the top of the well bore. The flow pattern may require change at times, to cause production from the second zone to flow through the tubing string to the top of the well bore and production from the first zone to flow through the annulus around the tubing string, or other region externally of the tubing string, to the top of the well bore.

An object of the present invention is to provide improved apparatus for conducting fluid from different well formations separately to the top of the well bore, the flow path of the fluid from one formation to the top of the well bore being interchangeable selectively with the flow path from another formation.

Another object of the invention is to provide apparatus for conducting fluid from different well formations separately to the top of the well bore, the flow path of one formation fluid being through a tubing string extending to the top of the well bore, and the flow path of another formation fluid being externally of the tubing string, such flow paths being selectively interchangeable by changing the position of the flow control device with respect to the tubing string.

A further object of the invention is to provide apparatus for producing fluids in a conventional manner from a lower zone in a well bore through tubing extending to the top of the well bore, and from an upper zone through the annulus around the tubing string, or for producing fluids in a crossed-over manner from the lower zone through the annulus and from the upper zone through the tubing, a flow control portion of the apparatus being shiftable with respect to the tubing string to selectively change the mode of production between conventional and crossed-over, in which shifting of the apparatus can be accomplished through the tubing string.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

FIGURES 1a, 1b and 1c together constitute a longitudinal section through apparatus disposed in a well bore for conducting production from a plurality of zones through separate paths to the top of the well bore, the apparatus being conditioned for conducting fluid in a

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crossed-over manner, FIGS. 1b and 1c being lower continuations of FIGS. 1a and 1b, respectively;

FIGS. 2a and 2b are views corresponding to FIGS. 1a and 1b, the apparatus having been positioned for producing fluid from a plurality of zones in a conventional manner, FIG. 2b being a lower continuation of FIG. 2a;

FIG. 3 is an enlarged cross-section taken along the line 3-3 on FIG. 2a;

FIG. 4 is a longitudinal section taken along the line 4-4 on FIG. 3;

FIG. 5 is a longitudinal section through a portion of the apparatus illustrating release of the latch or locking device to permit removal of a portion of the apparatus from the tubing string.

The apparatus A specifically illustrated in the drawings is intended to conduct fluid from upper and lower formation zones B, C through separate paths to the top of the well bore. A string of casing D is suitably mounted in the well bore, the casing ordinarily having cement deposited therearound between the upper and lower zones B, C to prevent communication therebetween. A lower packer E of any suitable type is anchored in packed-off condition in the well casing between upper and lower perforations 10, 11 in the casing opposite the upper and lower zones, respectively, and an upper well packer F of any suitable type may be disposed in the well casing above the upper perforations 10. This upper well packer F may be permanently anchored in the well casing D, or may be of the retrievable type, as desired. A tubular string G is disposed in the casing, extending from the top thereof. This tubing string is related in any suitable manner with the upper packer F in leak-proof relation with respect thereto, and extends downwardly therefrom and is suitably related to the lower packer E in leak-proof relation with respect thereto. The tubular string may include an outer body 12 which may, if desired, actually constitute the body portion of the upper packer F, the upper portion of this outer body being threadedly or otherwise suitably connected to a tubing string section 13 thereabove. The lower portion of the body may be threadedly connected to a section 14 of the tubing string extending therebelow, the latter being associated in leak-proof relation with the lower packer E.

It is desired to conduct the fluids from the upper and lower zones B, C to the top of the well bore. Such fluid may be conducted in a conventional manner by causing the lower formation fluid to pass through the lower perforations 11 into the casing D and upwardly through the lower packer E into the tubing string G, flowing upwardly through the tubing string to the top of the well bore. The production from the upper formation zone B may pass through the upper perforations 10 into the casing string D to be conducted through a path externally of the tubing string G to the top of the well bore, as through the tubing-casing annulus H around the tubing string. If desired, however, the production from the lower zone C can be crossed over into the tubing-casing annulus H to be conducted to the top of the well bore, the production from the upper formation zone B being conducted through the tubing string G to the top of the well bore.

A single mechanism K is disposed within the tubing G and can be located in different positions therein to conduct fluid from the upper and lower formation zones B, C to the top of the well bore in the conventional manner or in the crossed-over manner. As shown, the outer tubular body 12 has a plurality of outlet ports 15 above the upper packer F and a plurality of inlet ports 16 below the upper packer. The body 12 also has a set of equalizing ports 17 below the upper packer F. The outer body 12 also has an upper stop shoulder 18 to locate an

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inner tubular body or mandrel 19 in a predetermined position with respect to the ports 15, 16, 17, and it also has a lower stop shoulder 20 to locate the mandrel 19 in another predetermined position with respect to such ports. The inside diameter r of the outer body 12 above the lower stop shoulder 20 is greater than the inside diameter s of the body below such stop shoulder. Moreover, the tubing section 14 below the outer body 12 has a greater internal diameter than the internal diameter of the passage through the body 12 thereabove.

The outer body 12 also has an upper internal locking groove 21 in its enlarged internal diameter portion and a lower internal locking groove 22 in its smaller diameter portion. Such locking grooves, as explained hereinbelow, will lock the tubular mandrel 19 in two different longitudinal positions within the outer body 12, in order to determine the paths of fluid flow from the lower and upper formation zones C, B.

The tubular mandrel 19 has a longitudinal partition 23 extending therewithin to separate the mandrel into a longitudinal crossover passage having a lower inlet 25 and an upper outlet or port 26 communicating with the exterior of the mandrel. The partition also provides a lower inlet port 27 and a passage 28 communicating with the central tubular passage 29 through the mandrel 19 that communicates with the tubing string G thereabove. The mandrel can be placed in the crossed-over position illustrated in FIGS. 1a and 1b, in which the mandrel outlet port 26 communicates with the outlet port 15 of the outer body 12, and in which the mandrel inlet port 27 communicates with the inlet port 16 of the tubular body below the upper packer F. When the mandrel is in this position, its lower end 30 slidably seals with a suitable inner side seal 31 mounted in an internal groove 32 in the outer body below the equalizing ports 17, a suitable side seal 33 mounted on the mandrel then having a sealing engagement with the inner wall of the outer body 12 between the body inlet and outlet ports 16, 15, another side seal 34 on the mandrel sealingly engaging the wall of the outer body 12 above the outlet port 15, and, as shown in FIG. 1b, below the lower lock groove 22. An uppermost seal 35 is also mounted on the mandrel, this seal being adapted to seal against the wall of the lower outer body passage of lesser diameter below the lower stop shoulder 20.

With the ports and seals located as illustrated in FIGS. 1a and 1b, production from the lower zone C will pass upwardly through the lower packer E and the tubing G into the lower end of the outer body 12, flowing upwardly through the lower central inlet 25 of the mandrel 19, through its crossover passage 24 and out through its port 26, such fluid continuing to flow out through the outlet port 15 above the upper packer F for continued upward travel through the tubing-casing annulus H to the top of the well bore and casing. Production from the upper zone B will pass through the upper perforations 10 and upwardly around the exterior of the outer body 12 below the upper packer F, flowing through the body inlet ports 16 into the inlet port 27 of the mandrel for continued upward movement through the mandrel passage 28, 29 into the tubing string G, to be conducted by the latter to the top of the well bore and casing. Fluids from the upper and lower formation zones B, C cannot come in because of the second and third seals 34, 33 sealing against the wall of the outer body 12 on opposite sides of the outlet ports 15 and because of the sealing of the lower portion of the mandrel against the lowermost body seal 31.

If production from the upper and lower zones B, C is to be conducted to the top of the well bore in a conventional manner, the mandrel 19 is lowered and disposed in the position illustrated in FIGS. 2a and 2b. When in such position, the inlet port 27 of the mandrel has been shifted downwardly and disposed within the enlarged internal diameter tubing 14 below the outer body 12, the inlet port of the mandrel communicating with the annular

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passage 37 between the lower portion of the mandrel 19 and the tubing 14, so that fluid from the lower zone C can flow upwardly through the lower packer E and the tubing G, and through the annular passage 27 into the mandrel passage 28 for continued upward flow through the tubing string G to the top of the well bore. When the mandrel occupies the lower position shown in FIG. 2a, the uppermost seal 35 is disposed within the smaller internal diameter portion of the outer body 12 below the shoulder 20, sealing against the wall of the body above the outlet ports 15, the second seal 34 being disposed below the body inlet ports 16, the internal body seal 31 engaging the periphery of the mandrel 19 above the outlet port 26 of the crossover passage 24 so that the upper end of such passage has no communication with the tubing-casing annulus H, or with the upper well formation production at all. The fluid from the upper zone B will now pass through the body inlet ports 16 into a passage 38 between the first and second seals 35, 34 and between a reduced diameter portion 39 of the mandrel 19 and the inner wall of the outer body 12, such fluid flowing upwardly through such annular passage and out through the body outlet ports 15 into the tubing-casing annulus H to be conducted therethrough to the top of the well bore and casing (FIGS. 2a, 2b).

The mandrel 19 can be positively located in the tubing string G and in the outer body member 12 of the latter in either the position illustrated in FIGS. 1a and 1b, which is the crossover position, or in the conventional position illustrated in FIGS. 2a and 2b. It can also be releasably locked in these two positions. The mandrel can be locked in the position illustrated in FIGS. 1a and 1b or in FIGS. 2a and 2b by a lock or latch device mounted on the upper portion 40 of the mandrel, which latch or lock device is adapted to shift into either the upper locking groove 21 or the lower locking groove 22. As shown, the mandrel portion 40 has a pair of opposed elongate slots 41 in which upwardly holding latches or dogs 42 are disposed. Each of these latches is mounted on a pivot pin 43 extending across a slot 41 and suitably secured to the mandrel. The upper dog or lug portion 44 of each latch is urged outwardly and into a locking groove 21 or 22, when aligned therewith, by a helical compression spring 45 bearing thereagainst and also against an inner portion 46 of the mandrel or body portion 40. Outward shifting of the upper latch portion 44 is limited by engagement of a lower lock finger 47, on the opposite side of the pivot pin 43, with a body stop web 48 extending across the slot 41. When the upper dog or lug 44 is disposed outwardly in a lock groove, a retracting nose 49 on the lower portion of the latch 42 is adapted to extend inwardly of the central passage 50 through the mandrel 19.

A second pair of opposed elongate slots 51 is formed in the mandrel or body portion 40 angularly displaced from the other slots 41, receiving a second pair of latches 52 which are the same as the other pair of latches 42 except that they are reversely arranged, the locking or dog portion 53 being disposed on the lower portions of each latch 52 and the upper retracting nose 54 on the upper portion. Such second set of latches or dogs 52 is adapted to expand into a locking groove 21 or 22 and anchor the mandrel 19 against downward movement within the outer body 12.

When the upwardly and downwardly facing latches 42, 52 are disposed in the upper locking groove 21, the mandrel is in the position illustrated in FIGS. 1a and 1b, which is the crossover position. When the latches 42, 52 expand into the lower locking groove 22, the tubular mandrel 19 is in the position illustrated in FIGS. 2a and 2b, which is the conventional position for conducting production from the upper and lower producing formations B, C to the top of the well bore.

The location of the mandrel 19 and the latches 42, 52 in the upper position illustrated in FIGS. 1a and 1b is determined by limiting downward movement of the

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mandrel 19 in the outer body. As shown, the mandrel 19 with its latches 42, 52 can be lowered from the top of the well bore through the tubing string C on a running-in tool 60 releasably connected to the upper portion 61 of the mandrel. The running-in tool may have an upper threaded pin 62, or the like, adapted for connection to a wire line device (not shown) connected to a wire line (not shown) extending to the top of the well bore. A portion of the running-in tool is constituted as a head 63 having an outside diameter less than the inside diameter of the tubular string G above the body 12 but greater than the inside diameter of the upper passage through the outer body 12, so that the lower end of the head 63 will come into engagement with the upper stop shoulder 18. This head 63 is releasably secured to the upper retrieving head portion 61 of the mandrel by a pair of tangentially arranged shear screws 64 received within opposed recesses 65 in the running-in head and the mandrel head. The running-in tool also includes a retracting tube 66 threadedly secured to the head 63 and receivable in the upper passage portion 50 of the mandrel and engageable with the nose portions 54 of the downwardly holding latches 52 to swing their lower ends or dogs 53 inwardly within the confines of the outer body 19, thereby preventing such downwardly holding latches from entering any coupling recesses, or the like, in the tubing string G.

The mandrel and running-in tool combination 19, 60 are lowered in the tubing G, the upwardly holding latches or dogs 42 merely ratcheting past the tubing couplings, shifting inwardly and outwardly against the force of the expanding springs 45. The retracting tube 66, as explained above, holds the downwardly holding latches 52 in their retracted position. The mandrel and running-in tool apparatus will continue descending through the tubing string G, with the fluid in the tubing string being able to by-pass through the tool, flowing upwardly through the passages 24, 28 in the mandrel and up through the retracting tubing 66, discharging through the side ports 70 in the running-in tool 60. Descent of the mandrel and running-in tool can continue until the head 63 engages the upper stop shoulder 18, at which time the latch dogs 42, 52 are disposed in alignment with the upper lock groove 21 in the outer body 12, the springs 45 promptly expanding the upwardly holding latch dogs 42 into the recess 21, which will engage the upper side of the recess 21 and prevent substantial upward movement of the mandrel 19 within the outer body member 12. The mandrel 19 will then be in the position illustrated in FIGS. 1a and 1b, which is the crossover position described above. An upward strain or jarring action can now be taken on the wire line (not shown), which will shear the screws 64 and release the running-in head 63 from the mandrel head 61, the running-in tool being elevated to remove the retracting tube 66 from contact with the noses 54 of the downwardly holding latches, the latter then expanding outwardly into the upper recess 21 to prevent downward movement of the mandrel 19 with the outer body member 12. The running-in tool 60 with its retracting tube 66 can now be removed from the tubing string G by elevating the wire line.

As described above, the apparatus is now in the crossover position, with the production from the lower zone C flowing through the mandrel passage 24 and into the tubing-casing annulus H, production from the upper zone B flowing into the mandrel passages 28, 29 and up through the tubing string G to the top of the well bore.

If the flow pattern is to be changed from the crossover arrangement shown in FIGS. 1a and 1b to the conventional arrangement illustrated in FIGS. 2a and 2b, a suitable pulling tool 80, such as disclosed in FIG. 5, is lowered on a wire line (not shown) through the tubing string G. Such pulling tool includes a retracting tube 81 adapted to enter the mandrel 19 and engage the nose

portions 49, 54 of upwardly holding and downwardly holding sets of latches 42, 52, shifting the dogs 44, 52, inwardly from the upper lock groove 21 and entirely within the confines of the mandrel. The pulling tool 80 has a plurality of spring-like arms 82 depending therefrom which will expand over the retrieving head 61 of the mandrel and dispose its inwardly directed fingers 83 below 80 will cause the fingers 83 to engage the underside of the head. An upward pull now taken on the pulling tool the head 61 and result in upward elevation of the mandrel 19 from the body member 12 and its complete removal therefrom, the retracting tube 81 holding the latches 42, 53 in their retracted positions so that they will not inadvertently catch in coupling spaces or other recesses in the tubing string G. The entire mandrel apparatus 19 is removed from the tubing string at the top of the hole.

If desired, prior to lowering the pulling or retrieving tool 80 through the tubing G for the purpose of removing the mandrel 19 from the body 12, a suitable tool (not shown) can be lowered in the tubing on a wire line, which has a prong (not shown) on its lower portion adapted to move downwardly through the mandrel 19 and engage a pressure equalizing plug 85 threaded in the mandrel between the seals 33, 34, this plug having a central passage 86 and a closed inner end 87. The equalizing prong will engage and break the plug 85, establishing communication between the interior and the exterior of the mandrel 19 between the seals 33, 34, which will effect an equalizing of the pressure above and below the packer F and facilitate withdrawal of the mandrel 19 from the outer body 12.

Following withdrawal of the mandrel 19 from the tubing string G, a second running-in tool 60a (FIG. 2a) can be secured thereto by means of shear screws 64, the retracting tube 66 extending into the passage 50 to hold the downwardly facing or holding latches 52 in a retracted position. The second head 63a of this tool 60a has a smaller external diameter than the head 63 previously referred to, being of lesser diameter than the upper passage portion r through the outer body 12 but slightly greater than the internal diameter s of the lower passage. Accordingly, the apparatus is run down through the tubing G on a wire line and will pass into the outer body 12, but it will not come to rest until the second head 63a engages the lower stop shoulder 20, at which time the latches 42, 52 will be disposed in alignment with the lower locking groove 22 of the body, the parts being then located in the position illustrated in FIGS. 2a and 2b. Before the apparatus is lowered through the tubing string, however, the formerly broken equalizing plug 85 will have been replaced with another plug whose central passage 86 is intact and closed.

With the parts in the position illustrated in FIGS. 2a and 2b, an upward pull or jar is taken on the wire line, the upwardly facing latches 42 engaging the upper wall of the lower lock groove 22 to prevent substantial upward movement of the mandrel 19. The shear screws 64 are disrupted and the retracting tube 66 pulled upwardly from engagement with the downwardly holding latches 52, the latter then expanding outwardly under the influence of their springs 45 into the lock groove 22 to prevent downward movement of the mandrel with respect to the outer body. With the parts located in the position disclosed in FIGS. 2a and 2a and upon removal of the running-in tool 60a from the tubing string G, fluid from the lower zone C can flow upwardly into the mandrel passages 28, 29 to be connected through the tubing string G to the top of the well bore. Fluid from the upper zone B will flow through the body inlet ports 16 and through the annular passage 38 between the reduced diameter portion 39 of the mandrel and the outer body 12 into and through the outlet ports 15 above the upper packer F to be conducted through the tubing-casing annulus H to the top of the well bore.

In the event it is desired to again place the mandrel in the crossover position disclosed in FIGS. 1a and 1b, a suitable pressure equalizing tool is again lowered on a wire line through the tubing string G, passing into the upper mandrel portion and striking the frangible equalizing plug 85, breaking the latter, which is now in communication with the equalizing ports 17 of the body 12, the pressure across the mandrel being equalized by opening of the equalizing passage 86. The equalizing tool can now be withdrawn from the tubing string and the retrieving tool 80 lowered on a wire line, its retracting tube 81 entering the mandrel passage 50 to retract both sets of latches 42, 52 within the confines of the mandrel, its fingers 83 snapping over the mandrel head 61. Upward movement of the wire line and the pulling tool 80 will cause the fingers to engage the lower end of the head 61 and elevate the mandrel 19 from the outer body member 12 and through the tubing string G to the top of the well bore.

The running-in tool 60 with the larger head 63 can again be connected to the mandrel by means of the shear screws 64, or other releasable devices, the equalizing plug 85 having been replaced so that the equalizing passage 86 is again closed, and the mandrel 19 again lowered through the tubing G until the head 63 engages the upper stop shoulder 18, placing the apparatus in the crossover flow condition illustrated in FIGS. 1a and 1b. The upwardly facing latches 42 will again prevent upward movement of the mandrel, allowing an upward pull or jarring action of the wire line on the running-in tool 60 to shear the screws 64 and enable the running-in head 63 with its retracting tube 66 to be withdrawn through the tubing G, the downwardly facing latches 52 expanding outwardly into the recess 21 to prevent downward movement of the mandrel 19 within the outer body member 12.

The same mandrel mechanism can be used and be placed in different selected positions within the outer body 12 of the tubing string G to either secure flow in the conventional manner, such as disclosed in FIGS. 2a and 2b, or to secure flow in the crossover fashion illustrated in FIGS. 1a and 1b. It is only necessary to employ a different size stop head 63, 63a on the running-in tool 60 60a to locate the mandrel 19 in one position or the other and to lock it against upward and downward movement in the selected position. At any time, the mandrel 19 can be readily withdrawn from the tubing string G and shifted to another position within the outer body member 12 by appropriate selection of a stop head of the proper diameter, which will engage the desired stop shoulder.

I claim:

1. In apparatus for conducting fluids between upper and lower zones in a well bore and the top of the well bore: a lower packer set in the well bore between the zones; an upper packer set in the well bore above the upper zone; a tubular string in the well bore operatively connected to said packers and including tubular body means fixed to a portion of said tubular string thereabove to prevent rotational and longitudinal movement of the tubular string above said body means relative to said body means; mandrel means movably mounted in said body means and with respect to said tubular string; said mandrel means and body means providing separate passages for conducting fluids from the upper and lower zones to the interior of the tubular string above said upper packer and to the space in the well bore above said upper packer externally of the tubular string; coengageable means on said mandrel means and body means for locating said mandrel means in a first position in said body means wherein said passages conduct fluid separately from the lower zone to said interior of the tubular string and from the upper zone to said space; and coengageable means on said mandrel means and body means for locating said mandrel means in a second position in said body means wherein said passages conduct fluid separately

from the lower zone to said space and from the upper zone to said interior of the tubular string.

2. In apparatus for conducting fluids between upper and lower zones in a well bore and the top of the well bore: a lower packer set in the well bore between the zones; an upper packer set in the well bore above the upper zone; a tubular string in the well bore operatively connected to said packers and including tubular body means fixed to a portion of said tubular string thereabove to prevent rotational and longitudinal movement of the tubular string above said body means relative to said body means; mandrel means movably mounted in said body means and with respect to said tubular string; said mandrel means and body means providing separate passages for conducting fluids from the upper and lower zones to the interior of the tubular string above said upper packer and to the space in the well bore above said upper packer externally of the tubular string; coengageable means on said mandrel means and body means for locating said mandrel means in a first position in said body means wherein said passages conduct fluid separately from the lower zone to said interior of the tubular string and from the upper zone to said space; coengageable means on said mandrel means and body means for locating said mandrel means in a second position in said body means wherein said passages conduct fluid separately from the lower zone to said space and from the upper zone to said interior of the tubular string; and means for releasably securing said mandrel means within said body means in said first position and in said second position.

3. In apparatus for conducting fluids between upper and lower zones in a well bore and the top of the well bore: a lower packer set in the well bore between the zones; an upper packer set in the well bore above the upper zone; a tubular string in the well bore operatively connected to said packers and including tubular body means; mandrel means movable down through said tubular string into said body means; said mandrel means and body means providing separate passages for conducting fluids from the upper and lower zones to the interior of the tubular string above said upper packer and to the space in the well bore above said upper packer externally of the tubular string; stop means in said body means engaged by means on said mandrel means for locating said mandrel means in a first position in said body means wherein said passages conduct fluid separately from the lower zone to said interior of the tubular string and from the upper zone to said space; and stop means on said body means engaged by means on said mandrel means for locating said mandrel means in a second position in said body means wherein said passages conduct fluid separately from the lower zone to said space and from the upper zone to said interior of the tubular string.

4. In apparatus for conducting fluids between upper and lower zones in a well bore and the top of the well bore: a lower packer set in the well bore between the zones; an upper packer set in the well bore above the upper zone; a tubular string in the well bore operatively connected to said packers and including tubular body means; mandrel means movable down through said tubular string into said body means; said mandrel means and body means providing separate passages for conducting fluids from the upper and lower zones to the interior of the tubular string above said upper packer and to the space in the well bore above said upper packer externally of the tubular string; stop means in said body means engaged by means on said mandrel means for locating said mandrel means in a first position in said body means wherein said passages conduct fluid separately from the lower zone to said interior of the tubular string and from the upper zone to said space; stop means on said body means engaged by means on said mandrel means for locating said mandrel means in a second position in said body means wherein said passages conduct fluid separately from the lower zone to said space and from the

upper zone to said interior of the tubular string; and means on said mandrel means adapted to be releasably coupled to said body means to secure said mandrel means in said first position and in said second position.

5. In apparatus for conducting fluids between upper and lower zones in a well bore and the top of the well bore: a lower packer set in the well bore between the zones; an upper packer set in the well bore above the upper zone; a tubular string in the well bore operatively connected to said packers and including tubular body means; mandrel means movable down through said tubular string into said body means; said mandrel means and body means providing separate passages for conducting fluids from the upper and lower zones to the interior of the tubular string above said upper packer and to the space in the well bore above said upper packer externally of the tubular string; said body means having upper and lower stop shoulders therein; a first stop head adapted to be mounted on said mandrel means and engageable with one of said shoulders for locating said mandrel means in a first position in said body means wherein said passages conduct fluid separately from the lower zone to said interior of the tubular string and from the upper zone to said space; and a second stop head adapted to be mounted on said mandrel means and engageable with another of said shoulders for locating said mandrel means in a second position in said body means wherein said passages conduct fluid separately from the lower zone to said space and from the upper zone to said interior of the tubular string.

6. In apparatus for conducting fluids between upper and lower zones in a well bore and the top of the well bore: a lower packer set in the well bore between the zones; an upper packer set in the well bore above the upper zone; a tubular string in the well bore operatively connected to said packers and including tubular body means; mandrel means movable down through said tubular string into said body means; said mandrel means and body means providing separate passages for conducting fluids from the upper and lower zones to the interior of the tubular string above said upper packer and to the space in the well bore above said upper packer externally of the tubular string; said body means having upper and lower stop shoulders therein; a first stop head adapted to be mounted on said mandrel means and engageable with one of said shoulders for locating said mandrel means in a first position in said body means wherein said passages conduct fluid separately from the lower zone to said interior of the tubular string and from the upper zone to said space; a second stop head adapted to be mounted on said mandrel means and engageable with another of said shoulders for locating said mandrel means in a second position in said body means wherein said passages conduct fluid separately from the lower zone to said space and from the upper zone to said interior of the tubular string; said body means having upper and lower lock grooves therein; and coupling means on said mandrel means expandible into a selected lock groove to releasably secure said mandrel means in either of said positions, said mandrel means being expandible into said upper groove when one of said stop heads engages said upper shoulder, said coupling means being expandible into said lower groove when another of said stop heads engages said lower shoulder.

7. In apparatus for conducting fluids between upper and lower zones in a well bore and the top of the well bore: a lower packer set in the well bore between the zones; an upper packer set in the well bore above the upper zone; a tubular string in the well bore operatively connected to said packers and including tubular body means; mandrel means movable down through said tubular string into said body means; said mandrel means and body means providing separate passages for conducting fluids from the upper and lower zones to the interior of the tubular string above said upper packer and to the

space in the well bore above said upper packer externally of the tubular string; said body means having upper and lower stop shoulders therein; a first stop head adapted to be mounted on said mandrel means and engageable with one of said shoulders for locating said mandrel means in a first position in said body means wherein said passages conduct fluid separately from the lower zone to said interior of the tubular string and from the upper zone to said space; a second stop head adapted to be mounted on said mandrel means and engageable with another of said shoulders for locating said mandrel means in a second position in said body means wherein said passages conduct fluid separately from the lower zone to said space and from the upper zone to said interior of the tubular string; and shear means releasably securing each head to said mandrel means when mounted thereon.

8. In apparatus for conducting fluids between upper and lower zones in a well bore and the top of the well bore: a lower packer set in the well bore between the zones; an upper packer set in the well bore above the upper zone; a tubular string in the well bore operatively connected to said packers and including tubular body means; mandrel means movable down through said tubular string into said body means; said mandrel means and body means providing separate passages for conducting fluids from the upper and lower zones to the interior of the tubular string above said upper packer and to the space in the well bore above said upper packer externally of the tubular string; stop means in said body means engaged by means on said mandrel means for locating said mandrel means in a first position in said body means wherein said passages conduct fluid separately from the lower zone to said interior of the tubular string and from the upper zone to said space; stop means on said body means engaged by means on said mandrel means for locating said mandrel means in a second position in said body means wherein said passages conduct fluid separately from the lower zone to said space and from the upper zone to said interior of the tubular string; means on said mandrel means adapted to be releasably coupled to said body means to secure said mandrel means in said first position and in said second position; and retrieving means adapted for movement through the tubular string to release said coupling means and withdraw said mandrel means through the tubular string to the top of the well bore.

9. In apparatus for conducting fluids between upper and lower zones in a well bore and the top of the well bore: a lower packer set in the well bore between the zones; an upper packer set in the well bore above the upper zone; a tubular string in the well bore operatively connected to said packers and including tubular body means; mandrel means movable down through said tubular string into said body means; said mandrel means and body means providing separate passages for conducting fluids from the upper and lower zones to the interior of the tubular string above said upper packer and to the space in the well bore above said upper packer externally of the tubular string; said body means having upper and lower stop shoulders therein; a first stop head adapted to be mounted on said mandrel means and engageable with one of said shoulders for locating said mandrel means in a first position in said body means wherein said passages conduct fluid separately from the lower zone to said interior of the tubular string and from the upper zone to said space; a second stop head adapted to be mounted on said mandrel means and engageable with another of said shoulders for locating said mandrel means in a second position in said body means wherein said passages conduct fluid separately from the lower zone to said space and from the upper zone to said interior of the tubular string; said body means having upper and lower lock grooves therein; coupling means on said mandrel means expandible into a selected lock groove to releasably secure said mandrel means in either of said positions, said mandrel means being expandible into said

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upper groove when one of said stop heads engages said upper shoulder, said coupling means being expandible into said lower groove when another of said stop heads engages said lower shoulder; and retrieving means adapted for movement through the tubular string to release said coupling means from a lock groove in which it is disposed, said retrieving means embodying means for coupling to said mandrel means whereby said retrieving means can withdraw said mandrel means through the tubular string to the top of the well bore.

10. In apparatus to be disposed in a well bore having upper and lower producing zones and in which one zone is to be produced through a tubular string disposed in the well bore and the other zone through the annulus around the tubular string: tubular body means adapted to form part of the tubular string; mandrel means movably mounted in said body means; said mandrel means and body means providing separate passages adapted to conduct fluids from the upper and lower zones to the interior of the tubular string above said body means and to the annulus around the tubular string above said body means; coengageable means on said body means and mandrel means for locating said mandrel means in a first position in said body means wherein said passages conduct fluid separately from the lower zone to said interior of the tubular string and from the upper zone to said annulus; and coengageable means on said body means and mandrel means longitudinally spaced from said other coengageable means for locating said mandrel means in a second position in said body means wherein said passages conduct fluid separately from the lower zone to said annulus and from the upper zone to said interior of the tubular string.

11. In apparatus to be disposed in a well bore having upper and lower producing zones and in which one zone is to be produced through a tubular string disposed in the well bore and the other zone through the annulus around the tubular string: tubular body means adapted to form part of the tubular string; mandrel means movably mounted in said body means; said mandrel means and body means providing separate passages adapted to conduct fluids from the upper and lower zones to the interior of the tubular string above said body means and to the annulus around the tubular string above said body means; coengageable means on said body means and mandrel means for locating said mandrel means in a first position in said body means wherein said passages conduct fluid separately from the lower zone to said interior of the tubular string and from the upper zone to said annulus; coengageable means on said body means and said mandrel means longitudinally spaced from said other coengageable means for locating said mandrel means in a second position in said body means wherein said passages conduct fluid separately from the lower zone to said annulus and from the upper zone to said interior of the tubular string; and means for releasably securing said mandrel means in said body means in said first position and in said second position.

12. In apparatus to be disposed in a well bore having upper and lower producing zones and in which one zone is to be produced through a tubular string disposed in the well bore and the other zone through the annulus around the tubular string: tubular body means adapted to form part of the tubular string; mandrel means adapted for movement downwardly through the tubular string into the body means; said mandrel means and body means providing separate passages adapted to conduct fluids from the upper and lower zones to the interior of the tubular string above said body means and to the annulus around the tubular string above said body means; stop means in said body means engaged by means on said mandrel means for locating said mandrel means in a first position in said body means wherein said passages conduct fluid separately from the lower zone to said interior of the tubular string and from the upper zone to said

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annulus; and stop means on said body means engaged by means on said mandrel means for locating said mandrel means in a second position in said body means wherein said passages conduct fluid separately from the lower zone to said annulus and from the upper zone to said interior of the tubular string.

13. In apparatus to be disposed in a well bore having upper and lower producing zones and in which one zone is to be produced through a tubular string disposed in the well bore and the other zone through the annulus around the tubular string: tubular body means adapted to form part of the tubular string; mandrel means adapted for movement downwardly through the tubular string into the body means; said mandrel means and body means providing separate passages adapted to conduct fluids from the upper and lower zones to the interior of the tubular string above said body means and to the annulus around the tubular string above said body means; said body means having upper and lower stop shoulders therein; a first stop head adapted to be mounted on said mandrel means and engageable with one of said shoulders for locating said mandrel means in a first position in said body means wherein said passages conduct fluid separately from the lower zone to said interior of the tubular string and from the upper zone to said annulus; and a second stop head adapted to be mounted on said mandrel means and engageable with another of said shoulders for locating said mandrel means in a second position in said body means wherein said passages conduct fluid separately from the lower zone to said annulus and from the upper zone to said interior of the tubular string.

14. In apparatus to be disposed in a well bore having upper and lower producing zones and in which one zone is to be produced through a tubular string disposed in the well bore and the other zone through the annulus around the tubular string: tubular body means adapted to form part of the tubular string; mandrel means adapted for movement downwardly through the tubular string into the body means; said mandrel means and body means providing separate passages adapted to conduct fluids from the upper and lower zones to the interior of the tubular string above said body means and to the annulus around the tubular string above said body means; said body means having upper and lower stop shoulders therein; a first stop head adapted to be mounted on said mandrel means and engageable with one of said shoulders for locating said mandrel means in a first position in said body means wherein said passages conduct fluid separately from the lower zone to said interior of the tubular string and from the upper zone to said annulus; a second stop head adapted to be mounted on said mandrel means and engageable with another of said shoulders for locating said mandrel means in a second position in said body means wherein said passages conduct fluid separately from the lower zone to said annulus and from the upper zone to said interior of the tubular string; said body means having upper and lower lock grooves therein; and coupling means on said mandrel means engageable with a selected lock groove to releasably secure said mandrel means in either of said positions, said coupling means being expandible into said upper groove when one of said stop heads engages said upper shoulder, said coupling means being expandible into said lower groove when another of said stop heads engages said lower shoulder.

15. In apparatus to be disposed in a well bore having upper and lower producing zones and in which one zone is to be produced through a tubular string disposed in the well bore and the other zone through the annulus around the tubular string: tubular body means adapted to form part of the tubular string; mandrel means adapted for movement downwardly through the tubular string into the body means; said mandrel means and body means providing separate passages adapted to conduct fluids from the upper and lower zones to the interior of the tubular string above said body means and to the annulus

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around the tubular string above said body means; said body means having upper and lower stop shoulders therein; a first stop head adapted to be mounted on said mandrel means and engageable with one of said shoulders for locating said mandrel means in a first position in said body means wherein said passages conduct fluid separately from the lower zone to said interior of the tubular string and from the upper zone to said annulus; a second stop head adapted to be mounted on said mandrel means and engageable with another of said shoulders for locating said mandrel means in a second position in said body means wherein said passages conduct fluid separately from the lower zone to said annulus and from the upper zone to said interior of the tubular string; and shear

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means releasably securing each head to said mandrel means when mounted thereon.

References Cited by the Examiner

UNITED STATES PATENTS

2,368,428	1/45	Saurenman	166—45
2,649,916	8/53	Brown	166—145
2,717,041	9/55	Brown	166—45
2,766,831	10/56	Otis	166—116
2,840,167	6/58	Brown	166—152
2,936,832	5/60	Brown et al.	166—115
3,008,522	11/61	Fredd et al.	166—115

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