Aug. 28, 1962 T. H. SCHORR 3,051,247

PARALLEL TUBULAR STRING APPARATUS FOR WELL BORES

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FIG. 1.

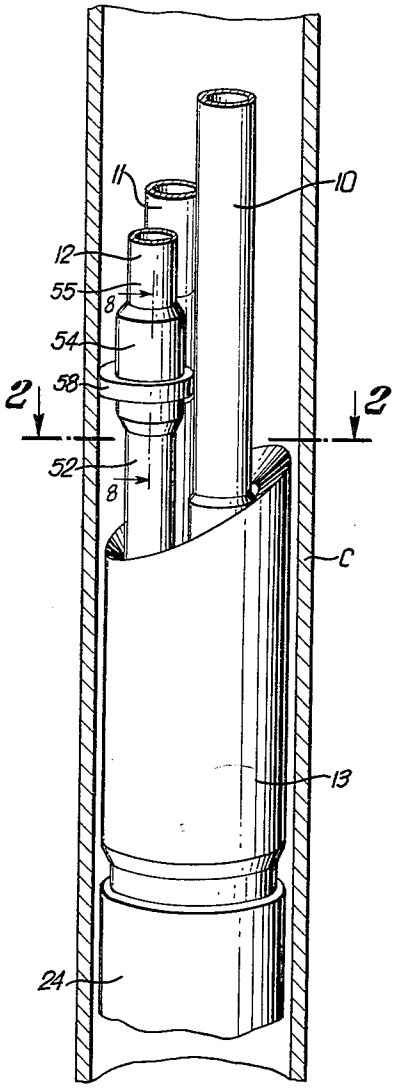


FIG. 2.

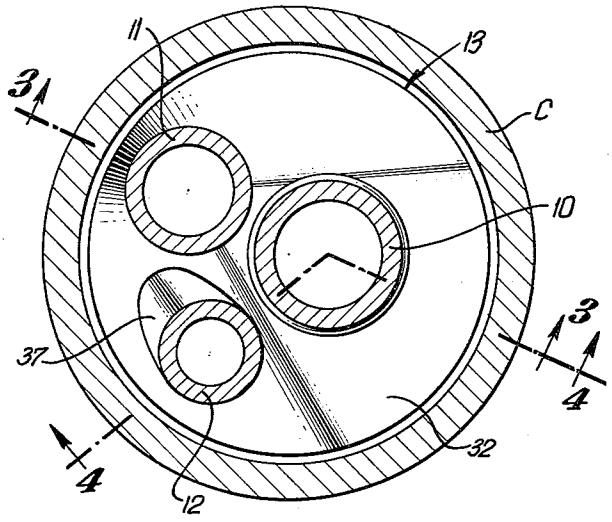
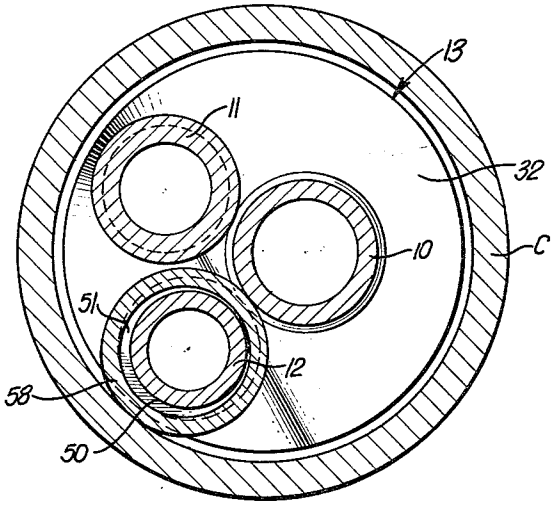


FIG. 5.



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FIG. 3.

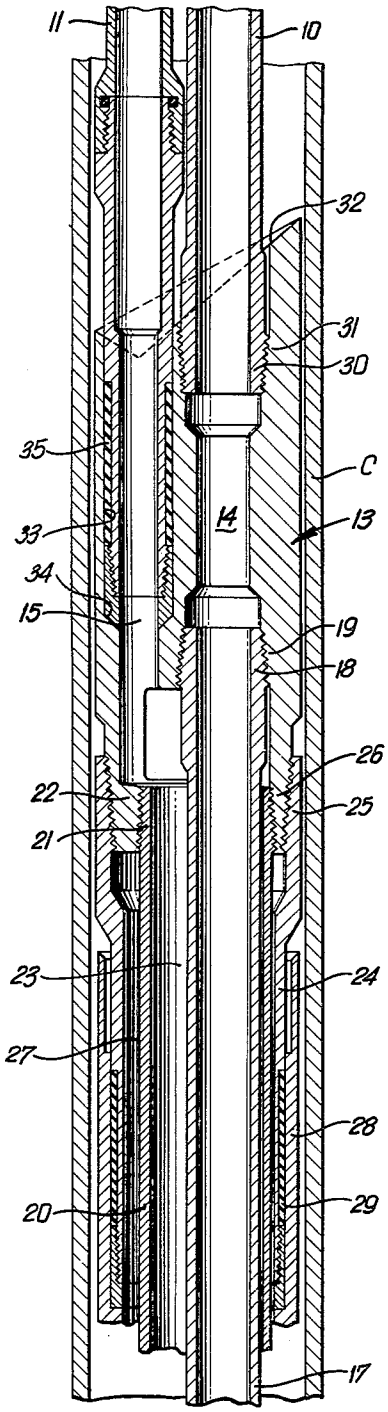
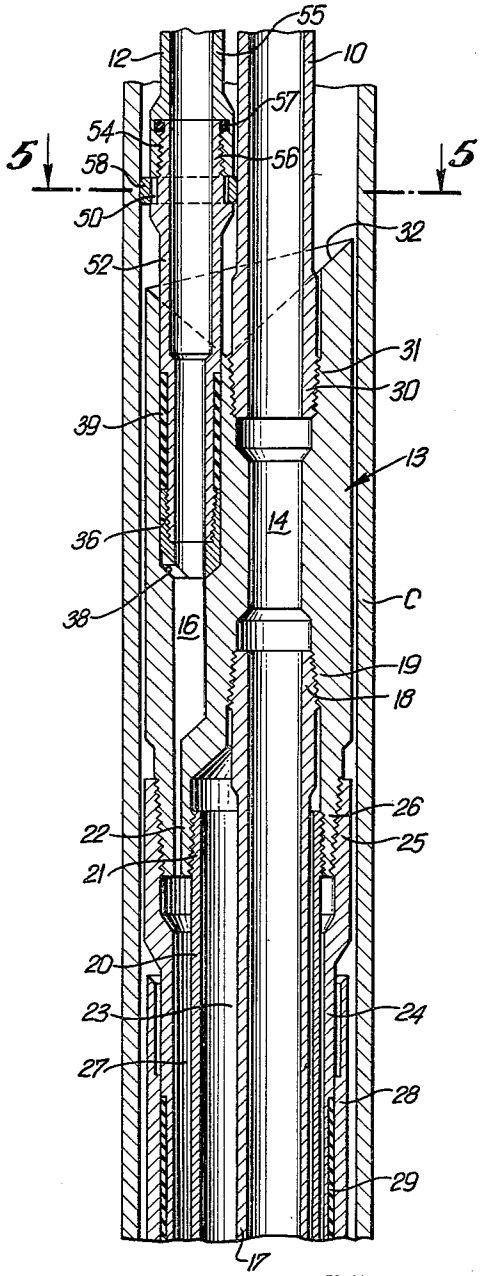


FIG. 4.



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FIG. 6.

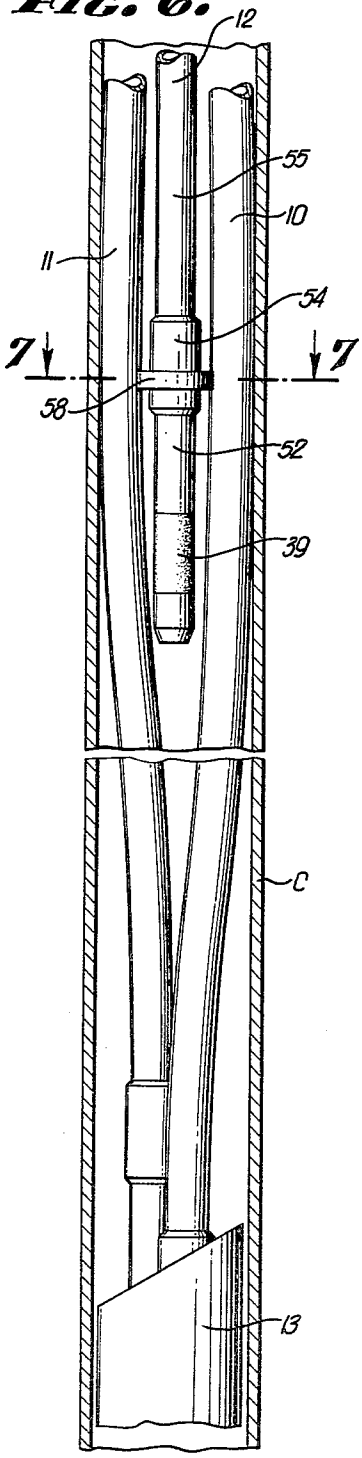


FIG. 7.

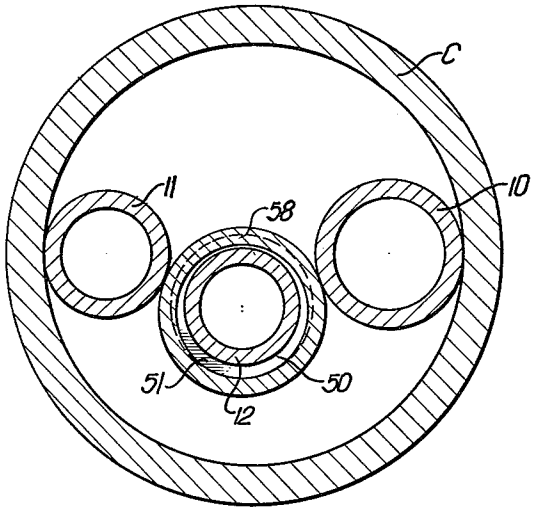
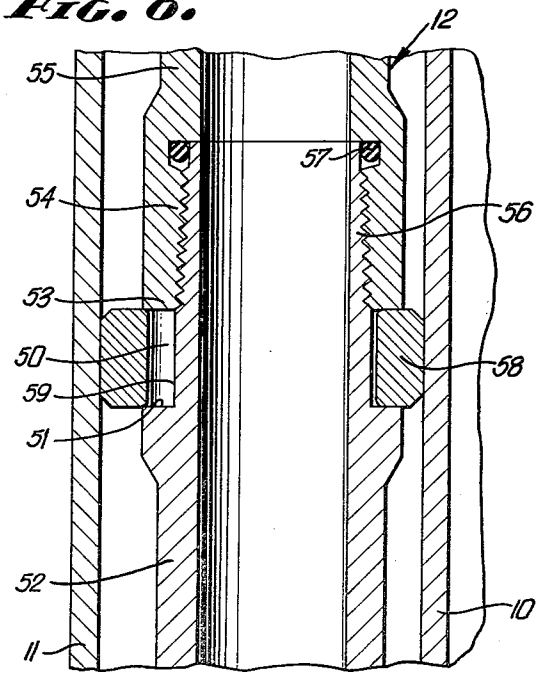


FIG. 8.



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PARALLEL TUBULAR STRING APPARATUS FOR WELL BORES

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9 Claims. (Cl. 166—241)

The present invention relates to subsurface well apparatus, and more particularly to apparatus capable of separately conducting fluids between the top of a well bore and a plurality of locations therewithin.

Parallel strings of tubing are run in a well bore to conduct production from separate zones in the well bore to the top of the ground. Such parallel strings may be associated with a common head having separate passages through which the well production passes, then flowing into the several separate parallel tubing strings. The parallel strings are not all attached to the head at the top of the well bore and then lowered therewithin. Instead, one or more of the strings are lowered into the well bore after the head has been located in position by means of another tubing string. Each tubing string is to fit into a specific passage in the head, but to do so it must remain on the proper side of the previously installed tubing string or a plurality of previously installed tubing strings. Otherwise, it might inadvertently cross over to the wrong side of the previously installed string or strings and be incapable of installation in its associated head passage.

It is an object of the present invention to provide parallel tubular string apparatus for installation in a well bore, in which one tubular string is prevented from inadvertently crossing over to the wrong side of a previously installed tubular string while being lowered in the well bore so that the tubular string can be located within its associated head passage.

Another object of the invention is to provide parallel string apparatus in which a third tubular string is prevented from inadvertently moving between two previously installed parallel strings, or around said parallel strings, to the wrong side thereof, thereby insuring appropriate positioning of the third string, when it reaches the multiple passage head installed in the well bore, for insertion in or relation to its corresponding head passage.

A further object of the invention is to provide parallel tubular string apparatus in which one tubular string has an effective outside diameter as to preclude its movement around a parallel string or between parallel strings previously installed in the well bore, and to the wrong side thereof, but in which the tubular string is still capable of shifting laterally upon reaching a companion head in the well bore for appropriate disposition in its associated passage in the head.

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:

FIGURE 1 is an isometric projection of a portion of an apparatus embodying the invention disposed in a well casing;

FIG. 2 is an enlarged cross-section taken along the line 2—2 on FIG. 1;

FIG. 3 is a longitudinal section on a reduced scale taken along the line 3—3 on FIG. 2;

FIG. 4 is a longitudinal section on a reduced scale taken along the line 4—4 on FIG. 2;

FIG. 5 is an enlarged cross-section taken along the line 5—5 on FIG. 4;

FIG. 6 is a side elevational view of a third tubular string being lowered in a well bore along a pair of previously installed tubular strings, and illustrating a condition that might pertain in the well bore;

FIG. 7 is an enlarged cross-section taken along the line 7—7 on FIG. 6;

FIG. 8 is an enlarged tubular section through a portion of a tubular string in its relationship to other apparatus in the well bore, taken generally along the line 8—8 of FIG. 1.

The apparatus illustrated in the drawings, for the purpose of exemplifying the invention, has for its objective the conducting of fluid from separate producing zones in the well bore to the top thereof through separate parallel tubular strings 10, 11, 12. The tubular strings are operatively associated with a fluid flow separating head 13 that has a plurality of longitudinally extending separate passages 14, 15, 16 therethrough. Thus, a first passage 14 communicates with a first tubular string 10 extending to the top of the well bore, a second passage 15 communicates with a second tubular string 11 extending to the top of the well bore, and a third passage 16 communicates with a third tubular string 12 extending to the top of the well bore.

Production from a lowermost zone (not shown) can pass into an inner tubing string 17 which has an upper threaded pin 18 threadedly attached to a threaded box portion 19 of the head 13 and communicating with the first passage 14. An intermediate tubing string 20 has its upper threaded pin 21 threadedly secured to a threaded box 22 in the head 13 and surrounds the inner tubing string, the space 23 between the inner and intermediate tubing strings providing a passage for the flow of fluid from an intermediate zone (not shown) into the second passage 15 and then into the second tubular string 11. An outer tubing string 24 has an upper threaded box 25 threadedly attached to a threaded pin 26 of the head 13, and this outer string 24 surrounds the intermediate string 20 and is spaced therefrom to provide a passage 27 therebetween communicating with the third passage 16 (FIG. 4). Fluid from an upper zone (not shown) will flow through the space 27 between the intermediate and outer tubing strings 20, 24 into the third passage 16, and then through the third tubular string 12 to the top of the well bore. The outer tubing string 24 extends into the upper portion 28 of a well packer and has a suitable side seal 29 engaging the inner wall of the packer to prevent leakage therebetween.

Actually, the general arrangement so far described is fully shown and set forth in the application of Hartley K. Todee, Serial No. 704,924, filed December 24, 1957, for "Subsurface Multiple Zone Production Apparatus," now Patent No. 2,976,934. In this patent application, lower, intermediate and upper producing zones in a well bore are illustrated, as well as lower, intermediate and upper packers set in a well casing in the well bore, in which the entire apparatus is disposed for the purpose of separating the production from the several producing zones and conducting such production through tubular strings to the top of the well bore. The inner tubing string 17 is appropriately sealed in the lower packer, the intermediate tubing string 20 in the intermediate packer, and, as illustrated, the outer tubing string 24 is sealed in the upper packer.

As described in the above-identified patent applica-

tion, the several packers may first be installed in the well bore, after which the flow separating head **13** with the inner, intermediate and outer tubing strings **17**, **20**, **24** attached to its lower portion lowered through the well casing by means of the first tubular string **10**, the threaded pin **30** of which is threadedly secured to a companion box **31**, and which communicates with the first passage **14**. After the head and the inner, intermediate tubing strings have been appropriately located in the well bore and sealed against their respective packers, the second tubular string **11** can be lowered in the well casing. Its lower end will engage a frusto-conical guide surface **32** at the upper end of the head **13** and be directed by such guide surface into the upper counterbore portion **33** of the second passage **15**, the lowermost portion of the guide surface **32** being at the second passage. The second tubing string **11** moves into the counterbore **33** until its lower terminus engages the bottom **34** of the counterbore. A suitable side seal **35** on the second tubular string seals against the wall of the counterbore **33** to prevent leakage between the second tubing string and the head **13**.

After the second tubing string **11** is in place, a third tubular string **12** is lowered in the well casing alongside the first and second tubular strings **10**, **11** until its lower end engages the frusto-conical guide surface **32**, which will direct it toward the upper counterbore portion **36** of the third passage **16** (FIG. 4). The entrance into this counterbore **36** is at a higher elevation than the entrance into the counterbore **33** of the second passage. The counterbore **36** for the third tubing string has a lesser inside diameter than the second tubing string **11**, so that the latter cannot enter the third passage **16** in moving along the guide surface **32** toward and into the second passage counterbore **33**. A reversely tapering guide surface **37** runs from a location adjacent to the second passage **15** to the third passage **16**, to insure the guiding of the third tubular string **12** into the third counterbore **36**. The third tubular string **12** will engage the bottom **38** of the counterbore **36** and a suitable side seal **39** on the third tubular string will engage the wall of the third counterbore.

With all three tubular strings **10**, **11**, **12** in position, it is evident that fluid flowing upwardly through the inner tubing string **17** will pass through the first passage **14** into the first tubular string **10**. Fluid flowing upwardly through the space **22** between the inner and intermediate tubing strings **17**, **20** will pass into the second passage **15** and then upwardly through the second tubular string **11**; whereas fluid flowing upwardly through the space **27** between the intermediate tubing string **20** and the outer tubing string **24** will flow through the third passage **16** into the third tubular string **12**, to be conducted thereby to the top of the well bore.

For the purpose of insuring the guiding of the third tubular string **12** into the third counterbore **36** and passage **16**, it should remain on the appropriate side of the first and second tubing strings **10**, **11** while being lowered therealong in the well casing C. If the third tubular string were to get on the wrong side of the first and second tubular strings it would engage the frusto-conical guide surface **32** and be directed downwardly toward the second tubular string passage **15**. Not only might the third tubular string get on the wrong side of the first and second tubular strings, but it might possibly corkscrew around one of the tubular strings to the extent that it is prevented from being lowered to the desired extent in the well casing. In fact, it might pass around the first tubular string **10**, for example, and then through the space between the first and second tubular strings **10**, **11** or vice versa.

In the present instance, passage of the third tubular string **12** around one of the other tubular strings **10**, **11** or between such tubular strings is prevented. Although only a relatively small gap appears between the tubular strings **10**, **11** in FIG. 2, they might be relatively widely separated at some other point along the length of the tubular strings and well casing, such as illustrated in FIG. 6, for example, in which the first and second tubing strings **10**, **11** are disclosed as leaning against the well casing C on opposite sides thereof. The outside diameter of the third tubular string **12**, or of any of its coupling collars, is oftentimes less than the inside diameter of the well casing C minus the sum of the outside diameters of the first and second tubular strings **10**, **11**. Accordingly, the third tubular string **12** could pass between the first and second tubular strings, were the latter to rest against the well casing on opposite sides thereof, such as illustrated in FIGS. 6 and 7. On the other hand, the first and second tubular strings **10**, **11** might engage one another with one of the tubular strings engaging the wall of the well casing C, and also leaving a wide gap between one of the tubular strings and the well casing through which the third tubular string **12** could pass to the wrong side of the pair of previously installed tubular strings, or to the wrong side of one of the tubular strings.

The third tubular string **12**, or one of its collars, could be increased in diameter to prevent its undesired crossing to the wrong side of one or both of the other tubular strings, but such increase in diameter would require a corresponding increase in the diameter of the third passage counterbore **36**. It is preferred that the diameter of the third tubular string **12** be a lesser value than the diameter of the second tubular string **11**, particularly since such diameter is dictated by the design limitations of the well apparatus. The third tubular string **12** must engage the head and be permitted to shift laterally thereof with respect to the first and second tubular strings for appropriate shifting and location in the third passage counterbore **36**.

The lateral shifting of the third tubular string **12** is permitted, its inadvertent crossing to the other side of one or both of the other tubular strings **10**, **11** being prevented, by the arrangement illustrated in the drawings. Near the lower end of the third tubular string **12**, it is provided with a peripheral groove **50** defined between an upwardly facing shoulder **51** on the lower section or nipple **52** of the third tubular string and the lower end **53** of the threaded box portion **54** of a tubing section **55** thereabove into which the pin end **56** of the nipple **52** is threaded. Leakage through the threaded joint is prevented by a suitable seal ring **57** between the nipple and the tubing section thereabove. Disposed in the groove **50** is a floating limit ring or annular member **58**, which permits the third tubular string **12** to shift laterally with respect thereto, inasmuch as the inside diameter of the ring **58** is substantially greater than the outside diameter of the base **59** of the groove **50**. However, the inside diameter of the ring is less than the outside diameter of the adjacent portions of the string **12**, so as to preclude dropping of the floating limit ring out of the groove.

The outside diameter of the floating ring **58** is greater than the inside diameter of the well casing C minus the sum of the external diameters of the first and second tubular strings **10**, **11**. As a result, after the first and second tubular strings have been disposed in the well casing, and the third tubular string **12** with the floating ring **58** thereon lowered in the casing at the top of the well bore, and started on the proper side of the first and second tubular strings for reception in the third passage counterbore **36**, the floating limit ring **58** will prevent the third string **12** from moving to the wrong side of the first and second tubular strings **10**, **11**. As illustrated by way of example in FIGS. 6 and 7, if the first and second tubular strings **10**, **11** are resting against the well casing C at some point along its length on diametrically opposite sides, the floating ring **58** will engage both tubing strings **10**, **11** and since its outside diameter is greater than the gap between these tubing strings, the third tubular string

is prevented from passing through such gap. Similarly, if both tubing strings were touching one another an insufficient gap would remain between one of the tubing strings and the well casing through which the ring **58** can pass to the opposite or wrong side of the tubing strings **10**, **11** from the one illustrated. As a result, the third tubing string is maintained on the right side of the first and second tubular strings during its descent along these strings in the well casing, insuring engagement of the lower end of the third tubular string **12** with the guide surface **32** at the upper end of the head **13** on the right side of the first and second tubular strings **10**, **11**, and its appropriate direction into the third passage counterbore **36**. Since the third tubular string **12** can shift laterally relative to the floating ring **58**, the latter will not prevent the appropriate disposition of the third tubing string into the third passage counterbore since the third tubing string can, if necessary, shift laterally of the limit ring into a position coaxial with the third passage counterbore **36**. This is to be distinguished from the provision of a solid collar on the third tubing string **12** having a diameter as large as the limit ring **58**. As shown in FIG. 5, such a solid collar would prevent the lateral shifting of the third tubing string into a coaxial position with the third passage **36**, **16**, and would, therefore, preclude appropriate sealing relation of the third tubular string **12** with the fluid flow separating head **13**.

I claim:

1. In well production apparatus for use in a well bore: a head adapted to be disposed in the well bore and having a plurality of passages therein; a tubular string extending to the top of the well bore and engaging the head in communication with one of said passages, said one passage being eccentric of the longitudinal axis of said head; another tubular string adapted to be lowered in the well bore along said first mentioned tubular string into engagement with said head and in communication with another of said passages; and means on said another tubular string relatively movable laterally thereon and engageable with said first mentioned tubular string to prevent movement of said another tubular string from one side of said first mentioned tubular string to an opposite side thereof.

2. In well production apparatus for use in a well bore: a head adapted to be disposed in the well bore and having a plurality of passages therein; a first tubular string extending to the top of the well bore and engaging the head in communication with a first passage; a second tubular string extending to the top of the well bore and engaging the head in communication with a second passage; a third tubular string adapted to be lowered in the well bore along said first and second tubular strings and on one side thereof and into engagement with said head in communication with a third passage; and means on said third string relatively movable laterally thereon and engageable with said first and second tubular strings to prevent movement of said third string between said first and second tubular strings to the opposite side thereof.

3. In well production apparatus for use in a well bore: a head adapted to be disposed in the well bore and having a plurality of passages therein; a first tubular string extending to the top of the well bore and engaging the head in communication with a first passage; a second tubular string extending to the top of the well bore and engaging the head in communication with a second passage; a third tubular string adapted to be lowered in the well bore along said first and second tubular strings and on one side thereof and into engagement with said head in communication with a third passage; and means on said third string relatively movable laterally thereon and engageable with said first and second tubular strings to prevent movement of said third string between said first and second tubular strings to the opposite side thereof; the effective outside diameter of said means being greater than the inside diameter of the well bore surrounding said strings minus the sum of the outside diameters of said first and second tubular strings.

4. In well production apparatus for use in a well bore: a head adapted to be disposed in the well bore and having a plurality of passages therein; a tubular string extending to the top of the well bore and engaging the head in communication with one of said passages, said one passage being eccentric of the longitudinal axis of said head; another tubular string adapted to be lowered in the well bore along said first mentioned tubular string into engagement with said head and in communication with another of said passages; and an annular member on said another tubular string relatively movable laterally thereon and engageable with said first mentioned tubular string to prevent movement of said another tubular string from one side of said first mentioned tubular string to an opposite side thereof.

5. In well production apparatus for use in a well bore: a head adapted to be disposed in the well bore and having a plurality of passages therein; a first tubular string extending to the top of the well bore and engaging the head in communication with a first passage; a second tubular string extending to the top of the well bore and engaging the head in communication with a second passage; a third tubular string adapted to be lowered in the well bore along said first and second tubular strings and on one side thereof and into engagement with said head in communication with a third passage; and an annular member on said third tubular string relatively movable laterally thereon and engageable with said first and second tubular string to prevent movement of said third strip between said first and second tubular strings to the opposite side thereof.

6. In well production apparatus for use in a well bore: a head adapted to be disposed in the well bore and having a plurality of passages therein; a first tubular string extending to the top of the well bore and engaging the head in communication with a first passage; a second tubular strip extending to the top of the well bore and engaging the head in communication with a second passage; a third tubular string adapted to be lowered in the well bore along said first and second tubular strings and on one side thereof and into engagement with said head in communication with a third passage; and an annular member on said third tubular string relatively movable laterally thereon and engageable with said first and second tubular string to prevent movement of said third string between said first and second tubular strings to the opposite side thereof; the outside diameter of said annular member being greater than the inside diameter of the well bore surrounding said strings minus the sum of the outside diameters of said first and second tubular strings.

7. In well production apparatus for use in a well bore: a head adapted to be disposed in the well bore and having a plurality of passages therein; a tubular string extending to the top of the well bore and engaging the head in communication with one of said passages, said one passage being eccentric of the longitudinal axis of said head; another tubular string adapted to be lowered in the well bore along said first mentioned tubular string into engagement with said head and in communication with another of said passages; said another tubular string having an external groove in its lower portion; and an annular member in said groove movable laterally of said another tubular member and engageable with said first mentioned tubular string to prevent movement of said another tubular string from one side of said first mentioned tubular string to an opposite side thereof; the outside diameter of said annular member being substantially greater than the outside diameter of said another tubular string adjacent to said groove and the inside diameter of said annular member being substantially greater than the diameter of the base of said groove.

8. In well production apparatus for use in a well bore: a head adapted to be disposed in the well bore and hav-

ing a plurality of passages therein; a first tubular string extending to the top of the well bore and engaging the head in communication with a first passage; a second tubular string extending to the top of the well bore and engaging the head in communication with a second passage; a third tubular string adapted to be lowered in the well bore along said first and second tubular strings and on one side thereof and into engagement with said head in communication with a third passage; said third tubular string having an external groove in its lower portion; and an annular member in said groove movable laterally of said third tubular string and engageable with said first and second tubular strings to prevent movement of said third tubular string between said first and second tubular strings to the opposite side thereof; the outside diameter of said annular member being substantially greater than the outside diameter of said third tubular string adjacent to said groove and the inside diameter of said annular member being substantially greater than the diameter of the base of said groove.

9. In well production apparatus for use in a well bore: a head adapted to be disposed in the well bore and having a plurality of passages therein; a first tubular string extending to the top of the well bore and engaging the head in communication with a first passage; a second tubular string extending to the top of the well bore and engaging the head in communication with a second passage; a third tubular string adapted to be lowered in the well bore along said first and second tubular strings and on one side thereof and into engagement with said head in communication with a third passage; said third tubular string having an external groove in its lower portion; and an annular member in said groove movable laterally of said third tubular string and engageable with said first and second tubular strings to prevent movement of said third tubular string between said first and second tubular strings to the opposite side thereof; the outside diameter of said annular member being substantially greater than the outside diameter of said third tubular string adjacent to said groove and the inside diameter of said annular member being substantially greater than the diameter of the base of said groove; the outside diameter of said annular member being greater than the inside diamter of the well bore surrounding said strings minus the sum of the outside diameters of said first and second tubular strings.

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