May 9, 1961 J. R. BAKER ET AL 2,983,318

SUBSURFACE MULTIPLE ZONE WELL PRODUCTION APPARATUS

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FIG. 1.

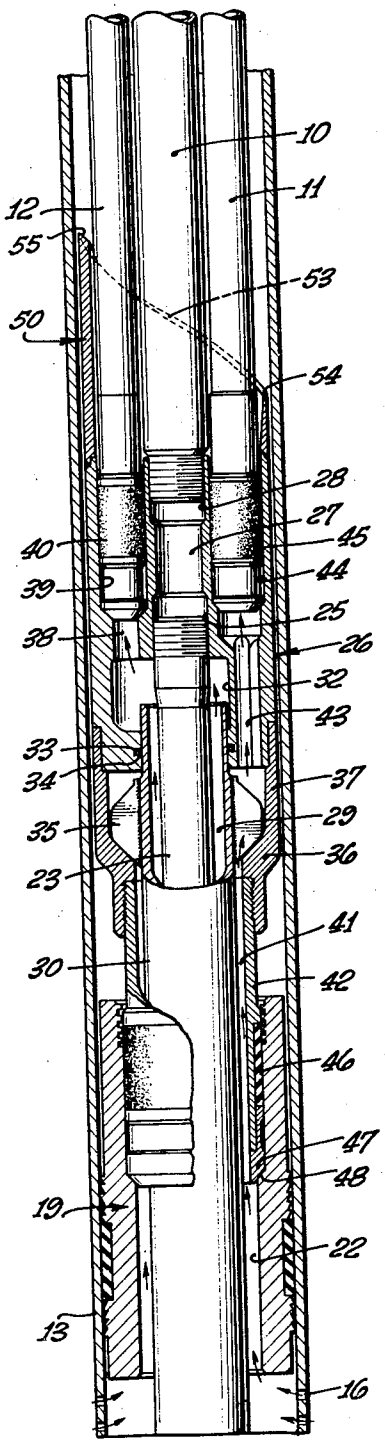


FIG. 1a.

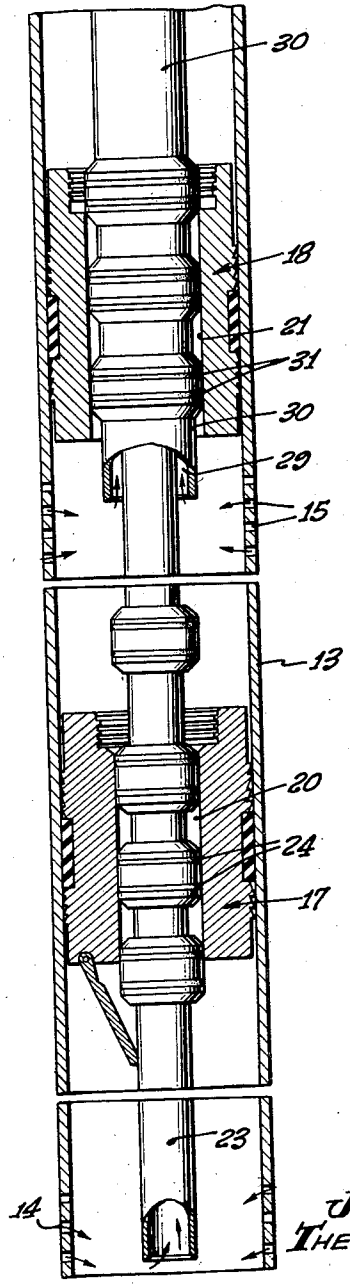


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FIG. 2.

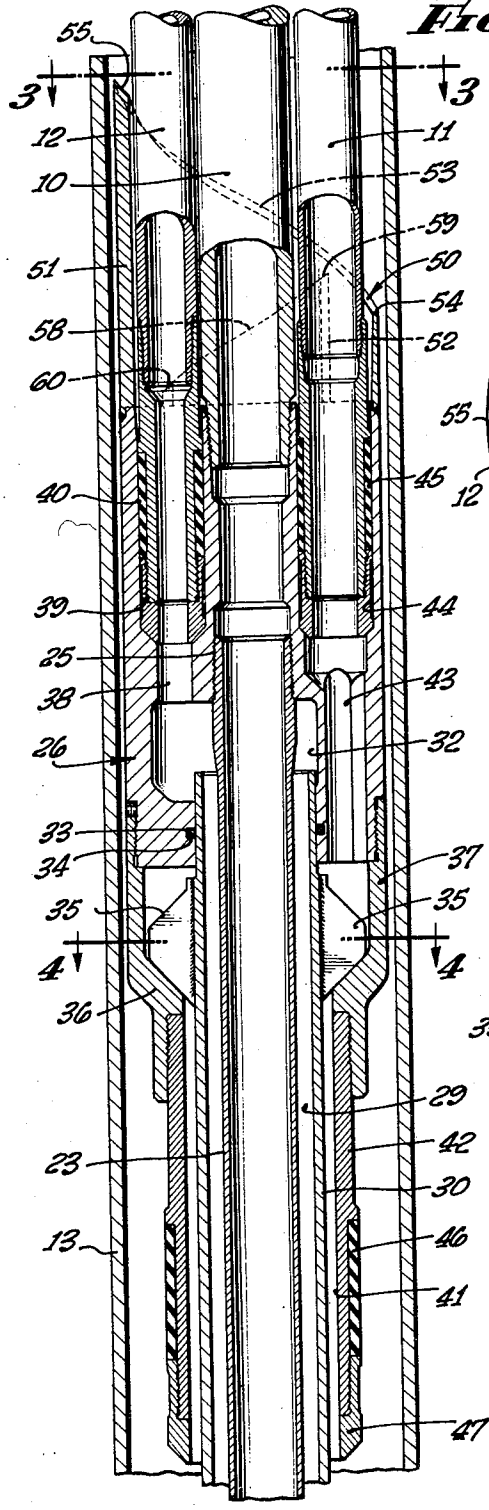



FIG. 3.

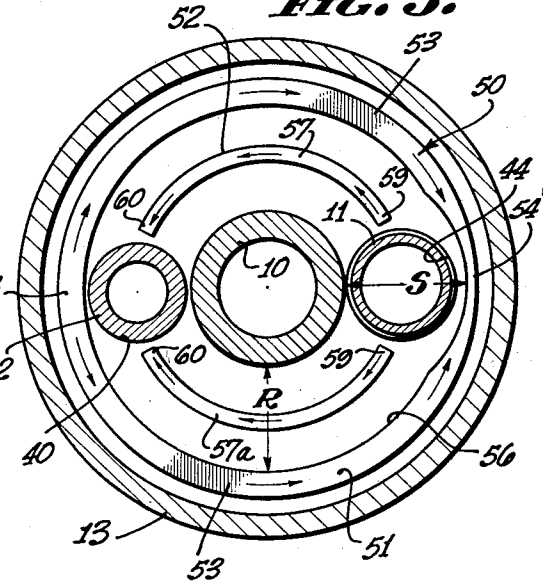
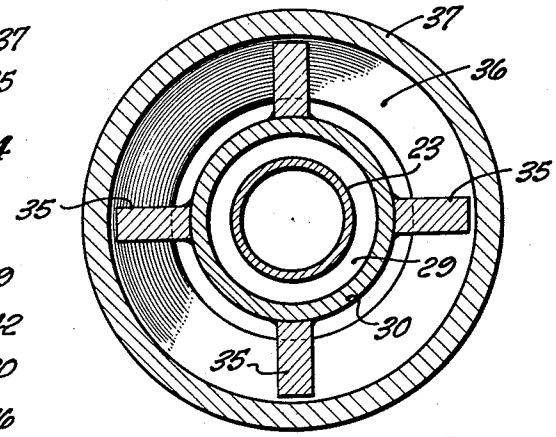



FIG. 4.

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2,983,318

# SUBSURFACE MULTIPLE ZONE WELL PRODUCTION APPARATUS

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12 Claims. (Cl. 166—243)

The present invention relates to subsurface multiple zone well production apparatus, and more particularly to the conducting of fluids from the formation zones through separate tubular strings extending to the top of the well bore.

An object of the present invention is to provide improved apparatus for conducting fluids through at least three separate parallel tubular strings between the top of a well bore and longitudinally spaced formation zones in the well bore.

Another object of the invention is to provide apparatus for conducting fluids from different formation zones in a well bore through at least three separate tubular strings to the top of the well bore, each tubular string being individually related to a single formation zone, the apparatus being lowered in the well bore on one of the tubular strings, followed by the other tubular strings which coact with individual guides or tracks to assume their proper assembled relation to other apparatus in the well bore.

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 1 and 1*a* together constitute a longitudinal section through an apparatus disposed in a well casing, parts of the apparatus being disclosed in side elevation, Fig. 1*a* being a lower continuation of Fig. 1;

Fig. 2 is an enlarged longitudinal section through a portion of the apparatus disclosed in Fig. 1;

Fig. 3 is an enlarged cross-section taken along the line 3—3 on Fig. 2;

Fig. 4 is an enlarged cross-section taken along the line 4—4 of Fig. 2.

In the form of invention disclosed in the drawings, it is desired to conduct fluid from three different and longitudinally spaced producing zones in a well bore through individual strings of tubing **10, 11, 12** to the top of the hole. A well casing **13** is disposed in the well bore and has longitudinally spaced sets of lower, intermediate and upper perforations **14, 15, 16** opposite the longitudinally spaced formation zones, the fluid being adapted to pass into the casing through the respective sets of perforations. Cementitious material (not shown) is usually deposited around the casing **13** between the lower and intermediate sets of perforations **14, 15,** and also between the intermediate and upper sets of perforations **15, 16,** so as to prevent migration of fluids from one formation zone to another formation zone along the exterior of the casing.

As disclosed, a lower packer **17** is anchored in packed-off condition within the well casing between the lower and



intermediate sets of perforations **14, 15,** an intermediate packer **18** is anchored in packed-off condition in the well casing between the intermediate and upper sets of perforations **15, 16,** while an upper packer **19** is anchored in packed-off condition in the well casing above the upper set of perforations **16.** These packers are shown diagrammatically in the drawings, and may be of the specific type shown in United States Patent Nos. 2,189,701 and 2,630,865. The lower packer **17** has a passage **20** therethrough which is smaller in diameter than the passage **21** through the intermediate packer **18,** this last-mentioned passage, in turn, being smaller in diameter than the passage **22** through the upper packer **19.**

As disclosed in the drawings, production from the lower zone is to be conducted through an inner tubing string **23** extending through all of the packers, this inner tubing string having side seals **24** thereon adapted to seal against the lower packer **17.** The upper end of the inner tubing string **23** is threaded within a companion bore **25** in a fluid conducting head **26,** this head having a first passage **27,** communicating with the inner tubing string **23,** which terminates in an upper threaded box **28** adapted to receive the lower threaded end of the first tubular string **10** extending to the top of the well casing **13.**

Production from the intermediate zone passes through the intermediate set of perforations **15** into the casing **13,** then continuing upwardly through an annular space **29** between the inner tubing string **23** and an intermediate tubing string **30** having suitable seals **31** thereon for sealing engagement against the intermediate packer **18.** The upper end of the intermediate string is piloted within a bore **32** in the lower portion of the head **26,** leakage of fluid between the exterior of the intermediate string and the head being prevented by a suitable side seal **33,** such as a rubber or rubber-like O-ring, disposed in an internal groove **34** in the head and sealingly engaging the periphery of the intermediate tubing string. This tubing string **30** is supported from the head **26** by the engagement of a plurality of wings **35,** secured to the upper portion of the intermediate string **30,** with a downwardly tapering shoulder **36** on a depending head extension **37,** which is threadedly secured to the main portion of the head **26.** The intermediate zone fluid passes through the annular space **29** between the intermediate tubing string and inner tubing string into the bore **32** and then into a third passage **38** in the head **26** having a counterbore **39** opening through the upper end of the head and adapted to receive the lower portion of the third tubular string **12** extending to the top of the well bore. This third tubular string may have suitable seals or packing **40** thereon adapted to engage the wall of the counterbore **39.**

Fluid from the upper zone will pass through the upper set of perforations **16** into the well casing **13** and then upwardly through the annulus **41** between the intermediate tubing string **30** and the well packer **19,** this annulus also being defined between an upper tubing string **42** encompassing but spaced laterally from the intermediate tubing string **30.** This upper tubing string **42** is threadedly secured to the head extension **37,** the fluid flowing upwardly from the annulus **41** into the head extension **37** and then continuing on upwardly through a second passage **43** in the head **26** terminating in an upper counterbore **44** adapted to receive the lower portion of a second tubular string **11** extending to the top of the well casing **13.** This second tubular string is also provided with a suitable seal **45** on its lower portion adapted to sealingly engage the wall of the second passage counterbore **44.**

Leakage of fluid between the upper packer **19** and the upper tubing string **42** is prevented by a suitable side seal **46** on the upper string engaging the upper packer **19.** The lower end **47** of the upper string **42** is adapted

to engage a shoulder 48 on the upper packer, to properly locate all of the tubing strings 23, 30, 42 with respect to the several packers 17, 18, 19 in the well bore. Thus, when the upper tubing string 42 engages the packer shoulder 48, its seal device 46 is in sealing engagement against the upper packer 19. At this time, the seals 31 on the intermediate tubing string 30 are in sealing engagement with the intermediate packer 18, while the seals 24 of the inner tubing string 23 are in sealing engagement with the lower packer 17.

In the use of the apparatus illustrated in the drawings, the lower, intermediate and upper packers 17, 18, 19 are first anchored in packed-off condition in the well casing at the respective regions between the lower, intermediate and upper sets of casing perforations 14, 15, 16. The inner tubing string 23, intermediate tubing string 30, and upper tubing string 42 are then connected to the flow directing head 26, and the first tubular string 10 threadedly secured to the upper portion of the head. The apparatus is then lowered in the well casing by means of the first tubular string. At this time, the second and third tubular strings 11, 12 have not been disposed in the well casing. Accordingly, the apparatus is lowered in the well casing on the first tubular string 10 until the upper tubing string 42 enters the upper packer 19 and engages the shoulder 48 therein. The several tubing strings 23, 30, 42 and the sealing members 24, 31, 46 mounted thereon are so related to one another that the engagement of the upper tubing string 42 with the upper packer shoulder 48 will locate the seals 31 on the intermediate string 30 in sealing engagement with the intermediate packer 18, and the seals 24 of the inner tubing string 23 in sealing engagement with the lower packer 17.

After the parts have been so related in the well casing 13, the second tubing string 11 is lowered in the well casing and is properly disposed in the second passage 43, after which the third tubing string 12 is lowered in the well casing 13 and is properly disposed in the third passage 38. Guide means 50 shown in the drawings is availed of to insure the proper assembly of the second tubing string 11 in the second passage 43 and of the third tubing string 12 in the third passage 38.

The guide means 50 consists of an outer track device 51 which will guide the second tubing string 11 into the second passage 43 and an inner track device 52 which will guide the third tubing string 12 into the third passage 38. The outer track 51, of tubular form, is secured, as by welding, to the upper portion of the head 26 and extends therearound adjacent the periphery of the head. The upper portion 53 of the track is inclined from a lower point 54 adjacent the axis of the second passage 43, and on one side of first passage 27, upwardly toward a higher point 55, which may be on the other side of the first passage 27 and tubing string 10. The lower end of the second tubing string 11 is adapted to engage this track 51 and to be guided thereby around the casing 13 until it reaches a point 54 of adjacency to the second passage 43. Since the upper edge 53 of the inclined track is beveled in a downward and inward direction, the second tubing string 11, when engaged with the inclined outer track 51, will tend to be shifted inwardly off this track. However, the distance R between the first tubing string 10 and the inner wall 56 of the track is less than the diameter of the second tubing string 11, or of a collar that may be mounted on the second tubing string. As a result, the second tubing string 11 cannot move inwardly off the outer track 51 until it reaches the region of the lowest point 54 on the track adjacent to the second passage 43, where the distance S between the first tubular string 10 and the inner surface of the outer track is greater than the diameter of the second string 11, the second string then dropping off the track 51 and into the second passage counterbore 44.



An inner track device 57, 57*a* is provided within the outer track device 51, the lower portion of the inner track device being suitably secured, as by welding, to the upper portion of the flow directing head 26. As illustrated, the inner track 57, 57*a* consists of two arcuate sections extending from a region adjacent to the second passage 43 to a region adjacent to the third passage 38. The upper ends 58 of each track section are inclined from a high point 59 adjacent the second passage 43, to a low point 60 adjacent the third passage 38, and these inclined upper ends 58 of the track section are also beveled in an inward direction, so as to tend to feed the third tubing string 12 inwardly against the first tubular string 10.

In view of the fact that the second tubing string 11 has a greater diameter than the distance R between the first tubing string 10 and the inner wall 56 of the outer track, except at a region adjacent the second passage 43, the second tubing string 11 cannot move inwardly between the first tubing string and the inner wall of the outer track, so as to engage the inner track 57, 57*a*, nor can the second tubing string 11 move inwardly off the outer track 51 in the region of the third passage 38, so as to possibly and inadvertently drop into such third passage. The upper inclined end 53 of the outer track is disposed at a substantially higher elevation than the inner track section 57, 57*a*, so that the inner track will not interfere with the sliding or guiding of the second tubular string 11 around the outer track 51 to its position of adjacency to the second passage 43, where the second tubing string will drop off the beveled end of the outer track 51 and into the second passage.

After the second tubing string 11 has been disposed in the second passage counterbore 44, with its sealing device 45 in engagement with the wall of the counterbore, the third tubing string 12 is lowered in the well casing 13. This third tubing string has a diameter which is less than the distance R between the first tubing string 10 and the inner wall 56 of the outer track 51. Accordingly, such tubing string may engage the beveled portion 53 of the outer track, which will direct it inwardly of the outer track for downward movement between the first tubular string 10 and the outer track 51 and into engagement with one of the inner track sections 57 or 57*a*. Since the upper end 58 of each section is inclined downwardly in a direction toward the third passage 38, the third tubular string will be guided arcuately around the inner track 57 or 57*a* and will drop into the third passage 38, with its seal 40 making appropriate sealing engagement with the wall of the third passage counterbore 40.

All of the tubing strings 10, 11, 12 have now been appropriately related to the flow directing head 26, occupying the positions disclosed in the drawings. The fluid from the lower zone will pass through the lower perforations 14 into the casing 13, then proceeding upwardly through the inner tubing string 23 into the first head passage 27, from where it will continue to flow upwardly through the first tubular string 10 to the top of the well bore. Fluid from the upper zone will pass through the upper perforations 16 into the casing 13, then upwardly through the annulus 41 between the intermediate tubing string 30, on the one hand, and the upper packer 19 and upper tubing string 42, on the other hand, flowing upwardly into the head 26 and then through the second passage 43 in the head, which is in communication with the second tubular string 11 disposed in the counterbore 44 and extending to the top of the well bore. The well production from the intermediate zone will pass through the intermediate set of perforations 15 into the casing 13, and then upwardly through the annulus 29 between the inner and intermediate tubing strings 23, 30, discharging into the head 26 and flowing through the third head passage 38 and

upwardly through the third tubular string 12 to the top of the well bore, this latter tubular string being appropriately located in the counterbore 39.

From the foregoing, it is evident that the second and third tubular strings 11, 23 are properly and positively guided into their respective second and third passages 43, 38 in the flow control head 26. The second tubular string 11 cannot inadvertently move into the third passage 38, whereas the third tubing string 12 will engage the inner track 57, 57*a* and be guided by either section positively toward and into the third passage 38.

The inventors claim:

1. In subsurface well production apparatus adapted for use with first, second and third tubular strings extending to the top of a well bore: a head adapted to be disposed in the well bore and having first, second and third passages therein; said head having means in said first passage for receiving the first tubular string which extends to the top of the well bore; first guide means on said head adapted to be engaged by the second tubular string which extends to the top of the well bore to direct the second tubular string into said second passage; and second guide means on said head separate from said first guide means and extending from said third passage to a position closely adjacent to one of said other passages, said second guide means being adapted to be engaged by the third tubular string which extends to the top of the well bore to direct the third tubular string from the position closely adjacent to said one of said other passages into said third passage.

2. In subsurface well production apparatus adapted for use with first, second and third tubular strings extending to the top of a well bore: a head adapted to be disposed in the well bore and having first, second and third passages therein; said head having means in said first passage for receiving the first tubular string which extends to the top of the well bore; a first track on said head curved arcuately about the axis of said head and inclined from a high point remote from said second passage to a low point adjacent said second passage, said first track being engageable by the second tubular string which extends to the top of the well bore to direct the second tubular string into said second passage; and a second track on said head inwardly of said first track and curved arcuately about the axis of said head, said second track having an upper surface inclined from a high point remote from said third passage to a low point adjacent said third passage, said second track being engageable by the third tubular string which extends to the top of the well bore to direct the third tubular string into said third passage, the upper surface of said second track extending upwardly to a lesser height than the upper surface of said first track in any radial direction intersecting said second track, the radial distance between the first tubular string and the inner wall of said first track being greater than the diameter of the third tubular string to enable the third tubular string to be lowered between the first tubular string and first track into engagement with the second track, such radial distance being less than the effective diameter of the second tubular string, except in the region of said second passage, to prevent the second tubular string from lowering between the first tubular string and first track except at the region of said second passage.

3. In subsurface well production apparatus adapted for use with first, second and third tubular strings extending to the top of a well bore: a head adapted to be disposed in the well bore and having first, second and third passages therein; said head having means in said first passage for receiving the first tubing string which extends to the top of the well bore; first guide means on said head adapted to be engaged by the second tubular string which extends to the top of the well bore to direct the second tubular string into said second passage; and second guide means on said head separate from said first guide means and adapted to be engaged by the third tubular string which extends to the top of the well bore to direct the third tubular string into said third passage; wherein said first guide means comprises a first track on said head inclined downwardly toward said second passage and engageable by the second tubular string which extends to the top of the well bore to direct the second tubular string into said second passage; and said second guide means comprises a second track on said head separate from said first track and inclined downwardly from said second passage toward said third passage and engageable at a location of close adjacency to said second passage, by the third tubular string which extends to the top of the well bore to direct the third tubular string into said third passage.

4. In subsurface well production apparatus adapted for use with first, second and third tubular strings extending to the top of a well bore: a head adapted to be disposed in the well bore and having first, second and third passages therein; said head having means in said first passage for receiving the first tubing string which extends to the top of the well bore; first guide means on said head adapted to be engaged by the second tubular string which extends to the top of the well bore to direct the second tubular string into said second passage; and second guide means on said head separate from said first guide means and adapted to be engaged by the third tubular string which extends to the top of the well bore to direct the third tubular string into said third passage; wherein said first guide means comprises a first track on said head curved arcuately about the axis of said head and inclined downwardly from a point remote from said second passage to a low point adjacent said second passage, said first track being engageable by the second tubular string which extends to the top of the well bore to direct the second tubular string into said second passage, and said second guide means comprises a second track on said head curved arcuately about the axis of said head and inclined downwardly from a high point remote from said third passage to a low point adjacent said third passage, said second track being engageable by the third tubular string which extends to the top of the well bore to direct the third tubular string into said third passage.

5. In subsurface well production apparatus adapted for use with first, second and third tubular strings extending to the top of a well bore: a head adapted to be disposed in the well bore and having first, second and third passages therein; said head having means in said first passage for receiving the first tubing string which extends to the top of the well bore; first guide means on said head adapted to be engaged by the second tubular string which extends to the top of the well bore to direct the second tubular string into said second passage; and second guide means on said head separate from said first guide means and adapted to be engaged by the third tubular string which extends to the top of the well bore to direct the third tubular string into said third passage; wherein said first guide means comprises a first track on said head curved arcuately about the axis of said head and inclined downwardly from a high point to a low point adjacent said second passage, said first track being engageable by the second tubular string which extends to the top of the well bore to direct the second tubular string into said second passage, and said second guide means comprises a second track on said head curved arcuately about the axis of said head and inclined downwardly from a high point to a low point adjacent said third passage, said second track being engageable by the third tubular string which extends to the top of the well bore to direct the third tubular string into said third passage.

6. In subsurface well production apparatus adapted for use with first, second and third tubular strings extending to the top of a well bore: a head adapted to be

disposed in the well bore and having first, second and third passages therein; said head having means in said first passage for receiving the first tubing string which extends to the top of the well bore; first guide means on said head adapted to be engaged by the second tubular string which extends to the top of the well bore to direct the second tubular string into said second passage; and second guide means on said head separate from said first guide means and adapted to be engaged by the third tubular string which extends to the top of the well bore to direct the third tubular string into said third passage; wherein said first guide means comprises a first track on said head curved arcuately about the axis of said head and inclined downwardly from a high point remote from said second passage to a low point adjacent said second passage, said first track being engageable by the second tubular string which extends to the top of the well bore to direct the second tubular string into said second passage, and said second guide means comprises a second track on said head curved arcuately about the axis of said head and inclined downwardly from a high point adjacent said second passage to a low point adjacent said third passage, said second track being engageable by the third tubular string which extends to the top of the well bore to direct the third tubular string into said third passage.

7. In subsurface well production apparatus adapted for use with first, second and third tubular strings extending to the top of a well bore: a head adapted to be disposed in the well bore and having first, second and third passages therein; said head having means in said first passage for receiving the first tubing string which extends to the top of the well bore; first guide means on said head adapted to be engaged by the second tubular string which extends to the top of the well bore to direct the second tubular string into said second passage; and second guide means on said head separate from said first guide means and adapted to be engaged by the third tubular string which extends to the top of the well bore to direct the third tubular string into said third passage; wherein said first guide means comprises a first track on said head curved arcuately about the axis of said head and inclined downwardly from a high point remote from said second passage to a low point adjacent said second passage, said first track being engageable by the second tubular string which extends to the top of the well bore to direct the second tubular string into said second passage, and said second guide means comprises a second track on said head including a pair of sections curved arcuately in opposite directions about the axis of said head, each section being inclined downwardly from a high point adjacent said second passage to a low point adjacent said third passage, said second track being engageable by the third tubular string which extends to the top of the well bore to direct the third tubular string into said third passage.

8. In subsurface well production apparatus adapted for use with first, second and third tubular strings extending to the top of a well bore: a head adapted to be disposed in the well bore and having first, second and third passages therein; said head having means in said first passage for receiving the first tubular string which extends to the top of the well bore; and guide means on said head adapted to be engaged by the second and third tubular strings to direct the second and third tubular strings into said second and third passages, respectively, said guide means including a surface tapering downwardly from a position closely adjacent to said third passage to said second passage to direct the second tubular string from a position closely adjacent to said third passage to said second passage and another surface offset from and tapering downwardly from a position closely adjacent to said second passage to said third passage to direct the third tubular string from a position closely adjacent to said second passage to said third passage.



9. In subsurface well production apparatus adapted for use with first, second and third tubular strings extending to the top of a well bore: a head adapted to be disposed within the well bore and having first, second and third passages therein; said head having first means in said first passage for receiving the first tubular string which extends to the top of the well bore; said head having second means in said second passage for receiving the second tubular string which extends to the top of the well bore; said head having third means in said third passage for receiving the third tubular string which extends to the top of the well bore; and a track curved arcuately with respect to the axis of the head and secured to and extending upwardly from said head, said track having an upper end inclined in a downward direction toward said third passage and adapted to be engaged by the third string to conduct the third string into said third means.

10. In subsurface well production apparatus adapted for use with first, second and third tubular strings extending to the top of a well bore: a head adapted to be disposed within the well bore and having first, second and third passages therein; said head having first means in said first passage for receiving the first tubular string which extends to the top of the well bore; said head having second means in said second passage for receiving the second tubular string which extends to the top of the well bore; said head having third means in said third passage for receiving the third tubular string which extends to the top of the well bore; and a track curved arcuately with respect to the axis of the head and secured to said head and extending arcuately from said second passage to said third passage, said track having an upper end inclined in a downward direction from a location adjacent said second passage to a location adjacent said third passage and adapted to be engaged by said third string to direct the third string into said third means.

11. In subsurface well production apparatus adapted for use with first, second and third tubular strings extending to the top of a well bore: a head adapted to be disposed in the well bore and having first, second and third passages therein; said head having first means in said first passage for receiving the first tubular string which extends to the top of the well bore; said head having second means in said second passage for receiving the second tubular string which extends to the top of the well bore; said head having third means in said third passage for receiving the third tubular string which extends to the top of the well bore; and a track curved arcuately with respect to the axis of the head and secured to said head and extending arcuately from said second passage, past said first passage to said third passage, said track having an upper end inclined in a downward direction from a location adjacent said second passage to a location adjacent said third passage and adapted to be engaged by the third string to direct the third string into said third means.

12. In subsurface well production apparatus adapted for use with first, second and third tubular strings extending to the top of a well bore: a head adapted to be disposed in the well bore and having first, second and third passages therein; said head having first means in said first passage for receiving the first tubular string which extends to the top of the well bore; said head having second means in said second passage for receiving the second tubular string which extends to the top of the well bore; said head having third means in said third passage for receiving the third tubular string which extends to the top of the well bore; a first track section curved arcuately with respect to the axis of the head and secured to said head and extending arcuately in one direction from said second passage, past said first passage to said third passage, said first track section having

an upper end inclined in a downward direction from a location adjacent said second passage to a location adjacent said third passage; a second track section curved arcuately with respect to the axis of the head and secured to said head and extending arcuately in the opposite direction from said second passage to said third passage, said second track section having an upper end inclined in a downward direction from a location adjacent said second passage to a location adjacent said third passage, said upper ends of said track sections being adapted to be engaged by the third string to direct the third string into said third means.




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## Disclaimer

2,983,318.—*John R. Baker*, Pasadena, and *Theodore H. Schorr*, Los Angeles, Calif. SUBSURFACE MULTIPLE ZONE WELL PRODUCTION APPARATUS. Patent dated May 9, 1961. Disclaimer filed Jan. 29, 1964, by the assignee, *Baker Oil Tools, Inc.*

Hereby enters this disclaimer to claims 1 and 8 of said patent.

[*Official Gazette April 21, 1964.*]