March 28, 1961 H. K. TODEE 2,976,934

SUBSURFACE MULTIPLE ZONE PRODUCTION APPARATUS

Filed Dec. 24, 1957 3 Sheets-Sheet 1

FIG. 1.

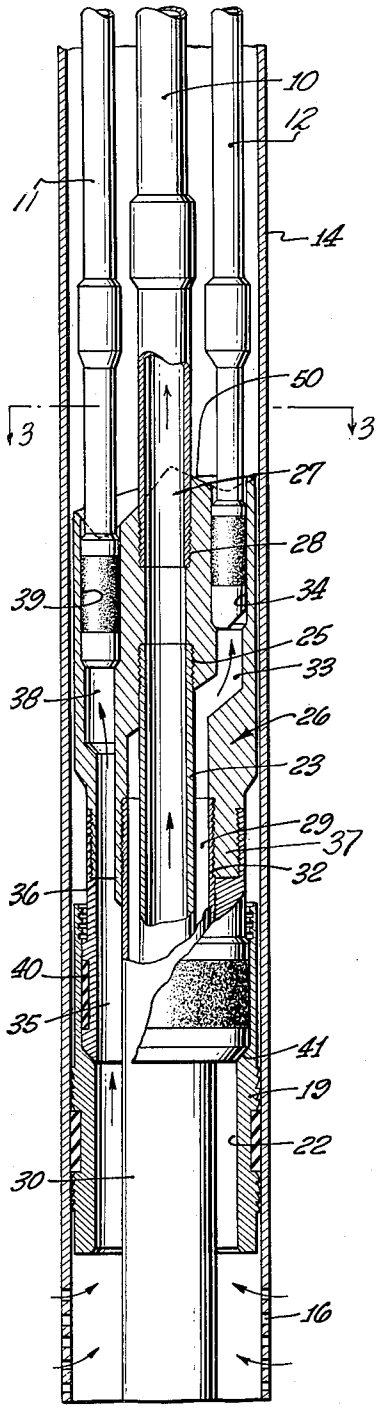


FIG. 1a.

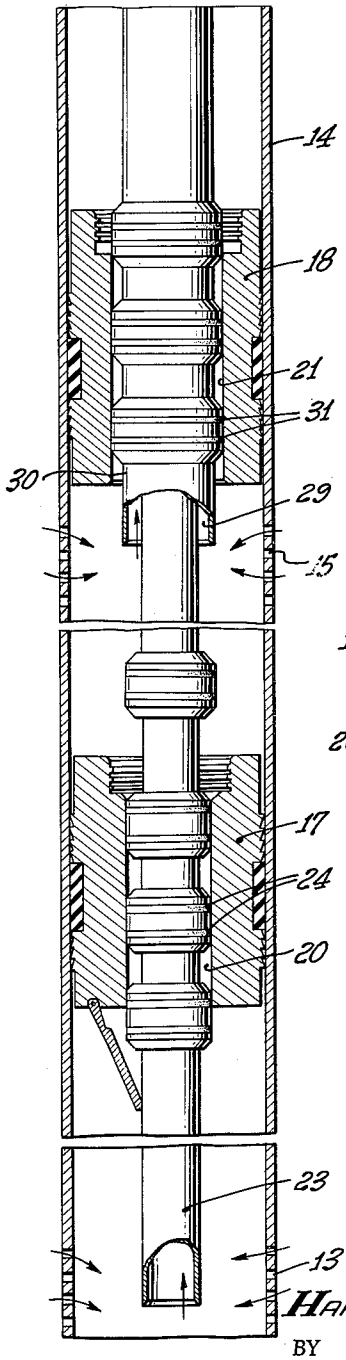
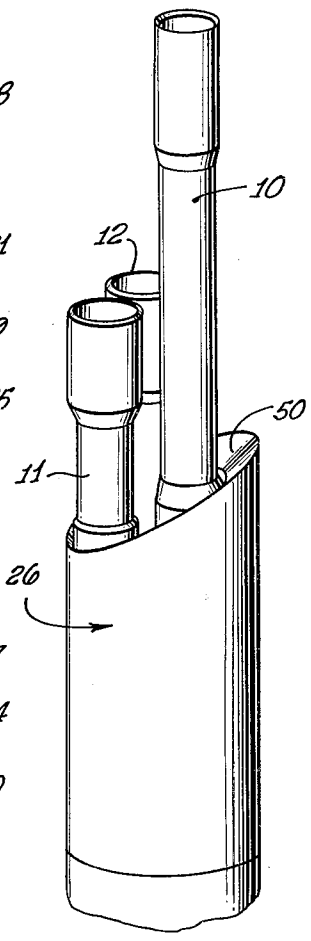


FIG. 2.



INVENTOR.
HARTLEY K. TODEE,
BY
Mellin and Hanscom
ATTORNEYS.

March 28, 1961 H. K. TODEE 2,976,934

SUBSURFACE MULTIPLE ZONE PRODUCTION APPARATUS

Filed Dec. 24, 1957 3 Sheets-Sheet 2

FIG. 3.

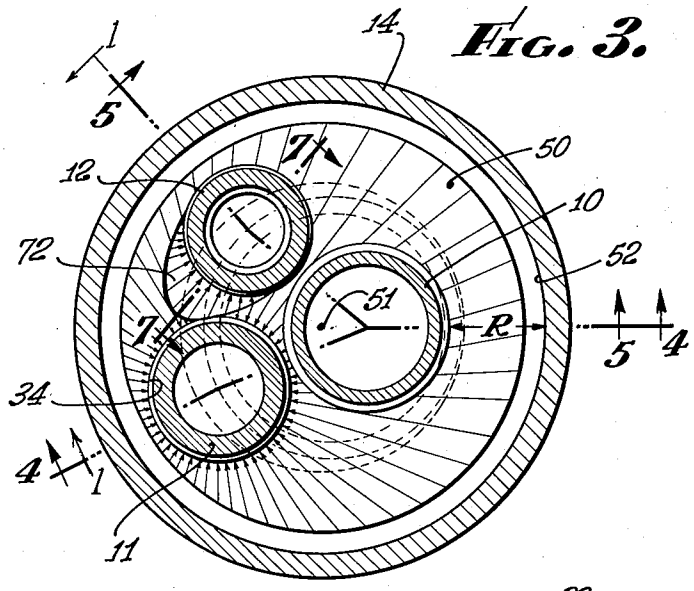


FIG. 6.

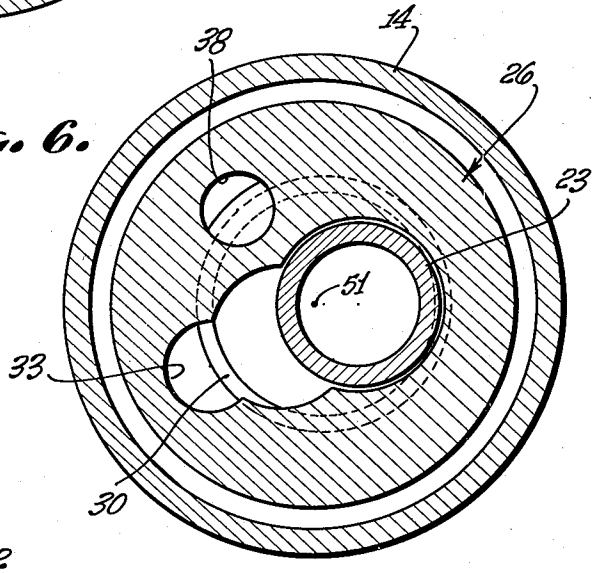
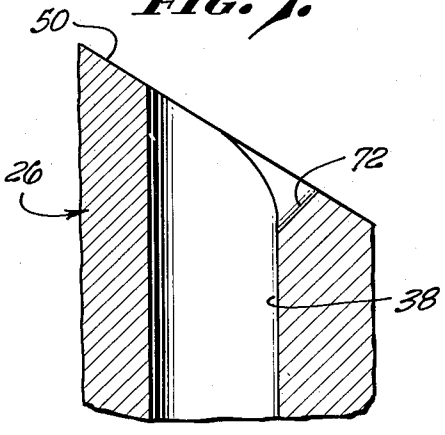


FIG. 7.



INVENTOR.
HARTLEY K. TODEE,
BY
Mellin and Hanscom
ATTORNEYS.

March 28, 1961 H. K. TODEE 2,976,934

SUBSURFACE MULTIPLE ZONE PRODUCTION APPARATUS

Filed Dec. 24, 1957 3 Sheets-Sheet 3

FIG. 4.

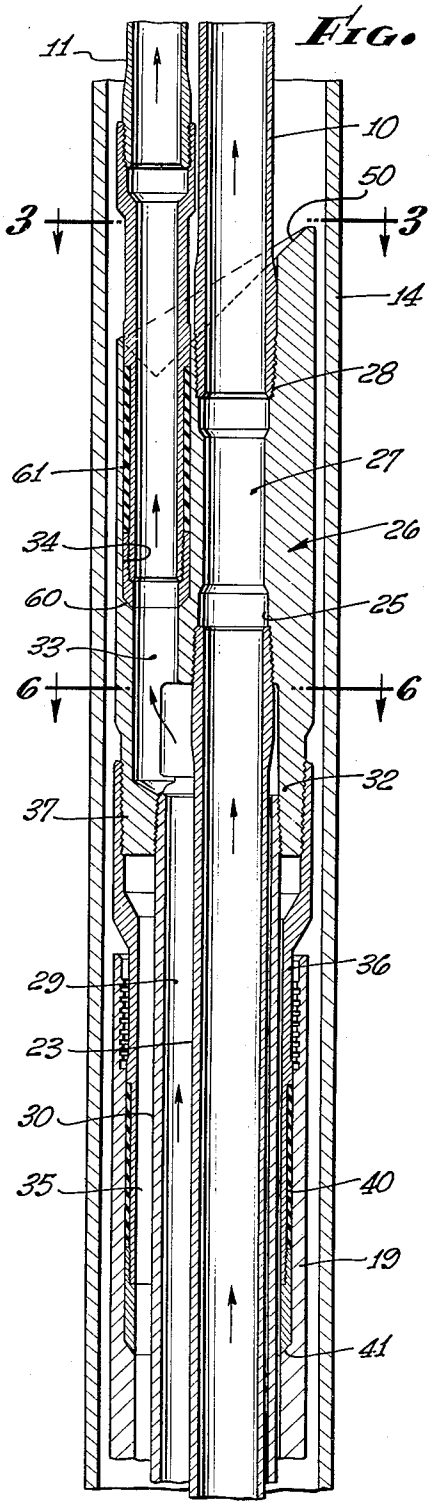
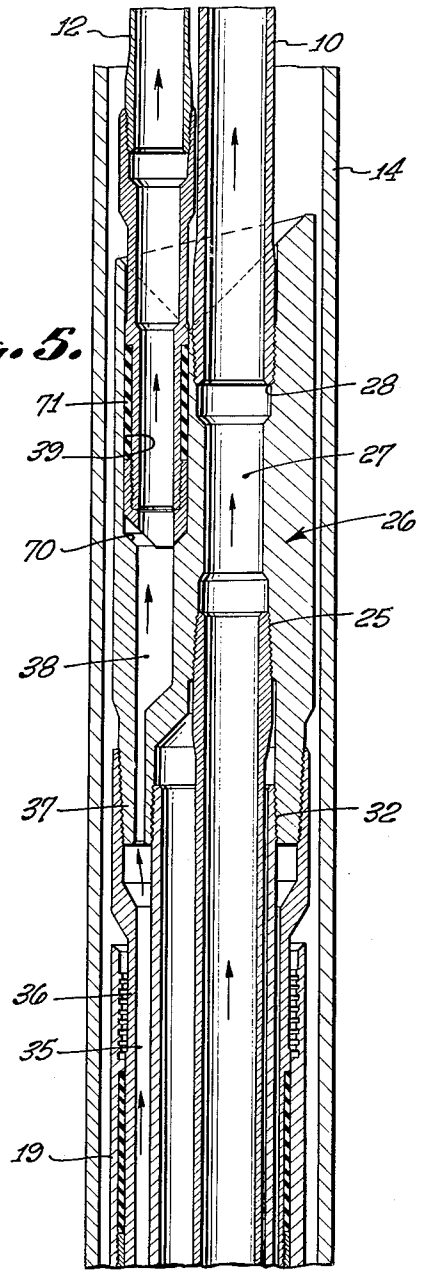


FIG. 5.



INVENTOR.
HARTLEY K. TODEE,
BY
Mellin and Hanscom
ATTORNEYS

United States Patent Office 2,976,934 Patented Mar. 28, 1961

2,976,934

SUBSURFACE MULTIPLE ZONE PRODUCTION APPARATUS

Hartley K. Todee, Houston, Tex., assignor to Baker Oil Tools, Inc., Los Angeles, Calif., a corporation of California

Filed Dec. 24, 1957, Ser. No. 704,924

5 Claims. (Cl. 166—243)

The present invention relates to subsurface well apparatus, and more particularly to apparatus capable of separately conducting fluid between the top of the well bore and separate formation zones in the well bore.

An object of the present invention is to provide apparatus for conducting fluids through at least three parallel tubular production strings disposed in the well bore and extending to the upper end thereof, the apparatus being lowered to its desired location on one of the production strings, after which the other production strings can be separately lowered in the well bore and placed in proper assembled relation to the apparatus.

Another object of the invention is to provide apparatus of the character indicated which is relatively simple and inexpensive to manufacture.

A further object of the invention is to provide an improved apparatus for conducting production from different formation zones in the well bore separately through three different tubular strings extending to the top of 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 diagrammatic longitudinal section through an apparatus disposed in the well bore, with parts shown in elevation, Fig. 1*a* constituting a lower continuation of Fig. 1, the section being taken along the line 1—1 on Fig. 3;

Fig. 2 is an isometric projection of a portion of the apparatus disclosed in Fig. 1;

Fig. 3 is a cross-section, on an enlarged scale, taken along the line 3—3 on Fig. 1 and also on Fig. 4;

Fig. 4 is a longitudinal section taken along the line 4—4 on Fig. 3;

Fig. 5 is a longitudinal section taken along the line 5—5 on Fig. 3;

Fig. 6 is an enlarged cross-section taken along the line 6—6 on Fig. 4;

Fig. 7 is an enlarged longitudinal section taken along the line 7—7 on Fig. 3.

The apparatus exemplifying the invention in the drawings is specifically designed for conducting production from three longitudinally spaced and separated formation zones in a well bore through separate tubular strings 10, 11, 12 to the top of the well bore. The well production from the lower zone can pass through a lower set of perforations 13 in a well casing 14 disposed in the well bore to the interior of the casing. Similarly, the well production in the intermediate zone can pass through an intermediate set of perforations 15 in the casing, while the well production in the upper zone can pass through an upper set of perforations 16 in the well casing 14 to its interior. The fluids from the different formation zones are prevented from commingling externally of the casing by placing cement (not shown) around the casing between the sets of perforations, which cement will serve to close the annular space around the well casing. Commingling between the fluids emanating from the different zones internally of the casing is also prevented by use of a plurality of packers and tubular equipment associated therewith, which will be described hereinbelow.

A lower packer 17 is anchored in packed-off condition in the well casing between the lower and intermediate sets of perforations 13, 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, whereas an upper packer 19 is anchored in packed-off condition in the well casing above the upper set of perforations 16. The central passage 20 through the lower packer 17 is smaller in diameter than the central passage 21 through the intermediate packer 18, which, in turn, is smaller in diameter than the central passage 22 through the upper packer 19. The packers or barriers 17, 18 and 19 are shown diagrammatically in the drawings, and may be of the specific type shown in United States Patent Nos. 2,819,701, 2,630,865.

In order to conduct well production from the several zones separately to the top of the well bore, a plurality of tubing strings are operatively associated with one another and with the several production packers. An inner tubing string 23 extends through all of the packers and has suitable seals 24 thereon adapted to seal off against the wall of the lower packer passage 20. Fluid from the lower formation zone will pass through the lower set of casing perforations 13 to the interior of the casing 14, thence flowing upwardly through the inner tubing string 23, the upper end of which is threaded into a threaded bore 25 of a flow direction head 26. This threaded bore forms part of a first longitudinal passage 27 extending through the head, the upper end of this passage being constituted as an upper threaded box 28 threadedly receiving the lower end of a first tubing string 10, which extends to the top of the well bore. Thus, the production from the lower zone can pass upwardly through the inner tubing string 23, through the first head passage 27, and into the first tubing string 10.

Production from the intermediate zone passes through the intermediate set of perforations 15 into the casing 14, then flowing upwardly through an annular space 29 provided between the inner tubing string 23 and an intermediate tubing string 30 which has suitable seal members 31 thereon to effect a seal with the wall of the intermediate packer passage 21. This intermediate tubing string 30 has its upper end threaded into a companion threaded box 32 in the lower portion of the head 26, this threaded box forming part of a second passage 33 extending through the head and opening into a counterbore 34 in the upper portion of the head which is adapted to receive the lower end of a second tubing string 11 extending to the top of the well bore. Thus, the well production from the intermediate zone will flow upwardly through the annulus 29 between the inner and intermediate tubing strings 23, 30 and through the second passage 33 into the second tubing string 12 to the top of the well bore.

The well production from the upper zone will pass through the upper set of perforations 16 to the interior of the casing 14 and thence upwardly through an annular space 35 between an intermediate tubular string 30

and the upper packer 19, thence into a continuation of this annular space 35 defined between an upper tubing string 36, the upper end of which is threadedly secured to a lower pin 37 of the head. The fluid will flow from the annulus 35 between the intermediate and upper strings 30, 36 to a third passage 38 extending through the head 26 and having its upper portion 39 counterbored to receive the lower portion of a third tubing string 12 extending to the top of the well bore. The upper tubing string 36 seals against the wall of the passage 22 by means of the sealing member 40 illustrated in the drawings. Thus, the fluid from the upper zone passes through the casing perforations 16 and up through the upper annulus 35 and into the third passage 38, from where it proceeds through the third tubular string 12 to the top of the well bore.

Ordinarily, the well packers 17, 18, 19 have been previously installed in the well casing 14 preparatory to running the tubing string apparatus in the well casing. In order to place its tubing strings 23, 30, 36 depending from the head 26 in appropriate sealing relation against the lower, intermediate, and upper packers, they are appropriately threaded to the lower portion of the head 26, and the first tubing string 10 is threadedly secured to the upper end of the head. At this time, the second and third tubing strings 11, 12 are not used. The apparatus is lowered in the well casing by means of the first tubing string 10, the engagement of the upper tubing string 36 depending from the head 26 with a packer shoulder 41 appropriately locating the seals 24 of the inner tubing string 23 within the lower packer 17, the seals 31 on the intermediate tubing string 30 within the intermediate packer 18 and the seal 40 on the upper tubing string 36 in the upper packer 19. After the apparatus has been run in the well casing in the manner indicated, the second tubing string 11 is then lowered in the well bore and appropriately related to the head 26, followed by lowering of the third tubing string 12 in the well bore and its placement in appropriate assembled relation within the head.

The upper portion of the head 26 is shaped to insure guidance of the second tubing string 11 into its passage 33 and also the third tubing string 12 into its flow passage 38 within the head. Thus, the three passages 27, 33, 38 open through a frusto-conical guide surface 50 formed in the upper portion of the head. This guide surface has its axis coinciding with the axis of the passage 33 for the second tubing string 11, so that the frusto-conical guide surface will have its lowermost point coincident with the second passage. The first passage 27 also opens upwardly through the frusto-conical surface, with its axis offset substantially from the axis of the head 26. The third passage 38 also opens upwardly through the conical surface 50, but at a higher point therein than the second passage 33 opens into the frusto-conical surface. The upper portion 34 of the second passage 33 has a substantially larger diameter than the upper portion 39 of the third passage, so that the lower end of the second tubing string 11, when engaging the tapered or frusto-conical guide surface 50, cannot move into the third passage 38, but will shift thereby and then enter the second passage and its counterbore 34.

The first passage 27 is offset to one side of the axis 51 of the head, whereas the second passage 33 is offset on the other side of the axis 51 and, in fact, is close to the periphery of the flow directing head 26. The third passage 38 is also offset with respect to the axis 51 of the head and on the opposite side of the axis as compared to the first passage 27. In fact, the first passage 27 is so located that when the first tubing string 10 is assembled therein and secured to the head 26, the distance R (Fig. 3) from the first string of tubing 10 to the wall 52 of the well casing 14 is substantially less than the outside diameter of the third tubing string 12 or of one of its couplings, in order to preclude the third

tubing string 12 from passing around the first tubing string 10 in a clockwise direction, as seen in Fig. 3.

After the apparatus has been lowered in the well bore by means of the first tubing string 10 and has been placed in sealed off relation within the several packers 17, 18, 19, the second tubing string 11 is lowered in the well casing. When the lower end of this tubing string engages the frusto-conical guide surface 50, it is deflected thereby toward the second passage 33. As an example, if the lower end of the second tubing string engages the frusto-conical surface to one side of the first tubing string, as below the first tubing string as seen in Fig. 3, it will be deflected in a clockwise direction to the second passage 33 and can then enter that second passage counterbore 34, coming to rest upon a locating shoulder 60 therein with a seal element 61 on this tubing string sealingly engaging the wall of the counterbore. If, however, the second tubing string 11 engages the guide surface 50 on the other side of the first tubing string 10, as above the first tubing string as seen in Fig. 3, then it will be deflected by the guide surface in a counter-clockwise direction toward the second passage counterbore 34. The second tubing string 11 cannot be fed into the third passage counterbore 39 since the diameter of its lower portion is greater than the diameter of the third passage. Instead, the tubing string 11 slides past the third passage counterbore 39 and comes to rest within the second passage counterbore 34.

The second tubing string 11 cannot move through the relatively narrow space R between the first tubing string 10 and the adjacent casing wall 52 since that space is substantially less than the diameter of the second tubing string.

After the second tubing string 11 has been appropriately asesembled in the head 26, the third tubing string 12 is lowered in the well casing and is started therewithin between the first and second tubing strings 10, 11 and on the side of such tubing strings that will bring the third string into the region above the third passage 38. Once the third string 12 is located in such position to one side of and between the first and second tubing strings, it cannot move around the first tubing string 10, as in a clockwise direction, as seen in Fig. 3, through the space R between the tubing string 10 and the wall 52 of the well casing, in order to be disposed on the other side of the tubing strings 10, 11, inasmuch as the third tubing string, or at least a coupling thereon near its lower portion, has a substantially greater diameter than this space R. Accordingly, when the lower end of the third tubing string 12 reaches the head 26, it will engage its frusto-conical guide surface 50 to one side of and above the first and second tubing strings 10, 11, as seen in Fig. 3. If the lower end of the third string engages the guide surface to the right of the third passage 38, as seen in Fig. 3, then it will be shifted automatically by such guide surface in a counter-clockwise direction into the third passage counterbore 39, where it will come to rest upon the shoulder 70 defining the lower end of the counterbore 39. The sealing element 71 on the third tubular string 12 will engage the wall of the counterbore 39 to prevent leakage of fluid past the third tubular string. If, however, the lower end of the third tubular string 12 engages the guide surface on the opposite side of the passage 38, as immediately above the second tubing string, as shown in Fig. 3, a reversely tapering surface 72 at the upper end of the head and leading down the surface 50 to the third passage counterbore 39 will direct the tubing string 12 in a clockwise direction, as seen in Fig. 3, into the third passage counterbore 39.

All three tubing strings 10, 11, 12 have now been appropriately related to the flow directing head 26. Production from the lower zone will pass through the inner tubing string 23 and first pasage 27 into the first tubing string 10 to be conducted to the top of the well bore. Production from the intermediate zone will pass through the annulus 29 between the inner and intermediate tubing

strings 23, 30 and to the second passage 33, from where it will flow through the second tubing string 11 to the top of the well bore. Finally, the well production from the upper zone will pass through the annulus 35 between the intermediate tubing string 30 and the upper packer 19 and upper tubing string 36 into the third passage 38 through the head 26, from where it will flow through the third tubing string 12 to the top of the well bore.

It is, accordingly, apparent that a simple parallel string production apparatus has been provided, in which the major portion of the apparatus is first lowered in the well casing in the first tubing string and properly related to the several packers or barriers therewithin, after which the second tubing string is lowered in the well casing, with assurance that it will be directed automatically into the second passage 33 after, and as a result of, engaging the frusto-conical guide surface 50. Such second tubing string cannot inadvertently or otherwise be placed in the third passage 38. Finally, the lowering of the third tubing string in the well casing can be performed with assurance that when it engages the frusto-conical guide surface 50 it will also be automatically directed into the third passage 38. The apparatus is simple to operate and assemble in a well bore, and is comparatively inexpensive to manufacture, considering its nature.

The inventor claims:

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; said head having an upper tapered surface through which said passages open, said second passage having a greater entrance diameter than said third passage, whereby engagement of said tapered surface by the second tubular string extending to the top of the well bore will direct the second tubular string into said second passage and engagement of said tapered surface by the third tubular string extending to the top of the well bore will direct the third tubular string 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; said head having an upper tapered surface through which said passages open, said second passage having a greater entrance diameter than said third passage and said third passage opening through said tapered surface at a higher elevation than said second passage opens through said tapered surface, whereby engagement of said tapered surface by the second tubular string extending to the top of the well bore will direct the second tubular string into said second passage and engagement of said tapered surface by the third tubular string extending to the top of the well bore will direct the third tubular string into said third 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 tubular string which extends to the top of the well bore; said head having an upper frusto-conical surface through which said passages open, the axis of said surface substantially coinciding with the axis of said second passage, said second passage having a greater entrance diameter than said third passage, whereby engagement of said frusto-conical surface by the second tubular string extending to the top of the well bore will direct the second tubular string into said second passage and engagement of said frusto-conical surface by the third tubular string extending to the top of the well bore will direct the third tubular string into said third passage.

4. In a well having a plurality of formation zones and a casing therein: production apparatus in the casing comprising first, second and third tubular strings extending to the top of the well bore, a head having first, second and third passages into which said first, second and third strings, respectively, are insertable, said head having an upper tapered surface through which said passages open, said second pasage having a greater entrance diameter than said third passage, said second string having a greater diameter than said third passage, whereby engagement of said tapered surface by said second tubular string will direct said second tubular string past said third passage into said second passage and engagement of said tapered surface by said third tubular string will direct said third tubular string into said third passage; the minimum distance between said first string and casing being less than the diameter of said third string when said first string is in said first passage.

5. In a well having a plurality of formation zones and a casing therein: production apparatus in the casing comprising first, second and third tubular strings extending to the top of the well bore, a head having first, second and third passages into which said first, second and third strings, respectively, are insertable, said head having an upper frusto-conical surface through which said passages open, the axis of said surface substantially coinciding with the axis of said second passage, said second passage having a greater entrance diameter than said third passage, said second string having a greater diameter than said third passage, whereby engagement of said frusto-conical surface by said second tubular string will direct said second tubular string past said third passage into said second passage and engagement of said frusto-conical surface by said third string will direct said third string into said third passage, the minimum distance between said first string and casing being less than the diameter of said third string when said first string is in said first passage.

References Cited in the file of this patent

UNITED STATES PATENTS

1,014,272	Waitz	Jan. 9, 1912
1,050,689	Pierce	Jan. 14, 1913
1,431,779	Conrader	Oct. 10, 1922
2,794,505	Allen	June 4, 1957
2,902,093	Brown	Sept. 1, 1959

FOREIGN PATENTS

1,011,346	France	Apr. 2, 1952
1,065,308	France	Jan. 6, 1954

Disclaimer

2,976,934.—*Hartley K. Todee*, Houston, Tex. SUBSURFACE MULTIPLE ZONE PRODUCTION APPARATUS. Patent dated Mar. 28, 1961. Disclaimer filed Jan. 29, 1964, by the assignee, *Baker Oil Tools, Inc.*

Hereby enters this disclaimer to claims 1 and 2 of said patent.

[*Official Gazette April 21, 1964.*]