April 4, 1961 G. G. GRIMMER 2,978,031

SELECTIVE CROSS-OVER DEVICE

Filed Sept. 25, 1956 2 Sheets-Sheet 1

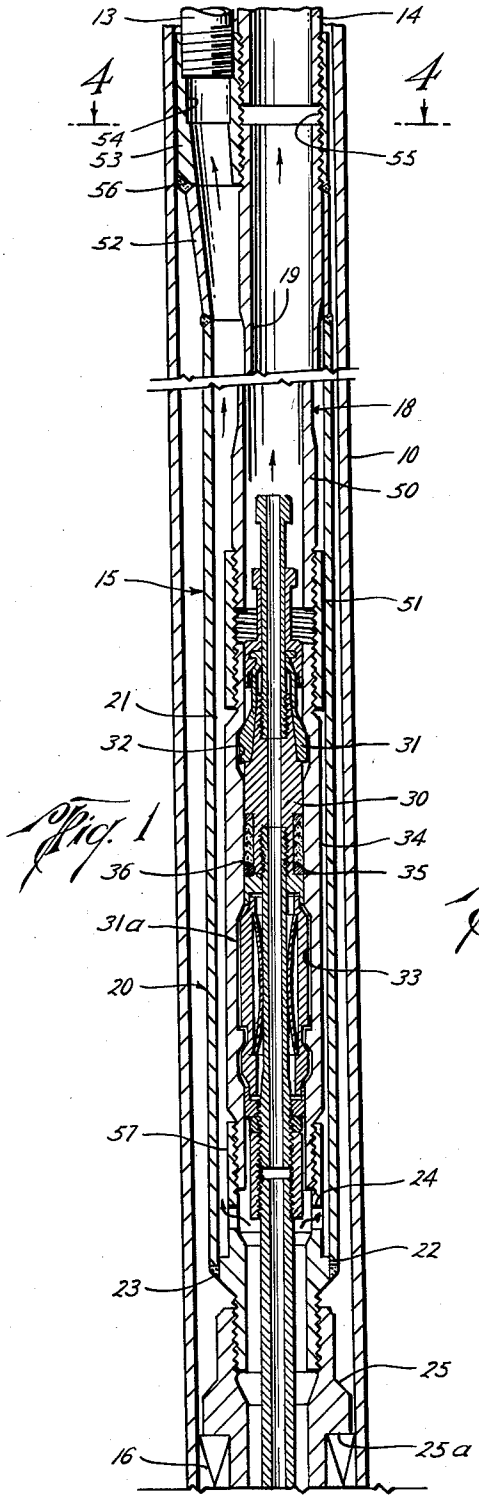


Fig. 1

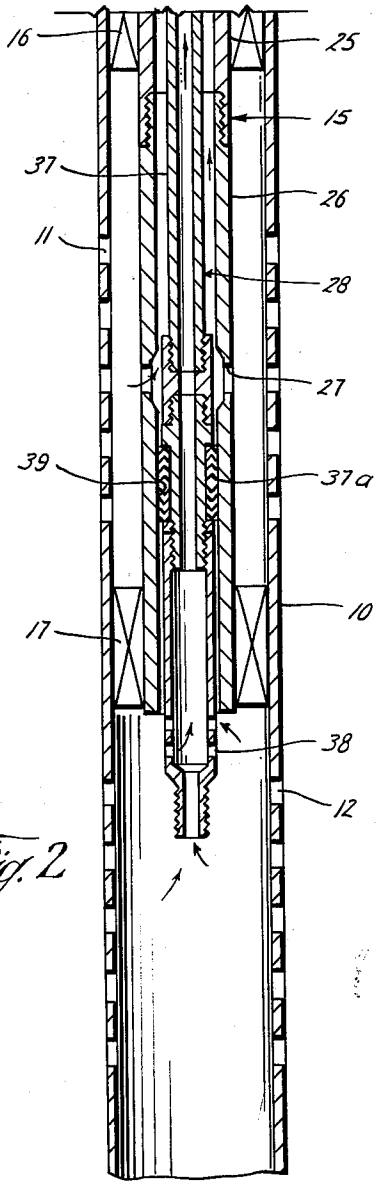


Fig. 2

George G. Grimmer
INVENTOR.

BY

Browning, Simms & Hyer

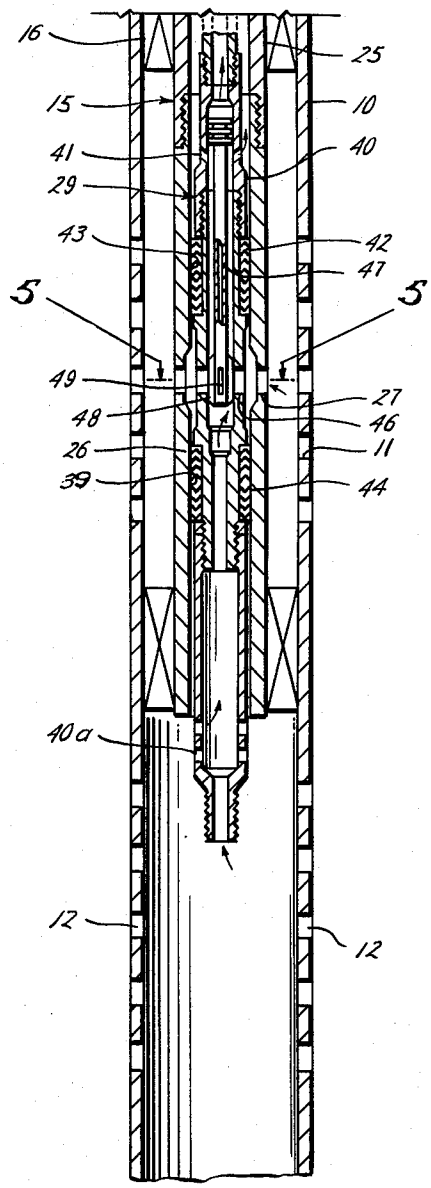
ATTORNEYS

April 4, 1961 G. G. GRIMMER 2,978,031

SELECTIVE CROSS-OVER DEVICE

Filed Sept. 25, 1956 2 Sheets-Sheet 2

Fig. 3



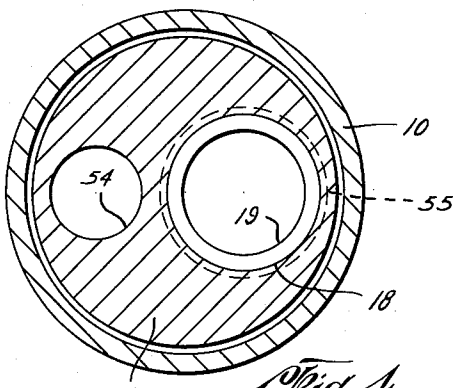


Fig. 4

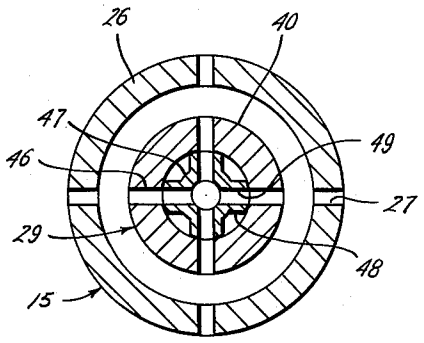


Fig. 5

George G. Grimmer
INVENTOR.

BY

Browning, Simms & Hyer

ATTORNEYS

United States Patent Office 2,978,031 Patented Apr. 4, 1961

2,978,031

SELECTIVE CROSS-OVER DEVICE

George G. Grimmer, Dallas, Tex., assignor to Otis Engineering Corporation, Dallas, Tex., a corporation of Texas

Filed Sept. 25, 1956, Ser. No. 611,959

14 Claims. (Cl. 166—114)

This invention relates to a selective cross-over device for use in wells which produce two zones separately through side-by-side tubing strings.

A device of the general type contemplated by the present invention, for use in wells which produce two zones through the tubing and tubing-casing annulus, respectively, is shown and described on page 4003 of the 1955–56 edition of the Catalog of Oil Field and Pipeline Equipment. Improvements in a device of this general type, which adapt it for use in permanently completed wells, are disclosed in a copending application, Serial No. 454,383, filed September 7, 1954, by John V. Fredd and Harry B. Schramm. In each case, there is provided apparatus which includes a housing connectable in the well tubing and flow directing tools removably landable in the housing for selectively and separately directing lower zone production upwardly to ground level through one of the tubing and tubing-casing annulus, and upper zone production through the other of said tubing and annulus.

There are many advantages to producing a two-zone well through sid-by-side strings, rather than through the tubing and tubing-casing annulus. For example, the space within the casing around the strings may be used for gas lift, chemical injection or mud loading.

In order to isolate the space within the casing for the purposes above-noted, it is conventional to pack off both strings above the upper production zone. Obviously a packer for accommodating two such side-by-side strings of a given flow capacity requires more space within the casing than would a packer for accommodating concentric strings of the same capacity. Also, as a practical matter, commercially available eccentric type packers are not settable by wire line, and therefore must be run on one of the tubing strings.

An object of this invention is to provide a selective cross-over device which will permit the two production zones of a well to be conducted to ground level separately and selectively through either of said side-by-side strings.

Another object is to provide, in a device of the character above-described, a housing adapted to be suspended from said strings and of such construction as to be packed off concentrically within the casing above the upper zone and to receive removable flow tools of substantially no greater length than required in connection with earlier selective cross-over devices.

Other objects, advantages and features of this invention will be apparent to one skilled in the art upon a consideration of the written specification, the attached claims and the annexed drawings.

In the drawings, wherein like reference characters are used throughout to designate like parts:

Fig. 1 is a longitudinal sectional view of a portion of a two-zone well in which the housing of a cross-over device constructed in accordance with the present invention is suspended from the lower end of a pair of side-by-side tubing strings and packed off concentrically within the well casing above the upper zone, and wherein a removable tool is shown disposed within the housing for directing flow from said two zones;

Fig. 2 is a longitudinal sectional view of the portion of the two-zone well below that shown in Fig. 1, and with the lower portion of a removable tool disposed within the housing of the cross-over device for directing lower zone production through the rightmost tubing string, as seen in Fig. 1, and upper zone production through the leftmost string;

Fig. 3 is a view similar to Fig. 2, but showing a removable tool disposed within the housing for directing lower zone production through the leftmost string and upper zone production through said rightmost string;

Fig. 4 is an enlarged cross-sectional view of the housing, taken substantially along broken line 4—4 of Fig. 1; and

Fig. 5 is an enlarged cross-sectional view of the housing and removable tool disposed therein, taken substantially along broken line 5—5 of Fig. 3.

As is conventional in the case of two-zone wells of the type contemplated by the present invention, and as shown in Figs. 1 to 3, a well casing **10** communicates with the upper and lower zones of the well through perforations **11** and **12**, respectively, and a pair of tubing strings **13** and **14** are extended downwardly from the wellhead in side-by-side relation for flowing the two zones separately to the surface level. Suspended from the lower ends of the tubing strings **13** and **14** is an elongate housing **15** of the cross-over device which is packed off concentrically within the well casing above the upper zone at **16** and intermediate the upper and lower zones at **17**. Thus, as shown in Fig. 1, the space about the tubing strings and housing above the packer **16** is isolated from both production zones, and as shown in Figs. 2 and 3, the upper and lower zones are isolated from one another by means of the packer **17**.

The housing **15** includes a tubular member **18** having an inner passageway **19** extending longitudinally therethrough and a tubular sleeve **20** about the tubular member **18** to provide an outer passageway **21** between the member and sleeve. As can be seen from Fig. 1 of the drawings, the upper end of the tubular sleeve **20** is arranged substantially tangentially of the tubular member, and the lower end of the sleeve is arranged substantially concentrically thereof. Thus, the outer passageway **21** tapers downwardly from an eccentric portion at its upper end to a substantially annular portion at its lower end.

The lower portion of the outer passageway **21** is closed above the packer **16** by an annular abutment **22** on the tubular member to which the lower end of the tubular sleeve **20** is welded as at **23**. The tubular member **18** is provided with a plurality of circumferentially disposed ports **24** therethrough just above the abutment **22** so as to connect the lower portion of outer passageway **21** with inner passageway **19**.

As shown in the lower portion of Fig. 1, the lower end of the tubular member **18** is threadedly connected to a coupling **25** having a shoulder **25***a* landable upon the packer **16**. It is contemplated that the packer **16**, which is shown diagrammatically in the drawings, may comprise any commercially available concentric type packer which is run and set by wire line, such as that shown and described on page 537 of the 1955–56 edition of the Composite Catalog of Oil Field and Pipeline Equipment.

As shown in Figs. 2 and 3, the lower end of the coupling **25** is threadedly connected to a tubular extension **26** forming the lower end of the housing **15** which is packed off at **17** concentrically within the casing intermediate the two production zones. As can be seen from the drawings, the bores through each of the coupling and tubular extension form continuations of the inner passage-

way 19. The extension 26 is provided with a plurality of ports 27 therein which communicate the upper zone production with the interior of the housing below the ports 42, and the lower end of the extension is open to communicate lower zone production with the interior of the housing beneath the ports 27.

With a removable tool 28 landed within the housing 15, as shown in Figs. 1 and 2, lower zone production is flowed upwardly through the tool and inner passageway thereabove into the tubing string 14, while upper zone production is flowed annularly of the tool and through the ports 24 and outer passageway 21 into tubing string 13. On the other hand, with a removable tool 29 connected to the lower end of the upper portion of the tool 28 shown in Fig. 1 and landed within the housing 15, as shown in Figs. 1 and 3, lower zone production is crossed over from the lower end of the interior of the tool to the space annularly thereof and flowed through the ports 24 and outer passageway 21 into tubing string 13. At the same time, upper zone production is crossed over from the space annularly of the tool to the upper end of the interior of the tool and flowed through the inner passageway thereabove into the tubing string 14.

As described in connection with the above-mentioned publication, as well as in connection with the above-mentioned copending patent application, each of the tools 28 and 29 may be landed within and removed from the positions shown for selectively flowing the well in the manner above-described. In this respect, it will be noted that the tubing string 13 in this particular embodiment of the invention is considerably smaller in capacity than the tubing string 14, so that it may be desirable to flow the zone having the least pressure through the smaller of the strings.

The inner passageway 19 through the tubular member 18 of the housing, as well as the continuation thereof through the coupling 25 and tubular extension 26, are "full-opening" in the sense that the minimum diameter thereof corresponds to the drift diameter of the tubing string 14. Thus, the device is particularly well-adapted for use in permanently completed wells wherein various oil tools may be passed downwardly through the tubing string 14 and housing 15 for workover operations on the lower zone. For this purpose, and as described in the aforementioned copending application, each of the tools 28 and 29 are provided with landing and locking parts receivable within recesses in the passageway 19 which do not obstruct the "full-opening" therethrough.

Thus, as indicated in Fig. 1, the upper end of each of the flow tools 28 and 29, respectively, may comprise a type "S" Otis removable mandrel assembly, as shown on page 4012 of the aforementioned 1955–56 edition of the Composite Catalog of Oil Field and Pipeline Equipment. This assembly includes an imperforate tubular mandrel 30 which is lowerable on a wire line into spaced relation within a nipple 34 forming an intermediate portion of the tubular member 18. This mandrel carries locking dogs 31 and selector keys 31*a* for disposal within and removal from complementary recesses 32 and 33 within the nipple 34. Seal means 35 are disposed about the mandrel for sealing engagement with a polished surface 36 on the bore of the nipple 34 above the ports 24 in the tubular member 18. Thus, the flow of production annularly about the mandrel 30 of either of the tools is directed outwardly through the ports 24 and into the outer passageway 21.

As shown in Fig. 2, the flow tool 28 is provided with a tubular body 37 connected to the lower end of mandrel 30 for disposal in spaced relation within the passageway through the tubular member 18, flow sub 25 and tubular extension 26. This body is imperforate throughout its length and carries seal means 37*a* thereabout for sealing engagement with a polished surface 39 on the bore of the tubular extension 26 intermediate the ports 27 and the lower open end of the tubular extension, so as to direct lower zone production, which enters its lower end through ports 38, into the string 14. On the other hand, upper zone production, which enters the annular space about the tool 28 through the ports 27, is directed upwardly into the ports 24 and thus through outer passageway 21 into tubing string 13.

As shown in Fig. 3, the tubular body 40 of the tool 29 is provided with ports 41 therethrough intermediate the upper end thereof which is connected to the mandrel 30 and an upper seal means 42 disposed thereabout for sealing engagement with a polished surface 43 on the bore of the tubular extension 26 above the ports 27. Additionally, the tubular body 40 is provided with ports 46 therethrough intermediate the upper seal means 42 and a lower seal means 44 thereabout sealable with the polished surface 39 of the tubular extension below the ports 27 and above the open lower end of the tubular extension 26. Thus, lower zone production is directed into the lower end of the tubular body 40 through ports 40*a* beneath the ports 46. Upper zone production, on the other hand, is directed from the ports 27 and into the ports 46 through the annular space about the tool 29 intermediate seal means 42 and 44.

A tube 47 having a closed lower end and open at its upper end is disposed within and sealed off with respect to the tubular body 40 above the ports 41. A spider 48 on the tube 47 having radial ports 49 therethrough is secured within the body 40 of the tool in a manner to communicate the ports 49 with ports 46 of the body and thus direct the upper zone production into the interior of the tube 47, while by-passing lower zone production around the spider 48 (see Fig. 5) and through an annular space between the tube 47 and interior of the body 40 into ports 41. As can be seen from Figs. 1 and 3, upper zone production flows upwardly through the open upper end of the tube 47 and tool 29 into the string 14, while lower zone production flows upwardly from the ports 41 through the annular space between the tool 29 and the housing above seal means 42 and into the outer passageway 21 and string 13 through the ports 24.

A more complete description of the above tools may be obtained from the aforementioned publication and copending patent application. It is important to note, in this respect, that it is the novel construction of the housing 15 which permits the use, in the cross-over device of the present invention, of flow directing tools of substantially no greater length than those usable in connection with earlier cross-over devices. More particularly, the novel construction of the housing 15 enables the use of removable flow directing tools of minimum length, while at the same time permitting the housing to be packed off concentrically within the casing.

Referring now to certain of the details of the upper portion of the housing 15, as it is shown in Fig. 1, the upper ends of the tubular member 18 and tubular sleeve 20 are connected to the lower ends of the tubing strings 13 and 14 by means of a fitting 53. This fitting is imperforate except for openings 54 and 55 therethrough, the upper ends of which threadedly receive the strings for communicating the interior of string 14 with the inner passageway 19 and the interior of string 13 with the outer passageway 21. More particularly, the tubular member 18 includes a pup joint 50 having its lower end coupled at 51 to the landing nipple 34 and threadedly received at its upper end within the lower end of fitting opening 55. If desired, the joint 50 may be welded to the lower side of the fitting about the opening 55. Connected between the upper end of the sleeve 20 and lower end of the fitting 53 as by welding at 56, in surrounding relation to the openings 54 and 55, is an eccentric adapter 52.

The lower end of the selective landing nipple 34 of the tubular member 18 is threadedly connected to a flow sub 57 through which the ports 24 are provided and upon which the annular abutment 22 is disposed.

It will be noted that the tubular sleeve 20 is substantial-

ly straight so that the inclination of outer passageway 21 with respect to inner passageway 19 through the housing 15 is substantially constant. It will further be noted that the concentric arrangement of the tubular member 18 within the lower end of tubular sleeve 20 not only enables the housing to be concentrically packed off within the casing just below the intersection of the two passageways, but also that it enables the ports 24 to be disposed circumferentially about the tubular member 18, whereby the capacity thereof is sufficiently large to provide unrestricted flow of production from the inner passageway of the housing into the outer passageway thereof.

In addition to its many other novel features, the housing 15 is made up principally of standard parts interconnected in a simple and space-saving manner.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the apparatus.

It will be understood that certain features and sub-combinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

The invention having been described, what is claimed is:

1. For use at a subsurface level in a two-zone well wherein production is flowed to ground level through a pair of side-by-side tubing strings, apparatus comprising a tubular member having a longitudinal passage therethrough forming a first flow passageway, a tubular sleeve about the tubular member to provide a second flow passageway therebetween, the upper end of the tubular sleeve being arranged substantially tangentially of the upper end of the tubular member and the lower end of said sleeve being arranged substantially concentrically of said member, means closing the lower end of the second flow passageway, a fitting on the upper ends of said sleeve and member having a pair of side-by-side openings therethrough, one of said openings communicating at its lower end with said first flow passageway and the other of said openings communicating at its lower end with said second flow passageway, means at the upper ends of each of said openings for receiving the lower end of one of said tubing strings to provide flow communication between said tubing strings and said flow passageway, port means through the tubular member providing communication between said first flow passageway and said second flow passageway just above the second passageway closing means, a sealing surface in the first passageway in the tubular member above said port means, and means on said tubular member for removably landing a well tool within the first flow passageway in sealed off relation with respect to said sealing surface.

2. Apparatus of the character defined in claim 1, wherein said sealing surface defines the minimum diameter through said first flow passageway and the fitting opening communicating therewith.

3. Apparatus of the character defined in claim 1, wherein said port means comprises a plurality of substantially circumferentially disposed ports.

4. Apparatus of the character defined in claim 1 wherein the upper end of the tubular member is provided with male threads connected to female threads in the lower end of the opening through said fitting communicating with the first flow passageway, and said attachment means comprises female threads in the upper end of each of said fitting openings.

5. Well apparatus for use in a two-zone well comprising an elongate housing adapted to be mounted in flow communicating connection with side-by-side tubing strings at a subsurface level within the well, said housing having a first tubular passageway extending longitudinally therethrough and a second passageway separate from said first passageway, the upper end of the second passageway being arranged eccentrically of the first passageway and the lower end of said second passageway being closed, a fitting on the upper end of the housing having a pair of openings therethrough, one of said openings communicating at its lower end with said first passageway and the other of said openings communicating at its lower end with said second passageway, means at the upper end of each of said openings for receiving the lower end of one of the tubing strings for establishing communication between said openings and said tubing strings, a port in the housing providing communication between the lower end of the second passageway and said first passageway, another port in the housing providing communication between said first passageway and the exterior of the housing, sealing surfaces on said housing within said first passageway above, intermediate and below said ports, and means on said housing for removably landing a well tool within the first passageway in sealed off relation with respect to at least two of said surfaces.

6. For use at a subsurface level in a two-zone well wherein production is flowed to ground level through a pair of side-by-side tubing strings, apparatus comprising a tubular member having a longitudinal passage therethrough forming a first flow passageway, a tubular sleeve about the tubular member to provide a second flow passageway therebetween, the upper end of the tubular sleeve being arranged substantially tangentially of the upper end of the tubular member and the lower end of said sleeve being arranged substantially concentrically of said member, means closing the lower end of the second flow passageway, a fitting on the upper ends of said sleeve and member having a pair of side-by-side openings therethrough, one of said openings communicating at its lower end with said first flow passageway and the other of said openings communicating at its lower end with said second flow passageway, means at the upper end of each of said openings for receiving the lower end of one of said tubing strings to establish communication between said openings and the tubing strings, port means through the tubing member providing communication between said first flow passageway and said second flow passageway just above the second passageway closing means, a sealing surface in the first passageway in the tubular member above said port means, and means on said tubular member for removably landing a well tool within the first flow passageway in sealed off relation with respect to said sealing surface.

7. Well apparatus for use in a two-zone well comprising an elongate housing adapted to be suspended from side-by-side tubing strings at a subsurface level within the well, said housing having a first tubular passageway extending longitudinally therethrough and a second passageway separate from said first passageway, the upper end of the second passageway being arranged eccentrically of the first passageway and the lower end of said second passageway being closed, a fitting on the upper end of the housing having a pair of openings therethrough, one of said openings communicating at its lower end with said first passageway and the other of said openings communicating at its lower end with said second passageway, means at the upper ends of each of said openings for attachment to the lower end of one of the tubing strings, a port in the housing providing communication between the lower end of the second passageway and said first passageway, another port in the housing providing communication between said first passageway below the first-mentioned port and the exterior of the lower portion of the housing, sealing surfaces on said housing within said first passageway above, intermediate, and below said ports, and means on said housing for removably landing a well tool within the first passageway in sealed off relation with respect to at least two of said surfaces.

8. Well apparatus of the character defined in claim 7, wherein the minimum diameter through the first passageway corresponds to the drift diameter of the tubing string to which the upper end of the fitting opening communicating therewith is attachable.

9. In a two-zone well, wherein a pair of tubing strings extend downwardly from the well head in side-by-side relation, apparatus comprising an elongate housing having flow communicating connection with said tubing strings and spaced upper and lower packing means sealing between said housing and the well casing, said upper packing means sealing above the upper zone and said lower packing means sealing intermediate said zones, said housing having an inner tubular passageway extending longitudinally therethrough and an outer passageway about the inner passageway, the upper end of the outer passageway being arranged eccentrically of the inner passageway and the lower end of said outer passageway being arranged substantially annularly of said inner passageway and communicating with the inner passageway above the upper packing means, the lower end of said outer passageway being closed, a fitting on the upper end of the housing connecting said housing to the lower ends of the tubing strings and having a pair of openings therethrough, one of said openings providing communication between one of said tubing strings and the inner passageway of said housing and the other of said openings providing communication between the interior of the other of said tubing strings and the outer passageway of said housing, a first port in the housing communicating the inner passageway with the housing exterior intermediate the upper and lower packing means, a second port in the housing communicating the inner passageway with the exterior of the housing below the lower packing means, and a flow directing tool removably locatable within the inner passageway of the housing, said tool having means providing fluid flow passages for separately communicating the second port with one of the outer passageway and the inner passageway above the tool and the first port with the other of the outer passageway and inner passageway above the tool.

10. Apparatus of the character defined in claim 9, wherein the minimum diameter through the inner passageway corresponds to the drift diameter of the tubing string with which its fitting opening communicates.

11. In a two-zone well, wherein a pair of tubing strings extend downwardly from the well head in side-by-side relation, apparatus comprising an elongate housing having a flow communicating connection with said tubing strings and spaced upper and lower packers sealing between the housing and the well casing, said upper packer sealing above the upper zone and said lower packer sealing intermediate said zones, said housing having an inner tubular passageway extending longitudinally therethrough and an outer passageway about the inner passageway, the upper end of the outer passageway being arranged eccentrically of the inner passageway and the lower end of said outer passageway being arranged substantially annularly of said inner passageway and communicating with the inner passageway above the upper packer, the lower end of said outer passageway being closed, a fitting on the upper end of the housing connecting said housing to the lower ends of the tubing strings and having a pair of openings therethrough, one of said openings communicating the interior of one of said strings with the inner passageway and the other of said openings communicating the interior of the other of said strings with the outer passageway, a first port in the housing communicating the inner passageway with the housing exterior intermediate the upper and lower packers, a second port in the housing communicating the inner passageway with the exterior of the housing below the lower packer, and a flow directing tool removably locatable within the inner passageway of the housing, said tool having means providing fluid flow passages for separately communicating the second port with the inner passageway above the tool and the first port with the outer passageway.

12. In a two-zone well, wherein a pair of tubing strings extend downwardly from the well head in side-by-side relation, apparatus comprising an elongate housing having flow communicating connection with said tubing strings and spaced upper and lower packers sealing between the housing and the well casing, said upper packer sealing above the upper zone and said lower packer sealing intermediate said zones, said housing having an inner tubular passageway extending longitudinally therethrough and an outer passageway about the inner passageway, the upper end of the outer passageway being arranged annularly of the inner passageway and the lower end of said outer passageway being arranged substantially concentrically of said inner passageway and communicating with the inner passageway above the upper packer, the lower end of said outer passageway being closed, a fitting on the upper end of the housing connecting said housing to the lower ends of the tubing strings and having a pair of openings therethrough, one of said openings communicating the interior of one of said strings with the inner passageway and the other of said openings communicating the interior of the other of said strings with the outer passageway, a first port in the housing communicating the inner passageway with the housing exterior intermediate the upper and lower packers, a second port in the housing communicating the inner passageway with the exterior of the housing below the lower packer, and a flow directing tool removably locatable within the inner passageway of the housing, said tool having means providing fluid flow passages for separately communicating the second port with the outer passageway and the first port with the inner passageway above the tool.

13. Well apparatus for use in a two-zone well wherein a pair of tubing strings extend downwardly from the well head in side-by-side relation, said well apparatus comprising an elongate housing having a first passageway extending longitudinally therethrough and a second passageway separate from said first passageway, the lower end of said second passageway being closed, means on the upper end of the housing providing for fluid flow communicating connection between said housing and the lower ends of the tubing strings comprising a pair of openings, each disposed to communicate at its upper end with the lower end of one of said tubing strings, one of said openings communicating at its lower end with said first passageway and the other of said openings communicating at its lower end with said second passageway, a port in the housing providing communication between the lower end of the second passageway and said first passageway, another port in the housing providing communication between said first passageway at a point spaced longitudinally of said first passageway from the first mentioned port and the exterior of the lower portion of the housing, sealing surfaces on said housing within said first passageway above, intermediate, and below said ports, and means on said housing for removably landing a well tool within the first passageway in sealed off relation with respect to at least two of said surfaces.

14. In a two-zone well, wherein a pair of tubing strings extend downwardly from the well head in side-by-side relation, apparatus comprising an elongate housing having flow communicating connection with said tubing strings and spaced upper and lower packing means sealing between said housing and the well casing, said upper packing means sealing above the upper zone and said lower packing means sealing intermediate said zones, said housing having a first passageway extending longitudinally of the housing and opening upwardly at its upper end, said housing having means providing a second passageway therein laterally spaced from said first passageway and opening upwardly; the lower end of said second passageway communicating with said first passageway above the upper packing means, the lower end of said

second passageway being closed, a fitting on the upper end of the housing connecting said housing to the lower ends of the tubing strings and having a pair of openings therethrough, one of said openings providing communication between one of said tubing strings and said first passageway of said housing and the other of said openings providing communication between the other of said tubing strings and said second passageway of said housing, a first port in the housing communicating said first passageway with the housing exterior intermediate the upper and lower packing means, a second port in the housing communicating said first passageway with the exterior of the housing below the lower packing means, and a flow directing tool removably locatable within said

first passageway of the housing, said tool having means providing fluid flow passageways for separately communicating the second port with one of said first and second passageways above the tool and the first port with the other of said first and second passageways.

References Cited in the file of this patent

UNITED STATES PATENTS

203,044	Hoadley	Apr. 30, 1878
1,861,332	Waitz	May 31, 1932
2,368,428	Saurenman	Jan. 30, 1945
2,717,041	Brown	Sept. 6, 1955
2,766,831	Otis	Oct. 16, 1956
2,785,754	True	Mar. 19, 1957