May 5, 1970 K. LEUTWYLER ET AL 3,509,941

CONFLUENT PRODUCTION APPARATUS

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FIG. 1.

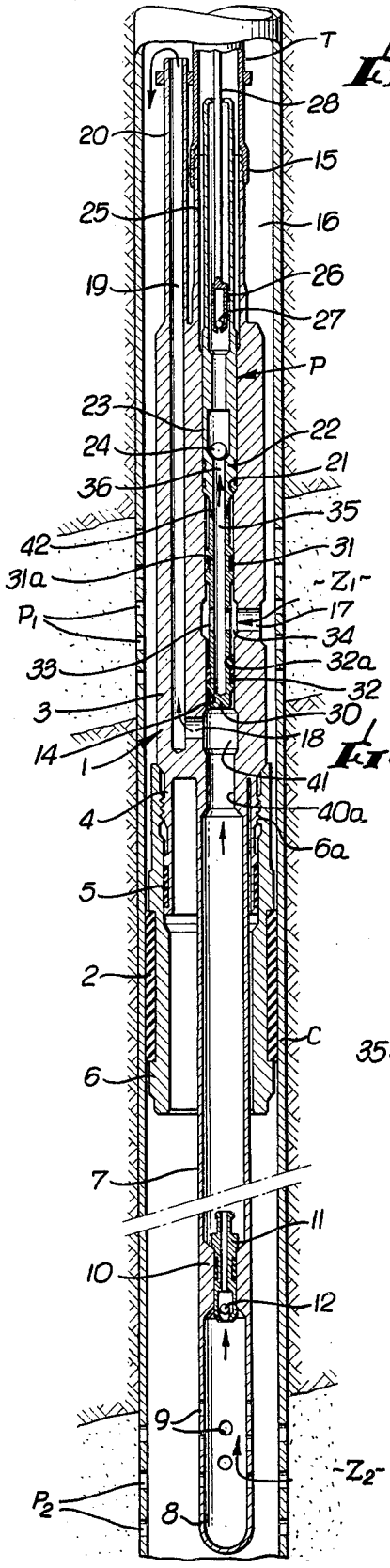


FIG. 1a.

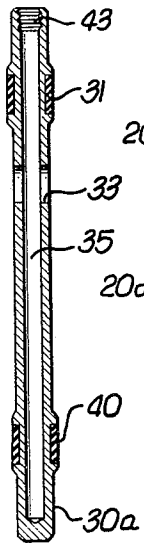


FIG. 1b.

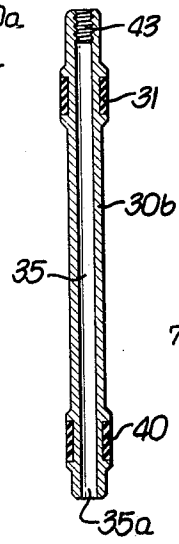
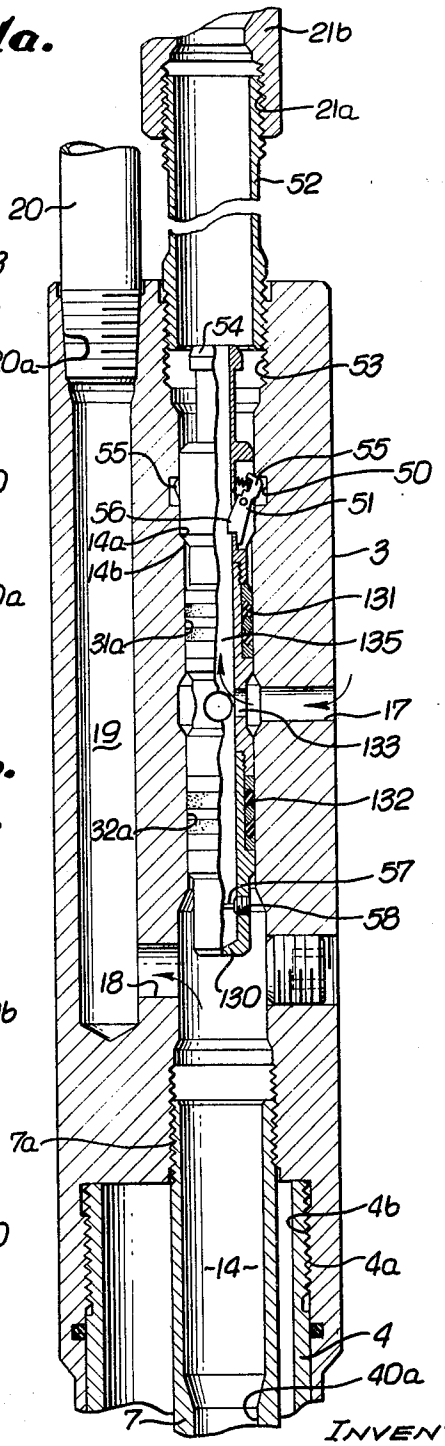


FIG. 2.



INVENTORS.
KURT LEUTWYLER
EARL W. DAVIS
WALDO W. HENSLEE, JR.
By Bernard Kriegel
ATTORNEY.

May 5, 1970 K. LEUTWYLER ET AL 3,509,941

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FIG. 3.

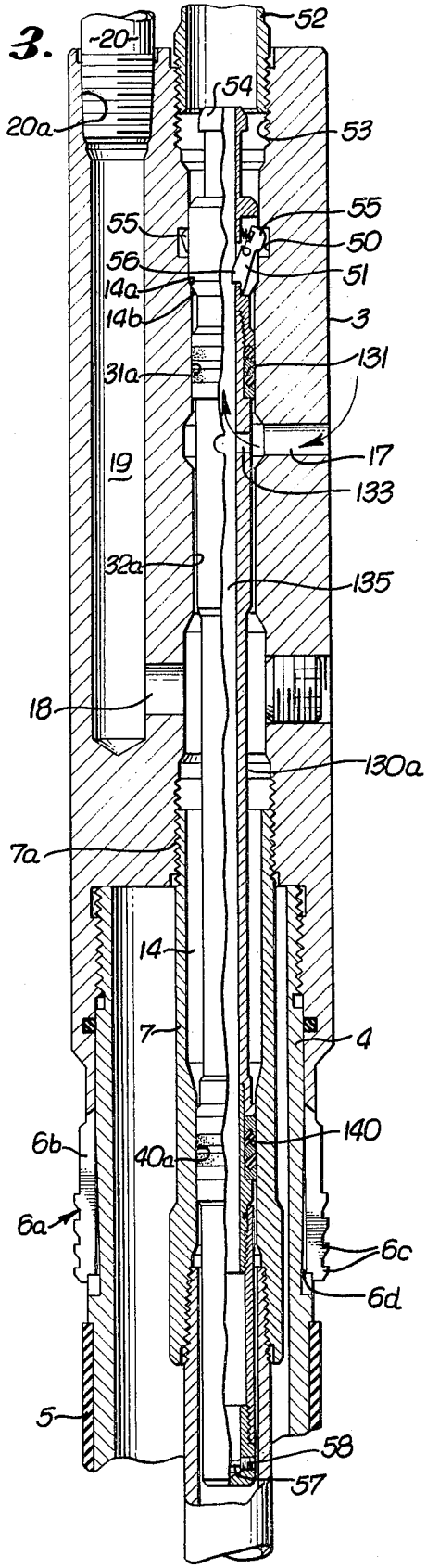
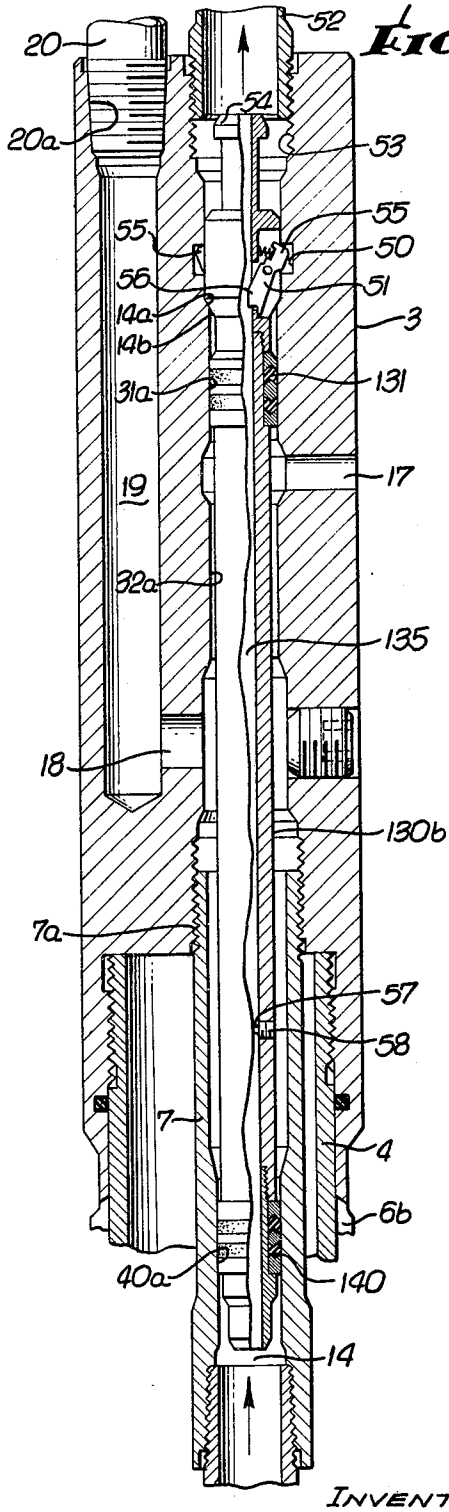


FIG. 4.



INVENTORS.
KURT LEUTWYLER
EARL W. DAVIS
WALDO W. HENSLEE, JR.
By Bernard Krieger
ATTORNEY.

May 5, 1970 K. LEUTWYLER ET AL 3,509,941

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FIG. 5.

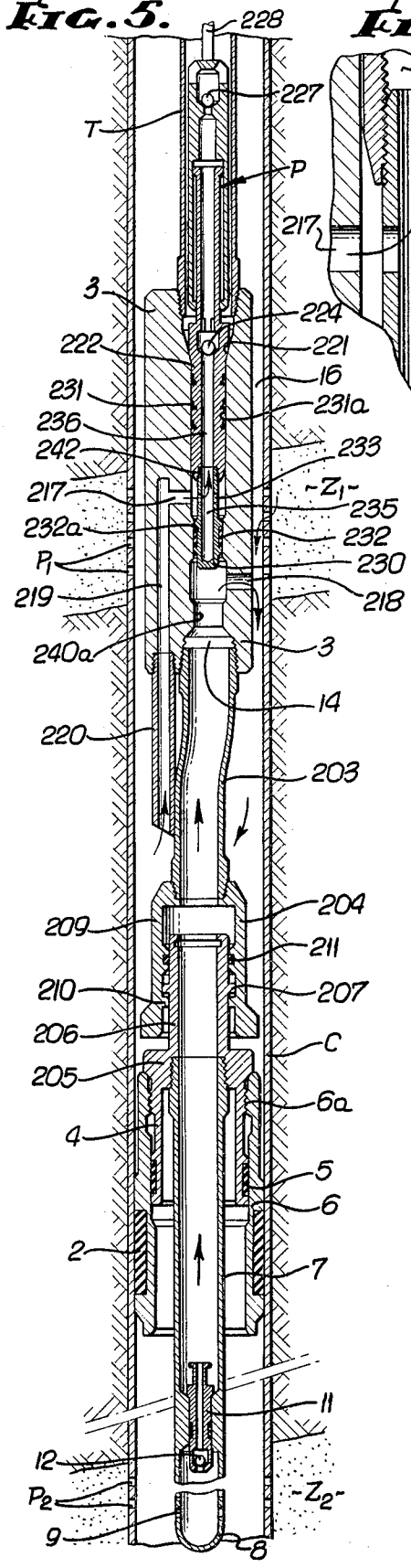


FIG. 6.

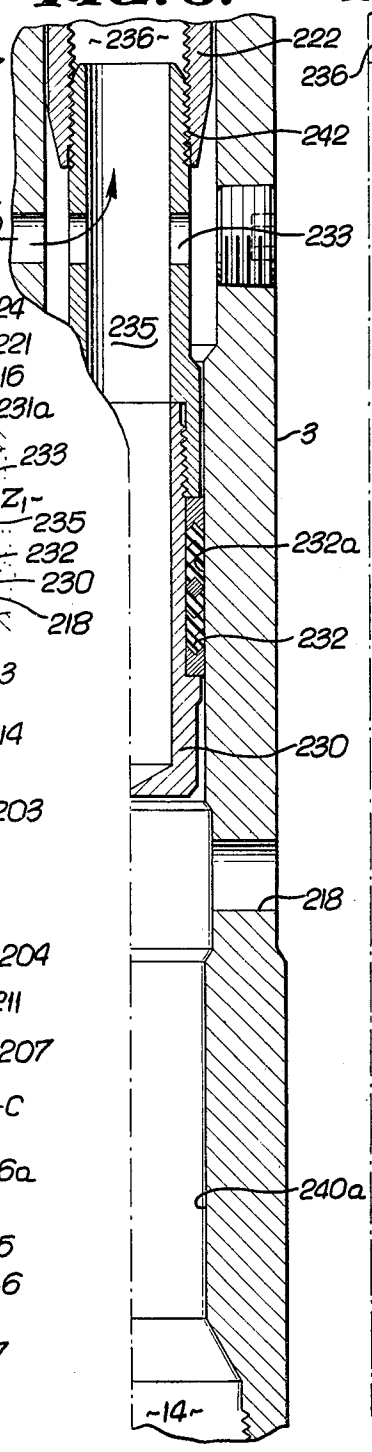


FIG. 7.

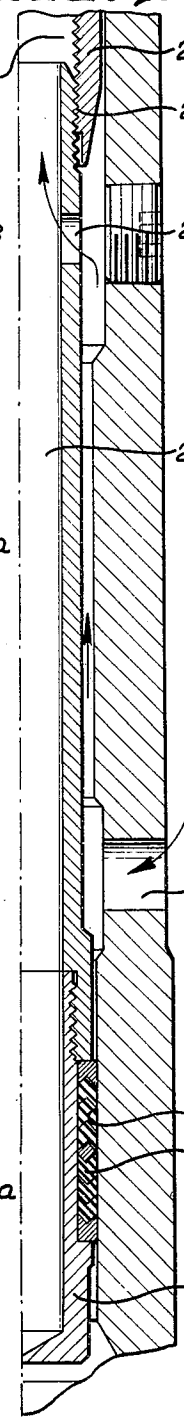
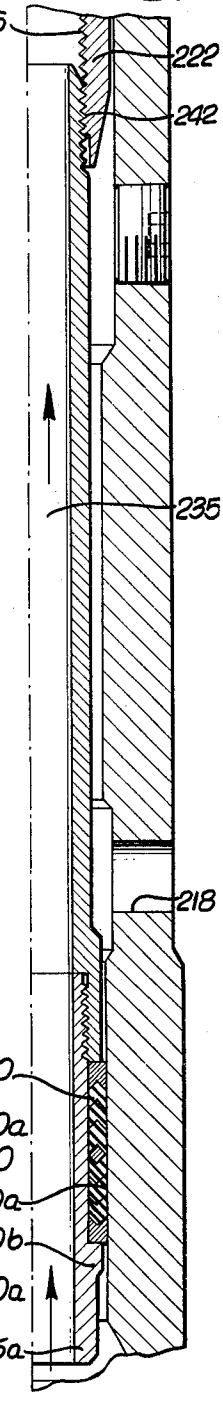


FIG. 8.



INVENTORS.
KURT LEUTWYLER
EARL W. DAVIS
WALDO W. HENSLEE, JR.
By Bernard Kriegel
ATTORNEY.

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FIG. 9.

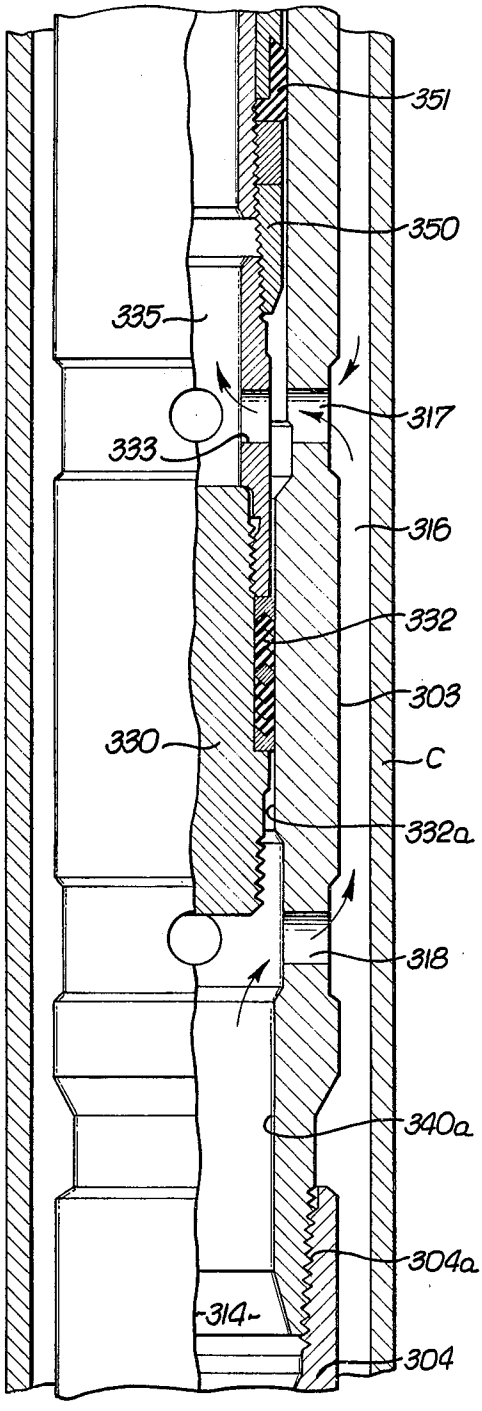


FIG. 10.

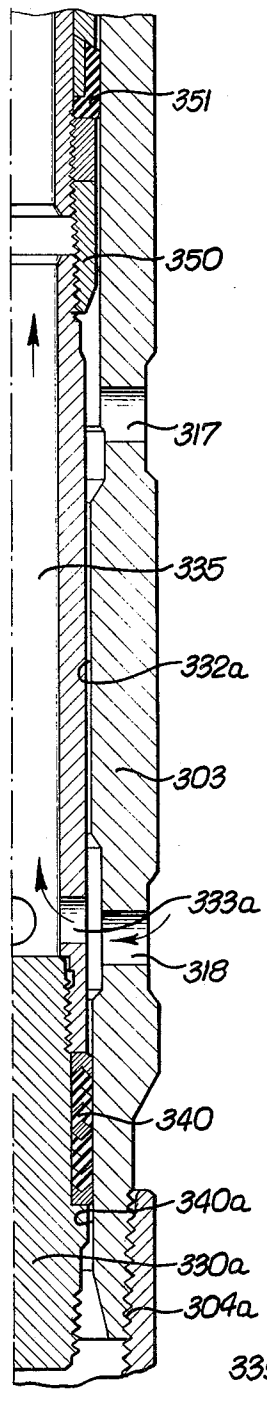
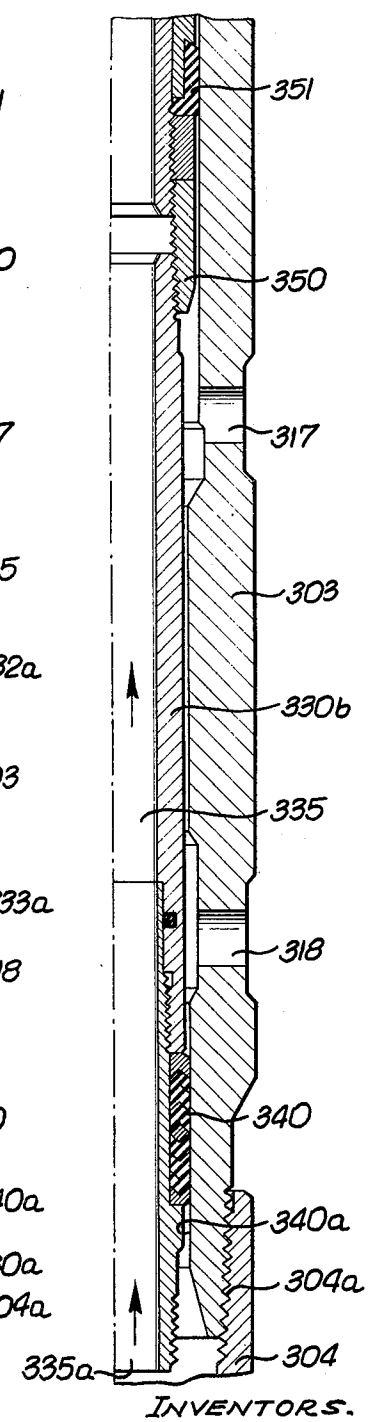


FIG. 11.



INVENTORS.
KURT LEUTWYLER
EARL W. DAVIS
WALDO W. HENSLEE, JR.
By Bernard Kriegel
ATTORNEY.

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CONFLUENT PRODUCTION APPARATUS

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FIG. 12.

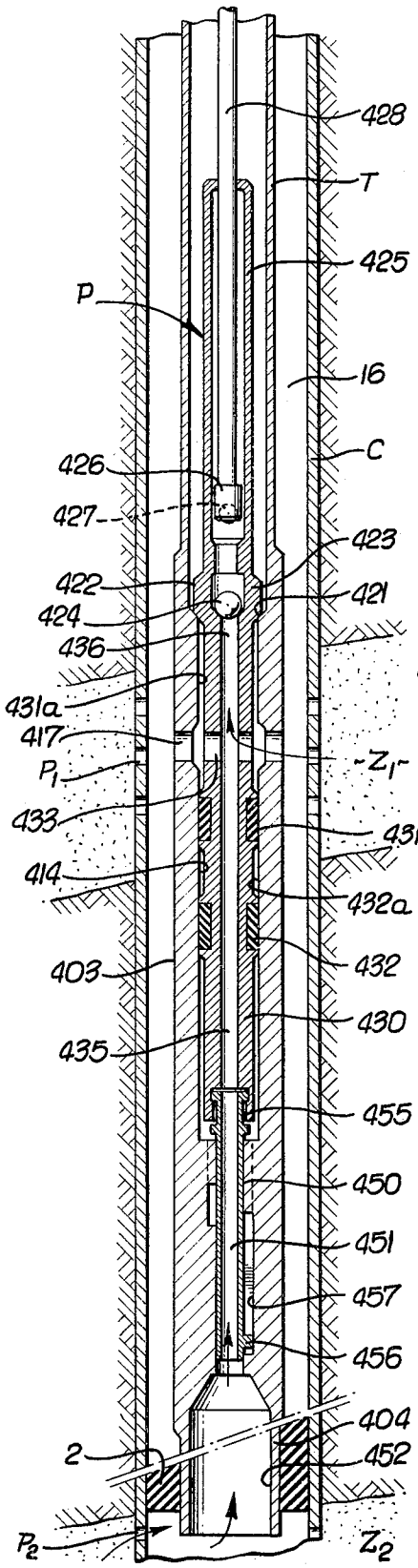


FIG. 13.

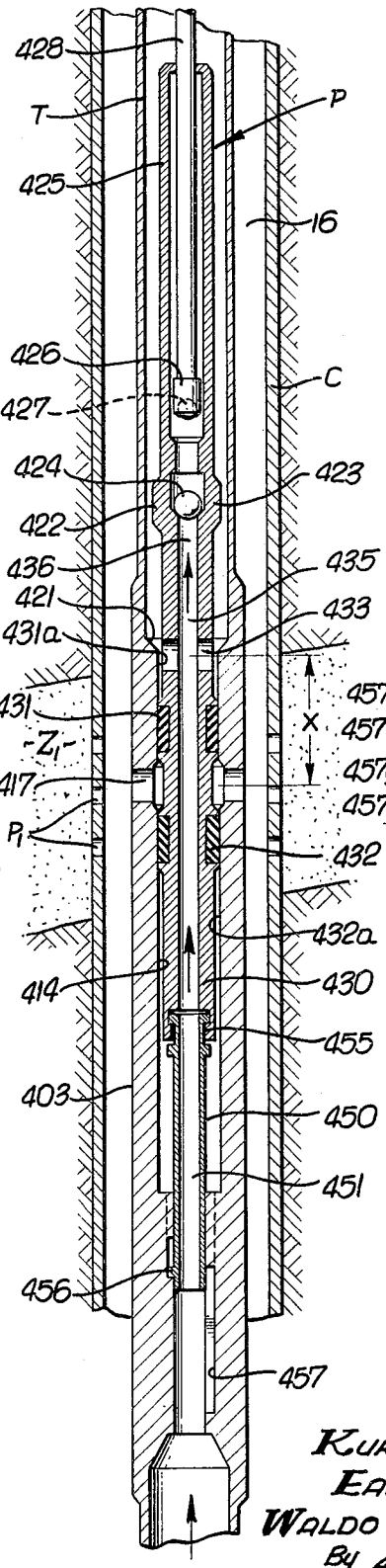
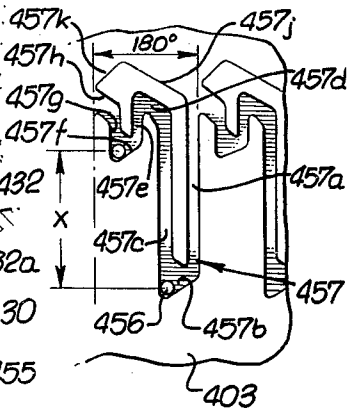


FIG. 14.



INVENTORS.
KURT LEUTWYLER
EARL W. DAVIS
WALDO W. HENSLEE, JR.
By Bernard Kriegel
ATTORNEY.

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3,509,941

CONFLUENT PRODUCTION APPARATUS

Kurt Leutwyler and Earl W. Davis, Houston, Tex., and Waldo W. Henslee, Jr., Lafayette, La., assignors to Baker Oil Tools, Inc., City of Commerce, Calif., a corporation of California

Filed Apr. 22, 1968, Ser. No. 723,007
Int. Cl. E21b 23/00
U.S. Cl. 166—149 32 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus for producing well fluid from a well traversing spaced producing earth zones, in which a tool assembly is disposed in the well casing between the zones and in sealing engagement with the well casing, the tool assembly having passages adapted to communicate with the respective zones, and a device being positionable in the tool for establishing communication between a production tubing string and either of the respective passages selectively, or both of said passages conjointly. Such apparatus wherein said device is removably connectible to a pump for enabling attachment of different devices for production of fluid from either of said zones selectively or from both of said zones conjointly. Such apparatus wherein said device is releasably latched in the tool and is retrievable on a wire line. Such apparatus wherein said device is carried by a pump and selectively positionable in the tool for enabling production of fluid from one of said zones or from both of said zones conjointly.

In the production of oil from wells traversing multiple productive earth zones, and, more particularly, two earth zones spaced from one another and traversed by the well casing, it has been the practice to perforate the casing at each of the zones and to produce one of the zones through tubing disposed in the casing while producing the other zone through the tubing-casing annulus. However, in the absence of sufficient formation pressure to economically produce both zones, or in the event that the production does not equal the allowable rate as prescribed by regulatory laws, artificial means of production are desirable or necessary to maintain a satisfactory production rate.

Heretofore, apparatus has been devised which may be set in the well casing between the zones, whereby production of the fluids may be selectively, by provision of cross-over flow means, alternated in such a manner that the lower zone of a dual completion well may be produced either through the tubing or through the tubing-casing annulus, while the upper zone is produced through the tubing-casing annulus or through the tubing, or vice versa. Such a selective cross-over means, however, does not lend itself to the production of both of the productive zones of a dually completed well by artificial lift or pumping means when the rate of production of the well falls below the total allowable by law.

Under these latter circumstances, it is desirable that a typical pump be employed to effect flow of the well fluid or oil from both of the zones, or either of the zones, selectively, and that it be possible to ascertain the rate of production of one of the zones, say the upper zone, so that, as a matter of subtraction, it is possible to determine the rate of production of the lower zone.

With the foregoing in view, the present invention provides apparatus adapted to be disposed in a well, effectively between the zones of a dual completion well, whereby either of the zones may be selectively produced in one flow path defined by well production tubing in the casing,

or both of the zones may be produced through said one flow path.

More specifically, the invention provides for selective production of either zone through the tubing under the influence of a typical well pump, such as a sucker rod pump, or the confluent production of both of the zones through the tubing.

In accordance with the foregoing, the invention contemplates a tool body, or a tool body assembly, adapted to be run into a well on tubing and to be disposed in a well casing, the body having means for sealing engagement with the well casing between the casing perforations at the spaced zones, the body also having a flow passage communicating with the tubing, ports being provided for establishing communication between the flow passage in the body and the respective zones, and a device being provided to selectively close certain of the ports when it is desired to produce from only one of the zones through the tubing, or, if desired, to allow confluent passage of fluid from both of the zones through the tubing.

In the practical application of the invention, the devices for closing certain of the ports are interchangeably disposable in the body or may be shifted to different positions in the body by manipulation of the pump rods, so as to blank off communication between one of the dual zones and the tubing or to allow communication of both of the zones with the tubing.

This invention possesses many other advantages, and has other purposes which may be made more clearly apparent from a consideration of several forms in which it may be embodied. Such forms are shown in the drawings accompanying and forming part of the present specification. These forms 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:

FIG. 1 is a view in vertical section showing confluent production apparatus made in accordance with the invention and disposed in a dually completed well, and adapted for confluent production from both zones;

FIG. 1*a* is a detail view in longitudinal section showing a bypass blanking plug for use in the apparatus of FIG. 1 for producing only from the upper zone;

FIG. 1*b* is a view corresponding to FIG. 1*a*, but showing a separation sleeve for producing only from the lower zone;

FIG. 2 is an enlarged fragmentary view in vertical section of the flow directing section of a modified apparatus, for confluent production from both zones;

FIG. 3 is an enlarged fragmentary view in vertical section of the flow directing section of the apparatus of FIG. 2, but showing the apparatus for producing only from the upper zone;

FIG. 4 is a view corresponding to FIGS. 2 and 3, but showing the apparatus for producing only from the lower zone;

FIG. 5 is a view in vertical section showing a modified apparatus in condition for confluent production from both zones;

FIG. 6 is an enlarged fragmentary detail view showing the flow directing apparatus of FIG. 5;

FIG. 7 is a view corresponding to FIG. 6, but showing the apparatus in condition for producing only from the upper zone;

FIG. 8 is a view corresponding to FIGS. 6 and 7, but showing the apparatus in condition for producing only from the lower zone;

FIG. 9 is a fragmentary view in vertical section, showing a further modified flow control section in condition for producing from both zones;

FIG. 10 is a view corresponding to FIG. 9, but showing the apparatus in condition for producing only from the upper zone;

FIG. 11 is a view corresponding to FIGS. 9 and 10, but showing the apparatus in condition for producing only from the lower zone;

FIG. 12 is a view in vertical section showing a further modification of the apparatus of the invention in condition for producing from both zones;

FIG. 13 is a view corresponding to FIG. 12, but showing the apparatus in condition for producing from only one of the zones; and

FIG. 14 is a planar development of the control slot means of the apparatus of FIGS. 12 and 13.

Referring to the drawings, the invention, as seen in FIG. 1, involves the control of the flow of oil or well fluid from the spaced zones Z1 and Z2 of earth formation penetrated by a well bore having casing C set therein, the casing having suitably formed perforations P1 and P2 for establishing communication between the respective productive zones Z1 and Z2 and the casing.

In accordance with the invention, apparatus is provided comprising a body or body assembly **1** having packing means **2** providing a seal for separating or isolating the casing C between the perforations P1 and P2. The body **1** comprises a body section or receptacle **3** including a reduced lower end **4** provided with seal means **5** adapted to be removably anchored by latch means at **6***a* in a tubular packer body **6** in a conventional manner. Depending from the upper receptacle **3** is a stinger **7** or elongated nipple which extends downwardly a suitable distance through the packer body **6** to the vicinity of the lower well zone Z2, the lower end **8** of the stinger having ports **9** for the admission of fluid from the zone Z2, which passes into the casing C through the perforations P2. Disposed in the stinger **7** is a seat **10** for a conventional retrievable standing valve assembly **11** including a downwardly seating ball valve **12** adapted to prevent the flow of fluid from zone Z1 into the zone Z2 below the packer means **2**.

The body section or receptacle **3** has an opening or passage **14** extending vertically therethrough and leading from the stinger **7** into an upwardly extended tubing string T which is connected to the receptacle **3** by suitable means, such as a nipple **15**, the tubing, in turn, leading to the top of the well. This tubing T and the receptacle **3** form with the casing C a tubing-casing annulus **16** above the packing **2** into which fluid passes from the upper zone Z1 through the perforations P1.

Axially spaced passage means, including a number of radial ports **17** and **18**, are provided for establishing communication between the annulus **16** and the receptacle passage **14**, the ports **18** communicating with the annulus **16** through an elongated passage **19** extending longitudinally upwardly through the receptacle **3** in laterally spaced relation to the passage **14**. In the illustrative embodiment, the passage **19** is further elongated by the provision of a tube **20** connected to or otherwise made a part of the receptacle **3**, the upper end of the tube **20** being connected to the tubing T and the passage **19** opening into the annulus **16**.

At its upper end, the receptacle **3** is provided with a typical pump seat **21** adapted to receive the usually pump anchor **22**, which, in the illustrative embodiment, is part of a conventional sucker rod pump assembly P, including standing valve means **23** having a downwardly closing ball valve **24** at the lower end of a pump barrel **25**. Reciprocable in the usual manner in the barrel **25** is travelling valve means **26** including a downwardly seating ball valve **27**, this travelling valve means being at the lower end of a reciprocable pump rod **28** extending upwardly from the barrel **25** for connection to the usual sucker rod string (not shown) which is caused to reciprocate to lift fluid through the tubing string T to the top of the well.

In the embodiment of the invention now being described, the pump anchor **22** has connected thereto a downwardly extending flow controlling device **30**, which may be characterized as a blanking plug in that it comprises means for separating the lateral ports **17** and **18**. More specifically, the blanking plug **30** is provided with an upper annular seal **31** adapted for sealing engagement with an upper cylindrical sealing surface **31***a* in the passage **14**, and spaced downwardly from the seal **31** is a second annular seal **32** adapted for sealing engagement with an intermediate cylindrical sealing surface **32***a* in the passage **14**. Between the seals **31** and **32**, the blanking plug **30** has a number of radial ports **33** leading from an annular space **34** in the receptacle **3** to a central passage **35** in the plug **30**, this passage opening upwardly and leading into the inlet **36** of the pump anchor **22**, but being closed at the bottom of the plug **30**.

It will be apparent that operation of the pump, as shown in FIG. 1, will cause the flow of production fluid from zone Z1, as shown by the arrows, through the perforations P1 into the annulus **16**, then through receptacle ports **17** into the annular space **34** between seals **31** and **32** and thence through plug ports **33** into the passage **35**. At the same time, fluid from zone Z2 may flow, as shown by the arrows, through the perforations P2 into the casing C below the packing **2**, then into the stinger **7** through ports **9**, upwardly through the standing valve **11**, through receptacle ports **18** below the plug **30**, then upwardly through the passage **19** into the annulus **16**, where such fluid from zone Z2 comingles with the fluid from zone Z1 for confluent production of the comingled fluids through the same path to the top of the earth, namely, through the tubing T. In this connection, however, if, as is customary in some wells, a cross-over device is provided in the tubing string above the pump P, the comingled fluids may be caused to be produced through the casing.

While the apparatus as described above is adapted to allow the confluent production of comingled fluid from the two earth zones, the apparatus is also adapted to be selectively conditioned to allow production of any the upper zone Z1 by use of the bypass blanking plug **30***a* of FIG. 1*a*, or to allow production of only the lower zone Z2 by use of the separation sleeve **30***b* of FIG. 1*b*.

In this connection, the receptacle or upper body **3** includes a third or lower cylindrical sealing surface **40***a* circumscribing the passage **14** and spaced below the bypass ports **18**, there being an enlarged space **41** between the sealing surface **32***a* and the sealing surface **40** from which the ports **18** lead.

The blanking plug **30** of FIG. 1 is removably connected to the pump anchor **22** by a threaded connection at **42**. Thus, as seen in FIG. 1*a*, the bypass blanking plug **30***a* is provided with an internal thread at **43** for connection to the pump anchor **22** in lieu of the plug **30**. This bypass blanking plug **30***a* is of greater length than the plug **30**, and has an annular seal **40** spaced below its upper seal **31** a sufficient distance as to engage in the sealing surface **40***a* referred to above when the pump P is landed on its seat **21**. The plug **30***a*, like plug **30**, has the ports **33** adapted to communicate with the ports **17** in the receiver, as well as the passage **35**, whereby fluid passing into the space **34** may flow into the passage **35** and thence into the pump inlet **36**. However, since the passage **14** in the receiver is blanked off by the seal **40** below the receiver ports **17**, fluid will be prevented from passing from zone Z2 into the annulus **16**, and, therefore, operation of the pump P will be effective to produce fluid only from the upper zone Z1. Thus, by subtraction, when the confluent production from both zones is known, the production from the lower zone may be determined, as may sometimes be required or desirable.

On the other hand, it may be desirable to produce only the lower zone Z2, under which circumstances the sepa-

ration sleeve or plug 30*b* of FIG. 1*b* will be secured by its internal thread 43 at its upper end to the pump anchor 22. This sleeve or plug 30*b*, like the plugs 30 and 30*a*, has an upper seal 31, and, like the plug 30*a*, has a lower seal 40 adapted to engage in the sealing surface 40*a*. In addition, the passage 35 in the plug or sleeve 30*b* opens at its lower end at 35*a* for entry of fluid from the stinger 7. The plug or sleeve 30*b* has no radial port between the seals 31 and 40, so that when it is in place upon seating of the pump P on its seat 21, the fluid in the tubing-casing annulus 16 is blocked from entering the passage 35. Therefore, only the fluid entering the casing C through the lower perforations P2 from zone Z2 will be produced upon actuation of the pump P.

In FIGS. 2, 3 and 4, there is illustrated modified apparatus wherein the same receptacle 3 and packer 2 may be employed, but the various plugs are adapted to be run into the receptacle and retrieved from the receptacle by use of conventional wireline equipment. In addition, the details of the receptacle 3 are more fully illustrated in FIGS. 2–4.

Referring first to the receptacle 3, it will be noted that the reduced downward extension 4 is provided by threadedly connecting it as at 4*a* within a threaded bore 4*b* in the lower end of the receptacle 3. The latch means 6*a*, by which the receptacle is releasably connectible to the packer body 6, as seen in FIG. 3, comprises a number of circumferentially spaced latch arms 6*b* having thread segments 6*c*. The body section 4 is relieved, as at 6*d*, so that the latch fingers are resiliently flexible inwardly, thereby enabling the latch means to be stabbed into the upper end of the packer body 6. When it is desired that the receptacle 3 be separated from the packer body 6, rotation of the receptacle will cause disengagement of the left-hand thread segments from complemental left-hand threads in the packer body. Such latches are well known and require no further reference herein.

At the upper end of the receptacle 3, the tubular member 20 providing an upward extension of the passage 19 is shown as being threaded into a threaded opening 20*a* in the receptacle 3. In addition, the stinger 7 is shown as being threaded at its upper end into a threaded opening 7*a* in the receptacle 3.

Within the passage 14 of the receptacle 3, the lowermost sealing surface 40*a* is shown as being provided within the stinger 7. Above the uppermost sealing surface 31*a* in passage 14, there is an annular channel or groove 50, the purpose of which is to allow the various plugs hereinafter to be described to be latched in the passage 14 by suitable latch means generally denoted at 51. At its upper end, the receptacle includes a nipple 52 threaded into an opening 53 in the receptacle and also threadedly connected at 21*a* to a sub 21*b*, which, as will be apparent, may be, in turn, connected to a pump seat or other device, such as a cross-over, as previously referred to. It will be understood that, inasmuch as the various plugs now to be described are not connected to the pump P, the pump seat may be conveniently located at any suitable location above the receptacle 3.

In FIG. 2, a blanking plug 130 is shown as having, as in the case of the plug 30, a pair of axially spaced annular seals 131 and 132, with radial ports 133 located between these seals and leading into the central passage 135 in the plug 130. The upper seal 131 is engageable in the sealing surface 31*a* and the lower seal 132 is engageable in the sealing surface 32*a* in the passage 14 of the receptacle, when the plug 130 is properly axially positioned in the passage 14. An upwardly facing shoulder 14*a* in the receptacle passage 14 is engageable with a downwardly facing shoulder 14*b* on the plug 130 to limit downward movement of the plug 130 in the passage 14, and the latch means 51, previously referred to, serve to releasably hold the plug 130 against upward movement in the passage 14, so that the plug 130 is effectively held in position when run into the passage 14.

The upper end of the plug 130 has a recovery head 54 through which the passage 135 opens, and the latch means 51 includes a number of latch elements 55 resiliently biased to effect latching engagement in the groove 50 when the plug is landed on the seat 14*a*, these elements having portions 56 extending into the passage 135 to cause release of the latch elements 55 upon engagement of a conventional recovery tool with the head 54. Such latch means and recovery tool are conventional, requiring no further description herein, but illustrative recovery apparatus is more particularly disclosed in United States Letters Pat. No. 2,885,007.

In the event that it is necessary to balance the pressure across the plug 130, for example, when the plug is to be removed from the receptacle, means may be provided for this purpose, comprising a frangible tube 57 extended across the lower end of the passage 135 below the seal 132 and supported by a perforated screw 58. Breaking of the tube will intercommunicate the passage 135 and nipple 7.

It will now be apparent that when the plug 130 is seated as shown in FIG. 2, the inlet ports 17 of the receptacle communicate with the plug passage 135 through the ports 133, whereby fluid from the tubing-casing annulus, not shown in FIG. 2, may be produced through the plug 130; while fluid from the casing below the packer, also not shown in FIG. 2, may pass through the lower receptacle ports 18, and passage 19 into the annulus above the packer for confluent production of both fluids from the annulus through the ports 17, 133.

Referring to FIG. 3, there is shown the same receptacle structure with a bypass blocking plug 130*a* in the passage 14. Like the plug 30*a* of FIG. 1*a*, the plug 130*a* is elongated so that it spans the received ports 18 and has a lower seal 140 engageable in the sealing surface 40*a* below these ports 18. Thus, when the bypass plug 130*a* is in the receiver, fluid may be produced or may flow through only the upper ports 17, as shown by the arrows.

In the event that production only from the lower zone is desired, the plug 130*a* may be retrieved and the separating sleeve or plug 130*b*, shown in FIG. 4, may be disposed in the receiver 3. This plug 130*b* has the seals 131 and 140 for sealing engagement in the seal surfaces 31*a* and 40*a*, but intermediate these seals the plug 130*b* is imperforate, while the passage 135 opens downwardly into the pasage 14 below the seal 140. Thus, the ports 17 and 18 are blocked off and fluid from the lower zone will flow directly through the plug 130*b*.

Passing to FIGS. 5–8, another modified apparatus is shown which comprises, as in the previous embodiment, a flow change receiver body 3 and a packer assembly including a packing 2, but, here, these two components are interconnected by an intermediate conduit 203 and releasable, sealed connecter means 204. As in the previous embodiment of FIG. 1, the apparatus is shown in well casing C extending through spaced production zones Z1 and Z2, the casing being perforated at P1 and P2 at the respective zones, and the receptacle 3 being connected to a string of production tubing T leading to the top of the well.

The packer assembly as seen in FIG. 5 comprises a body 6, as previously described, in which is releasably latched by latch means 6*a* a body section 4 having a seal 5 engaged in the body 6 and a downwardly extended stinger 7, this stinger being provided with a retrievable standing valve 11 having a downwardly seating ball valve 12, the stinger having inlet ports 9 for entry of fluid in the casing below the packing 2.

The body 4 at its upper end has a wall 205 provided with an upward extended tubular neck 206 having lock pins 207 projecting therefrom. Removably connected to the neck 206 is a hollow body 209 of the sealed connector means 204 having an inner flange 210 provided with openings (not shown), whereby the pins 207 can

pass through the flange **210**, but rotation of the body **209** will angularly displace the pins from said slots, as is typical of a bayonet or J slot structure, requiring no further specific disclosure herein. A seal ring **211** is provided between the body **209** and the neck **206**. The above-mentioned conduit **203** is connected at its lower end to the sealed connector body **209**, and at its upper end to the body or receptacle **3** so that fluid may flow from the casing beneath the packing **2**, upwardly through the stinger **7**, as shown by the arrows, and thence into the passage **14** of the receptacle **3**.

Spaced axially along the passage **14** of the receptacle **3**, as best seen in FIGS. 5 and 6, from top to bottom is an upper cylindrical sealing surface **231***a*, in this embodiment formed as part of the pump seat **221**, an intermediate sealing surface **232***a*, and a lower cylindrical sealing surface **240***a*. Upper radial ports **217** lead into the passage **14** above the sealing surface **232***a*, and lower radial ports **218** lead from the passage **14** between the sealing surfaces **232***a* and **240***a* An elongated passage **219** extends downwardly through the receptacle **3**, the latter having a tube **220** connected thereto to provide a downward extension of the passage **219**. Thus, fluid entering the annulus from zone Z1 and fluid entering the casing C below the packing **2** are comingled as shown by the arrows in FIG. 5, and such comingled fluid may be produced through the tubing T, since the blanking plug **230** is disposed in the passage **14** and has a seal **232** engaged with the sealing surface **232***a* and ports **233** which communicate with the ports **217**.

This blanking plug **230** has a central passage **235** which leads to the inlet **236** of a rod pump P having an anchor **222** seating on a pump seat **221**, as previously described, so that operation of the pump will cause confluent production of fluid from both of the zones Z1 and Z2. The pump of FIG. 5 needs no further description herein, except to note that it is a typical, well known rod pump construction including the usual standing valve **224** and travelling valve **227** operable by a rod **228**. The above-mentioned sealing surface **231***a* is sealingly engaged by seal rings **231** carried by the pump anchor **222**. In this construction, moreover, the blanking plug **230** is removably connected by a threaded joint at **242** to the pump anchor **222**, but, if desired, the anchor and plug may be separate, and the plug **230** may be provided with latch and recovery means, such as, for example, shown in FIGS. 2–4.

In FIG. 7, there is illustrated a modified plug **230***a* constituting a bypass plug, which, like plugs **30***a* and **130***a*, is adapted to block off the flow of fluid from the lower zone Z2 so that only the upper zone Z1 will be produced. Thus, the plug **230***a* spans the ports **218** and has a lower seal **240** engageable in the cylindrical sealing surface **240***a*. When this plug **230***a* is connected at **242** to the pump anchor **222**, fluid from the casing C below the packing **2** is precluded from entering the passage **14** of the receptacle **3**, and such fluid, therefore, cannot pass into the annulus **16** above the packing **2**, from which annulus the pump P lifts the production fluid.

On the other hand, if it is desired to produce only the lower zone, a separation sleeve or plug **230***b*, as shown in FIG. 8, may be employed to block off flow of fluid from the annulus through the ports **217** into the passage **235** in the plug **230***b*. In this construction, the passage **235** is open at the lower end **235***a* of the plug **230***b*, and there are no lateral ports in the plug, such as the ports **233** in plugs **230** and **230***a*. Thus, the only flow path open through the plug **230***b* for the flow of formation fluid is upwardly from the conduit **203**, through the plug passage **235**, directly to the pump inlet **236** from zone Z1.

Referring now to FIGS. 9–11, there is shown a further modified construction involving concentric flow paths for the fluid from the respective zones, as distinguished from the offset by pass flow paths of the previously described embodiments.

More specifically, as seen in FIG. 9, the receiver **303** comprises an elongated tubular body having at its lower end a threaded connection **304***a* with a downward extension **304**, which, as now will be understood, is adapted to be connected to packer means forming a seal with the well casing to separate the tubing-casing annulus **316** above the packer from the casing C below the packer, in the typical dually completed well referred to above. At its upper end, the receiver is adapted, as will now be understood, to be connected to a production tubing string. Extending longitudinally through the receiver **303** is a passage **314**, there being an upper set of ports **317** and a lower set of ports **318** leading into the passage **314** from the annulus **316**. Between the ports **317** and **318** is a cylindrical sealing surface **332***a*, and below the ports **318** is a cylindrical sealing surface **340***a*.

In order to condition the apparatus for the confluent production of fluid from a pair of spaced well zones, such as the zones Z1 and Z2 previously described, a blanking plug **330**, generally corresponding to the plugs **30**, **130** and **230** previously described, is adapted to be disposed in the receiver passage **314**. This plug **330** has a seal **332** engageable with the surface **332***a*. Above the seal **332**, the plug has ports **333** adapted to communicate with the upper receiver ports **317** and a central passage **335** in the plug **330**, so that fluid in the annulus **316** may pass into the plug through these ports. At its upper end, the plug **330** is provided with a sealing nipple **350** having a seal ring **351** sealingly engageable in the receiver passage **314** above the ports **317** to provide the uppermost seal. It will be understood that the nipple **350** may be connected to a pump, so that the plug **330** may be run into the receiver with the pump, as previously described, or the plug may be provided with releasable latch means so as to be recoverable on a wire line, also as previously described. In any event, the fluid from below the assembly may flow upwardly through the body **304** into the passage **314** of the receiver **303**, thence outwardly through the ports **318** into the annulus **316** above the packer, where it will comingle with fluid flowing into the annulus **316** from the upper well zone. The comingled fluid is then free to flow into the plug **330** through ports **317** and **333** for upward flow in plug passage **335** into the production tubing.

In FIG. 10, the apparatus is shown conditioned to allow production only of the upper zone of the well, as in the previously described embodiments, by a bypass plug **330***a*, this plug serving to block off communication between ports **318** and the casing below the packer, as previously described. Thus, the plug **330***a* is of such greater length than the plug **330** that the sealing means **340** engages in the sealing surface **340***a*. In this embodiment, when the plug **330***a* is in the position shown in FIG. 10, fluid from the annulus only is free to enter the plug passage **335** through the ports **318** and the ports **333***a* in the plug, the fluid from the casing below the packer being blocked off.

Referring to FIG. 11, a separation sleeve or plug **330***b* is shown, wherein the seal **340** engages in the sealing surface **340***a*, and the lower end **335***a* of the plug is open so that fluid from the casing below the packer may flow upwardly through the plug passage **335**. The plug, otherwise, is imperforate so as to preclude flow of fluid from the tubing-casing annulus, and, therefore, only the lower well zone is produced.

Without requiring further illustration herein, it will be understood that the respective flow controllers or plugs **330**, **330***a*, and **330***b* of FIGS. 9, 10 and 11, may be either connected to a pump in the manner illustrated in FIG. 1 or FIG. 5, on the one hand, or may be, on the other hand, adapted to be seated and latched in the passage **314** in the manner illustrated in FIGS. 2, 3 and 4, within the purview of the invention.

All of the forms of apparatus described above involve the substitution of the various blanking plugs, bypass plugs, and separation sleeves or plugs in order to selectively produce from either of the two zones or confluently. Sometimes, however, it is desirable that both zones be produced normally, but only one of the zones be produced for a period of time to allow a determination to be made respecting the relative production from the zones as a matter of simple subtraction. In FIGS. 12, 13 and 14, there is illustrated a further modified apparatus, wherein the apparatus may be adjusted by simple manipulation without pulling the pump or recovering a plug by wire line in order to effect the change.

As in the previously described embodiments, the casing C is cemented in the well and extends through the upper and lower producing zones Z1 and Z2, respectively, a suitable packer **2** being set in the casing between the zones so that fluid enters the tubing-casing annulus **16** from zone Z1 through perforations P1 above the packer **2**, and fluid enters the casing C below the packer **2** through perforations P2 from zone Z2.

In this embodiment, the receiver **403** comprises an elongated body having a bore **414**. At its upper end, the receiver body **403** is connected in the usual manner to a string of production tubing T extending to the top of the well. A pump seat **421** is provided for seating of the anchor **422** of a typical rod pump P, including a standing valve **423** having a downwardly seating ball valve **424**, and a travelling valve **426** having a downwardly seating ball valve **427**, the travelling valve being reciprocable in the pump barrel **425** by a pump rod **428**.

Within the bore **414** of the receiver body **403** is a blanking plug or sleeve **430** having axially spaced annular seals **431** and **432**, and the bore **414** is defined by axially spaced annular sealing surfaces **431***a* and **432***a*. Between these sealing surfaces **431***a* and **432***a*, the body **403** has a number of radial ports **417** for establishing communication between the annulus **16** and the bore **414** when the plug **430** is in one position, as seen in FIG. 12, but such communication being prevented when the plug **430** is in another or second position, as shown in FIG. 13, wherein the seal **431** is engaged in the sealing surface **431***a* and the seal **432** is engaged in the surface **432***a*, so as to blank off the ports **417**.

This plug or sleeve **430** has radial ports **433** leading to a central passage **435** in the plug, so that when the ports **417** and **433** communicate, as in FIG. 12, fluid from the annulus **16** may pass into the passage **435** and thence to the pump inlet **436**, whereby to produce from the upper zone Z1. In order to produce from the lower zone, a tubular member **450** having a passage **451** extends downwardly from the plug **430**, the passage **451** communicating at its lower end with the central opening **452** in the packer body **404**. Thus, fluid from the casing C below the packer **2** may pass upwardly through passages **452**, **451**, and **435**, comingling with fluid entering the passage **435** from the annulus **16** through ports **417** and **433** for confluent production in response to operation of the pump P.

Means are provided for positioning the plug or sleeve **430** in the position shown in FIG. 13, at which the seals **431** and **432** straddle the receptacle ports **417** to prevent flow of annulus fluid into the pump. Such means includes, in this illustrative embodiment, the tubular member **450**. This member **450** and the body **403** are provided with cooperative pin and slot means, whereby, upon pulling upwardly on the pump rod **428** a distance greater than a normal pumping stroke, the pump P and, therefore, the plug **430**, will be moved upwardly to the blanking position shown in FIG. 13, and thereafter the pump may be operated to produce fluid only from the lower zone.

In this connection, the tubular member **450** is connected to the lower end of the plug **430** by means of a swivel connection at **455**. Adjacent its lower end, the tubular member **450** is provided with a pin **456** projecting radially into a control slot **457** suitably formed with the body **403**, the configuration of which is best seen in FIG. 14. This slot is repetitive in form, and each element of the slot includes a vertical open topped slot **457***a*, terminating in an inclined bottom slot **457***b* which leads to another vertical slot **457***c*, terminating at its upper end in an inclined slot **457***d* which leads to a short vertical slot **457***e*, terminating in an inclined slot **457***f* which leads to a short vertical slot **457***g*, terminating in an inclined slot **457***h*, this latter inclined slot opening, effectively, into the upper portion of the long vertical slot **457***a*. Angular guide surfaces **457***j* and **457***k* are provided, whereby the pin **456** is always guided back into a slot **457***a* following movement of the pin **456** upwardly out of one of the slots **457***a*. The bottoms of slots **457***c* and **457***g* effectively provide axially spaced shoulders, spaced a distance X, corresponding to the desired range of axial movement of the plug **430**.

Therefore, it is apparent that the plug or sleeve **430** will be held in either a position at which the pump is seated on its seat **421** and the pin **456** is substantially at the bottom of slot **457***c*, or in an upwardly displaced position at which the pin **456** is at the bottom of slot **457***g*. When it is desired to shift the plug **430** from the first position, as shown in FIG. 12, it is only necessary to lift upwardly on the pump rod **428** a distance greater than the pumping stroke, whereby to pull upwardly on the plug **430**, and, as the plug moves upwardly, the pin **456** will be cammed angularly in the inclined slot **457***d*. Thereafter, when the pump rod **428** is lowered, the pin **456** will arrest downward movement of the plug **430** when the pin engages at the bottom of slot **457***g* to locate the sleeve in the position shown in FIG. 13. In this position, of course, the seal **431** serves to anchor the pump against upward movement in the same manner that the usual anchor **422** functions to hold the pump on the seat **421**.

We claim:

1. In oil well producing apparatus for use in producing a pair of spaced well zones through a single well pipe: packer means sealingly engageable in said well between said zones, a body adapted to be disposed in said casing above said packer means, said body having a first flow path leading between said well pipe and said well outside of said body above said packer means through which fluid from an upper zone can flow, means providing a second flow path leading between said well outside of said body above said packer means and said well below said packer means through which fluid from a lower zone can flow and comingle above said packer means and outside of said body with fluid from said upper zone, and plug means selectively positionable in said body to close off one of said flow paths and to open both of said flow paths, whereby fluid can flow only from one of said zones to said well pipe and confluently from both of said zones for comingling above said packer means and outside said body and into said well pipe.

2. Oil well producing apparatus as defined in claim **1**, wherein pump means are provided in said well pipe.

3. Oil well producing apparatus as defined in claim **1**, wherein pump means are removably disposed in said well pipe, and said plug means are positionable by said pump means.

4. Oil well producing apparatus as defined in claim **1**, wherein said plug means and said body have cooperative means for positioning said plug means.

5. Oil well producing apparatus as defined in claim **1**, wherein said plug means and said body have cooperative means for positioning said plug means including releasable latch means on said plug means, said plug means having means engageable by a recovery tool for releasing said latch means for allowing removal of said plug means from said body.

6. Oil well producing apparatus as defined in claim **31**, wherein said plug means and said body have cooperative means for positioning said plug means including pin and slot means for positioning said plug means, and means for

moving said plug means to operate said pin and slot means.

7. Oil well producing apparatus as defined in claim 31, wherein said plug means and said body have cooperative means for positioning said plug means including pin and slot means for positioning said plug means, and means for moving said plug means to operate said pin and slot means including pump means disposed in said tubing and connected to said plug means.

8. Oil well producing apparatus as defined in claim 1, wherein said body is provided with an elongate passage having axially spaced cylindrical sealing surfaces and a radial port in said first flow path leading into said passage from outside of said body between said sealing surfaces, and said plug means comprises a tubular member having seals engageable with said sealing surfaces, said plug means having a passage therein leading to said well pipe, and an opening in one of said flow paths leading into said passage in said plug means.

9. Oil well producing apparatus as defined in claim 8, wherein said opening is in said first flow path and comprises a port in said plug means between said seals.

10. Oil well producing apparatus as defined in claim 8, wherein said opening is in said second flow path and comprises an open end of said plug means.

11. In oil well producing apparatus for use in producing a pair of spaced well zones through a single well pipe: packer means sealingly engageable in said well between said zones, a body adapted to be disposed in said casing above said packer means, said body having a first flow path leading between said well pipe and said well outside of said body above said packer means, means providing a second flow path separate from said first flow path and leading between said well outside of said body above said packer means and said well below said packer means, and plug means selectively positionable in said body to close off one of said flow paths and to open both of said flow paths, whereby fluid can flow only from one of said zones to said well pipe and confluently from both of said zones to said well pipe, wherein said body is provided with an elongate passage having axially spaced upper, intermediate, and lower cylindrical sealing surfaces and a radial port in said first flow path leading into said passage from outside of said body between said upper and intermediate sealing surfaces, said plug means comprises an elongate member having sealing rings for engagement with certain of said sealing surfaces, and said plug means having a passage therein leading to said well pipe and an opening in said second flow path communicating with said passage.

12. In oil well producing apparatus for use in producing a pair of spaced well zones through a single well pipe: packer means sealingly engageable in said well between said zones, a body adapted to be disposed in said casing above said packer means, said body having a first flow path leading between said well pipe and said well outside of said body above said packer means, means providing a second flow path separate from said first flow path and leading between said well outside of said body above said packer means and said well below said packer means, and plug means selectively positionable in said body to close off one of said flow paths and to open both of said flow paths, whereby fluid can flow only from one of said zones to said well pipe and confluently from both of said zones to said well pipe, wherein said body is provided with an elongate passage having axially spaced upper, intermediate, and lower cylindrical sealing surfaces and a radial port in said first flow path leading into said passage from outside of said body between said upper and intermediate sealing surfaces, and said plug means comprises an elongate member adapted to be disposed in said passage and having a central passage opening upwardly into said well pipe and a port in said second flow path, said elongate member having sealing rings engageable with said upper and intermediate sealing surfaces.

13. In oil well producing apparatus for use in producing a pair of spaced well zones through a single well pipe: packer means sealingly engageable in said well between said zones, a body adapted to be disposed in said casing above said packer means, said body having a first flow path leading between said well pipe and said well outside of said body above said packer means, means providing a second flow path separate from said first flow path and leading between said well outside of said body above said packer means and said well below said packer means, and plug means selectively positionable in said body to close off one of said flow paths and to open both of said flow paths, whereby fluid can flow only from one of said zones to said well pipe and confluently from both of said zones to said well pipe, wherein said body is provided with an elongate passage having axially spaced upper, intermediate, and lower cylindrical sealing surfaces and a radial port in said first flow path leading into said passage from outside of said body between said upper and intermediate sealing surfaces, and said plug means comprises an elongate member adapted to be disposed in said passage and having a central passage opening upwardly into said well pipe and a port in said second flow path, said elongate member having sealing rings engageable with said upper and lower sealing surfaces, said port of said elongate member being between said sealing rings.

14. In oil well producing apparatus for use in producing a pair of spaced well zones through a single well pipe: packer means sealingly engageable in said well between said zones, a body adapted to be disposed in said casing above said packer means, said body having a first flow path leading between said well pipe and said well outside of said body above said packer means, means providing a second flow path separate from said first flow path and leading between said well outside of said body above said packer means and said well below said packer means, and plug means selectively positionable in said body to close off one of said flow paths and to open both of said flow paths, whereby fluid can flow only from one of said zones to said well pipe and confluently from both of said zones to said well pipe, wherein said body is provided with an elongate passage having axially spaced upper, intermediate, and lower cylindrical sealing surfaces and a radial port in said first flow path leading into said passage from outside of said body between said upper and intermediate sealing surfaces, and said plug means comprises an elongate member adapted to be disposed in said passage and having a central passage therethrough in said second flow path, said elongate member having sealing rings engageable with said upper and lower sealing surfaces.

15. In oil well producing apparatus for use in producing a pair of spaced well zones through a single well pipe: packer means sealingly engageable in said well between said zones, a body adapted to be disposed in said casing above said packer means, said body having a first flow path leading between said well pipe and said well outside of said body above said packer means, means providing a second flow path leading between said well outside of said body above said packer means and said well below said packer means, and plug means selectively positionable in said body to close off one of said flow paths and to open both of said flow paths, whereby fluid can flow only from one of said zones to said well pipe and confluently from both of said zones to said well pipe, wherein said body is provided with an elongate passage having upper and lower cylindrical sealing surfaces, a radial port in said first flow path above said upper sealing surface leading into said passage from outside of said body, a radial port in said second flow path between said upper and lower sealing surfaces leading into said passage from outside of said body, and said plug means comprises an elongate member having a central passage leading to said well pipe and an opening in one of said flow paths, said elongate member having sealing ring means engageable with one of said sealing surfaces.

16. In oil well producing apparatus for use in producing a pair of spaced well zones through a single well pipe: packer means sealingly engageable in said well between said zones, a body adapted to be disposed in said casing above said packer means, said body having a first flow path leading between said well pipe and said well outside of said body above said packer means, means providing a second flow path leading between said well outside of said body above said packer means and said well below said packer means, and plug means selectively positionable in said body to close off one of said flow paths and to open both of said flow paths, whereby fluid can flow only from one of said zones to said well pipe and confluently from both of said zones to said well pipe, wherein said body is provided with an elongate passage having upper and lower cylindrical sealing surfaces, a radial port in said first flow path above said upper sealing surface leading into said passage from outside of said body, a radial port in said second flow path between said upper and lower sealing surfaces leading into said passage from outside of said body, said plug means comprises an elongate member having a central passage and an opening in one of said flow paths, said elongate member having sealing ring means engageable with one of said sealing surfaces, and including support means sealingly engaged in said passage in said body for supporting said plug means and having an opening leading from said passage in said body into said well pipe.

17. In oil well producing apparatus for use in producing a pair of spaced well zones through a single well pipe: packer means sealingly engageable in said well between said zones, a body adapted to be disposed in said casing above said packer means, said body having a first flow path leading between said well pipe and said well outside of said body above said packer means, means providing a second flow path leading between said well outside of said body above said packer means and said well below said packer means, and plug means selectively positionable in said body to close off one of said flow paths and to open both of said flow paths, whereby fluid can flow only from one of said zones to said well pipe and confluently from both of said zones to said well pipe, wherein said body is provided with an elongate passage having upper and lower cylindrical sealing surfaces, a radial port in said first flow path above said upper sealing surface leading into said passage from outside of said body, a radial port in said second flow path between said upper and lower sealing surfaces leading into said passage from outside of said body, and said plug means comprises an elongate member having a central passage opening upwardly and a port in said first flow path, said elongate member having sealing ring means below said port engageable with said upper sealing surface.

18. In oil well producing apparatus for use in producing a pair of spaced well zones through a single well pipe: packer means sealingly engageable in said well between said zones, a body adapted to be disposed in said casing above said packer means, said body having a first flow path leading between said well pipe and said well outside of said body above said packer means, means providing a second flow path leading between said well outside of said body above said packer means and said well below said packer means, and plug means selectively positionable in said body to close off one of said flow paths and to open both of said flow paths, whereby fluid can flow only from one of said zones to said well pipe and confluently from both of said zones to said well pipe, wherein said body is provided with an elongate passage having upper and lower cylindrical sealing surfaces, a radial port in said first flow path above said upper sealing surface leading into said passage from outside of said body, a radial port in said second flow path between said upper and lower sealing surfaces leading into said passage from outside of said body, and said plug means comprises an elongate member having a central passage opening upwardly and a port in said first flow path, said elongate member having sealing ring means below said port engageable with said lower sealing surface.

19. In oil well producing apparatus for use in producing a pair of spaced well zones through a single well pipe: packer means sealingly engageable in said well between said zones, a body adapted to be disposed in said casing above said packer means, said body having a first flow path leading between said well pipe and said well outside of said body above said packer means, means providing a second flow path leading between said well outside of said body above said packer means and said well below said packer means, and plug means selectively positionable in said body to close off one of said flow paths and to open both of said flow paths, whereby fluid can flow only from one of said zones to said well pipe and confluently from both of said zones to said well pipe, wherein said body is provided with an elongate passage having upper and lower cylindrical sealing surfaces, a radial port in said first flow path above said upper sealing surface leading into said passage from outside of said body, a radial port in said second flow path between said upper and lower sealing surfaces leading into said passage from outside of said body, and said plug means comprises an elongate member having a central passage therethrough, said elongate member having sealing ring means engageable with said lower sealing surface.

20. Oil well producing apparatus as defined in claim 31, wherein said body is provided with an elongate bore having upper and lower cylindrical sealing surfaces, a radial port in said first flow path leading into said bore between said sealing surfaces, said plug means including an elongate member having a central opening therethrough in said second flow path, said elongate member having upper and lower sealing rings and a port in said first flow path above said upper sealing ring and including means for selectively positioning said elongate member in a first position with said upper and lower seal rings engaged with said upper and lower sealing surfaces to close said first flow path and a second position with said upper and lower seal rings engaged with said lower sealing surfaces to open said first flow path.

21. Oil well producing apparatus as defined in claim 31, wherein said body is provided with an elongate bore having upper and lower cylindrical sealing surfaces, a radial port in said first flow path leading into said bore between said sealing surfaces, said plug means including an elongate member having a central opening therethrough in said second flow path, said elongate member having upper and lower sealing rings and a port in said first flow path above said upper sealing ring and including cooperative pin and slot means in said body and carried by said elongate member for selectively positioning said elongate member in a first position with said upper and lower seal rings engaged with said upper and lower sealing surfaces to close said first flow path and a second position with said upper and lower seal rings engaged with said lower sealing surfaces to open said first flow path.

22. Oil well producing apparatus as defined in claim 31, wherein said body is provided with an elongate bore having upper and lower cylindrical sealing surfaces, a radial port in said first flow path leading into said bore between said sealing surfaces, said plug means including an elongate member having a central opening therethrough in said second flow path, said elongate member having upper and lower sealing rings and a port in said first flow path above said upper sealing ring and including cooperative pin and slot means in said body and carried by said elongate member for selectively positioning said elongate member in a first position with said upper and lower seal rings engaged with said upper and lower sealing surfaces to close said first flow path and a second position with said upper and lower seal rings

engaged with said lower sealing surfaces to open said first flow path, said pin and slot means including a tubular member, means swivelly connecting said tubular member to said elongate member, said tubular member having an opening in said second flow path communicating with said passage in said elongate member, said tubular member having a pin, and said body having a slot configuration including axially spaced shoulders engageable by said pin for holding said elongate member in said first and second positions.

23. In oil well producing apparatus for use in producing through production tubing a pair of spaced well zones in which a perforated casing is set: a well packer having means sealingly engageable with the casing between said zones, a body connected above said packer, said body having a passage extended vertically therethrough and leading to said tubing, means for conducting fluid from below said packer to said passage, an upper radial port leading into said passage from outside of said body, a lower radial port leading to said passage from outside of said body, and plug means selectively positionable in said passage for closing off said passage above said lower port and establishing communication between said upper port and said passage, and for closing off said passage below said lower port and establishing communication between said upper port and said passage, and for closing off both of said ports and establishing communication between said tubing and said casing below said packer.

24. Oil well producing apparatus as defined in claim **23**, wherein pump means are provided in said tubing, said pump means having an inlet communicating with said plug means.

25. Oil well producing apparatus as defined in claim **23**, wherein pump means are provided in said tubing, and including means for removably connecting said plug means to said pump means for selectively positioning said plug means in said passage.

26. Oil well producing apparatus as defined in claim **23**, wherein releasable latch means are provided for releasably retaining said plug means in position.

27. Apparatus as defined in claim **23**, wherein said body is provided with an upwardly opening second passage communicating with said lower port.

28. Apparatus as defined in claim **23**, wherein said body is provided with a downwardly opening second passage communicating with said lower port.

29. Apparatus as defined in claim **23**, including releasable latch means for connecting said body to said packer.

30. Apparatus as defined in claim **23**, including releasable sealing coupling means for interconnecting said body to said packer, and a conduit leading from said coupling means to said passage in said body.

31. In oil well producing apparatus for use in producing a pair of spaced well zones through a single well pipe: packer means sealingly engageable in said well between said zones, a body adapted to be disposed in said casing above said packer means, said body having a first flow path leading between said well pipe and said well outside of said body above said packer means, means providing a second flow path separate from said first flow path and leading between said well outside of said body above said packer means and said well below said packer means, and plug means selectively positionable in said body in said first flow path to close off one of said flow paths and to open both of said flow paths, whereby fluid can flow only from one of said zones to said well pipe and confluently from both of said zones to said well pipe.

32. Oil well producing apparatus as defined in claim **1**; wherein said plug means is selectively positionable in said body in said first flow path to close off one of said flow paths and to open both of said flow paths.

References Cited

UNITED STATES PATENTS

2,970,648	2/1961	Daffin et al.	166—189
3,064,580	11/1962	Calvert et al.	166—313
3,208,527	9/1965	Bayless	166—106
3,252,515	4/1966	Donaldson et al.	166—189
3,282,341	11/1966	Hodges	166—313

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166—189