

Feb. 27, 1962

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3,022,829

WELL ASSEMBLY FOR REDUCING LIQUID LEVEL IN WELL TUBING

Filed July 2, 1958

4 Sheets-Sheet 1

Fig. 1

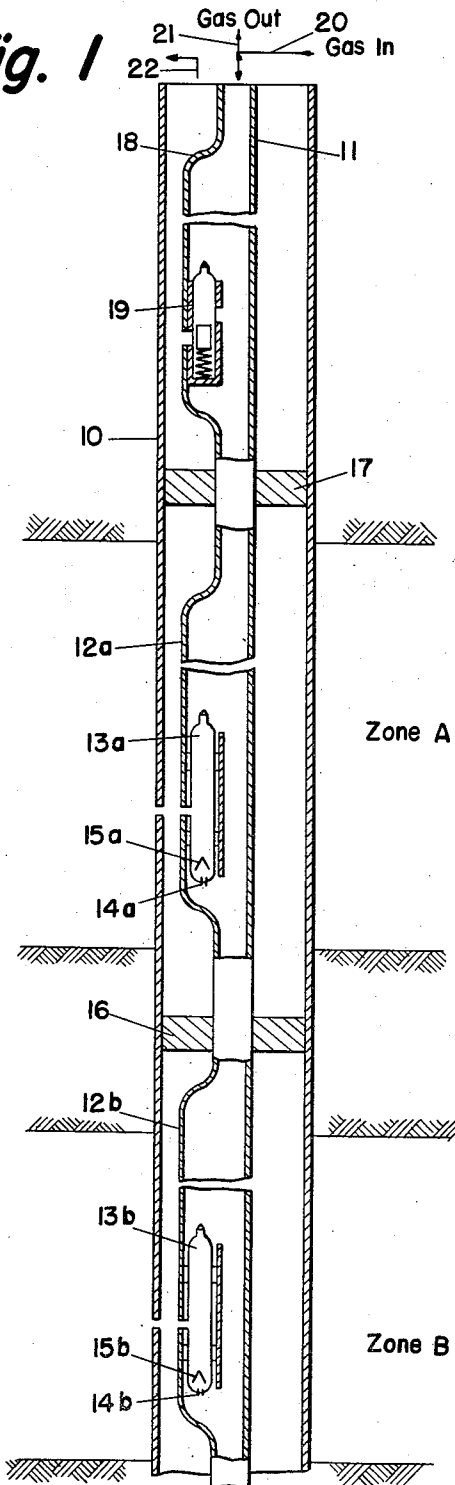
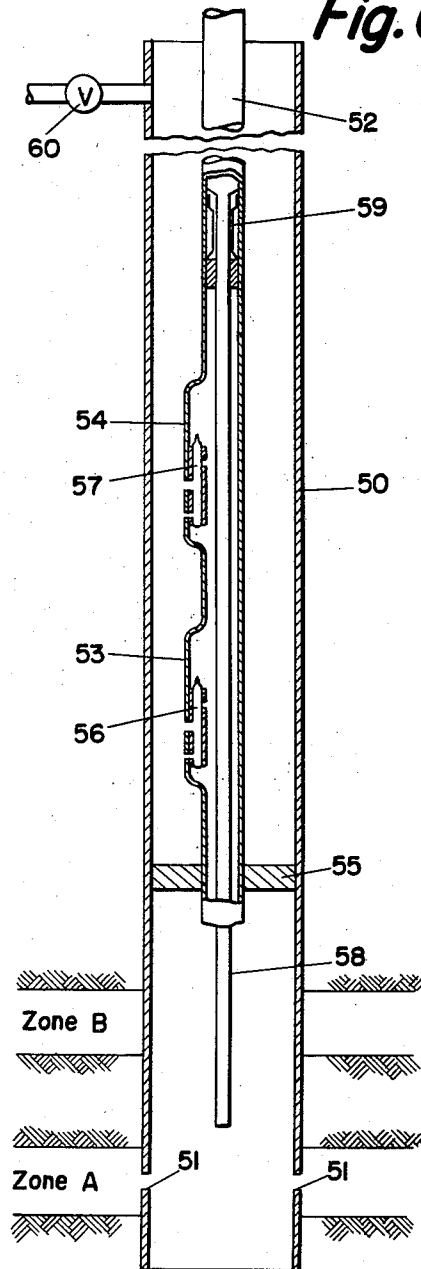


Fig. 6



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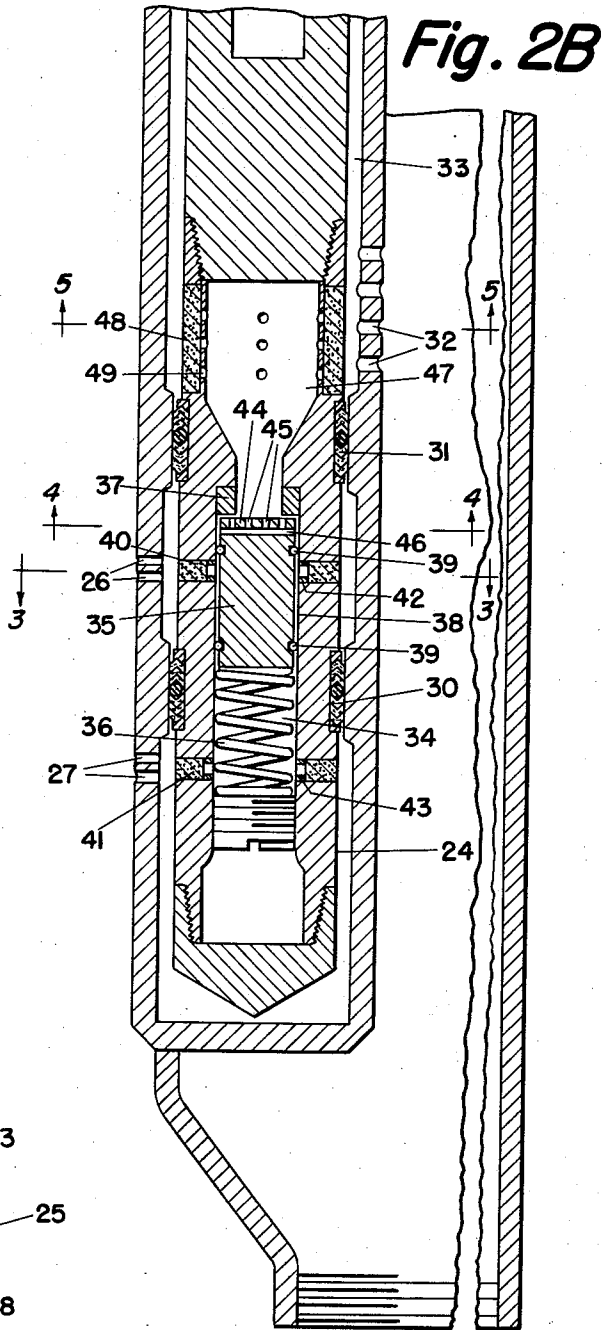
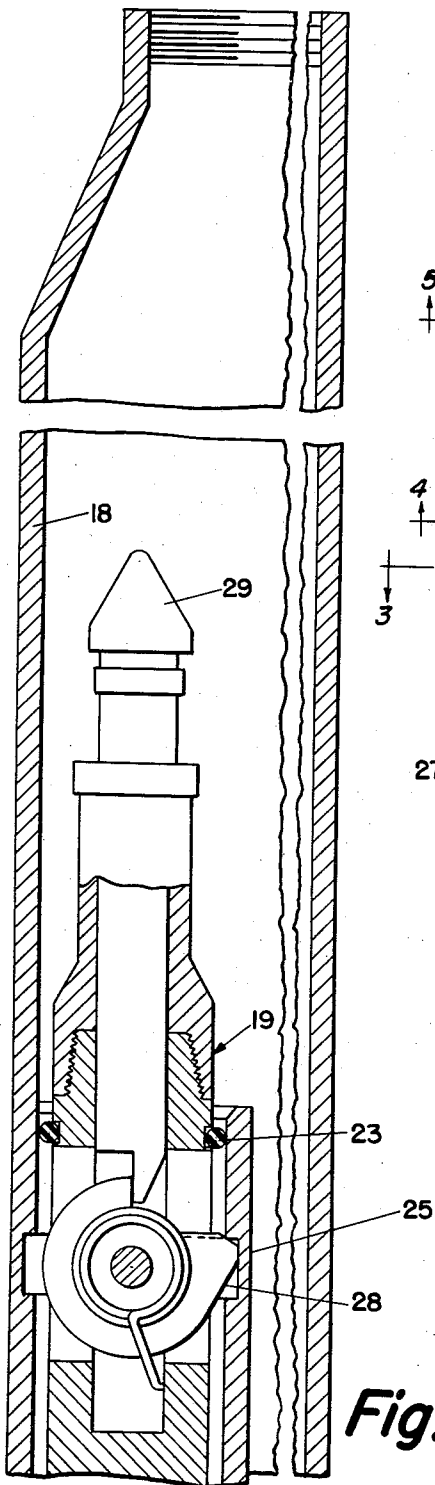


Fig. 2B

Fig. 2A

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Fig. 3

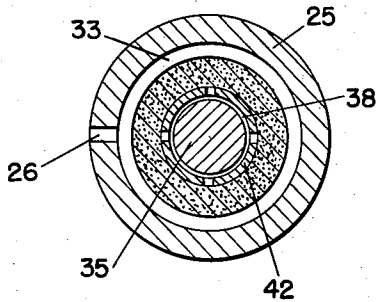


Fig. 4

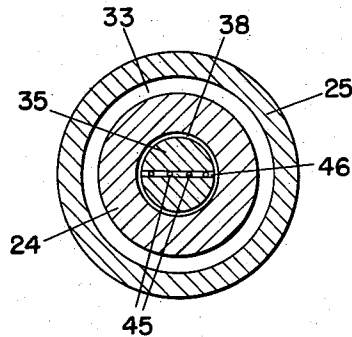


Fig. 5

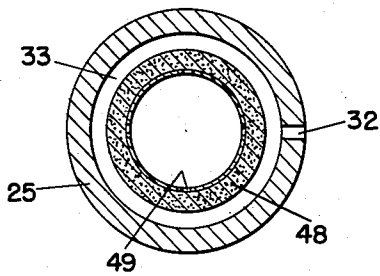


Fig. 8

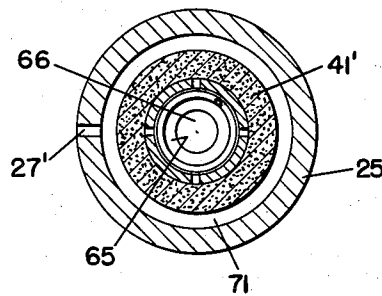
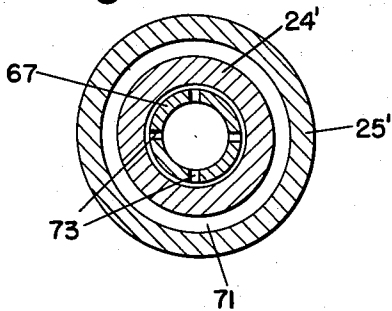


Fig. 9



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Fig. 7A

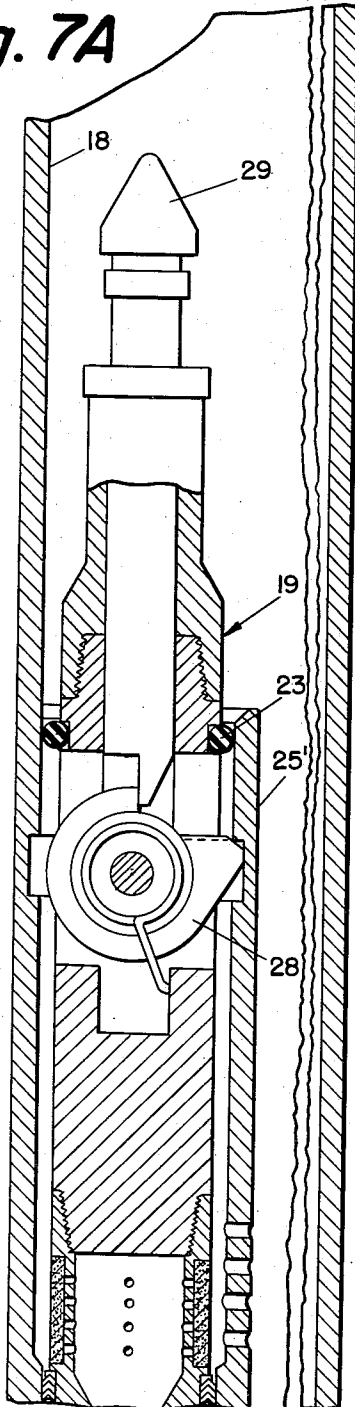
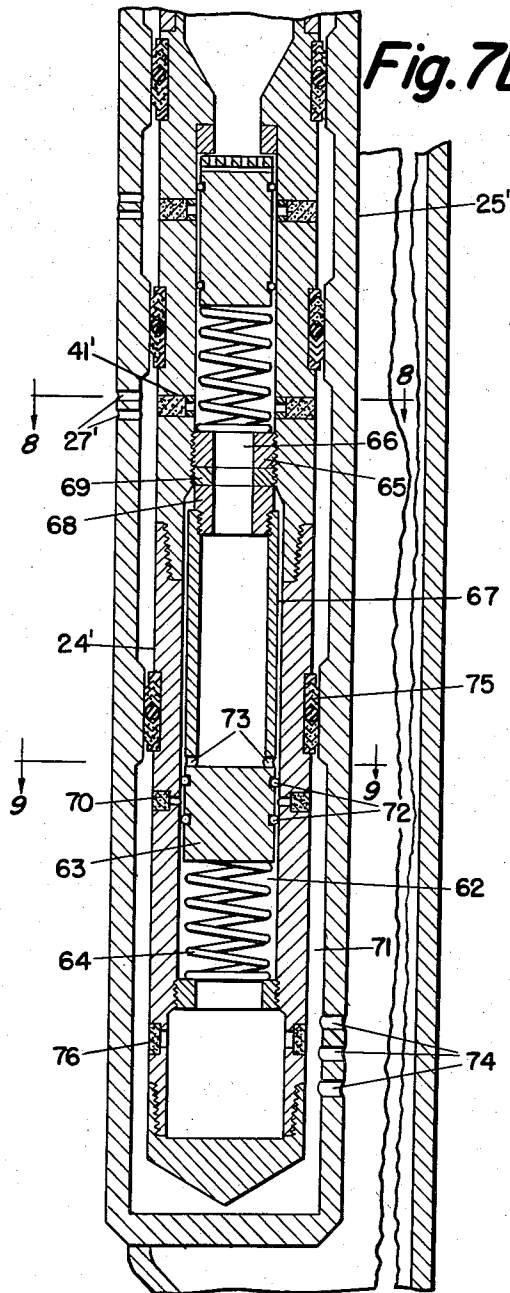


Fig. 7B



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WELL ASSEMBLY FOR REDUCING LIQUID LEVEL IN WELL TUBING

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Filed July 2, 1958, Ser. No. 746,277

9 Claims. (Cl. 166-224)

This invention relates to means for lowering the liquid level in an oil or gas well and more particularly is directed to a well assembly including a valved device adapted for positioning in a side pocket mandrel in a tubing string and which can be hydraulically operated to permit fluid withdrawal through the mandrel wall.

In order for a completed oil or gas well to flow naturally it is essential that the pressure due to the hydrostatic head of liquid in the well be less than the reservoir pressure. In many cases after a completed well has been washed and the packer has been set between the tubing and casing, the reservoir pressure will be insufficient to overcome the hydrostatic head of the water column within the tubing and the well will not flow. In such cases it is necessary to reduce the water level in the tubing sufficiently to allow the well to be brought in. Also, during the course of producing a well, salt water generally will accumulate in the tubing and may increase the hydrostatic head sufficiently to stop the flow of oil. When this happens it likewise is necessary to remove water from the tubing so that production can be continued.

Various procedures are known for removing water from the tubing in a well. In some cases a device, which is run as a part of the tubing string at a suitable depth, is employed to function as a valve which can be opened to permit water to flow from the side of the tubing string into the annulus between the tubing and casing. These devices generally are sliding sleeve valves which have to be opened by means of a shifting tool that is run on a wire line. Use of the shifting tool is time-consuming and expensive and furthermore is injurious in cases where plastic-coated tubing is used in the well.

Another device for lowering the liquid level in well tubing is disclosed and claimed in my co-pending but now abandoned patent application Serial Number 659,873, filed May 17, 1957. This device comprises a spring loaded valve positioned in a housing located on the outside of the well tubing at a suitable depth above the packer. By applying gas pressure at the top of the tubing, the valve, which is pre-set to open at a given pressure, can be made to open and permit water to flow from the tubing into the annulus from which it is withdrawn from the well. However, if anything should go wrong with this device so that repair work is required, the well tubing must be pulled in order to get to the device. This is time-consuming and costly.

The present invention provides an improved device for unloading well tubing which is located in a side pocket mandrel that constitutes part of the tubing string. The device can readily be set in position or removed from the tubing by means of a wire line. The device comprises a slidable valve member which contains a passageway that can be brought into alignment with a corresponding passageway in the mandrel wall by the application of hydraulic pressure. The valve normally is closed but can readily be opened at any time it is desired to reduce the fluid level in the tubing merely by applying gas or air pressure to the tubing at the well head. After sufficient water has been forced from the tubing to lower the liquid level to the desired depth, application of the gas or air pressure is stopped and the valve then automatically closes. The device is particularly useful in wells which have been completed for mul-

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tiple production from a plurality of formations. It is especially advantageous in permanent type completion wells in permitting work-overs that otherwise could not be carried out without pulling the well tubing. It can also be employed in non-flowing wells for intermittently forcing oil from the tubing into the casing and up the casing annulus to the well head by means of gas or air pressure applied to the top of the tubing.

The invention is described more specifically with reference to the accompanying drawings in which:

FIG. 1 is a schematic illustration of a multiple completion oil well equipped with an unloading assembly according to the invention.

FIGS. 2A and 2B, taken together, constitute a sectional elevational view showing details of the unloading assembly.

FIGS. 3, 4 and 5 are cross-sectional views taken, respectively, on the lines 3-3, 4-4 and 5-5 of FIG. 2B.

FIG. 6 is a schematic illustration of a permanent type completion well utilizing the unloading assembly shown in FIGS. 2A-5 for work-over operations.

FIGS. 7A and 7B, taken together, constitute a sectional elevational view of an improved assembly for use in work-over operations of a permanent type completion well whereby flow can be obtained either from the tubing to the casing annulus or in the reverse direction.

FIGS. 8 and 9 are cross-sectional views taken on the lines 8-8 and 9-9, respectively, of FIG. 7B.

Referring to FIG. 1, a well is schematically indicated, which well has been completed for simultaneous production from two oil zones designated as zones A and B. The well has a casing 10 perforated adjacent each of the oil zones and a tubing 11 which contains side pocket mandrels 12a and 12b holding flow control devices 13a and 13b for regulating the oil flow from the zones. These devices suitably can be of the type described in my co-pending patent application Serial Number 741,925, filed June 13, 1958.

They include chokes 14a and 14b for regulating flow rates into tubing 11 and also resilient check valve members 15a and 15b which prevent backflow to the formations. Devices of this type can be lowered into position in the well or removed therefrom by a wire line employing conventional kickover apparatus to set them in their respective mandrel side pockets. A packer 16 is positioned in the annulus between the tubing and casing to prevent fluid flow between zones A and B, and another packer 17 is located in the annulus above zone A. Above packer 17 another side pocket mandrel 18, forming a section of the tubing string, contains a device 19 according to the present invention for unloading liquid from tubing 11. This device, which is shown in detail in FIGS. 2A-5, likewise can be positioned in the mandrel side pocket by means of a wire line and can readily be removed at any time for repair or cleaning without pulling the tubing from the well. This arrangement also permits either of the control devices 13a and 13b to be removed from the tubing without disturbing the unloading device 19.

FIGS. 2A-5 show details of the mandrel 18 and unloading tool 19. The mandrel contains a cylindrical side pocket 25 having a wall portion integral with the mandrel wall with two sets of ports 26 and 27 permitting fluid flow therethrough. The tool 19 is positioned in the side pocket 25 and comprises a housing 24 to which are attached conventional latching means 28 and a pulling head 29. A packing ring 30 between ports 26 and 27 and an additional packing ring 31 above ports 26 prevent fluid flow along the lower part of the annulus 33 between the tool and the side pocket wall. Above the upper packing ring 31 the side pocket contains ports 32 which provide for fluid communication between the device and

the well tubing. An O-ring 23 located in annulus 33 near the top of side pocket 25 prevents silt from entering the top of the annulus from the tubing.

Housing 24 has a chamber 34 containing a piston valve member 35 which is urged upwardly by spring 36 so that, during normal operation of the well, its upper end abuts against ring shoulder 37 leaving an open faced area 44. Shoulder 37 preferably contains one or more magnets for attracting piston 35 to its upward position. Annulus 38 of the chamber around piston 35 contains O-rings 39 which normally prevent fluid flow in the annulus. Above and below packing ring 36 means are provided for fluid communication with mandrel ports 26 and 27, respectively, through the wall of housing 24. For this purpose a series of ports in the housing wall adjacent the mandrel ports could be employed, if desired. However, the construction illustrated in FIG. 2B is distinctly preferable. This involves the use of circular bands of sintered metal 40 and 41 which are incorporated in and form a part of the housing wall. Adjacent the inside of these bands perforated stainless steel rings 42 and 43 are incorporated in the wall to provide structural strength.

The upper end of piston valve member 35 contains a series of longitudinal channels 45 connecting with one or more cross-channels 46 leading to the annulus 38. This provides for fluid flow through the valve when it is in open position. Above the valve a chamber 47 provides for fluid communication with the well tubing through ports 32. The housing wall adjacent ports 32 likewise is preferably constructed of a sintered metal band 48 and a perforated stainless steel ring 49. This allows fluid to flow into the unloading tool while preventing any solid matter from entering it.

During normal operation of the well the valve member 35 is in its uppermost position as shown in FIG. 2B. However, whenever it is desired to remove water from the well tubing, the valve can be caused to open by applying gas or air pressure to the tubing at the well head. This is illustrated in FIG. 1 which schematically shows gas inlet line 20 leading to the well tubing. Check valves 15a and 15b in the control devices adjacent zones A and B prevent fluid from being forced into the formations. The pressure applied in the tubing increases the force acting on face 44 of piston 35 and causes it, along with O-rings 39, to slide downwardly in chamber 34 against the upward thrust of spring 36. As the piston moves downwardly fluid in the lower part of chamber 34 is forced through sintered metal ring 41 and mandrel ports 27. The valve reaches its open position when channel 46 comes into alignment with sintered metal ring 40, and fluid then can pass through the device and flow through mandrel ports 26 into the casing annulus and out of the well via line 22 shown in FIG. 1. When the water level is lowered to the desired depth, admission of gas at the well head is stopped and gas in the tubing is slowly vented as indicated by line 21 of FIG. 1. Normal operation of the well is then continued.

The above-described unloading assembly can, as previously stated, be used to pump oil from a well which will not normally flow up the full length of the well tubing. Referring again to FIG. 1, assume that zones A and B have sufficient pressure to cause the oil to rise above the unloading device 19 but insufficient for flowing oil from the well tubing. Pumping of the well can be effected by alternately admitting gas or air through line 20 and releasing it via line 21. During the time when the pressure is released, oil will rise and accumulate in the tubing above mandrel 18. Then when gas pressure is applied, oil will be forced through the unloading device into and up the casing annulus. Oil can thus be intermittently withdrawn through line 22 at the top. Check valve 15a and 15b in control devices 13a and 13b will prevent the oil from flowing back to the formations.

FIG. 6 illustrates a permanent type completion well having a casing 50 traversing two production zones indi-

cated as lower zone A and upper zone B. It is assumed that the well originally had been completed for production only from zone A through perforations 51 and that zone A has become depleted so that it is now desirable to plug off zone A and then perforate the casing for production from zone B. The well tubing 52 contains two side pocket mandrels 53 and 54 and a packer 55 is positioned for sealing the casing annulus beneath the lower mandrel. The lower mandrel 53 contains an unloading device 56 such as is shown in FIGS. 2A, 2B, while the upper mandrel 54 contains another device 57, such as a gas lift valve, which will permit flow from the annulus into the tubing 52 when sufficient pressure is applied at the top of the annulus.

Preparatory to squeezing cement into zone A, an extension tube 58 is run into the tubing 52 on a wire line and placed in extension hanger 59 as shown in FIG. 6. Cement grout is then pumped down the tubing and through tube 58 to form a body of cement grout adjacent zone A. During this time the unloading device 56 functions to permit water from the tubing 52 to pass into the casing annulus, with water being withdrawn therefrom through valve 60 at the well head. After sufficient cement has been placed in the well, valve 60 is closed and cement is squeezed into zone A through perforations 51 in the usual manner. In order to wash out the excess cement valve 60 is then opened and water is pumped into the annulus at the well head. Water passes through tool 57 into mandrel 54 and downwardly around extension tube 58 and then flows up tube 58 and well tubing 52, thus washing out the excess cement. Tube 58 is then removed from the well and the casing adjacent zone B is perforated. In order to bring in the well for production from zone B, the level of water in tubing 52 is reduced by opening valve 60 and applying gas or air pressure at the top of the tubing. This causes unloading device 56 to open and allow the water to flow into and up the annulus.

Use of the unloading device 56 as above described is distinctly advantageous as compared to the conventional procedure which requires pulling a dummy valve from its position in a side pocket mandrel to permit water to flow from the tubing to the annulus through a port in the mandrel while the cement grout is being pumped into the well. The dummy valve subsequently must be set in place again, thus necessitating two more trips into the well with a wire line than are required in the foregoing procedure. The assembly illustrated in FIG. 6 thus permits well work-over operations to be carried out at reduced cost.

FIGS. 7A-9 illustrate an improved assembly for use in permanent type completion wells wherein a single tool performs the dual functions of the devices 56 and 57 shown in FIG. 6. The arrangement above the line 8-8 of FIG. 7B is essentially the same as previously described with reference to FIGS. 2A, 2B and accordingly will not be described again. This portion of the device functions upon the application of hydraulic pressure in the well tubing to open the piston valve and allow fluid to pass from the tubing into the casing annulus. At the line 8-8 the assembly includes a sintered metal band 41' adjacent mandrel ports 27' which form a flow path for fluid to pass into or out of the device from outside the tubing string. Beneath this level the housing 24' contains a second chamber 62 which has a valve member 63 slidably positioned therein and a spring 64 for urging member 63 upwardly toward an annular shoulder 65 which provides an opening 66 between the upper and lower valve chambers. Valve member 63 has a tubular portion 67 that normally abuts against the shoulder. The upper end of the valve member and the lower side of shoulder 65 preferably contains one or more magnets 68 and 69 for attracting the valve member toward its upward position. The lower part of valve member 63 normally is positioned adjacent a sintered metal band 70 in the housing wall which provides a fluid passageway into the

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annulus 71 in the mandrel side pocket 25'. O-rings 72 above and below band passageway 70 normally prevent passage of fluid into annulus 71. The tubular portion 67 of the valve member contains ports 73 which are out of fluid communication with passageway 70 when the valve member is in its upward position as shown in FIG. 7B. However, when the valve member moves downwardly, ports 73 come into alignment with band 70 and allow fluid to pass into annulus 71 and thence out into the tubing string through ports 74. Packing means 75 in annulus 71 prevent such fluid from flowing upwardly along the side pocket wall.

The lower part of chamber 62, in which spring 64 is located, could, if desired, be made gas tight and be filled with gas which would be compressed whenever valve member 63 moves downwardly. It is distinctly preferable, however, to have a fluid passageway in the lower wall of the housing so that chamber 62 will be maintained at the same pressure as that in the tubing string. This is provided preferably by means of another sintered metal band 76 adjacent mandrel ports 74. Thus, as valve member 63 moves upwardly or downwardly, fluid passes between the lower part of chamber 62 and the tubing string via passageway 76 and ports 74.

Referring again to FIG. 6, the device shown in FIGS. 7A, 7B can be substituted for device 56 in mandrel 53, and mandrel 54 and device 57 can be omitted. The single device then will allow fluid to flow either from the tubing string into the casing annulus or vice versa. When sufficient gas or air pressure is applied to the tubing, the valve member in the upper chamber of the device of FIGS. 7A, 7B will move downwardly and allow liquid to pass from the tubing string to the casing annulus. After cement has been squeezed into the formation, the excess cement can be washed out by pumping water into the annulus. With reference to FIG. 7B, this water is forced through ports 27' and passageway 41' and increases the downward force on valve member 63. This causes it to move downwardly, bringing ports 73 into alignment with passageway 70, and permits the water to flow through ports 74 into the tubing. After working-over the well in this manner, it can subsequently be brought in by utilizing the device of FIGS. 7A, 7B to reduce the water level in the tubing. It should also be noted that such device can be employed as a gas lift valve if it is desired to employ gas lifting for producing the well. This would involve merely admitting gas under pressure into the casing annulus to force valve member 63 to open position, whereby gas would enter the tubing string and aid in lifting the liquid therefrom.

I claim:

1. For use in well tubing containing a side pocket mandrel, said mandrel containing a side pocket and having therein an external flow port extending through the pocket wall: an assembly comprising a housing adapted to be positioned in the mandrel side pocket, said housing having a wall passageway for fluid communication with said flow port and having also a valve chamber communicating with said passageway; a valve member slidably mounted in said chamber adjacent said passageway, said valve member having therein a flow channel normally out of alignment with said passageway; a spring in said chamber pushing against one end of said valve member and normally disaligning its flow channel, a ring shoulder in said housing contacting a portion only of the other end of said valve member, the ends of said flow channel communicating respectively with said other end of said valve member and with said chamber, means in the wall of said side pocket and in the wall of said housing providing fluid communication from the interior of the tubing to the valve chamber above said uncontacted portion of said other end of said valve member, whereby application of hydraulic pressure to said uncontacted portion of said valve member moves such member in opposition to said spring to bring said channel into

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alignment with said passageway, and annular packing means between the housing and said side pocket above and below said port.

2. For use in well tubing containing a side pocket mandrel, said mandrel containing a side pocket and having therein upper and lower external flow ports extending through the pocket wall: an assembly comprising a housing adapted to be positioned in the mandrel side pocket, said housing having upper and lower wall passageways for fluid communication, respectively, with the upper and lower flow ports and having also a valve chamber extending adjacent each of said passageways; a valve member slidably mounted in said chamber adjacent one of said passageways, said valve member having therein a flow channel normally out of alignment with the adjacent housing passageway; a spring in said chamber adjacent the other passageway and pushing against one end of said valve member and normally disaligning its flow channel, a ring shoulder in said housing contacting a portion only of the other end of said valve member, the ends of said flow channel communicating respectively with said other end of said valve member and with said chamber, means in the wall of said side pocket and in the wall of said housing providing fluid communication from the interior of the tubing to the valve chamber above said uncontacted portion of said other end of said valve member, whereby application of hydraulic pressure to said uncontacted portion of said valve member moves such member in opposition to said spring to bring said channel into alignment with said adjacent passageway, and annular packing means between the housing and said side pocket between said ports and above the upper port.

3. An assembly according to claim 2, including also magnetized means associated with said ring shoulder for exerting an attracting force on said valve member.

4. An assembly according to claim 2, wherein said housing wall passageways are provided by sintered metal bands in the housing wall, and wherein said means in the wall of said housing providing fluid communication comprises another sintered metal band.

5. An assembly according to claim 4, including also magnetized means associated with said ring shoulder for exerting an attracting force on said valve member.

6. An assembly according to claim 2, wherein said housing contains a second chamber communicating with the first-mentioned chamber at a shoulder adjacent said spring; said assembly including also a second valve member slidably mounted in said second chamber, a second spring therein urging the second valve member toward said shoulder, means including another passageway in the housing wall for providing fluid communication between said second chamber and the interior of the well tubing; and annular packing means between the housing and said side pocket above said last-mentioned passageway, said second valve member having therein a flow channel normally out of alignment with said last-mentioned passageway and opening into said second chamber, whereby application of hydraulic pressure to its upper face moves the second valve member in opposition to said second spring to bring the last-mentioned channel into alignment with said last-mentioned passageway.

7. An assembly according to claim 6, wherein the housing wall has a fluid passageway adjacent said second spring and cooperating with the last-mentioned fluid communication means.

8. For use in well tubing containing a side pocket mandrel, said mandrel containing a side pocket and having therein upper and lower external flow ports extending through the pocket wall: an assembly comprising a housing adapted to be positioned in the mandrel side pocket and having upper and lower chambers in fluid communication with each other; a first shoulder at the top of said upper chamber and a second shoulder at the opening between said chambers, a valve member slidably mounted in each chamber, a spring in each chamber for normally

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maintaining the valve members against the respective shoulders, said housing having upper, middle, and lower fluid passageways in its wall respectively adjacent the upper valve member, the upper spring, and the lower valve member, said upper and middle fluid passageways being aligned respectively with said upper and lower flow ports; means including said lower fluid passageway for providing fluid communication between the interior of the well tubing and said lower chamber; and means including another fluid passageway in said housing wall for providing fluid communication between the interior of the well tubing and the top of said upper chamber; said upper valve member having therein a flow channel which comes into fluid communication with said upper passageway when such valve member is forced downwardly by hydraulic pressure, thereby to place said upper passageway in fluid communication with the top of said upper chamber by way of said flow channel, and said lower valve member having therein a flow channel which comes into fluid communication with said lower passage-

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way when such valve member is forced downwardly by hydraulic pressure, thereby to place said lower passageway in fluid communication with said upper chamber by way of the last-named flow channel.

9. An assembly according to claim 8, wherein said housing wall has another fluid passageway therein which provides fluid communication from beneath said lower valve member to the exterior of the housing.

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