July 30, 1946. P. H. GRANGER 2,404,876

OIL WELL TOOL

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Fig. 1.

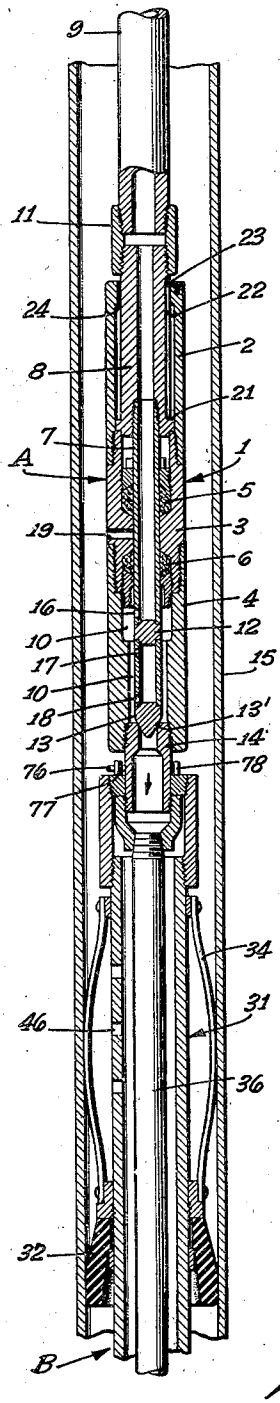
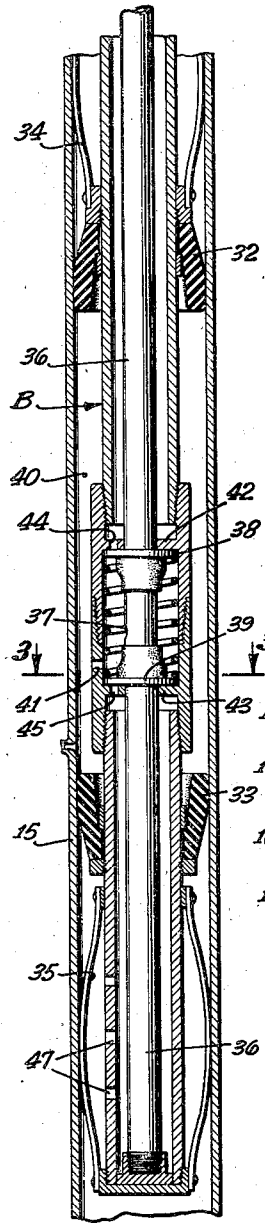


Fig. 2.



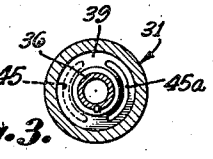


Fig. 3.

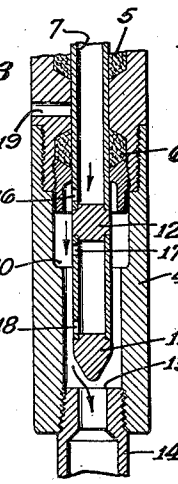


Fig. 4.

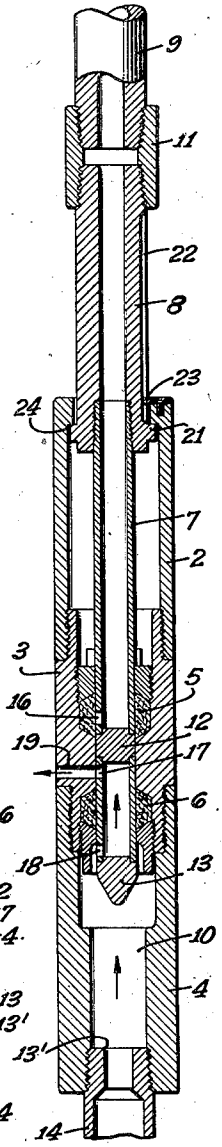


Fig. 5.

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Fig. 6.

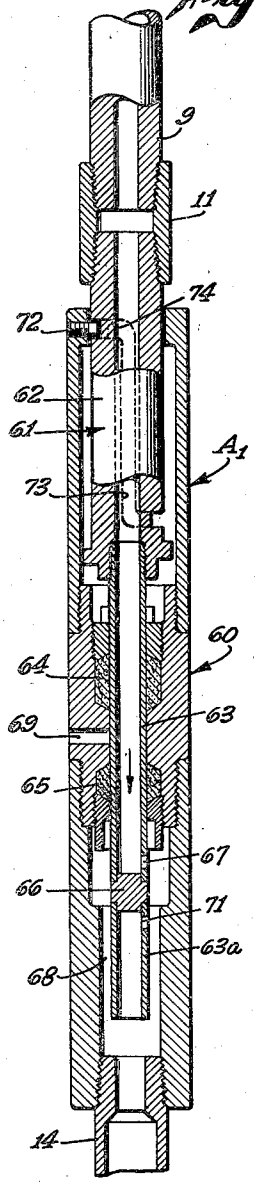


Fig. 7.

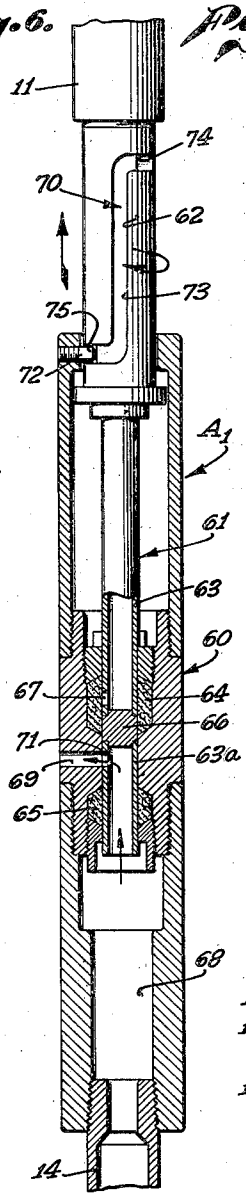


Fig. 8.

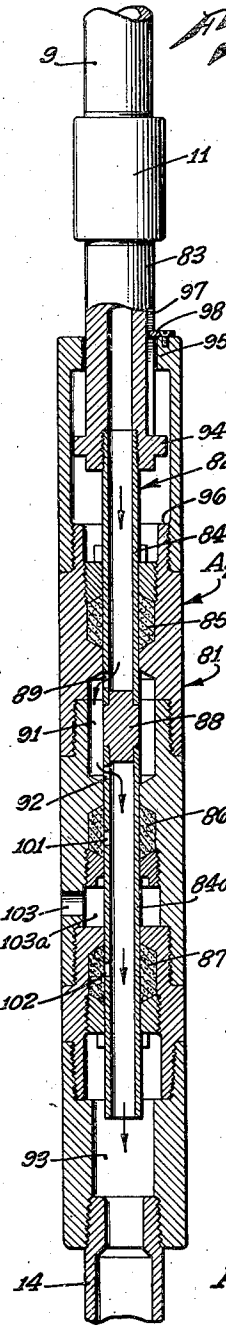
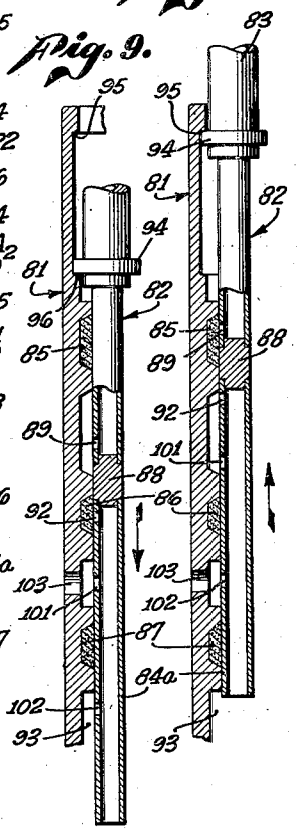


Fig. 10.

Fig. 9.



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Fig. 14.

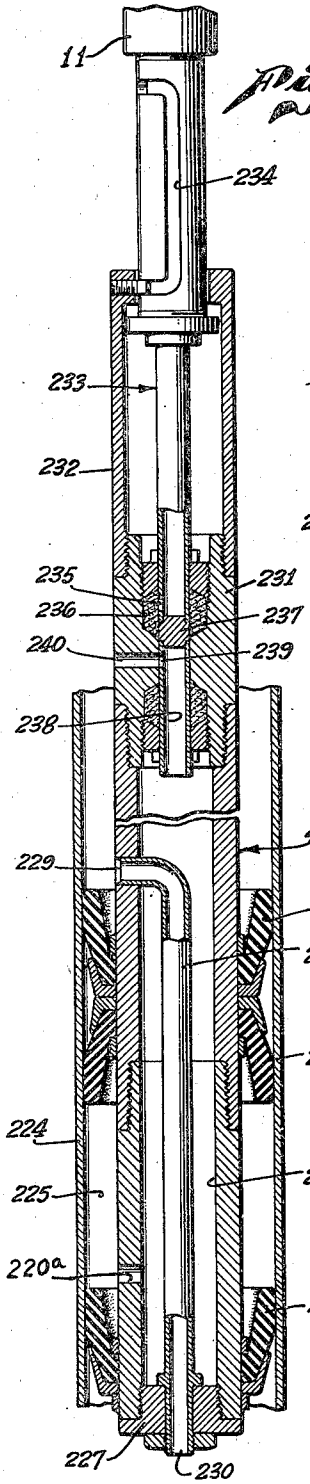


Fig. 11.

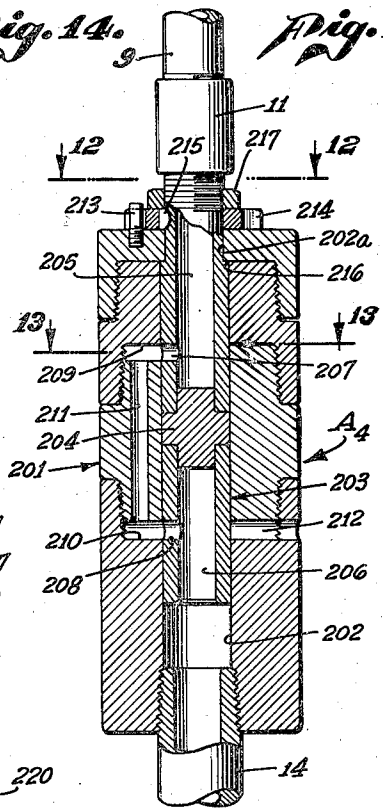


Fig. 13.

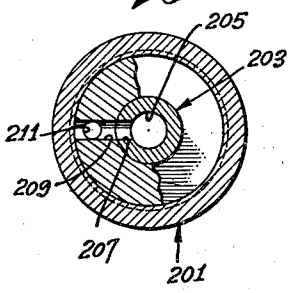
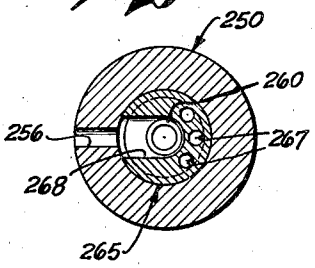


Fig. 18.



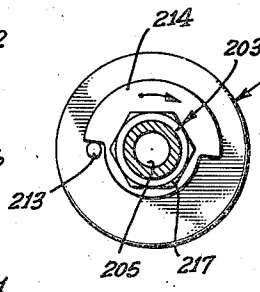


Fig. 12.

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Fig. 15.

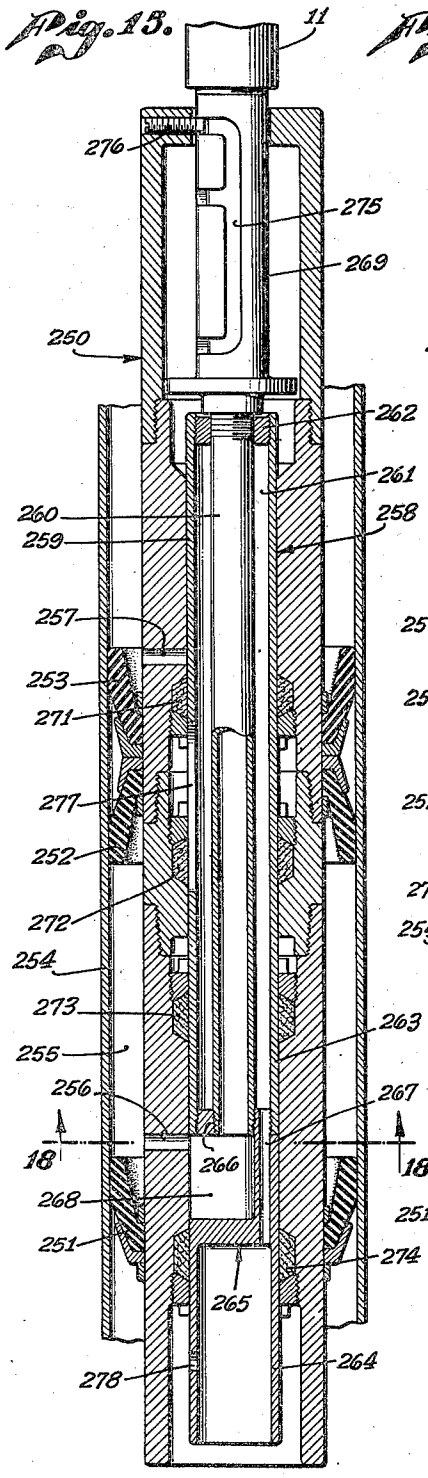


Fig. 16.

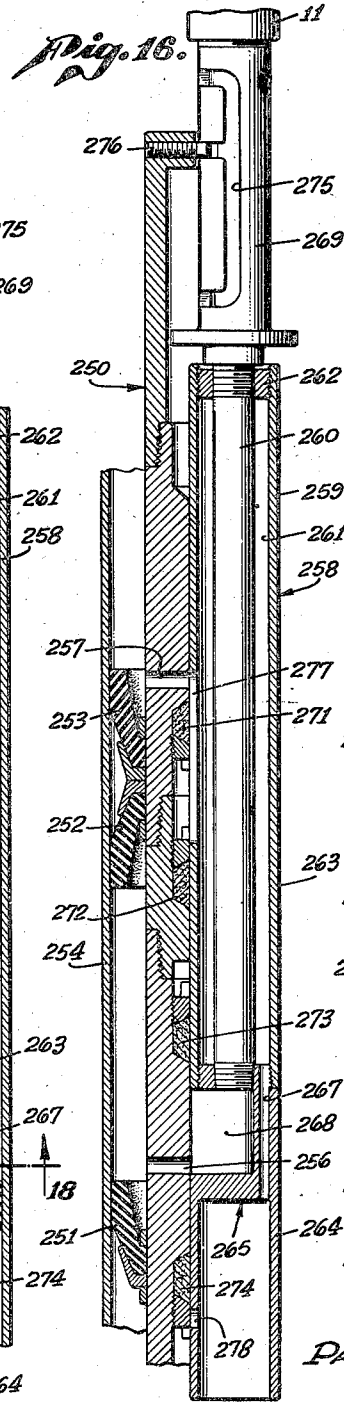
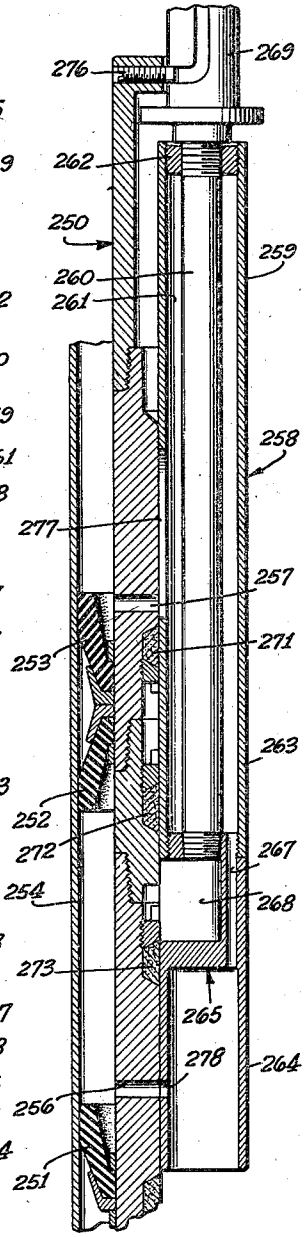


Fig. 17.



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Patented July 30, 1946 2,404,876

UNITED STATES PATENT OFFICE

2,404,876

OIL WELL TOOL

Paul H. Granger, Los Angeles, Calif.

Application January 6, 1942, Serial No. 425,780

12 Claims. (Cl. 166—11)

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This invention relates to oil well tools and pertains more particularly to apparatus for controlling the fluid flow through the tubular well string in testing for leaks in casings, cementing, washing, and other operations involving the introduction of fluid through a tool suspended from the well string.

After testing for leaks at a given position in an oil well casing with a tool such as shown in my Patent No. 2,248,169, issued July 8, 1941, or with comparable tools, the fluid contained in the tubular well string drains therefrom as the tool is moved vertically to a different position in the casing, due to the fact that the well string communicates with the interior of the casing at a position removed from the packing cups, as with the by-pass passage through which fluid is permitted to flow past the tool. Thus, if tests are carried out at a large number of locations, considerable liquid will be released in the well. In general this has a deleterious effect on the well and is wasteful in that time and energy are consumed in resupplying the lost liquid to the well string at each test location.

When cleaning fluid or oil is introduced through such a tool, as in perforation cleaning, the cost of the liquid is high and it is expensive to let it drain unnecessarily from the well string. It is also valuable to have control of the flow of fluid through the well string in other operations requiring the controlled placement of liquid at a given location in the casing through the string.

It is therefore an important object of this invention to provide an apparatus for controlling the flow of liquid through the well string.

Another object of the invention is to provide a valve mechanism in the well string in the vicinity of the point of discharge of liquid to be delivered through the well string and operable by manipulation of the well string for controlling the flow of liquid through the string.

Another important object of the invention, according to one form thereof, is to provide a valve mechanism at the lower end of the well string operable by manipulation of the string to decrease the fluid pressure on the valves of a cementing or leak-locating tool or the like and/or the pressure on the packing cups to facilitate operation or movement thereof.

This pressure-relieving is particularly important in preventing the wear on the valves in cementing or leak-locating tools or the like. For example, when the tool in my above-mentioned patent is used for testing and the valves are closed and under high pressure in the operating

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chamber, it is extremely difficult to open the valves without subjecting them to undue mechanical stress and wear. By providing means for reducing the fluid pressure on the valves, as by equalizing the pressure inside and outside of the tool, the valves may be readily opened without excessive wear.

Another and more specific object of the invention is to provide a valve mechanism operable by manipulation of the well string to open communication between the interior of a cementing or leak-locating tool or the like and the exterior thereof to equalize the pressure difference between the interior and exterior thereof. This feature is of particular importance when movement of the tool is required to operate the valves therein. (See Costello Patent No. 2,214,121 as an example.)

Another object of the invention is to provide a valve mechanism for use with an oil well tool such as a cementing or leak-locating tool which will operate to close the well string and prevent outflow of liquid therefrom upon either upward or downward movement of the string.

My invention comprises a valve mechanism or flow control device interposed in the well string and operable upon manipulation of the well string to control fluid flow through the well string. The flow control device may be either a separate device interposed between the well string and a cementing tool or the like for controlling flow between the well string and tool, or it may comprise the valve mechanism of a cementing tool or the like. The preferred embodiment of the invention also includes means for relieving pressure between the cups of a cementing tool or the like.

Further objects and advantages of the invention will be specifically brought out in the ensuing description or will be apparent therefrom.

In the accompanying drawings:

Fig. 1 is a longitudinal section through one form of fluid flow control device of my invention showing it attached to the upper part of a cementing tool;

Fig. 2 is a longitudinal section through the lower portion of the tool illustrated in Fig. 1;

Fig. 3 is a transverse section taken along line 3—3 in Fig. 2, illustrating the construction of the valves in the cementing tool;

Figs. 4 and 5 are enlarged longitudinal sectional views of the lower part of the flow control device illustrated in Fig. 1, showing different positions of the parts during operation thereof;

Fig. 6 is a longitudinal section through a mod-

ified form of fluid flow control device according to my invention;

Fig. 7 is another longitudinal section thereof showing the parts in a different position;

Fig. 8 is a longitudinal section through a further modified form of fluid flow control device of the present invention;

Figs. 9 and 10 are diagrammatic partial longitudinal sectional views thereof illustrating the operation;

Fig. 11 is a longitudinal section through another form of fluid flow control device according to my invention;

Fig. 12 is a partly sectional plan view taken along line 12—12 in Fig. 11;

Fig. 13 is a transverse section taken along line 13—13 in Fig. 11;

Fig. 14 is a longitudinal section of a tool embodying a flow control device according to my invention;

Fig. 15 is a longitudinal section of another tool embodying valve means according to my invention;

Figs. 16 and 17 are partial longitudinal sections illustrating different relative positions of the parts; and

Fig. 18 is a transverse section thereof taken on line 18—18 in Fig. 15.

Referring to Figs. 1 and 2, I have illustrated my flow control apparatus, indicated generally at A, as applied to a well tool B, such as is shown in Fig. 1 of my above-mentioned Patent No. 2,248,169. The flow control apparatus A is shown as comprising tubular body means comprising a tubular outer body 1 and an inner tubular body extending within the outer body and longitudinally slidable relative thereto. The outer tubular body 1 comprises a plurality of threadedly joined sections 2, 3, and 4, and the inner tubular body comprises a tubular member 7 having an enlarged upper end section indicated at 8. The central section 3 of tubular body 1 is provided with upper and lower packing glands 5 and 6 at its ends sealingly engaging the outer surface of the longitudinally slidable inner tubular member 7. The enlarged upper end section 8 is shown as a separate tubular member threadedly secured to member 7, and extends through the upper body section 2 and is threadedly secured at its upper end to the lower tubing section 9 of a tubular well string by means of a collar 11.

The inner tubular member 7 is provided adjacent its lower end with a partition means 12 and a valve plug 13. The partition means 12 is effective to completely close off longitudinal communication through the inner tubular member 7.

The lower end of the lower body section 4 is threadedly secured to a nipple 14 comprising the upper part of the cementing tool B. The plug 13 is formed with a conical lower end which is adapted to engage a seat 13' at the upper end of the nipple 14 to shut off fluid communication therethrough. The inner tubular member 7 is provided with a port 16 located above the partition means 12 and with a pair of vertically spaced ports 17 and 18 which are located between the partition means 12 and the plug 13 and spaced apart a distance somewhat greater than the vertical extent of the lower packing gland 6. The internal diameter of the lower body section 4 is somewhat greater than that of the inner member 7 so as to provide a passage 10 for flow of fluid. The central section 3 of the body 1 is provided with a radially extending port 19 which is located between the packing glands 5 and 6.

Inner tubular member 7 is mounted for longitudinal sliding movement relative to the outer tubular member 1 and upper tubular section 2 has an internal diameter which is somewhat greater than the internal diameter of the tubular section 3. An annular flange 21 is provided on the lower end of the inner tubular section 8 and is adapted to engage the upper end of the section 3 to limit relative motion in one direction. The upper end portion of the section 2 is of reduced internal diameter to provide an inwardly extending shoulder 24, whereby the flange 21 will engage said shoulder to limit relative motion in the other direction. As will be brought out below in describing the operation of the apparatus, the member 7 constitutes a valve means operable by manipulation of the well string, to open and close the passages through the flow control device A. To provide means for transmitting rotary movement of the tubing string 9 through the tubular body 1, the inner tubular member 8 is provided with a longitudinally extending slot or recess 22 and a cooperating key 23 extending into the recess is provided in the upper end of the body section 2.

The tool illustrated at B in Figs. 1 and 2 is the same as disclosed in my above-mentioned patent and comprises an outer tubular body member 31 having vertically spaced packing cups 32 and 33 thereon for sealingly engaging with the inner wall of the well casing 15 to seal off a localized zone in the casing therebetween indicated at 40. The cups 32 and 33 are shown facing one another whereby an excess pressure in the zone 40 will cause the cups to expand and seal tightly against the casing. The body member 31 is further provided with bow springs 34 and 35 which are adapted to frictionally engage the interior of the casing to resist relative rotational or vertical movement of the body 31 with respect to the casing.

The tool B is further provided with an inner tubular member 36 adapted for relative rotation with respect to the body member 31 and secured against relative vertical movement therein. The inner tubular member 36 communicates at its upper end with the nipple 14 to which it is secured and is provided intermediate its ends with a port 37 located between vertically spaced partitions 42 and 43 and cooperating valves 38 and 39 which define with the interior of the tubular member 31 a chamber which communicates through a discharge opening or port 41 in the outer tubular member 31 with the zone 40 in the casing between the packers 32 and 33. The lower end of member 36 is closed.

The valves 38 and 39 rotatably engage partitions or seats 42 and 43 in the tubular member 31, each of these partitions being provided with an opening 44 and 45, respectively, communicating with the space between the tubular members 31 and 36 above and below the respective partitions. The valves 38 and 39 are provided with openings adapted to aline with the openings 44 and 45. In Fig. 3 the valve 39 is shown provided with an opening 45a adapted to aline with the opening 45 to open the valve and to be spaced therefrom when the valve is rotated closed as shown. It may be assumed that the valves 38 and 39 in Fig. 2 are rotated 180° counter-clockwise as viewed downward from the position shown in Fig. 3 and are open. The valve 39 is shown in its closed position in Fig. 3 in order to clarify its illustration. The upper valve 38 is similarly constructed. The outer tubular member 31 is provided with one or more upper by-pass openings 46 and one or more

lower by-pass openings 47, located respectively above and below the packing cups 32 and 33 and communicating through the interior of the outer tubular member 31 with the openings 44 and 45, respectively.

The valves 38 and 39 are opened and closed by relative movement of the inner tubular member 36 with respect to the outer tubular member 31. Rotation in one direction opens the valves (alines the ports in the partitions and plates) to provide communication between the by-pass openings 46 and 47 whereby liquid may by-pass between the spaces in the casing above and below the packing means and the tool may be freely moved vertically. Relative movement of the inner tubular member 36 with respect to the outer tubular member 31 in the opposite direction will close the valves 38 and 39 (moves the ports in the plates and partitions out of alinement) and seal off a zone in the casing between the packing members 32 and 33. Suitable means, such as pin 76 on nipple 14 and pins 77 and 78 on the upper end of the outer tubular body of the tool, are provided for limiting relative rotation of the inner and outer members of the tool. In Fig. 2 the valves 38 and 39 are shown in open position, with pin 76 engaging pin 77.

In running the tool B down the casing to any given position, the valves 38 and 39 are opened by rotative manipulation of the well string 9 and the valve mechanism in the flow control apparatus A is closed, the parts thereof assuming the positions illustrated in Fig. 1. In this position communication between the port 19 and the passage 10 within the body 1 is cut off by the packing member 6. Communication between the interior of the cementing tool and the port 16 through the passage 10 is cut off by the engagement of the plug 13 with the seat 13'. Thus the lower end of the tubing string 9 is completely sealed off and no liquid can flow therefrom.

When the tool has been lowered to a desired position, the tubing string is then rotated in a clockwise direction as viewed downward in Fig. 1, to close the valves 38 and 39. The tubing string is then raised a short distance to bring the valve member 7 in the flow control apparatus A to the intermediate position illustrated in Fig. 4. In this position the port 16 is below the lower packing member 6 and the plug 13 is raised from the seat 13', whereby liquid may flow from the tubing string 9, through tubular members 8 and 7, port 16, and passage 10, into the open end of the nipple 14, and thence into the interior of the tool B. It will be noted that when the valve member 7 is in its intermediate position the port 19 is isolated from the tubing string and the tool B.

With the flow control valve mechanism in the intermediate position and with the valves 38 and 39 in the tool closed, liquid may be forced down the tubing string, through the above-defined passage means in the flow control apparatus, through the inner tubular member 36, and out through the ports 37 and 41 into the zone 40. Leak-locating or cementing operations as described in my above-mentioned patent, or other operations involving the placement or introduction of fluid, may thus be performed with the valve mechanism in the intermediate position.

In order that the tool may then be moved up in the casing with a minimum loss of liquid from the tubing string, the tubing string is first raised a short distance from the intermediate position to its upper or extended position indicated in Fig. 5, in which the flow control valve means (member 7) again closes off the lower end of the tubing string 9. The port 16 is raised to a position within the upper packing gland 5, thereby closing the passage from the tubing string to the point of liquid discharge in the tool B and also closing off communication from the tubing string to the space in the casing above tool B. In moving to the upper position there is a slight loss of liquid from the tubing string as the port 16 passes the port 19, but this loss is for all practical purposes negligible. If desired, however, such loss may be completely eliminated by placing port 16 at a different angular position, out of alinement with port 19.

When the valve mechanism is in its upper position the port 18 occupies substantially the same position as the port 16 did when the tool was in the intermediate position indicated in Fig. 4. Thus the port 18 communicates with the passage 10 which is in open communication with the nipple 14, and with the port 17 through the interior of the member 7. At this time the port 17 is alined with the port 19. Thus the zone 40 is in open communication through the port 18 with the space in the casing immediately above the upper packing cup 32 and the pressure above and below the packing cup 32 is substantially equalized. This relieves the pressure on the valve plates 38 and 39 and facilitates rotation thereof.

During normal operations, as in leak testing, or cementing, or flushing out following cementing, the valve plates 38 and 39 are forced against the partitions 42 and 43 by pressures which may reach several thousand pounds per square inch. Unless this pressure is reduced before the valve plates are rotated, considerable mechanical force is required to rotate them and the wear on the valve plates and partitions is excessive, especially when abrasive particles such as cement particles are present.

The tubing string 9 is then rotated to open valves 38 and 39, and the tool may be raised in the casing to a new position without loss of liquid from the tubing string. It will be noted that when the flow control valve member 7 is in its upper position, closing the lower end of the well string, flange 21 is in engagement with shoulder 24, whereby upward movement of the string 9 will raise the tool. When the desired higher position of the tool is reached, the tubing string may be rotated to close the valves 38 and 39 in the tool and then lowered to bring the valve mechanism in flow control apparatus A to the intermediate position illustrated in Fig. 4, to again open communication between the tool and tubing string.

If it is desired to move the tool to a lower position in the casing after the valve mechanism has been raised to its upper position as indicated in Fig. 5 and the valves 38 and 39 in the tool are open, as above described, the tubing string is simply lowered to place the valve mechanism in its lowered position as illustrated in Fig. 1, in which the lower end of the tubing string is again completely sealed off and loss of liquid therefrom is prevented. Further downward movement of the tubing string forces the tool downward, due to engagement of flange 21 with the upper end of intermediate section 3 of tubular body 1.

Valve member 7 closes the passage from the tubing string to the point of liquid discharge in the tool when said valve member is in either its lowered position (Fig. 1) or its raised position (Fig. 5), and when in the latter position it also opens a passage from the interior of the tool to

the space in the casing above the tool; on the other hand, when in its intermediate position (Fig. 4) it opens the first-mentioned passage and closes the last-mentioned passage.

In Figs. 6 and 7 I have illustrated a flow control apparatus A_1 having a modified form of valve mechanism which eliminates the plug 13 of Figs. 1, 4 and 5 and the valve function thereof. This form of the valve mechanism may be used for the same operations as that previously described, but manipulation thereof is somewhat different.

In Figs. 6 and 7 it may be assumed that the flow control apparatus A_1 is to be employed with the cementing tool of Figs. 1 and 2, and the illustration thereof has not been repeated, it being sufficient to show only the connection of the nipple 14 of such a tool to tubular outer body 60 of the flow control mechanism. A tubular inner body indicated at 61 is both slidably and rotatably mounted with respect to the body 60 and comprises an upper cylindrical portion 62 and a lower cylindrical portion 63 of reduced diameter. The upper portion 62 extends above the outer tubular body 60 and is suitably secured to the well string 9 through the agency of the coupling 11.

The outer body 60 is provided in its interior and intermediate its ends with longitudinally spaced packing members 64 and 65 which are adapted to sealingly engage with the outer cylindrical surface of the portion 63 of the inner tubular valve member and yet permit sliding movement thereof. The portion 63 of the inner tubular member is closed by a partition 66 intermediate its ends and is provided with a port 67 in its wall located above the partition.

Referring particularly to Fig. 6, the outer tubular member is of such internal configuration as to provide a passage 68 which communicates at its lower end with the nipple 14 and at its upper end with the port 67 at a position below the lower packing member 65 when the inner tubular valve member 61 is in its lowered position, whereby fluid may flow from the well string 9 through the interior of the inner tubular member 61 to the port 67 and thence through the passage 68 into the open end of the nipple 14.

To cut off communication between the well string and the nipple 14, the well string is manipulated to raise the inner tubular valve member 61 to the position illustrated in Fig. 7. In this position the port 67 is located within the longitudinal confines of the packing members and more specifically is sealed by the packing member 64. The partition 66 cooperates to prevent fluid flow longitudinally of the inner tubular member 61.

The outer tubular member 60 is provided with a port 69 which communicates at one end with the exterior of this member and at the other end with the interior thereof at a position intermediate the longitudinal boundaries of the packing means and more specifically between the packing members 64 and 65. The reduced portion 63 of the inner tubular member extends below the partition 66 as indicated at 63*a* and is in open communication at its lower end with the passage 68. The tubular portion 63*a* is provided with a port 71 which registers with the port 69 when the valve member 61 is in its raised position. Thus pressures in the passage 68 and the exterior of the body 60 are equalized. This makes it possible to operate the valves in the tool communicating with the valve mechanism through the nipple 14, under relatively low pressure differences, and/or to relieve the pressure on the packing cups whereby

the tool may be moved, if the tool is of the type which must be moved in order to operate the valve.

Thus, in this form of the invention, movement of valve member 61 to its raised position (Fig. 7) closes the passage from the tubing string to the tool and opens the passage from the tool to the space in the casing above the tool, while movement thereof to its lowered position (Fig. 6) opens the first-mentioned passage and closes the last-mentioned passage.

In order to transmit desired longitudinal and rotational movements of the well string 9 through the outer tubular member 60 to the tool suspended from the nipple 14, the enlarged portion 62 of the inner tubular member 61 is provided with a Z slot 70 on its outer surface and a cooperating pin 72 engaging the slot is secured to the upper end of the outer tubular body 60. The center of the Z extends vertically as indicated at 73 and the horizontally extending arms of the Z are indicated at 74 and 75. It may be assumed that the pin 72 is in engagement with the arm 74 of the slot when the tool is in the position indicated in Fig. 6 and that it is in engagement with the arm 75 of the slot when it is in the position illustrated in Fig. 7.

To raise or lower the inner tubular member with respect to the outer tubular member it is first rotated with respect to the outer tubular member to move the particular arm of the slot, which the pin 72 engages, past the pin and bring the central portion 73 of the slot into vertical alinement with pin 72. Then with the central portion 73 positioned vertically opposite pin 72 the inner tubular member may be moved up or down as the case may be. Upon reaching the new position the well string may be rotated to move the desired arm of the slot 70 past the pin 72 and lock the inner tubular member against vertical movement and rotational movement in one direction with respect to the outer tubular member. Obviously, limited rotative movement in the opposite direction is afforded.

In general, any tool which is suspended from the nipple 14 and through which fluid flow from the well string is to be controlled, is provided with some means such as bow springs resisting its movement relative to the casing. Thus relative movement of the inner and outer tubular members 61 and 60 may be obtained since the outer tubular member 60 is relatively fixed with respect to the casing through its connection to the nipple 14 which is attached to the cementing tool or the like. In the case of the tool illustrated at B in Figs. 1 and 2, the outer tubular member is rather rigidly held against vertical movement by the action of the bow springs 34 and 35. Limited rotational movement is permitted since such movement is required to operate the valves 38 and 39.

In general, the frictional forces in the cementing tool will be sufficiently greater than the frictional forces in the valve mechanism to allow operation thereof without rotating the valves in the tool. It will be noted that the arms of the slot 70 are so faced as to give rotation of the valves 38 and 39 in the correct direction when the pin 72 is moved from the central portion 73 into the arms 74 and 75. It should be obvious that the valves 38 and 39 are to be open when the pin 72 is in arm 75 and closed when the pin is in arm 74.

It should be apparent that the portion 63*a* of the inner tubular member may be omitted if desired as its only function is to guide the inner tubular member in its travel through the packing

members and prevent undue wear on the packing members. It should also be noted that the arms 74 and 75 of the slot 70 may be omitted if desired, their only function being to lock the inner tubular member 61 in its raised or lowered positions. It is also apparent that a different shaped slot may be desirable with other tools. Such locking in the raised position permits downward movement of the tool in the casing without loss of liquid from the well string.

Referring to Figs. 8 to 10, a further modified form of flow control mechanism is indicated at A_2 and is shown as comprising an outer tubular body 81 adapted to be secured at its lower end to a cementing tool or the like as to the nipple 14 of the tool illustrated in Figs. 1 and 2. Extending downward into the upper end of the body 81 and adapted for sliding longitudinal movement therein is an inner tubular member 82 comprising an upper portion 83 and a lower cylindrical portion 84 of reduced diameter. The upper portion 83 is adapted to be secured to the lower end of the tubular well string 9 through the agency of the coupling 11.

The central portion of the body 81 is provided with a plurality of longitudinally spaced packing members 85, 86 and 87 which are adapted to sealingly engage with the outer cylindrical surface of the portion 84 of the inner tubular member and yet permit longitudinal movement thereof. The inner tubular member is provided with a partition 88 intermediate its ends for preventing fluid flow through the inner tubular member past the partition. The portion of the inner tubular member below the partition is designated at 84*a*. Immediately above the partition 88, the inner tubular member 82 in the portion 84 thereof is provided with a port 89. The member 84*a* is provided with longitudinally spaced upper, intermediate and lower parts 92, 101 and 102, respectively. The interior surface of the outer body 81 is spaced from the inner tubular member 82 to provide a passage 91 located between packings 85 and 86; a passage 103*a* located between the packings 86 and 87; and a passage 93 located below the packing 87 and communicating with the open lower end of the tube 84*a* and the open upper end of the nipple 14. The outer body 81 is provided with a port 103 opening radially outward from the passage 103*a*.

The inner tubular member 82 is movable relative to the outer member 81 to a raised position indicated in Fig. 10, a lowered position as indicated in Fig. 9, and an intermediate position as indicated in Fig. 8. The raised position is defined by engagement of flange 94 with upper end 95 of body 81 and the lowered position is defined by engagement of said flange with shoulder 96. In order to transmit rotational movement of the well string 9 to the outer tubular body 81 cooperating elements such as a longitudinally extending groove 97 and a key 98 are provided on the inner tubular member 82 and outer tubular member 81, respectively.

With the inner tubular member in the intermediate position (Fig. 8), the port 103 performs no function since it is located opposite a blank space in the member 84*a* and is sealed from the ports 101 and 102 by the packing members 86 and 87. Communication is established between the well string 9 and the nipple 14 through the interior of members 83 and 84, port 89, passage 91, port 92, the interior of member 84*a* and passage 93.

Relation of the parts for the lowered position of the inner tubular member is indicated in Fig. 9. The port 92 is sealed by the packing member 86 whereby no liquid can drain from the well string 9. The port 101 registers with the port 103, whereby liquid may flow through the open lower end of the tubular section 84*a* through ports 101 and 103 to the exterior of the body member 81. The port 102 performs no function at this time.

The relation of the parts for the raised position of the inner tubular member is indicated in Fig. 10. The uppermost packing member 85 seals the port 89 and prevents flow of liquid out of the well string 9. The port 102 registers with the port 103, whereby communication is provided between the passage 93 and the exterior of the body 81 through the tubular member 84*a* and the ports 102 and 103. In this position of the tool the ports 92 and 101 perform no function, being sealed from the port 89 by the packing member 85.

With the form of the invention illustrated in Figs. 8 to 10, the passage between the well string and the tool is automatically closed upon sufficient longitudinal movement of the well string to bring the inner tubular member to either its raised or lowered position, whereby the associated tool may be run up or down the casing. When a desired location is reached, upward or downward movement of the well string to bring the inner tubular member to its intermediate position will automatically place the well string in communication with the tool.

Referring to Figs. 11 to 13, a modified form of flow control mechanism is indicated at A_4 and is shown as comprising a sectional cylindrical outer body 201 provided with a cylindrical vertically extending bore 202 threaded at its lower end for attachment to a suitable cementing tool or the like such as the nipple 14 of the tool illustrated in Figs. 1 and 2. The bore 202 is of reduced diameter at its upper end as indicated at 202*a* and is provided with a close fitting cylindrical mandrel 203 which extends from a position intermediate its ends to a position above the upper end of the body 201 and is adapted to be secured at its upper end to the lower section 9 of the tubing string by means of collar 11.

The mandrel 203 is provided with partition means 204 intermediate its ends and with upper passage means 205 in open communication with the string 9 and lower passage means 206 in open communication with the nipple 14. Radially extending ports 207 and 208 are provided in the wall of the mandrel 203 communicating with the passages 205 and 206 respectively.

Radially extending internal passages 209 and 210 adapted to register with ports 207 and 208 respectively are provided on the interior of the body 201 and are connected by a longitudinally extending internal passage 211. A port 212 is also provided in the wall of the outer body 201 at a position substantially diametrically opposite the passage 210.

With the outer body 201 and the mandrel 203 in the relative rotative positions illustrated in Figs. 11 to 13 liquid may flow from the tubing string 9 through passage 205, port 207, passages 209, 211, 210, port 208, and passage 206 to the nipple 14. The port 212 is closed by the blank wall of the mandrel 203 and is ineffective.

Rotation of the tubing string 9 substantially 180° relative to the outer body 201 in a clockwise direction as viewed in Fig. 12 will cut off communication between the tubing string 9 and the nipple 14 since the passage 209 will be closed by a blank portion of the mandrel 203 and longi-

tudinal flow through the mandrel is cut off by the partition 204. Communication between the nipple 14 and the exterior of the body 201 is established through registry of the ports 208 and 212.

Relative rotational movement of the mandrel and body is limited by cooperating stop means comprising pin 213 secured to the upper end of the body and a notched disc 214 keyed as at 215 to the upper portion of the mandrel 203. (See Figs. 11 and 12.) Upward movement of the mandrel with respect to the body is prevented by the cooperating shoulder means provided at 216 and downward movement is prevented by nut 217 which holds the plate 214 in position.

The flow control device A_4 may be substituted for the devices A, A_1, A_2 or A_3. If it is desired to reverse the direction of rotation to move between the two operating positions of the device A_4, the plate 214 may be removed and turned over and then replaced.

Referring to Fig. 14 a cementing tool is illustrated embodying a flow control device as a part thereof. The tool is shown as comprising a tubular outer body 220 of sectional construction provided on its outer surface with a lower upward facing packing cup 221, an intermediate downward facing packing cup 222, and an upper upward facing cup 223. The packing cups are adapted to sealingly engage with the inner wall of a casing indicated at 224, the cups 221 and 222 defining therebetween a localized zone 225 in the casing. Passage means 226 defined by the hollow interior of the outer body is closed at its lower end by a partition 227. A separate by-pass tube 228 as distinguished from a passage provided with manually operable valves, extends through the passage 226 and is secured at its upper end to the body 220 and at its lower end to the partition 227. The by-pass tube opens at 229 into the space of the casing 224 above the packing cup 223 and at its lower end at 230 into the space in the casing below the packing cup 221. A discharge port 220*a* is provided in the body 220 intermediate the cups 221 and 222 and adjacent the cup 221.

Upper tubular sections 231 and 232 are identical with the upper sections of the body 10 of Figs. 6 and 7 and are provided with a mandrel 233 substantially identical to the mandrel 61 of Figs. 6 and 7. The only change in the mandrel construction is the substitution of a C slot indicated at 234 for the Z slot of Figs. 6 and 7. The mandrel is secured at its upper end to the tubing string not shown by the coupling 11 and is in fluid communication with the tubing string.

The tool is shown in its extended position with the mandrel 233 in its raised position cutting off communication between the tubing string and the passage 226. Port 235 is sealed by packing 236 in the section 231 and longitudinal flow in the mandrel past the port is cut off by partition 237. Communication between the passage 226 and the interior of the casing above the cup 223 is provided through the interior of the lower end of the mandrel indicated at 238, port 239 in the mandrel, and port 240 in the section 231. With the tool in the position shown it may be raised or lowered in the casing 224 without loss of liquid from the tubing string.

Manipulation of the tubing string to put the tool in its contracted position with the mandrel 233 in its lowered position places the port 235 in communication with the passage 226 and closes the port 240. In this position cement or other liquid may be forced down the tubing string through the mandrel, the port 235, passage 226, and port 220*a* into the localized zone 225. With the tool in the contracted position it may be flushed by forcing liquid down the casing outside the tubing string, down through the by-pass 228, thence upward around the cup 221 into the localized zone 225 and out through the port 220*a*, passage 226, and port 235 into the tubing. The upward facing cup 223 prevents the flow of liquid into the localized zone without first passing down through the by-pass tube.

Obviously, the flow control devices A, A_2, A_3 or A_4 may be incorporated in the tool illustrated in Fig. 14 in place of the illustrated flow control valve mechanism.

Referring to Figs. 15 to 18, and particularly to Fig. 15, a further modified form of tool is illustrated incorporating a built-in flow control valve mechanism. The tool comprises a sectional tubular outer body 250 provided with a lower upward facing packing cup 251, an intermediate downward facing packing cup 252, and an upper upward facing packing cup 253. The cups are adapted to sealingly engage the inner surface of a well casing or the like 254 and the cups 251 and 252 define therebetween a localized zone 255 in the well casing.

The body 250 is provided with a discharge port 256 communicating with the localized zone 255 at a position immediately above the cup 251 and with a by-pass port 257 communicating with the interior of the casing at a position above the upper cup 253.

The tool further comprises a rigid inner tubular assembly 258 in the form of spaced concentric outer and inner tubular members 259 and 260. The annular space between the members 259 and 260 defines a longitudinally extending passage 261 which is closed at its upper end by an annular partition 262. The member 259 comprises an upper section 263 and a lower section 264. The upper end of the lower section 264 is provided with partition means 265 which is threaded as at 266 to receive the lower end of the tube 260 and is provided with a vertical passage 267 providing communication between the annular passage 261 and the interior of the casing below the cup 251 through the open lower ends of the members 264 and 260. The partition 265 is radially recessed intermediate its ends to provide a chamber 268 communicating with the open lower end of the tube 260. The upper end of the tube 260 is connected to an enlarged cylindrical mandrel portion 269 which is in turn connected through the collar 11 to the lower end of the tubing string not shown with which it communicates. The interior of the body 250 is provided with a plurality of longitudinally spaced packing glands 271, 272, 273, and 274 which sealingly engage the tubular member 259.

The inner tubular assembly 258 and the outer body 250 are adapted for relative longitudinal movement and are movable to a contracted position illustrated in Fig. 15, an intermediate position illustrated in Fig. 16, and an extended position illustrated in Fig. 17. The cylindrical member 269 is provided with an E slot 275 and a cooperating pin 276 is provided on the body 250 for locking the inner tubular assembly in each of its three positions.

In the contracted position in Fig. 15 liquid may flow from the tubing string through the collar 11, cylindrical member 269, tube 260, chamber 268, and port 256 into the localized zone 255. The by-pass port 257 is ineffective since it is sealed by a blank wall of the member 259. Chamber 268 is

sealed from the by-pass passage by the packing glands 273 and 274. By-pass port 277 in the wall of the member 259 is sealed from the by-pass port by the packing gland 271. With the tool in the contracted position cementing or other operations involving the controlled placement of fluid from the tubing string through the port 256 to the localized zone 255 may be practiced.

In the intermediate position illustrated in Fig. 16 chamber 268 still communicates with cement port 256 and is sealed from the by-pass passage by the packing glands 273 and 274. The by-pass passage is now effective and communication is established between the interior of the casing above the upper cup 253 and the interior of the casing below the lower cup 251 through by-pass ports 257 and 277, and passages 261 and 267. With the tool in this position the flushing operation described in connection with Fig. 14 may be practiced.

When the tool is in the extended position illustrated in Fig. 17 the chamber 268 is sealed from the discharge port 256 by the packing gland 273 and from the other ports and passages in the tool by the packing gland 272. The by-pass passage defined in connection with Fig. 16 is still effective since the by-pass ports 257 and 277 are still in registry. A relief port 278 provided in the wall of the member 264 and which has previously been ineffective is now in registry with the discharge port 256 and communication between the localized zone 255 and the space in the casing below the lower packing cup 251 is established through the ports 256, 278, and the open lower ends of the members 264 and 250, whereby the pressure in the localized zone is reduced.

The tool illustrated in Fig. 15 has advantages over the tool illustrated in Fig. 14 in that the by-pass may be closed when the tubing string communicates with the discharge port. This is valuable when cementing in perforated casings where the perforations extend from the localized zone to a position below the lower packing cup. A closed by-pass prevents cement from flowing up the casing through the by-pass.

It should be apparent that the tools illustrated in Figs. 14 and 15 may be provided with casing engaging means such as the bow springs illustrated in Figs. 1 and 2. Also the ratio of length to diameter of the tools illustrated in Figs. 14 and 15 may be modified if desired.

A particular advantage of the invention lies in the provision of means for reducing the pressure on the packing cups in the localized zone without movement of the cups relative to the casing, that is, by movement of the well string relative to the tool. In general, movement of the tool with a high pressure in the localized zone is difficult and will sometimes result in tearing the cups. In low fluid-level wells a well string full of liquid will put a high pressure on the localized zone. By providing means for closing the well string above the tool, the pressure between the cups in the localized zone is reduced, movement of the tool is facilitated and wear reduced.

My invention is obviously subject to considerable modification. Hence, I do not choose to be limited to the embodiments disclosed herein but rather to the scope of the appended claims.

I claim:

1. The combination with an oil well tool for use in cementing or the like suspended from a tubular well string and having a discharge opening for discharging liquid from the interior of the tool, of a fluid flow control device interposed between the well string and tool and having means defining a passage therein providing communication between the interior of the tool and the interior of the well string; said flow control device comprising a body member connected to the tool and mounted on the well string in such manner as to permit limited vertical movement of the well string relative to said body member; and valve means within said body member connected to the well string and operable by manipulation of the well string to an intermediate position to open said passage; said valve means being operable by upward movement of the well string relative to said body member, to a position above said intermediate position to close said passage, and by downward movement of the well string relative to said body member, to a position below said intermediate position to close said passage.

2. A well tool to be suspended from a well string in a casing or the like and comprising an outer tubular body having a discharge opening and by-pass openings located above and below the discharge opening; a packing member located between each of said by-pass openings and said discharge opening and adapted to sealingly engage the inner wall of the casing; and a tubular mandrel adapted for connection at its upper end to the well string and extending downward into the outer body, said mandrel having a discharge passage communicating with the well string, a by-pass passage separate from the discharge passage, and a relief port communicating with the exterior of the body below the packing members, said mandrel being movable longitudinally relative to the body by manipulation of the well string to a first position in which the discharge passage communicates with the discharge opening, a second position in which the by-pass passage communicates with the by-pass openings, and a third position in which the discharge opening communicates with the relief port.

3. A device for use on a tubular well string and adapted to operate in a well casing or the like to control fluid flow between the interior of the well string and a position outside the well string, comprising: a vertically extending tubular body having means at its upper end for connection to the lower end of a well string, an opening at its upper end for receiving fluid from the well string, and a fluid passage communicating with said opening; and another vertically extending tubular body slidably connected to the first-mentioned tubular body in such manner as to provide for limited vertical movement of said first-mentioned tubular body relative thereto, said second-mentioned tubular body having a fluid outflow opening at its lower end and another fluid passage communicating with said fluid outflow opening; said first-mentioned tubular body being provided with means movable therewith relative to said second-mentioned tubular body and positioned to control communication between said two passages, said last-named means being movable relative to said second-mentioned tubular body to an intermediate position to establish communication between said passages and being movable to another position to shut off communication between said passages upon relative upward movement thereof from said intermediate position and to yet another position to shut off communication between said passages upon relative down-

ward movement thereof from said intermediate position.

4. In a well tool of the type to be suspended from a tubular well string in a well casing or the like and having body means provided with spaced packing means adapted to sealingly engage the casing to seal off a localized zone therein and with a discharge opening communicating with said zone, the combination which comprises: means defining a passage within said tool leading from the upper end of the tool to said discharge opening; valve means in said passage slidably disposed within said body means for limited vertical movement relative thereto, said valve means being movable to an intermediate position to open said passage, to a position above said intermediate position to close said passage, and to a position below said intermediate position to close said passage; and a tubular member extending within said body means and connected to said valve means, said tubular member extending above said body means and being adapted for connection to a drill stem for movement therewith relative to said body means, the interior of said tubular member forming part of said passage and being open at its upper end to receive fluid from the drill stem.

5. A device for use on a tubular well string and adapted to operate in a well casing or the like to control fluid flow between the interior of the well string and a position outside the well string, comprising vertically extending body means having a relief passage communicating with the exterior thereof at a position between the upper and lower ends of said body means; said body means comprising two vertically extending tubular bodies connected together in such manner as to provide for limited vertical and relative movement of one of said tubular bodies relative to the other of said tubular bodies; said one of said tubular bodies having means at its upper end for connection to the lower end of a well string, an opening at its upper end for receiving fluid from the well string, and a fluid inflow passage communicating with said opening; said other of said tubular bodies having a fluid outflow opening below said relief passage and having a fluid outflow passage communicating with said fluid outflow opening; said one of said tubular bodies being provided with means positioned to control communication between said passages, said last-named means being connected to said one of said tubular bodies for vertical movement therewith relative to said other of said tubular bodies, to one position to establish communication between said fluid inflow and fluid outflow passages and shut off both said fluid inflow and fluid outflow passages from communication with said relief passage, and to another position to shut off communication between said fluid inflow and fluid outflow passages and establish communication between said fluid outflow passage and said relief passage; and said tubular bodies being provided with locking members movable relative to each other by relative rotative movement of said one of said tubular bodies when said last-named means is in the last-mentioned position, into and out of engagement with each other to prevent vertical movement of said one of said tubular bodies relative to said other of said tubular bodies.

6. A device for use on a tubular well string and adapted to operate in a well casing or the like to control fluid flow between the interior of the well string and a position outside the well string, comprising vertically extending body means having a relief passage communicating with the exterior thereof at a position between the upper and lower ends of said body means; said body means comprising two vertically extending tubular bodies connected together in such manner as to provide for limited movement of one of said tubular bodies relative to the other of said tubular bodies; said one of said tubular bodies having means at its upper end for connection to the lower end of a well string, an opening at its upper end for receiving fluid from the well string, and a fluid inflow passage communicating with said opening; said other of said tubular bodies having a fluid outflow opening below said relief passage and having a fluid outflow passage communicating with said fluid outflow opening; and said one of said tubular bodies being provided with means positioned to control communication between said passages, said last-named means being connected to said one of said tubular bodies for movement therewith relative to said other of said tubular bodies, to one position to establish communication between said fluid inflow and fluid outflow passages and shut off both said fluid inflow and fluid outflow passages from communication with said relief passage, and to another position to shut off communication between said fluid inflow and fluid outflow passages and establish communication between said fluid outflow passage and said relief passage.

7. The combination with an oil well tool for use in introducing fluid into a localized zone at any desired level in a well casing, suspended from a tubular well string and having a discharge opening for discharging fluid from the interior of the tool, of a fluid flow control device interposed between the tool and the well string and comprising vertically extending body means having a relief passage communicating with the exterior thereof at a position between the upper and lower ends of said body means; said body means comprising two vertically extending tubular bodies connected together in such manner as to provide for limited movement of one of said tubular bodies relative to the other of said tubular bodies; said one of said tubular bodies being connected at its upper end to the well string and having a fluid inflow passage communicating with the interior of the well string; said other of said tubular bodies being connected at its lower end to said tool and having a fluid outflow passage communicating with the interior of said tool; and said one of said tubular bodies being provided with means positioned to control communication between said passages, said last-named means being connected to said one of said tubular bodies for movement therewith relative to said other of said tubular bodies, to one position to establish communiaction between said fluid inflow and fluid outflow passages and shut off both said fluid inow and fluid outflow passages from communication with said relief passage, and to another position to shut off communication between said fluid inflow and fluid outflow passages and establish communication between said fluid outflow passage and said relief passage.

8. The combination set forth in claim 7, said last-named means being operable, upon movement from said one position toward said other position, to first shut off communication between said fluid inflow and fluid outflow passages and then establish communication between said fluid outflow passage and said relief passage.

9. In a well tool of the type to be suspended

from a tubular well string in a well casing for introducing fluid at any desired level therein, vertically extending body means comprising two vertically extending tubular bodies connected together in such manner as to provide for limited movement of one of said tubular bodies relative to the other of said tubular bodies; said one of said tubular bodies having means at its upper end for connection to the lower end of a well string, an opening at its upper end for receiving fluid from the well string, and a fluid inflow passage communicating with said opening; said other of said tubular bodies being provided with spaced packing means adapted to sealingly engage the casing to seal off a localized zone therein between said packing means, with means for frictionally engaging the casing to resist movement thereof relative to the casing, with a fluid discharge opening communicating with the exterior thereof between said packing means, and with a fluid outflow passage communicating with said discharge opening; said body means having a relief passage communicating with the exterior thereof at a position outside the localized zone between said packing means; and said one of said tubular bodies being provided with means positioned to control communication between said passages, said last-named means being connected to said one of said tubular bodies for movement therewith relative to said other of said tubular bodies, to one position to establish communication between said fluid inflow and fluid outflow passages and shut off both said fluid inflow and fluid outflow passages from communication with said relief passage, and to another position to shut off communication between said fluid inflow and fluid outflow passages and establish communication between said fluid outflow passage and said relief passage.

10. In combination with a tubular well string for operation in a well casing; a tool adapted to be moved vertically within said casing and provided with two vertically spaced packers projecting outward therefrom and adapted for sealing engagement with the casing to seal off a zone within the casing between the packers and with means for frictionally engaging the casing to resist movement of the tool relative to the casing, said tool also having a passage extending downward from the upper end thereof and communicating with the exterior of the tool within said zone, and having fluid by-pass passage means extending therethrough for establishing communication between the exterior of the tool above the upper packer and the exterior of the tool below the lower packer, two vertically spaced valves within said tool provided with seats and adapted for movement between positions opening said by-pass passage means and positions closing said by-pass passage, said by-pass passage means including a chamber located between said valves and communicating with the first-named passage, and said valves being located between their respective seats and said chamber and movable toward and away from said seats, whereby they are held tightly against said seats when in closed position by fluid pressure in said chamber; and a fluid-controlling device connected to the upper end of said tool and provided with a relief passage communicating with the exterior of said device at a position above the upper packer of said tool; said fluid-controlling device comprising two vertically extending tubular bodies connected together in such manner as to provide for limited movement of one of said tubular bodies relative to the other of said tubular bodies; said one of said tubular bodies being connected at its upper end to the well string and having a fluid inflow passage communicating with the interior of the well string; said other of said tubular bodies being connected at its lower end to said tool and having a fluid outflow passage communicating with the first-mentioned passage in the tool; and said one of said tubular bodies being provided with means positioned to control communication between said fluid inflow and fluid outflow passages and said relief passage, said last-named means being connected to said one of said tubular bodies for movement therewith relative to said other of said tubular bodies, to one position to establish communication between said fluid inflow and fluid outflow passages and shut off both said fluid inflow and fluid outflow passages from communication with said relief passage, and to another position to shut off communication between said fluid inflow and fluid outflow passages and establish communication between said fluid outflow passage and said relief passage.

11. In combination with a tubular well string for operation in a well casing; a tool adapted to be moved vertically within said casing and provided with two vertically spaced packers projecting outward therefrom and adapted for sealing engagement with the casing to seal off a zone within the casing between the packers and with means for frictionally engaging the casing to resist movement of the tool relative to the casing, said tool also having a passage extending downward from its upper end and communicating with the exterior of the tool within said zone; and a fluid-controlling device connected to the upper end of said tool and provided with a relief passage communicating with the exterior of said device at a position above the upper packer of said tool; said fluid controlling device comprising two vertically extending tubular bodies connected together in such manner as to provide for limited movement of one of said tubular bodies relative to the other of said tubular bodies; said one of said tubular bodies being connected at its upper end to the well string and having a fluid inflow passage communicating with the interior of the well string; said other of said tubular bodies being connected at its lower end to said tool and having a fluid outflow passage communicating with said passage in the tool; and said one of said tubular bodies being provided with means positioned to control communication between said fluid inflow and fluid outflow passages and said relief passage, said last-named means being connected to said one of said tubular bodies for movement therewith relative to said other of said tubular bodies, to one position to establish communication between said fluid inflow and fluid outflow passages and shut off both said fluid inflow and fluid outflow passages from communication with said relief passage, and to another position to shut off communication between said fluid inflow and fluid outflow passages and establish communication between said fluid outflow passage and said relief passage.

12. A device for use on a tubular well string and adapted to operate in a well casing or the like to control fluid flow between the interior of the well string and a position outside the well string, comprising vertically extending body means having a relief passage communicating with the exterior thereof at a position between the upper and lower ends of said body means; said body means comprising two vertically ex-

tending tubular bodies connected together in such manner as to provide for limited vertical movement of one of said tubular bodies relative to the other of said tubular bodies; said one of said tubular bodies having means at its upper end for connection to the lower end of a well string, an opening at its upper end for receiving fluid from the well string, and a fluid inflow passage communicating with said opening; said other of said tubular bodies having a fluid outflow opening below said relief passage and having a fluid outflow passage communicating with said fluid outflow opening; and said one of said tubular bodies being provided with means positioned to control communication between said passages, said last-named means being connected to said one of said tubular bodies for vertical movement therewith

relative to said other of said tubular bodies, to an intermediate position to establish communication between said fluid inflow and fluid outflow passages and shut off both said fluid inflow and fluid outflow passages from communication with said relief passage, to a position above said intermediate position to shut off communication between said fluid inflow and fluid outflow passages and establish communication between said fluid outflow passage and said relief passage, and to yet another position below said intermediate position to shut off communication between said fluid inflow and fluid outflow passages and establish communication between said fluid outflow passage and said relief passage.

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