

April 16, 1968

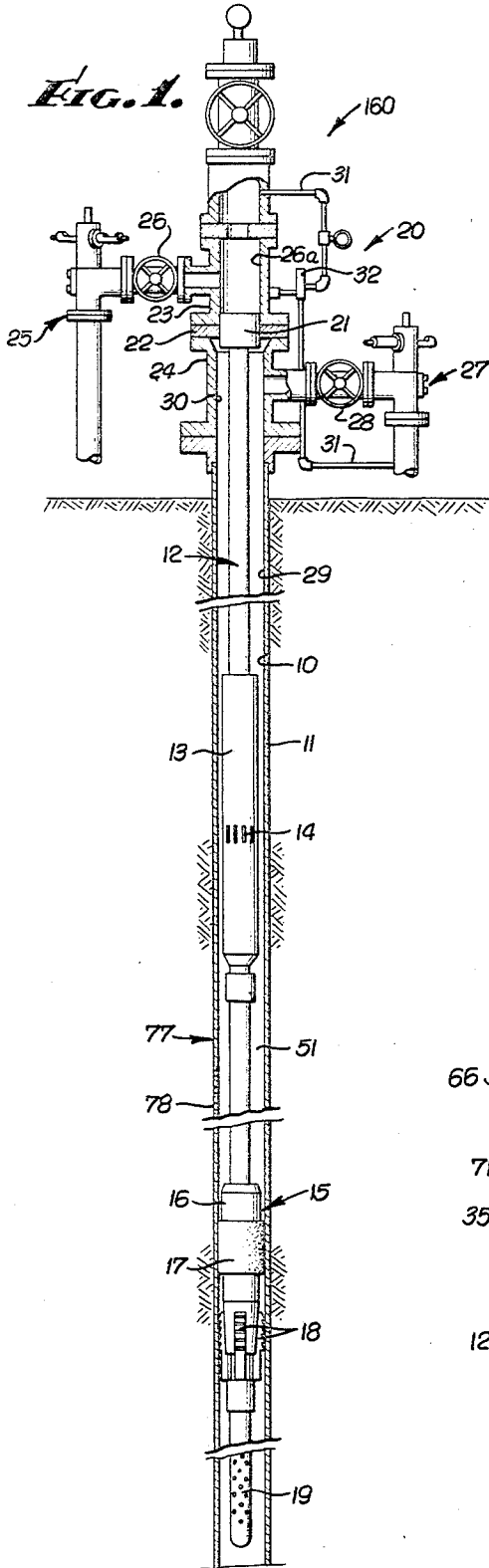
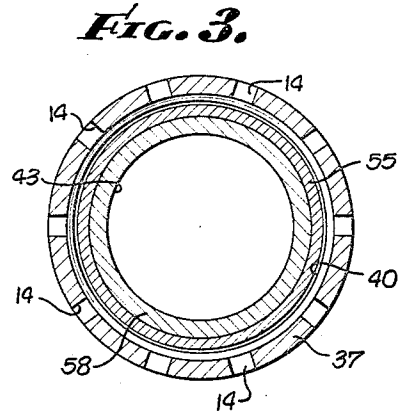
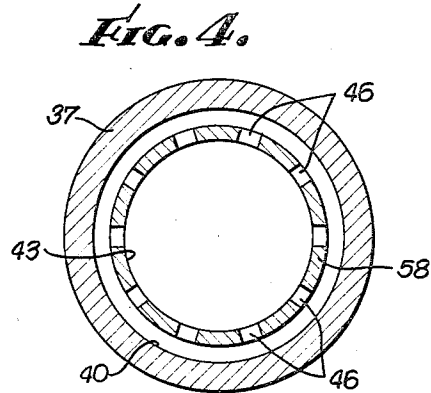
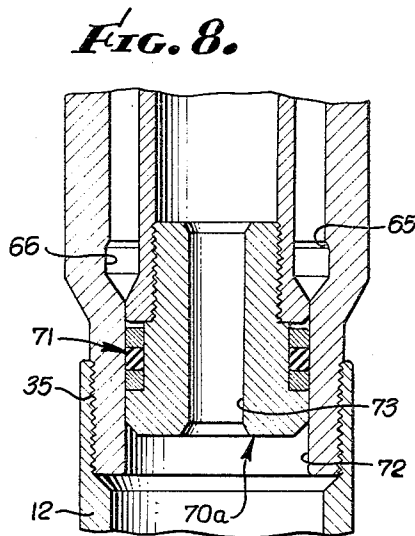
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3,378,068

SLEEVE VALVE AND OPERATION THEREOF IN A WELL

Filed Oct. 20, 1965

5 Sheets-Sheet 1



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SLEEVE VALVE AND OPERATION THEREOF IN A WELL

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FIG. 2a.

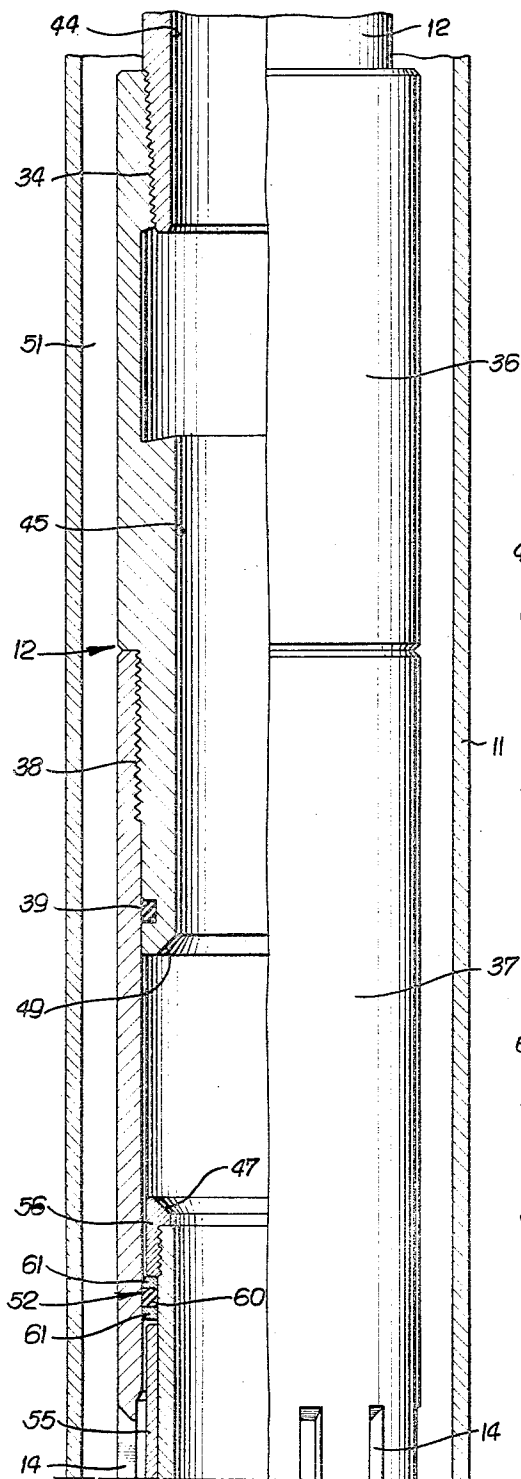
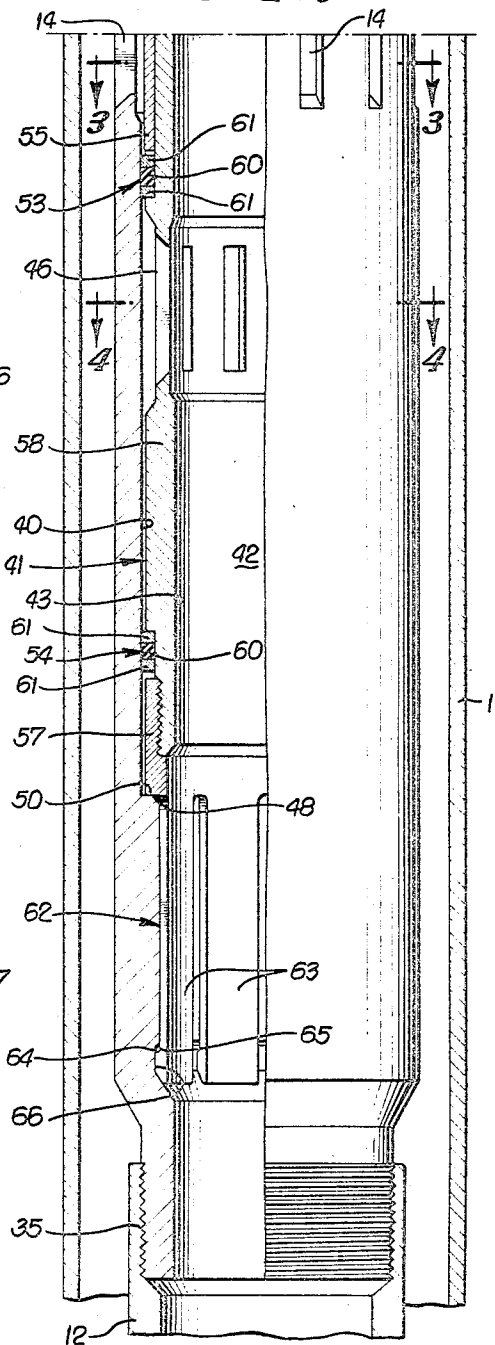


FIG. 2b.



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FIG. 5a.

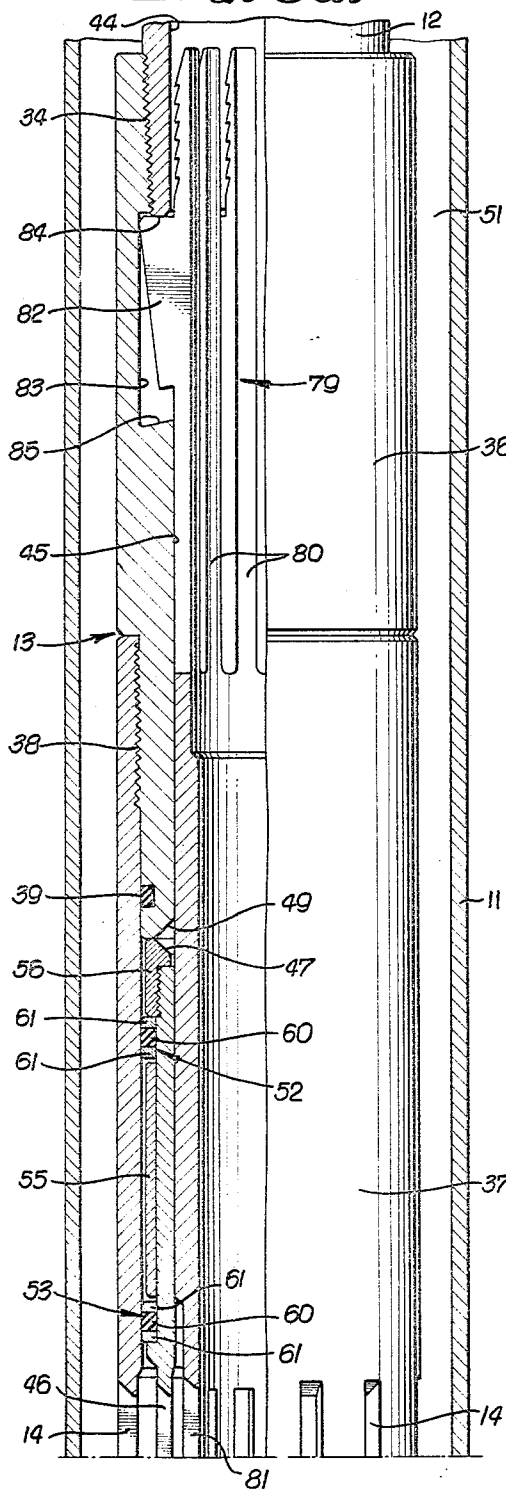
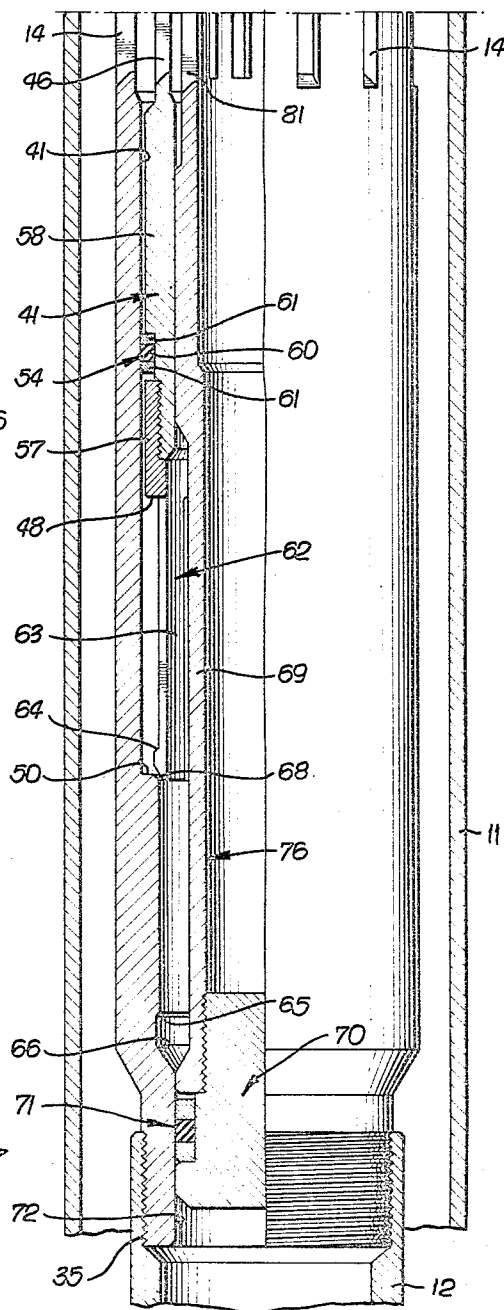


FIG. 5b.



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FIG. 6a.

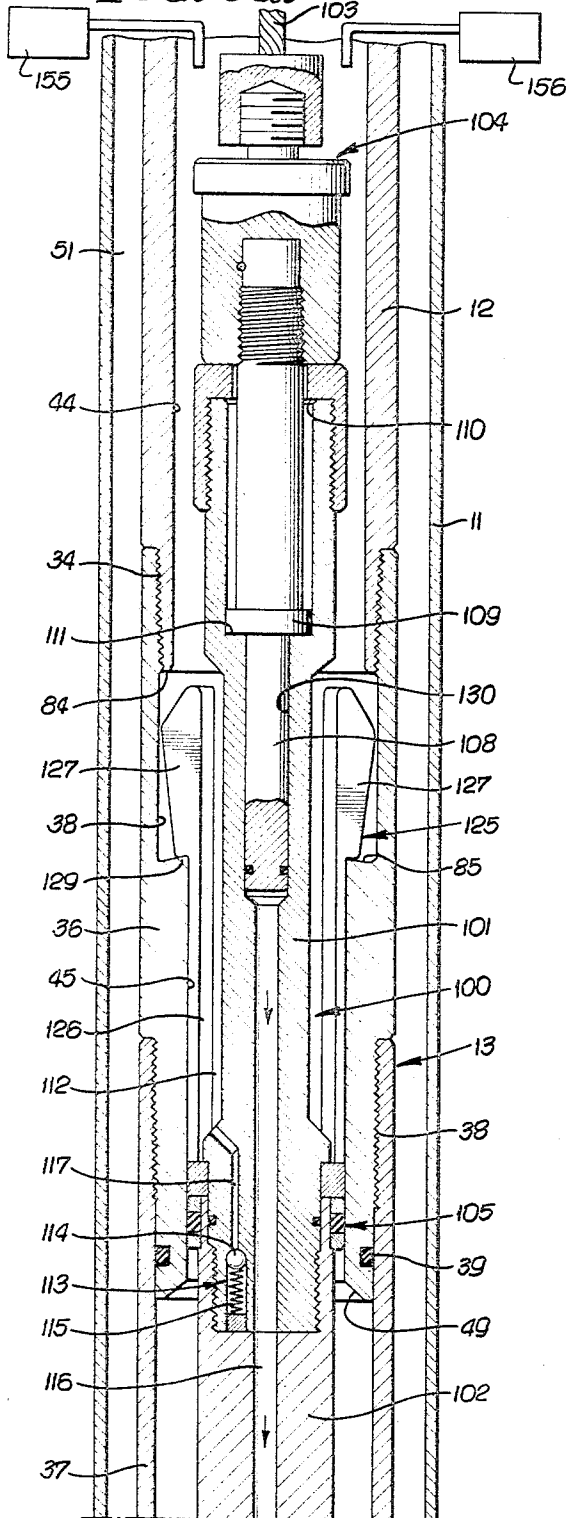
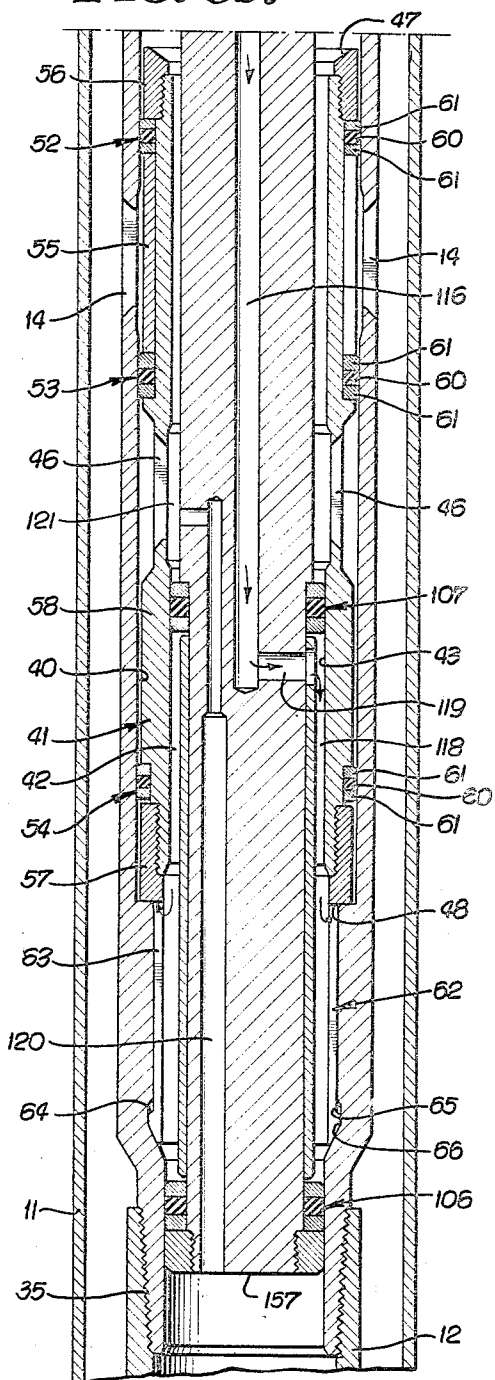


FIG. 6b.



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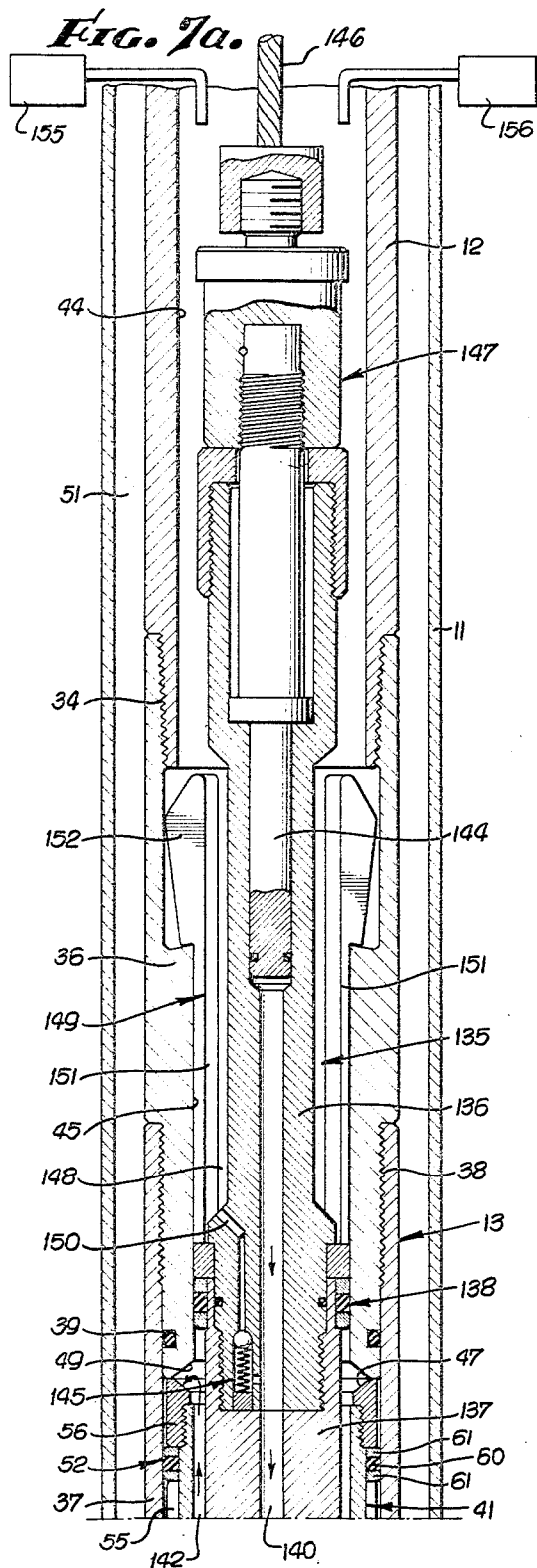
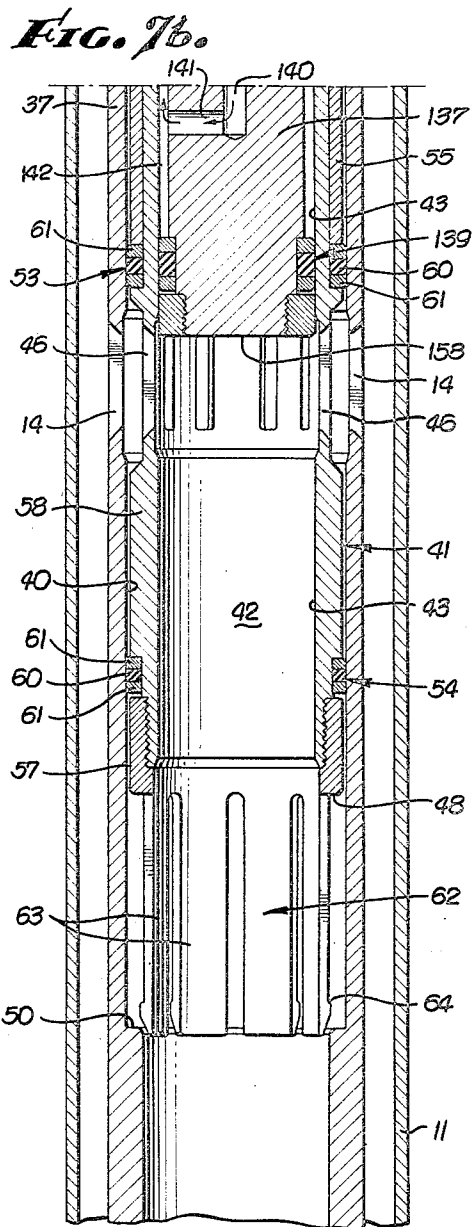
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SLEEVE VALVE AND OPERATION THEREOF IN A WELL

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26 Claims. (Cl. 166-1)

ABSTRACT OF THE DISCLOSURE

The disclosed invention concerns a well fluid flow control assembly connectible in a tubing string and characterized by fluid pressure responsive shifting of a sleeve valve between up and down positions to control well fluid flow between the interior and exterior of tubing in a well. The sleeve valve may cooperate with a wire line suspended shifting tool from which fluid pressure is communicated to a piston surface for shifting the sleeve vertically.

This invention relates generally to well fluid control, and more particularly concerns valves that are capable of controlling well fluid flow between the interior and exterior of tubing in a well.

It is a major object of the invention to provide a novel well fluid flow control assembly connectible in a tubing string and characterized by operation to control well fluid flow between the interior and exterior of tubing in a well, by hydraulic or fluid shifting of a sleeve valve between up and down positions to effect such flow control, by lack of need for surface control of hydraulic or fluid pressure to effect such shifting, by adaptation to wire line control of hydraulic shifting of the sleeve valve, and by adaptation of the sleeve valve to pass well tools vertically therethrough. Additional advantages in operation of wells made possible by the invention will be brought out in the description. Thus, the invention overcomes problems associated with prior equipment lacking the features of construction and mode of operation as well as the unusually advantageous results afforded by the present invention.

Summary of the invention

Basically, the invention comprises a well fluid flow control assembly connectible in a tubing string, and including vertically elongated tubular body structure having flow passing side porting; sleeve valve means having a vertical through opening and flow passing side porting and shiftable vertically within the body structure to bring the body and sleeve side porting into flow passing communication; piston surfaces on the sleeve valve communicating with the through opening therein to receive application of fluid pressure for controllably shifting the sleeve valve vertically within the tubular body structure; and body shoulders to limit vertical shifting of the sleeve valve. Typically, the sleeve valve and body structure are constructed to receive downward insertion therein of a wire line suspended shifting tool to communicate sleeve shifting fluid pressure to one of the piston surfaces for shifting the sleeve in one vertical direction, and to block communication of such sleeve shifting fluid pressure to another of the piston surfaces for preventing shifting of the sleeve in a direction opposite to that one direction. Thus, a sleeve opening tool may communicate shifting fluid pressure to a valve opening (lower) piston surface while blocking such pressure application to a valve closing (upper) piston surface, and a sleeve closing tool may communicate shifting fluid pressure to a valve closing (upper) piston surface while blocking such pressure application to a valve opening (lower) pis-

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ton surface. In this regard, such tools may themselves be considered to embrace sub-combination aspects of the invention.

Additional objects and advantages of the invention include the provision of a sleeve valve as defined, with a bore substantially as large as the bore diameter of tubing in the string; the provision of insert means within the body structure to project within the sleeve valve and restrict the flow of fluid vertically therethrough, the insert having a collet releasably latching to the body; the provision of such an insert with a plug below the collet and side porting in all positions of the sleeve valve to block the upward flow within the sleeve valve, the insert itself having a side port communicating with the sleeve side porting; the provision of such an insert wherein the plug is orificed; the provision of a releasable holder yieldably restraining upward travel of the sleeve valve between down and up positions; and the provision of the novel and unusually advantageous shifting tool, such as the opening and closing tools referred to above, details of which will further appear.

These and other objects and advantages of the invention, as well as the details of illustrative embodiments, will be more fully understood from the following detailed description of the drawings in which:

FIG. 1 is a vertical section showing the flow control assembly installed in a well;

FIGS. 2a and 2b are enlarged vertical sections showing one preferred form of the sleeve valve and body structure, the valve being in closed position;

FIGS. 3 and 4 are horizontal sections taken on lines 3-3 and 4-4 of FIG. 2b;

FIGS. 5a and 5b are like FIGS. 2a and 2b but showing also the inclusion of an insert to plug the upward flow;

FIGS. 6a and 6b show the sleeve valve and body in combination with a tool to shift the sleeve to open position;

FIGS. 7a and 7b show the sleeve valve and body in combination with a tool to shift the sleeve to closed position; and

FIG. 8 is a view showing a modified insert plug in combination with the sleeve and body.

Referring first to FIG. 1, a well 10 is shown as cased at 11 and receiving a tubing string 12. Connected in the latter is a vertically elongated tubular body 13 having flow passing side porting 14 and containing sleeve valve means. Typically, packer apparatus 15 is set in the well below the body 13 and sleeve valve, and includes a body 16, annular elastomer packer 17 and slips 18. Perforations 19 in the tubing string below the level of apparatus 15 pass well fluid into the string for upward flow therein, as for example when flow porting 14 is effectively closed.

FIG. 1 also shows well head equipment 20. The latter may include landing sub 21 mounting flange 22 received between casing head sections 23 and 24. Piping 25, which is valve controlled at 26, has communication with the interior of the string 12 via the passage 26a in section 23, and piping 27, valve controlled at 28, has communication with the interior of the annulus 29 via the passage 30 in section 24. Fluid pressure from piping 27 may be returned to the string via piping 31 and pilot valve 32.

Turning now to FIGS. 2a and 2b, the body structure 13 has upper and lower thread connections at 34 and 35 with the string 12. Also, the body may be constructed in two sections 36 and 37 having thread connection at 38 and sealed at 39. Received in the lower section counter-bore 40 is the sleeve valve means 41. The latter has a vertical through opening 42 defined by bore 43 that is open to substantially the same diameter as the string bore 44 and body bore 45, thereby to facilitate vertical running of tools through the valve. Also, the sleeve valve has flow passing side porting 46, and it is shiftable ver-

tically within the body structure 13 to bring the side porting 46 in the sleeve and 14 in the body structure into and out of flow passing communication. In this regard, the sleeve valve also has piston surfaces 47 and 48 communicating with the opening 42 to receive application of fluid pressure for controllably shifting the valve sleeve vertically within the tubular body structure, and furthermore, the latter has shoulders 49 and 50 to limit such vertical shifting of the sleeve valve. FIGS. 2a and 2b show the valve to have a down position in which body side porting 14 is out of flow passing communication with the sleeve valve side porting 46, this configuration being desired for example during production of well fluid from lower zone 50 in FIG. 1 up the string and through the valve bore. At this same time, well fluid production from upper zone 51 may flow up through the casing annulus to piping 27.

Also illustrated in FIGS. 2a and 2b are upper, lower and intermediate annular seal assemblies 52, 53 and 54 respectively, and packing off between the sleeve valve means 41 and the body structure at counterbore 40. Upper and lower seals 52 and 54 remain respectively above and below the body side porting 14, whereas the intermediate seal assembly 53 blocks communication between the body and valve side porting 14 and 46 when the sleeve is in the down position of FIG. 2b. When the sleeve is in up or open position as seen in FIGS. 5a and 5b, the seal 53 is above the body side porting 14. Seal assemblies 52 and 53 are separated on the sleeve by a spacer 55, and a sleeve cap 56 retains seal 52 in position. Lower seal 54 is retained by a lower sleeve cap 57, and the caps 56 and 57 are threaded on the sleeve cylinder 58. The seals are formed as sandwiches, with a plastic or elastomer ring such as 60 bonded to two metal rings 61.

FIGS. 2b and 5b illustrate one form of releasable holder means yieldably restraining upward travel of the sleeve between down and up positions. As illustrated, the holder means may include a collet 62 integral with cap 57 and having spring fingers 63 projecting downwardly to provide shoulders 64 having releasable interengagement with the body shoulder 65. For example, when the upward fluid pressure on piston surface 48 is sufficient, the spring fingers yield inwardly to release the engagement of shoulders 64 and 65, allowing the sleeve valve means to swiftly shift to up position. Shoulder 65 is formed by annularly recessing the body bore at 66. In up position, engagement of collet finger shoulders 67 with body shoulder 68 resists downward travel of the sleeve.

FIGS. 5a and 5b illustrate the fact that the sleeve valve is formed to be capable of reception of insert means operable to restrict the flow of fluid vertically through the open sleeve. One such insert 76 includes a tubular member 69 projecting within and below the sleeve valve, and carrying a plug 70 below the collet 62 and below the side porting 14 and 46 in all positions of the sleeve valve to block the upward flow of fluid within the sleeve valve means. Typically, the plug includes a seal 71 packing off against the body bore 72, which may be of tubing string diameter. If desired, the plug 70 may be solid to block all vertical flow past the plug when the sleeve valve is open, or a modified plug 70a may be orificed at 73 as seen in FIG. 8 to permit reduced upward flow past the plug when the sleeve valve is closed. Thus, when the solid plug is landed in the body structure 13, circulation may be established between the tubing interior above the plug and the casing annulus 51 above the packer 15 via side ports 14, 46, and 81 in the body, sleeve and insert, when the sleeve valve is in open or up position. The upper zone or formation 77 outwardly of casing perforations 78 may then be treated with chemicals, without disturbing the lower zone. Another operation thus made possible is the circulation of water past the upper zone.

The insert means 76 also includes a collet 79 having releasable latching engagement with the body structure 14. Thus, collet 79 may have spring fingers 80 project-

ing upwardly from member 69 and provided with latch dogs 82 receivable in grooving 83 in the body 13. The body step shoulders 84 and 85 limit upward and downward movement of the landed insert. Serrated projections 86 on the fingers are inwardly deflectable and may be locked onto a retrieving collar suspended by wire line, for retrieval of the insert.

The invention is also concerned with the provision of a shifting tool insertible within the valve body structure and within the sleeve valve to communicate sleeve shifting fluid pressure to one of the piston surfaces for shifting the sleeve in one direction, and to block communication of that pressure to another of the piston surfaces for preventing shifting of the sleeve in a direction opposite to that one vertical direction. Such a tool may be used for opening or closing the sleeve valve. Referring to FIGS. 6a and 6b, they illustrate the provision of a shifting tool 100 for opening the sleeve valve. The tool includes a mandrel having upper and lower sections 101 and 102, the upper section suspended from the wire line 103 by the connection 104. The tool also includes upper, lower and intermediate annular seals 105, 106 and 107 respectively. The upper and lower seals 105 and 106 are located to seal off between the mandrel and body structure respectively above and below the valve sleeve 41, and the intermediate seal 107 is located to seal off between the mandrel and valve sleeve bore 43.

The opening tool 100 also includes a fluid pump within upper section 101, the pump having a plunger 108 through which the upper section 101 is suspended by the connection 104. In this regard, the plunger typically has a flange 109 adapted to stroke between the upper and lower limits 110 and 111. Furthermore, the pump is responsive to vertical stroking of the plunger to take in well fluid from outside the tool, for example at 112, and to transmit sleeve shifting fluid pressure to the piston surface 48. For example, the pump may include a check valve 113 having a ball 114 urged by spring 115 to pass fluid into the passage 116 of the mandrel via the ball check controlled port 117 in response to upward stroking of the plunger, the ball check blocking reverse or outward flow through port 117 in response to down stroking of the plunger. Such down stroking applies sleeve shifting fluid pressure via passages 116 and 119 to the space 118 outside the tool but between the seals 106 and 107, for upward application to the sleeve piston shoulder 48. When that shifting pressure is sufficient, the collet 62 releases and the valve shifts upwardly as previously described. Note in this regard that the shifting fluid pressure is blocked from communication to the piston surface 47 of the valve sleeve so that the fluid pressure application to the sleeve is unbalanced.

The mandrel lower section 102 also has a by-pass 120 to communicate well fluid from below the shifting tool 100 to the mandrel exterior 121 above the intermediate seal 107 and below the upper seal 105. This communication allows fluid in confined exterior space 121 to the displaced out below the tool as the sleeve is shifted up.

The shifting tool 100 also includes a collet 125 with spring fingers 126 projecting alongside the mandrel up section 101, the spring fingers having lugs 127 outwardly receivable into annular groove 83 formed within the body structure 13. Accordingly, the shifting tool is landed when the lug shoulders 129 engage the body shoulder 85. Also, the body shoulder 84 prevents upward withdrawal of the shifting tool until sufficient lifting force is transmitted by wire line 103 to effect inward camming of the lugs 127 on the spring fingers. Accordingly, the plunger 108 may be vertically displaced within plunger bore 130 without withdrawing the tool.

FIGS. 7a and 7b show a shifting tool 135 useable to close the sleeve valve. Tool 135 includes a mandrel having upper and lower sections 136 and 137, with upper and lower annular seals 138 and 139. The upper seal is located to seal off between the mandrel and body structure 13

above the sleeve valve 41 whereas the lower seal is located to seal off between the mandrel and the sleeve valve bore 43 defining the sleeve vertical through opening. The mandrel has passages 140 and 141 to communicate shifting fluid pressure to the mandrel exterior 142 between the seals 138 and 139 for communication to the upward facing piston surface 47 thereby to urge the sleeve valve downwardly. The tool also includes a pump having plunger 144, and check valve 145 of the same type as previously described in connection with FIG. 6. As the plunger is vertically reciprocated by the wire line 146 through connection 147, well fluid is taken in at 150 from the tool exterior at 148 and displaced in passage 140 to apply the shifting fluid pressure. The closing tool also includes a collet 149 of the type described at 125 in FIG. 6, and having spring fingers 151 and locking loop 152. Seal 139 blocks application of closing fluid pressure to the sleeve valve piston surface 48.

Another important advantage of the assemblies shown in FIGS. 6 and 7 is the provision for shifting of the sleeve valve 41 up or down in the event the wire line operated pumps are inoperative. Thus, in FIGS. 6a and 6b, sufficient pressure can be applied at the surface, as by pressure source 155, and to hydraulic fluid in the tubing interior to pass through the ball check 113 and via mandrel passages 116 and 117 to become applied against sleeve surface 48 to shift the sleeve up. Similarly, sufficient pressure can be applied from the surface source 155 in FIG. 7 to pass the ball check 145 and communicate via mandrel passages 140 and 141 for application to sleeve piston surface 47, thereby to shift the sleeve downwardly. Accordingly, the dependability of the apparatus is greatly enhanced.

Further, either of the shifting tools seen in FIGS. 6 and 7 may be dropped down the tubing string without connection to the wire line, and the tool will land in the correct position in the body 13. Fluid pressure may then be applied at the surface as from source 155 to shift the sleeve valve, and thereafter the shifting tool may be removed by the lifting force of fluid in the string. As to the latter, fluid can be pumped down the annulus, as indicated at 156 in FIGS. 6a and 7a to pressurize the lower surfaces 157 and 158 of the shifting tool; or, well pressure can be used to lift the shifting tools, as controlled by opening of valve 26 at the surface. Capping structure 160 at the well head may be removed to facilitate transfer of the shifting tools into and out of the tubing string.

I claim:

1. A well fluid flow control assembly connectible in a tubing string, comprising vertically elongated tubular body structure having flow passing side porting, sleeve valve means having a vertical through opening and flow passing side porting and shiftable vertically within said body structure to bring said side porting in the body and sleeve valve means into and out of flow passing communication, the sleeve valve means having piston surfaces communicating with said through opening to receive application of fluid pressure for controllably shifting the valve sleeve up and down within said tubular body structure, and the body structure having shoulders to limit said vertical shifting of the sleeve valve means.

2. The combination of claim 1 including a shifting tool insertible within said body structure and said sleeve valve means to communicate sleeve shifting fluid pressure to one of said piston surfaces for shifting the sleeve in one vertical direction and to block communication of said sleeve shifting fluid pressure to another of said piston surfaces for preventing shifting of the sleeve in a direction opposite to said one vertical direction.

3. The combination of claim 1 including insert means within said body structure to project within said sleeve valve means and restrict the flow of fluid vertically therethrough, said insert means including a collet having releasable latching engagement with said body structure.

4. The combination of claim 3 in which said insert

means includes a plug below the collet and below said body and sleeve side porting in all positions of the sleeve valve means to block the upward flow of fluid within the sleeve valve means, and the insert having a side port communicating with the sleeve side porting.

5. The combination of claim 3 in which said insert means includes a reduced orifice below the collet and below said body and sleeve side porting in all positions of the sleeve valve means to reduce the upward flow of fluid within the sleeve valve means.

6. The combination of claim 1 in which said sleeve valve means has a bore defining said vertical through opening, said bore having substantially as large a diameter as the bore diameter of tubing in the string.

7. The combination of claim 2 in which the body structure carries a stop to limit downward insertion into the body and sleeve of said shifting tool.

8. The combination of claim 1 in which said sleeve valve means has an up position in which the body structure side porting is in flow passing communication with sleeve valve side porting, and a down position in which the body structure side porting is out of flow passing communication with the sleeve valve side porting.

9. The combination of claim 8 in which said assembly includes upper, lower and intermediate annular seals packing off the sleeve valve means and said body structure, said upper and lower seals remaining respectively above and below said body side porting, and said intermediate seal blocking communication between the body and valve side porting when the sleeve is on said down position.

10. The combination of claim 8 in which the assembly includes releasable holder means yieldably restraining upward travel of the sleeve valve between said down and up position.

11. The combination of claim 10 in which said holder means includes a collet carried by the sleeve valve means and having releasable interengagement with the body structure.

12. The combination of claim 2 in which said shifting tool is adapted for wire line suspension and includes a fluid pump having a plunger, the pump being responsive to vertical stroking of said plunger to take in well fluid from outside said tool and to displace said fluid within the tool to transmit said sleeve shifting fluid pressure to said one piston surface.

13. The combination of claim 12 in which said pump includes a check valve to pass fluid into the tool in response to upstroking of said plunger and to block reverse fluid flow past the check valve in response to down stroking of said plunger.

14. The combination of claim 12 in which the shifting tool is usable to open the sleeve valve and includes a mandrel and upper, lower and intermediate annular seals, the upper and lower seals located to pack off between the mandrel and said body structure respectively above and below said valve means, and said intermediate seal located to pack off between the mandrel and a sleeve valve bore defining said vertical through opening.

15. The combination of claim 14 in which the mandrel has a passage to communicate said shifting fluid pressure to the mandrel exterior below said intermediate seal and above said lower seal for communication to a downward facing piston surface, thereby to urge the valve upwardly.

16. The combination of claim 14 in which the mandrel has a by-pass to communicate well fluid from below said tool to the mandrel exterior above said intermediate seal and below said upper seal for communication to said sleeve valve side porting.

17. The combination of claim 12 in which the shifting tool is useable to close the sleeve valve and includes a mandrel and upper and lower annular seals, the upper seal located to pack off between the mandrel and said body structure above the sleeve valve means, and said lower seal located to pack off between the mandrel and

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a sleeve valve bore defining said vertical through opening, the mandrel having a passage to communicate said shifting fluid pressure to the mandrel exterior between said seals for communication to an upward facing piston surface, thereby to urge the valve downwardly.

18. The combination of claim 1 including a well packer connected with said assembly to pack off the well bore below the level of said assembly.

19. For combination with vertically elongated tubular body structure having flow passing side porting, sleeve valve means having a vertical through opening and flow passing side porting and shiftable vertically within said body structure to bring said side porting in the body and sleeve valve means into and out to flow passing communication, the sleeve valve means having piston surfaces communicating with said through opening to receive application of fluid pressure for controllably shifting the valve sleeve vertically within said tubular body structure, and the body structure having shoulders to limit said vertical shifting of the sleeve valve means, the improvement which comprises a shifting tool insertible within said body structure and said sleeve valve means to communicate sleeve shifting fluid pressure to one of said piston surfaces for shifting the sleeve in one vertical direction and to block communication of said sleeve shifting fluid pressure to another of said piston surfaces for preventing shifting of the sleeve in a direction opposite to said one vertical direction, said tool being adapted for wire line suspension and including a fluid pump having a plunger, the pump being responsive to vertical stroking of said plunger to take in well fluid from outside said tool and to displace said fluid within the tool to transmit said sleeve shifting fluid pressure to said one piston surface.

20. The method of operating a vertically shiftable sleeve valve in a tubing string in a well, that includes lowering a shifting tool within the string to the sleeve valve location, and applying fluid pressure via the shifting tool to unbalance the fluid pressure application to the sleeve valve, said fluid pressure application step including transferring fluid from within the tubing string into the shifting tool interior, and applying fluid pressure from

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within the shifting tool to a localized portion of the sleeve valve.

21. The method of claim 20 in which said fluid transferring step is carried out by operating a reciprocating pump in response to vertical reciprocation of a wire line.

22. The method of claim 20 in which said fluid transferring step is carried out by pressurizing fluid in the tubing string to enter the shifting tool via a check valve in said tool.

23. The method of claim 20 including the step of elevating the shifting tool within the string by application of lifting fluid pressure directly beneath the tool.

24. The method of claim 23 in which lifting fluid pressure application beneath the tool is effected by transmitting fluid pressure from the string exterior to the string interior beneath the tool.

25. The method of claim 23 in which lifting fluid pressure application beneath the tool is effected by flowing fluid upwardly within the string above said tool.

26. A well fluid flow control assembly connectible in a tubing string, comprising vertically elongated tubular body structure having flow passing side porting, sleeve valve means having a vertical through opening and flow passing side porting and shiftable vertically within said body structure to bring said side porting in the body and sleeve valve means into and out of flow passing communication, the sleeve valve means having piston surfaces communicating with said through opening to receive application of fluid pressure for controllably shifting the valve sleeve vertically within said tubular body structure, and the body structure having shoulders to limit said vertical shifting of the sleeve valve means.

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