

Oct. 12, 1965

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3,211,232

PRESSURE OPERATED SLEEVE VALVE AND OPERATOR

Filed March 31, 1961

2 Sheets-Sheet 1

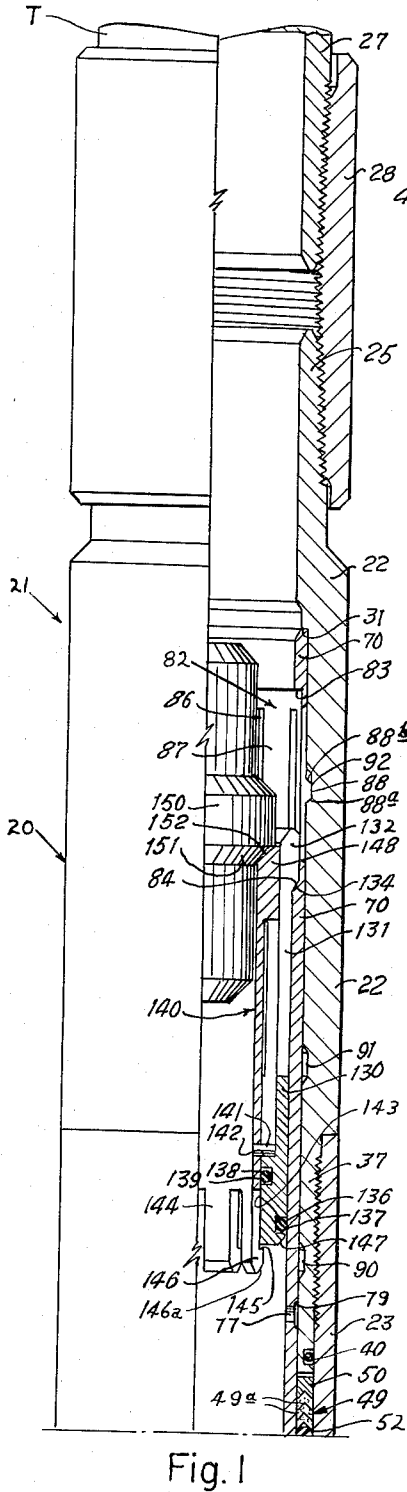


Fig. 1

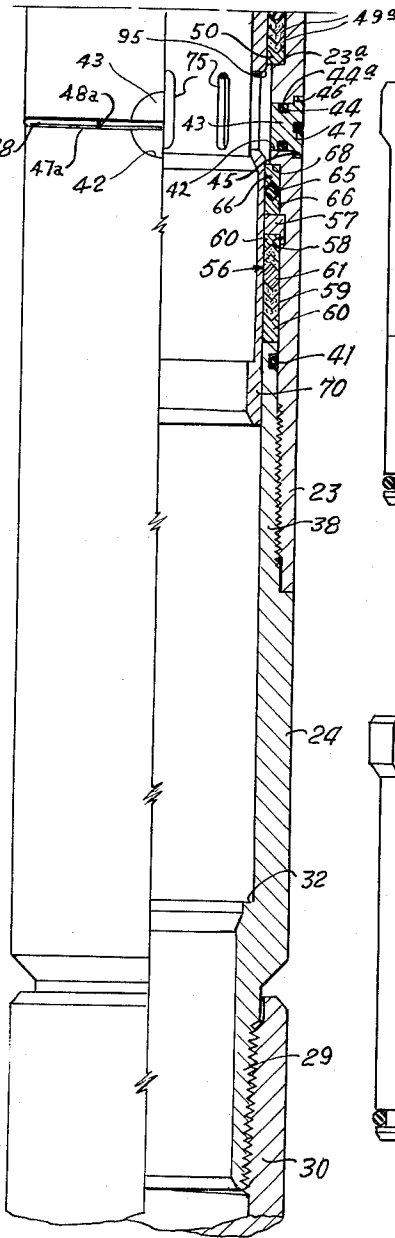


Fig. 2

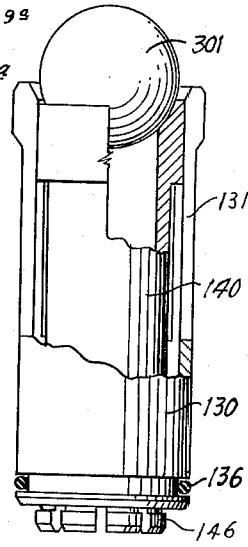


Fig. 6

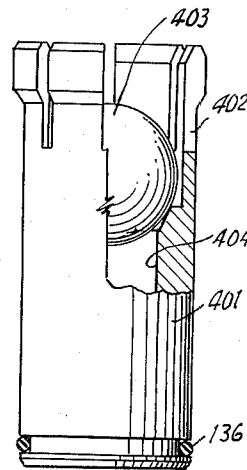


Fig. 7

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2 Sheets-Sheet 2

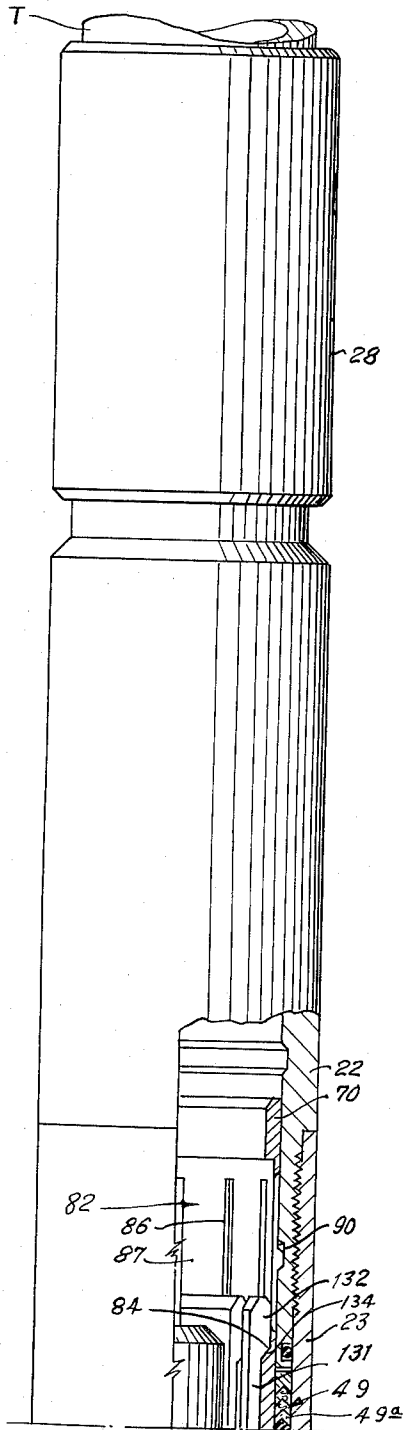


Fig. 3

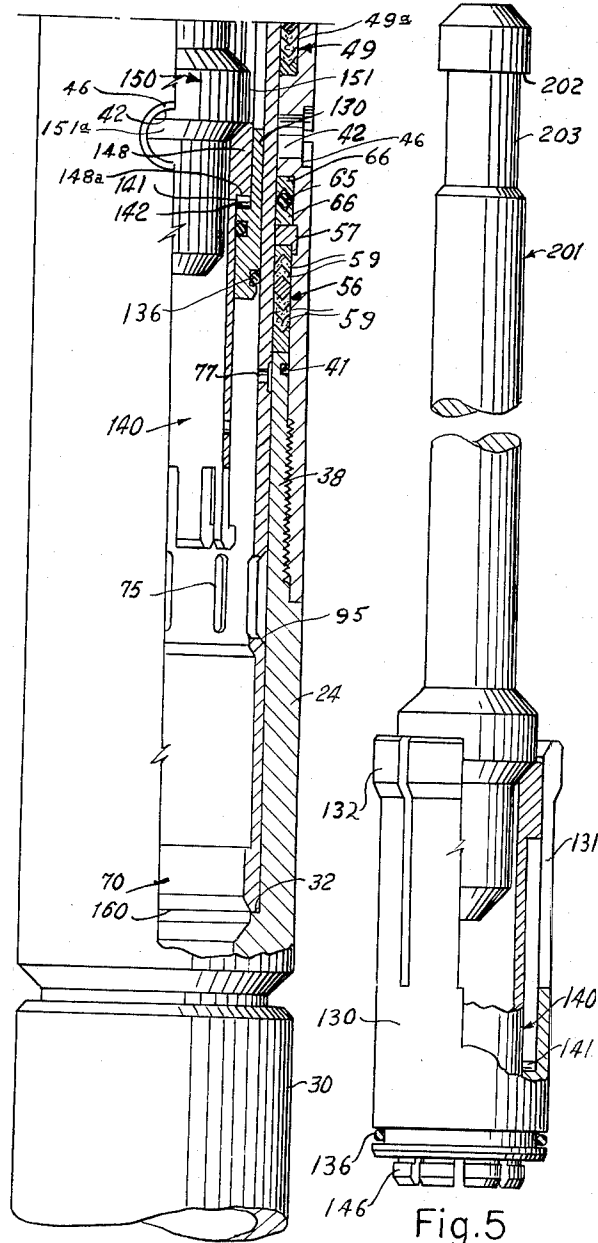


Fig. 4

Fig.5

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## PRESSURE OPERATED SLEEVE VALVE AND OPERATOR

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Filed Mar. 31, 1961, Ser. No. 99,890

13 Claims. (Cl. 166—194)

This application is a continuation-in-part of the co-  
pending application, Serial No. 780,112, filed Decem-  
ber 12, 1958, now Patent No. 3,051,243.

This invention relates to well tools and more particu-  
larly to flow control devices connectable in a well flow  
conductor and to well tools for operating the flow con-  
trol devices while they are connected in the well flow  
conductor.

An object of this invention is to provide a new and  
improved flow control device which is connectable in a  
well flow conductor or pipe to control the flow of fluids  
therein.

Another object is to provide a new and improved flow  
control device having side port means which is connect-  
able in a well flow conductor or pipe and is responsive  
to fluid pressure in the flow conductor to open the port  
means.

Another object is to provide a flow control device hav-  
ing a sleeve valve for controlling the flow of fluids through  
a side port of a flow conductor.

Still another object is to provide a new and improved  
shifting tool for shifting a sleeve valve in a flow con-  
ductor between open and closed positions.

A further object is to provide a shifting tool for the  
sleeve valve of a flow conductor which is automatically  
expelled or ejected from the conductor after moving the  
valve to closed position.

A still further object is to provide a shifting tool for  
a sleeve valve which is destructible by chemicals.

A still further object is to provide a flow control de-  
vice including a flow conductor having side ports, a  
valve sleeve in the flow conductor and initially disposed  
in a position opening the ports, and means responsive  
to fluid pressure in the flow conductor for shifting the  
valve sleeve to a position in said flow conductor closing  
said ports, said sleeve being movable back to a position  
opening the ports.

Additional objects and advantages of the invention will  
be readily apparent from the reading of the following  
description of a device constructed in accordance with  
the invention, and with reference to the accompanying  
drawings thereof, wherein:

FIGURE 1 is a view partly in elevation and partly in  
longitudinal section, of the upper portion of a flow con-  
trol device embodying the invention, showing the sleeve  
valve of the device in open position;

FIGURE 2 is a view similar to FIGURE 1, being a  
continuation thereof, and showing the lower portions of  
the device;

FIGURE 3 is a view partly in elevation and partly  
in longitudinal section, of the upper portions of the de-  
vice showing the sleeve valve of the device in closed po-  
sition;

FIGURE 4 is a view similar to FIGURE 3, being a  
continuation thereof, and showing the lower portion of  
the apparatus;

FIGURE 5 is an elevational view, partly broken away,  
showing a modified form of a drop plug which may be  
used to shift the valve sleeve;

FIGURE 6 is a view similar to FIGURE 5, showing  
still another modified form of drop plug; and,

FIGURE 7 is an elevational view, partly broken  
away, showing a modified form of the valve shifting tool.

Referring particularly to FIGURES 1 and 2 of the  
drawing, a flow control device 20, shown connected in a  
tubing string T, includes a nipple 21 having an upper sub  
section 22, an intermediate or sealing section 23, and a  
lower sub section 24. The upper sub section 22 has a  
reduced externally threaded upper end portion 25 so  
that it may be connected to the lower end of a well flow  
conductor or tubing string section 27 by means of a tubu-  
lar coupling or collar 28. The lower sub section 24 is  
provided with a similar externally threaded lower end  
portion 29 so that it may be connected to the upper end  
of a lower flow conductor or tubing string section (not  
shown) by means of a tubular coupling 30. The upper  
and lower sub sections 22 and 24 are provided with in-  
ternal annular shoulders 31 and 32, respectively, formed  
by reduction of their bores adjacent their end portions  
25 and 29.

The upper and lower sub sections have reduced lower  
and upper end portions 37 and 38, respectively, which  
are threaded into opposite ends of the intermediate or  
sealing section 23. The reduced end portions 37 and 38  
of the upper and lower sub sections are provided with  
external annular recesses in which are disposed O-rings or  
seal means 40 and 41, respectively, which seal between  
the sub sections and the intermediate section 23.

The sealing section 23 is provided with a plurality of  
circumferentially spaced lateral apertures or ports 42 in  
which are disposed removable plugs 43. Each of the  
plugs is provided with an external annular groove 44  
which receives an O-ring 44a which seals between the plug  
and the sealing section in the aperture. An external flange  
45 at the outer end of each plug abuts an annular shoulder  
46 provided by an enlargement of the aperture 42 near its  
outer end. The flange prevents the plugs from being  
forced further inwardly by greater pressure from without  
the nipple assembly. The outer end of each plug 43 is  
provided with a groove 47 which is aligned with an an-  
nular groove 47a formed in the exterior surface of the  
sleeve section 23. A wire 48, disposed within the groove  
with its ends welded together, as at 48a, serves to retain  
the plugs in plugging position as shown in FIGURE 2  
until it is desired to remove them.

An upper seal assembly 49 is carried by the sealing  
section 23 above the ports 42 of the sealing section and  
is held between the upper annular shoulder 23a of an  
internal flange of the sealing section 23 and the lower  
end of the upper sub section 22. The upper sealing  
assembly may be of the chevron type having a plurality  
of resilient elements 49a positioned between female adapt-  
ers 50, which engage the upwardly facing shoulder 23a  
of the sealing section and the lower end of the upper  
sub section 22, and may also include a male adapter 52  
disposed in the usual manner between oppositely facing  
resilient elements of the assembly adjacent thereto.

The sealing section 23 is provided with a similar lower  
seal assembly 56 which is held in place therein by a split  
retainer ring 57 disposed in a suitable internal annular  
recess 58 of the sealing section 23, and by the upper end  
of the lower sub section 24. The sealing assembly 56  
may include a plurality of resilient elements 59 disposed  
between female adapters 60 which bear against the re-  
tainer ring 57 and the upper end of the lower sub section  
24. A male adapter 61 may be disposed centrally of the  
assembly between adjacent and oppositely facing resilient  
elements 59 in the usual manner.

An O-ring seal 65 is carried by the sealing section 23  
and is disposed between a pair of female adapters 66 so  
that only small portions of the O-ring or sealing ele-  
ment 65 extend outwardly of the female adapters. The  
female adapters 66 abut the annular downwardly facing  
shoulder 68 of the sealing section 23 and the upper end  
of the retainer ring 57 which thus hold the O-ring 65 and

the female adapters 66 in proper operative position between the lower seal assembly 56 and the ports 42.

The upper and lower sealing assemblies 49 and 56 and the O-ring 65 are adapted to seal between the sealing section 23 and an internal valve element or valve sleeve 70 which is longitudinally movable in the nipple 21. The valve sleeve is provided with a plurality of circumferentially spaced longitudinal slots or flow ports 75 disposed above the lower end thereof which are adapted to be aligned with the lateral ports 42 of the nipple when the valve sleeve is in the uppermost position in the nipple shown in FIGURES 1 and 2.

The valve sleeve is also provided with a plurality of pressure equalizing ports 77 above the ports 75, which are of restricted diameter. The pressure equalizing ports are adapted to communicate with the lateral ports 42 of the nipple when the plugs are removed from the ports 42 and the valve sleeve is in an intermediate position in the nipple, as when moving between the uppermost position illustrated in FIGURES 1 and 2 and the lowermost position illustrated in FIGURES 3 and 4. The valve sleeve 70 has external reliefs or recesses 79 to prevent damage to the lower packing assembly and the O-ring 65 as the equalizing ports move therepast. It will be noted that the slow equalization of pressures through the ports 77 prevents application of a pressure differential to the lower packing assembly 56 while the longitudinal flow ports 75 of the valve sleeve 70 are moved through such sealing assembly to the upper open position, as by use of a shifting tool, such as is disclosed in application Serial No. 780,112, now Patent No. 3,051,243. The packing is thus protected against damage or injury as the ports move therepast in either direction.

The upper portion of the valve sleeve 70 above the equalizing ports 77 has an upper annular internal recess 82 which provides an abrupt downwardly facing shoulder 83 and an inwardly and upwardly facing cam shoulder 84. A lower internal annular recess 82a is formed in the lower portion of the bore of the sleeve 70 below the flow ports 75 and has an abrupt upwardly facing lower shoulder 73a at its lower end and a downwardly and inwardly facing cam shoulder 84a at its upper end. The bore of the sleeve below the recess 82a conforms in size to the bore of the sleeve above the recess 82 and between the recesses 82 and 82a of the sleeve. The valve sleeve at the upper recess 82 is provided with a plurality of longitudinal slots 86 which provide resilient flexible collect sections 87, each having an external boss 88 provided with outwardly convergent upper and lower shoulders 88a and 88b. The bosses 88 are receivable in the internal longitudinally spaced annular locating recesses 90, 91 and 92 of the upper sub section 22.

When the bosses 88 are located in the uppermost locating recess 92, the sleeve is in its uppermost position relative to the nipple, and the slots 75 are aligned with the lateral ports 42 of the nipple so that should the plugs 43 be removed from the ports, substantially unrestricted flow through the ports 42 may take place between the interior and the exterior of the tubing string. When the valve sleeve is in its lowermost position relative to the nipple, the bosses 88 are disposed in the lowermost locating recess 90, and the ports 42 are closed by the valve sleeve so that no flow of fluids between the interior of the well flow conductor and the exterior thereof can take place. When the bosses are disposed in the intermediate locating recesses 91, the equalizing ports 77 are in alignment with the lateral ports 42 and in communication therewith when the plugs are removed, so that a restricted flow of fluids may take place between the exterior and the interior of the flow conductor and the pressure differential therebetween may be equalized slowly.

The outwardly extending lower shoulders 88a of the sleeve bosses 88 are adapted to cooperate with the upwardly facing shoulders of the locating recesses to cam the bosses, and therefore the resilient sleeve collet strips

87 inwardly, when a downward force is applied to the valve sleeve, thereby permitting movement of the valve sleeve between the uppermost, intermediate, and lowermost positions. The sleeve is limited in its upward movement within the nipple assembly by means of the annular shoulder 31 of the upper sub section 22 and adapted to abut the upper end of the valve sleeve. Downward movement of the valve sleeve is limited by the engagement of its lower end with the upwardly facing annular shoulder 32 of the lower sub section 24.

The valve sleeve has an external annular recess 95 providing outwardly divergent bevels or shoulders which extend from the upper and lower ends of the slots 75 to prevent the edges of the slots from damaging the resilient elements of the lower packer assembly and the O-ring 65.

It will further be seen that the landing nipple 21 is provided with seal means which seal between the valve sleeve and the nipple on opposite sides of the lateral ports 42 and the longitudinal slots 75 when the valve sleeve is in its upper open position and these slots are in alignment so that all flow of fluids between the exterior and the interior of the flow device is directed through these ports and slots. Similarly, when the valve sleeve is in its lower closed position, the seal means 49, 56 and 65 positively seal between the valve sleeve and the nipple at opposite sides of the ports 42 to thereby close the ports and prevent any flow of fluids therethrough into the sleeve.

A collet 130 having resilient fingers 131 provided with bosses 132 is disposed within the slidable valve sleeve 70 with the bosses engaged within the internal upper recess 82 of the valve sleeve. Downwardly facing shoulders 134 of the bosses 132 permit insertion of the collet in the sleeve by engaging the inner bore wall of the sleeve above the recess and causing the collet fingers to be cammed inwardly until the bosses enter the sleeve recess 82. Expansion of the fingers 131 as the bosses enter the recess 82 and engagement of their downwardly facing shoulders 134 with the corresponding upwardly facing annular shoulder 84 of the sleeve then limits further downward movement of the collet in the sleeve unless the collet is acted upon by a downward force of sufficient magnitude to cause the fingers to again be cammed inwardly by coaction of the shoulders 134 and 84. An O-ring 136 disposed within the annular groove 137 in the exterior surface of the collet adjacent the lower end of the collet seals between the collet and the sleeve.

A collet mandrel 140 having fingers 144 at the lower end thereof has a shear pin 141 above the fingers 144, which extends outwardly of the collet mandrel to engage the upwardly facing annular shoulder 142 provided by the internal flange 143 at the lower end of the collet. In this position of the collet mandrel, as shown in FIGURE 1, the collet mandrel fingers 144 extend below the lower end of the collet 130 and the external bosses 146 of the fingers 144 to limit upward movement of the collet mandrel relative to the collet by engagement of their upwardly facing shoulders 145 with the lower end 147 of the collet. The bosses 146 have inwardly and downwardly beveled shoulders or surfaces 146a to facilitate insertion of the mandrel within the collet by causing the fingers 144 to be cammed inwardly when the beveled surfaces 146a of the bosses engage the annular shoulder formed at the restriction of the collet bore 143 as the collet mandrel is inserted into the collet. In such relative position of the collet and collect mandrel, an external annular flange 148 of the collet mandrel is positioned inwardly of the collet fingers 131 to prevent inward flexing of the collet fingers and thus locks the collet in the nipple against downward movement from the upper position illustrated in FIGURE 1. Further, an O-ring 138 disposed within an internal annular groove 139 of the collet provides a fluid tight seal between the collet and the collet mandrel. In use, the nipple 21 is connected in a tubing string to form a portion thereof with the collet, the collet mandrel and the valve sleeve in the positions illustrated in FIG-

FIGURE 1 wherein the valve sleeve is in its upper position in the nipple and with the collet locked against downward movement in the valve sleeve by the collet mandrel. A well packer of any suitable type is connected to the tubing string below the nipple 21 and may be provided with a tubing anchoring or setting device for anchoring the tubing against movement relative to the well casing of a well. The tubing string is lowered into the well to a predetermined position.

After the tubing is in place in the well and the well packer has been set to close the annulus between the tubing and the well casing below the nipple, it is usually desirable to test the holding or sealing ability of the packer by introducing fluid pressure into the tubing-casing annulus at the surface to build up pressure therein against the packer. During such testing, the plugs 43 of the flow device effectively prevent communication between the bores of the tubing and the casing.

The annular flanges 45 of the plugs, by engaging the annular shoulders 46 of the nipple, prevent their inward displacement through the ports 42 due to the increased pressure in the annulus. If the packer holds satisfactorily, the fluid pressure in the annulus is released by pressure bleeding at the surface to prepare for other operations, wherein the flow device may be actuated to open its lateral ports 42 and permit fluid communication between the annulus above the well packer and the interior or bore of the tubing string.

It will be apparent that with the valve sleeve in its uppermost position, fluid pressure introduced into the tubing string will be communicated through the bore of the valve sleeve and the sleeve ports 75 to act upon the plugs 43 in the nipple assembly so as to tend to force them outwardly. When the fluid pressure in the tubing is increased to a predetermined value, the outward force of pressure acting against the plug is caused to exceed the strength of the wire retainer 48 thus causing the wire to break and the plugs to be expelled from the apertures 42. Fluid communication between the tubing bore and the tubing-casing annulus is now established, and any desired operations may now be performed which require fluid flow between the interior of the tubing string and the annulus between the tubing string and the well casing above the packer.

When it is desirable to close off the apertures 42 of the nipple assembly to prevent flow or communication therethrough, a drop plug 150 is dropped into the tubing and allowed to fall until it contacts the collet mandrel 140 as shown in FIGURE 1. The plug, which is substantially cylindrical in form and circular in cross-section, is provided with an external annular flange 151 having a downwardly facing beveled shoulder 151a which sealingly engages the upwardly facing inclined shoulder 152 provided at the upper end of the collet mandrel. Fluid pressure introduced into the tubing above the device now creates a pressure differential acting not only across the drop plug but also across the entire area sealed by the collet O-ring 136. The force resulting from this pressure differential causes the sleeve collet sections 87 to be cammed inwardly by camming action between the upwardly facing shoulder of the recess 92 and the downwardly facing shoulders of the sleeve bosses 88. The sleeve valve is now free to move to its lowermost position in the nipple illustrated in FIGURES 3 and 4. The drop plug, collet, and collet mandrel remain in the relative positions with respect to the sleeve, shown in FIGURE 1, since the shear pin 141 prevents downward movement of the collet mandrel relative to the collet. The fluid pressure moves the valve sleeve to its lowermost position in the nipple wherein the slots 75 of the sliding sleeve, as well as the pressure equalizing ports 77, are located below the lower seal assembly 56 and therefore cannot communicate with the port 42 of the intermediate section 23 of the nipple. The seal means 46 now seals between the valve sleeve and the nipple above the ports 42 so that the ports are effectively closed to prevent any flow of fluids there-

through between the annulus and the interior of the tubing string.

After the sliding valve sleeve has been forced to its lowermost position, wherein its extreme lower end 160 abuts the upwardly facing shoulder 32 formed in the inner wall of lower sub section 24, the pressure differential across the drop plug 150 may be increased by increasing tubing pressure above the plug to cause the shear pin 141 to fail, whereupon the collet mandrel is forced to its lowermost position relative to collet 130 wherein the downwardly facing shoulder 148a of the mandrel flange 148 abuts the upwardly facing annular shoulder 142 in the collet bore 143, as shown in FIGURE 4.

As the collet mandrel 140 moves downwardly relative to the collet 130 with the drop plug 150 remaining in its position of sealing engagement with the upper end of the collet mandrel, the external annular flange 148 at the upper end of the collet mandrel moves out of engagement with the upper portions of the collet fingers 131 and permits them to be cammed inwardly out of the sleeve recess 82 by the cam action between the inclined collet shoulder 134 and the upwardly facing shoulder 84 of the sleeve valve. The pressure differential which still exists across the drop plug, then forces the collet 130 with the collet mandrel and drop plug supported therein further downwardly through the sleeve 70 and the lower sub section to the bottom of the tubing or well.

The collet, collet mandrel, and drop plug are preferably made of aluminum or similar metal which can be readily dissolved in the well by caustic or acid solutions should it be desired or necessary that these elements be removed or eliminated from the well.

It will thus be seen that the flow control device described herein is connectable in a tubing string and is responsive to fluid pressure in the tubing to establish fluid communication between the interior of the tubing and the exterior thereof.

It will also be seen that the flow control device includes a valve sleeve for establishing fluid communication between the interior or bore of the tubing and the annulus between the tubing and the well casing having valve shifting means which comprises a drop plug adapted to be dropped through the tubing into the flow control device to permit fluid pressure in the tubing to shift the sleeve valve from open to closed position.

It will further be seen that the shifting tool means described herein, which are provided in the flow control device and responsive to fluid pressure in the tubing to shift the sleeve valve to closed position, may be moved out of the flow control device to fall downwardly in the tubing when the pressure in the tubing above the flow control device is increased above the predetermined value necessary to shear the shear pin 141.

A modified form of drop plug which may be used in the device illustrated in FIGURES 1 to 4 is shown in FIGURE 5. The plug 201 is similar to the drop plug 150, except that its upper portion is much more elongated and is provided with a downward facing annular shoulder 202 formed by an annular recess 203 in the cylindrical surface of its upper portion. The shoulder 202 is adapted to be hooked or engaged by a wire line fishing tool if upward retrieval of the plug becomes necessary. The lengthening of the upper portion of the drop plug tends to prevent the possibility of its lodging in offset mandrels, or the like, although should the plug do so, the fishing flange would facilitate its retrieval by a fishing tool.

Still another modified form of drop plug which may be used in the flow control device is illustrated in FIGURE 6. The plug 301 is in the form of a simple sphere or ball of sufficient circumference to plug and sealingly engage the collet mandrel for the purposes explained above. Like the drop plugs 150 and 201, the drop plug 301 is preferably made of aluminum or other similar materials which may be readily dissolved when desired.

In FIGURE 7, a modified form of valve shifting tool is disclosed which may be used in the invention instead of

the collet and collet mandrel shown in FIGURES 1 to 6. The tool comprises a collet 401 which is provided with short, resilient but fairly stiff fingers 402. The fingers are provided with sufficient strength so that when a pressure differential is created across the O-ring 136 and the drop plug 403 which plugs the bore 404, the tool will move the valve sleeve downwardly from its uppermost position to its lowermost position without the need of a collet mandrel to hold the collet fingers in the sleeve recess 82 as shown in FIGURE 1. Of course, when fluid pressure is further increased, the collet fingers 402 are cammed inwardly to free the collet and plug for downward movement through the sleeve valve.

It will now be seen that a flow control device for controlling fluid flow between a tubing string and the tubing-casing annulus of a well has been disclosed which is provided with side ports adapted to be opened by fluid pressure and closed by means of a fluid pressure actuated valve shifting mechanism within the device.

It will also be seen that the valve shifting mechanism of the device is automatically expelled from the tubing by fluid pressure after it has effected shifting of the valve sleeve.

It will further be seen that the shifting mechanism can be dissolved by chemicals if it is desired to eliminate it from the well.

The foregoing description of the invention is explanatory only, and changes in the details of construction illustrated, may be made by those skilled in the art, within the scope of the appended claims, without departing from the spirit of the invention.

I claim:

1. A flow control device including: a flow conductor having a lateral port, valve means in said flow conductor for controlling the flow of fluids between the interior and the exterior of said conductor through said lateral port; said valve means including an elongate sleeve having a lateral passage formed therein and slidable longitudinally of said conductor between an initial position in which said lateral passage is in communication with the lateral port of said conductor and a second position in which said sleeve closes the lateral port of the conductor, and releasable plug means disposed in said lateral port of said conductor and supported therein against displacement inwardly by pressure of fluids exteriorly of the housing; said plug means being displaceable outwardly of said lateral port of said housing by fluid pressure from within the conductor while said sleeve is in said initial position; sleeve valve operator means engaging said sleeve within said flow conductor responsive to fluid pressure therein for moving said valve sleeve of said valve means from open position wherein said sleeve permits fluid flow through said lateral port to closed position whereby said sleeve prevents fluid flow through said lateral port, said operator means being displaceable longitudinally out of said sleeve and said conductor; said sleeve having means in its bore adapted to be engaged by a shifting tool for moving said sleeve from said second position closing said lateral port to said initial position reopening said lateral port.

2. A flow control device for a flow conductor including: a nipple connectable in the flow conductor to constitute a section thereof, said nipple having a lateral port providing communication between the exterior and interior thereof; a valve sleeve having a lateral flow port slidably mounted in said nipple for limited longitudinal movement therein, said valve sleeve being initially disposed in and movable between a first open position wherein said flow port of said sleeve is in communication with the lateral port of said nipple and a second closed position wherein said valve sleeve prevents flow of fluids through said lateral port; plug means in said lateral port of said nipple preventing inward flow of fluids through said port and displaceable outwardly of said port while said valve sleeve is in said first position by fluid pressure from within said nipple; and a shifting tool disposable within said sleeve

to plug the bore thereof, whereby fluid pressure of a predetermined level introduced into said flow conductor and acting against said tool will cause said sleeve to move from said first position to said second position to again close off the flow of fluids through said lateral port of said nipple, said sleeve having means in its bore adapted to be engaged by a shifting tool for moving said sleeve from said second position back to said first position to reopen said lateral port of said nipple.

3. A flow control device for a flow conductor including: a nipple connectable in the flow conductor to constitute a section thereof, said nipple having a lateral port providing communication between the exterior and interior thereof; a valve sleeve having a lateral flow port and slidably mounted in said nipple for limited longitudinal movement therein, said valve sleeve being initially disposed in a first position wherein said flow port of said sleeve is in communication with the lateral port of said nipple, and movable between said first open position wherein said flow port of said sleeve is in communication with the lateral port of said nipple and a second closed position wherein said valve sleeve prevents flow of fluids through said lateral port; and shifting means operatively associated with said valve sleeve and responsive to a first predetermined value of fluid pressure within said sleeve for moving said sleeve from said first open position to said second closed position, said shifting means being ejected from said sleeve and nipple when the fluid pressure exceeds said first predetermined value by a predetermined degree, said sleeve having means in its bore adapted to be engaged by a shifting tool lowerable into the sleeve after the same has been shifted to said second closed position for moving said sleeve from said second position to said first open position, and having second means in its bore engageable by a shifting tool lowerable into said sleeve after the tool has again been moved to the first open position to move the same downwardly to said second closed position.

4. A flow control device for a flow conductor including: a nipple connectable in the flow conductor to constitute a section thereof, said nipple having a lateral port providing communication between the exterior and interior thereof; a valve sleeve having a lateral flow port slidably mounted in said nipple for limited longitudinal movement therein; co-operable means on said valve sleeve and said nipple for yieldably holding said sleeve in an open position wherein said flow port of said sleeve is in communication with the lateral port of said nipple; plug means disposed in said lateral port of said nipple and restrained against displacement outwardly thereof, said plug means closing off flow of fluids inwardly of said lateral port into said nipple and being displaceable outwardly of said port by fluid pressure from within said nipple; and shifting means operatively associated with said valve sleeve and responsive to a predetermined fluid pressure within said sleeve for releasing said co-operable means and moving said sleeve from said open position to a closed position wherein said valve sleeve prevents flow of fluids through said lateral port after said plug has been displaced from said lateral port, said shifting means being displaceable longitudinally out of said sleeve by fluid pressure after said sleeve has been shifted to said closed position, said valve sleeve having means in its bore engageable by a shifting tool lowerably thereto through the well conductor for shifting said valve sleeve from said position closing said lateral port of said nipple back to a position opening said lateral port to flow therethrough.

5. A flow control device for a flow conductor including: a nipple connectable in the flow conductor to constitute a section thereof, said nipple having a lateral port providing communication between the exterior and interior thereof; a valve sleeve having a lateral flow port and slidably mounted in said nipple for limited longitudinal movement therein, said valve sleeve being initially disposed in a position having its lateral flow port communicating with the lateral port of said nipple and being movable be-

tween said first open position wherein said flow port of said sleeve is in communication with the lateral port of said nipple and a second closed position wherein said valve sleeve prevents flow of fluids through said lateral port; cooperable means on said sleeve and nipple for yieldably holding said sleeve in said first position; a closure plug disposed in said lateral port of said nipple and held against inward displacement from said port to prevent inward flow of fluid through said port, said plug being displaceable outwardly of said port; means releasably holding said plug in said port and releasable upon the application of a predetermined fluid pressure within said nipple to said plug to displace said plug outwardly of said port; and shifting means operatively associated with said valve sleeve and responsive to a first predetermined fluid pressure in said sleeve for moving said sleeve from said first position to said second closed position, said second closed position to reclose said lateral port of said nipple, said shifting means being displaceable longitudinally out of said sleeve and said nipple upon the application of a fluid pressure of a predetermined value in excess of such first predetermined fluid pressure to open the longitudinal bore through said nipple and said sleeve, said sleeve having means in its bore engageable by a shifting tool lowerable through said flow conductor into said sleeve for moving said sleeve from said second position back to said first position to reopen said lateral port of said nipple, said sleeve being movable from said second position back to said first position to reopen said lateral port of said nipple.

6. A flow control device for a flow conductor including: a nipple connectable in the flow conductor to constitute a section thereof, said nipple having a lateral port providing communication between the exterior and interior thereof; a valve sleeve having a lateral flow port and slidably mounted in said nipple for limited longitudinal movement therein, said valve sleeve being initially disposed in a first position wherein said flow port of said sleeve is in communication with the lateral port of said nipple and movable between said first open position wherein said flow port of said sleeve is in communication with the lateral port of said nipple and a second closed position wherein said valve sleeve prevents flows of fluids through said lateral port; first cooperable means on said sleeve and nipple for yieldably holding said sleeve in said first position; plug means for plugging the bore of said sleeve whereby fluid pressure within said sleeve and acting against said plug causes the release of said first cooperable means to move said sleeve from said first position to said second position; and second cooperable means on said plug means and said sleeve for yieldably holding said plug in said sleeve, said second cooperable means being responsive to a second higher predetermined fluid pressure within said sleeve for ejecting said plug from said sleeve, said sleeve having means in its bore engageable by a shifting tool lowerable through said flow conductor into said sleeve to move said sleeve from said second position back to said first position to reopen said lateral port of said nipple, said sleeve having second means in its bore engageable by a shifting tool lowerable through the conductor into said sleeve to again move said sleeve from said first position to said second position to reclose said lateral port of said nipple.

7. A flow control device including: a tubular member having a lateral flow port; a tubular valve sleeve having a lateral port slidably mounted in said tubular member for longitudinal movement therein; first cooperable latch means on said sleeve and said tubular member for releasably holding said sleeve in a first position relative to said tubular member wherein the lateral port of said sleeve is in communication with the lateral port of said tubular member; said valve sleeve being shiftable longitudinally in said tubular member from said first position to a second position wherein the lateral port of said sleeve is out of communication with the lateral port of said tubular mem-

ber; a tubular shifting member disposed in said valve sleeve for shifting said valve sleeve from said first position to said second position in response to fluid pressure; second cooperable latch means on said tubular shifting member and said valve sleeve for releasably holding said shifting member in said valve sleeve; tubular lock means in said shifting member engageable with said second latch means for locking said shifting member in said sleeve; means on said lock means and said shifting member restraining said lock means in position engaging said second latch means of said shifting member; plug means engageable with said tubular lock means for closing off flow of fluids therethrough whereby fluid pressure in said sleeve above said lock means acts on said lock means and shifting member to shift said sleeve from said first position to said second position in said tubular member and continued application of fluid pressure in said sleeve above said lock means moves said lock means downwardly longitudinally relative to said shifting member to release said shifting member for movement out of said sleeve when said sleeve is plugged.

8. In combination, a flow control device including: a tubular member having a lateral flow port; a tubular valve sleeve having a lateral port slidably mounted in said tubular member for longitudinal movement therein; first cooperable latch means on said sleeve and said tubular member for releasably holding said sleeve in a first position relative to said tubular member wherein the lateral port of the tubular sleeve is in communication with the lateral port of said tubular member; and a tubular shifting member disposed in said valve sleeve; second cooperable latch means on said tubular shifting member and said valve sleeve for releasably holding said shifting member in said valve sleeve; a tubular lock means in said shifting member engageable with said second latch means for locking said shifting member in said sleeve; means releasably retaining said lock means in position engaging said second latch means; a drop plug adapted to be releasably disposed in sealing relation with the bore of said lock means as to plug the bore thereof, whereby said first latch means is releasable in response to a first predetermined fluid pressure in said tubular member and acting against said plug to cause said sleeve to be moved from said first position and said lock means is movable in response to a second predetermined fluid pressure in said tubular member to release said second latch means and permit the movement of said shifting member, lock means, and drop plug longitudinally out of said valve sleeve.

9. In combination, a flow control device including: a tubular member having a lateral flow port; a tubular valve means slidably mounted in said tubular member for longitudinal movement therein; first cooperable latch means on said tubular valve means and said tubular member for releasably holding said tubular valve means in a first position wherein said lateral port permits fluid flow between the exterior and interior of said tubular member and movable in said tubular member from said first position to a second position in which said valve means closes said lateral port of said tubular member to prevent flow between the exterior and interior of said tubular member; and a tubular shifting member disposed in said tubular valve means; second cooperable latch means on said tubular shifting member and said tubular valve means for releasably holding said shifting member in said valve means; a lock means in said shifting member engageable with said second latch means for holding said second latch means in cooperable engagement with said valve means for locking said shifting member in said tubular valve means, said lock means being movable relative to said shifting member to release said shifting member for movement out of said tubular valve means; means on said lock means and said shifting means coengageable for restraining said lock means in position engaging said latch means for locking said shifting member in said tubular valve means; and plug means engageable

with said lock means for closing off fluid flow there-through whereby fluid pressure applied to said lock means and said shifting member moves said valve means from said first position to said second position in said tubular member, and whereby further fluid pressure applied to said lock means and said shifting member within said tubular valve means moves said lock means longitudinally relative to said second latch means to free said shifting member from locking engagement with said valve means to permit said shifting member to be moved longitudinally out of said valve means and said flow control device by such fluid pressure.

10. A shifting tool for moving a valve sleeve slidably disposed in a flow conductor including: a shifting member adapted to be disposed in said valve sleeve; seal means on the exterior of said shifting member adapted to engage said valve sleeve to seal against flow of fluids therebetween; external latch means on said shifting member engageable with said valve sleeve for releasably holding said shifting member in said valve sleeve; tubular lock means slidable longitudinally within said shiftable member engageable with said latch means for holding said latch means in position to engage said valve sleeve for locking said shifting member against movement in said valve sleeve; and means on said lock means and said shifting member coengageable for holding said lock means in position engaging said latch means; said lock means being movable longitudinally relative to said shifting member out of engagement with said latch means to free said latch means for movement out of position to engage said valve sleeve to release said shifting member for movement out of said valve sleeve.

11. A shifting tool for moving a valve sleeve slidably disposed in a flow conductor and having an internal annular groove therein, said shifting tool including: a tubular shifting member adapted to be disposed in said valve sleeve; external seal means on said shifting member adapted to engage said valve sleeve to seal off fluid therebetween; external outwardly biased latch means on said shifting member engageable with said groove of said valve sleeve for releasably holding said shifting member in said valve sleeve; tubular lock means longitudinally slidably mounted within said shifting member engageable with said latch means for holding said latch means against inward movement out of engagement with said groove of said valve sleeve for locking said shifting member against movement longitudinally out of said valve sleeve; means on said lock means and said shifting member coengageable for holding said lock means against movement relative to said shifting member and out of engagement with said latch means and releasable to permit movement of said lock member out of engagement with said latch means; said lock means being movable longitudinally relative to said shifting member out of locking engagement with said latch means to permit said latch means to move out of said groove of said valve sleeve to release said shifting member for movement out of said valve sleeve; seal means on said lock means engageable with said shifting member for closing off flow of fluids therebetween; and a plug engageable with the lock means to close off flow of fluids therethrough whereby said shifting member, said lock means and said plug are released for movement out of said sleeve valve when fluid pressure of predetermined force acts on said plug to move said plug and lock means relative to said shifting member.

12. A well tool including: a tubular housing having a bore therethrough and having a lateral flow passageway providing an outlet from the bore intermediate the ends thereof to the exterior of the housing; sleeve means slidably mounted for longitudinal movement in the bore of said housing and having means providing when in a first

longitudinal position in said housing a closure for said lateral passage of said housing and when in a second longitudinal position providing fluid communication between the bore of the housing and the passageway; means on said sleeve means and said housing coengageable when said sleeve means is in said first position for initially holding said sleeve means in said first position; fluid pressure releasable plug means in said passageway exterior of said sleeve means and initially secured in position closing said passageway, said plug means being releasably upon application of sufficient fluid pressure from within said housing to open said passageway to fluid communication between the bore of said housing and the exterior thereof; said sleeve means being movable longitudinally in said housing to said first position positively closing off fluid flow in either direction through said passageway after said plug means is released by fluid pressure to open said passageway; and means releasably secured to said sleeve means and responsive to fluid pressure within said housing for moving said sleeve means from said second longitudinal position to said first longitudinal position and releasable from said sleeve means to be displaced longitudinally out of said housing, said sleeve means being movable from said first position back to said second position after said shifting means has been displaced from said housing.

13. A flow control device for wells including: a flow conductor having a bore therethrough and having a lateral port opening from intermediate the ends of said bore to the exterior of said conductor; plug means secured in said lateral port closing said port against flow of fluid inwardly therethrough; slide valve means in said flow conductor for controlling the flow of fluids between the bore and the exterior of said conductor through said lateral port; said slide valve means being initially disposed in said flow conductor in a position permitting flow through said lateral port and being movable longitudinally in said conductor to a second position closing said lateral port; said plug means being releasable from position closing said port upon the application of a predetermined fluid pressure thereagainst from within the bore of said conductor while said slide valve means is in said initial position; and means releasably secured to said slide valve means and responsive to fluid pressure within said housing for moving said slide valve means from said initial longitudinal position to said second longitudinal position and releasable from said slide valve means to be displaced longitudinally out of said housing; said slide valve means being movable from said second position to said initial position after said shifting means has been displaced from said housing.

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UNITED STATES PATENT OFFICE  
CERTIFICATE OF CORRECTION

Patent No. 3,211,232

October 12, 1965

George G. Grimmer

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 22, for "thet" read -- the --; column 11, line 21, for "shiftable" read -- shifting --; column 12, line 10, for "releasably" read -- releasable --.

Signed and sealed this 24th day of May 1966.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

EDWARD J. BRENNER

Commissioner of Patents