Aug. 2, 1966 M. B. CONRAD 3,263,752

ACTUATING DEVICE FOR VALVES IN A WELL PIPE

Filed May 14, 1962 2 Sheets-Sheet 1

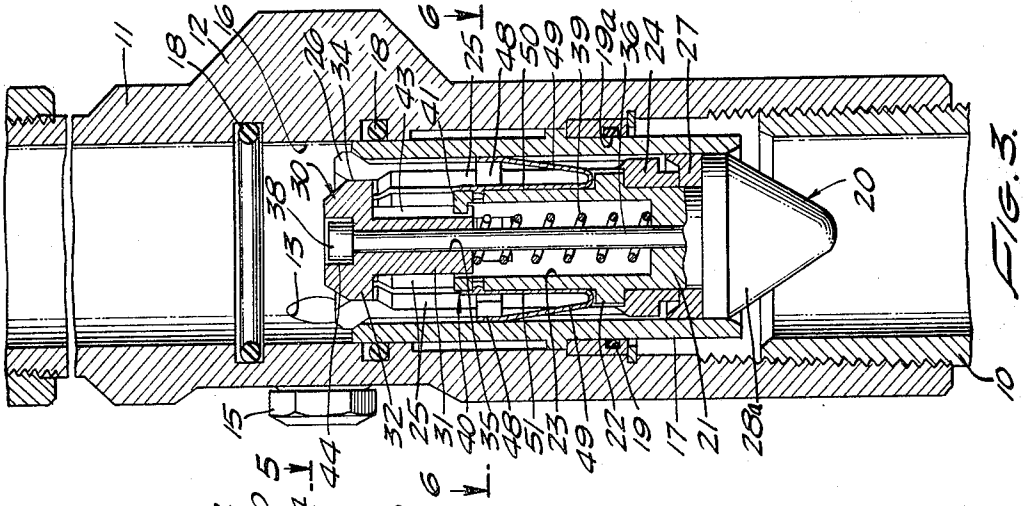

FIG. 3.

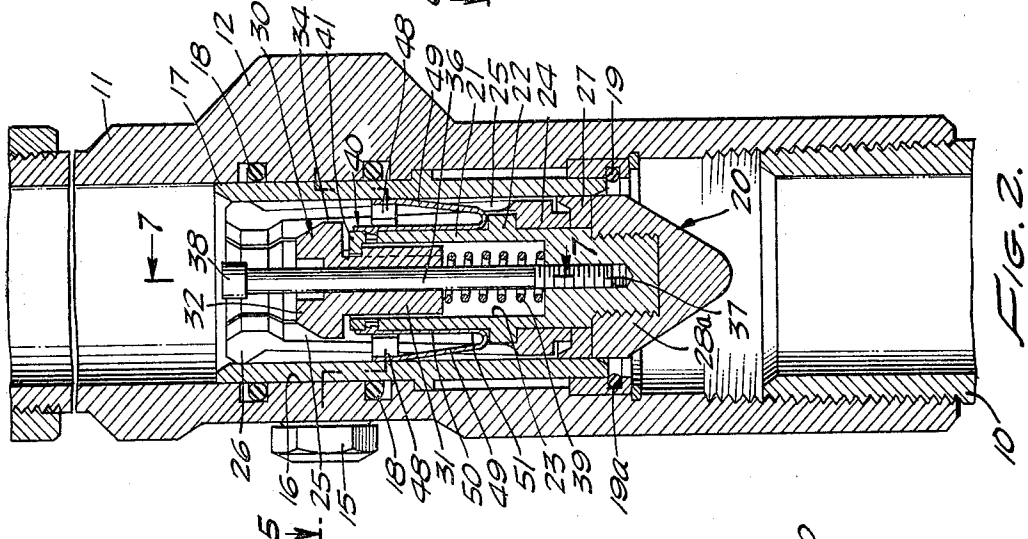

FIG. 2.

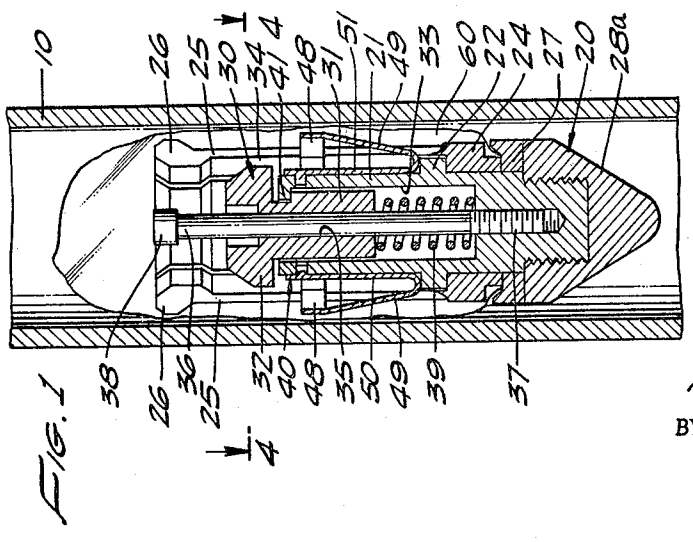

FIG. 1

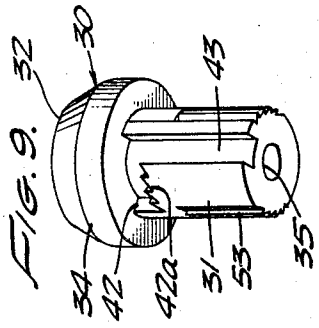

FIG. 9.

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ACTUATING DEVICE FOR VALVES IN A WELL PIPE

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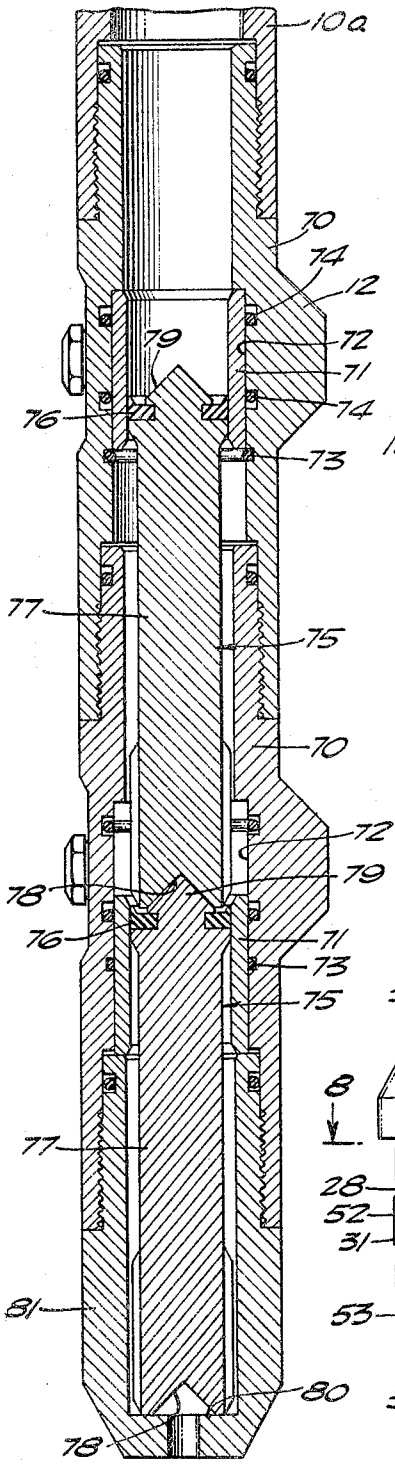
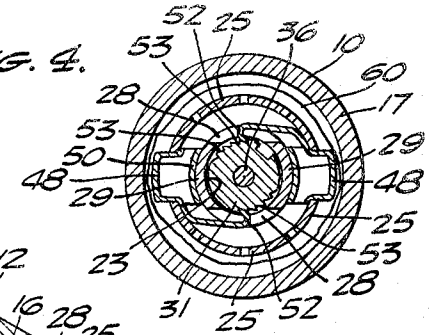


FIG. 10.

FIG. 4.



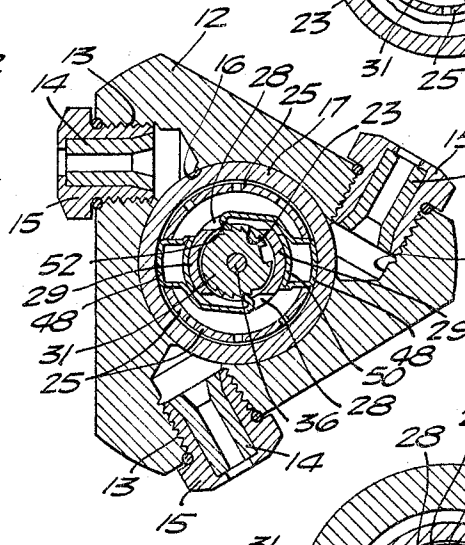


FIG. 5.

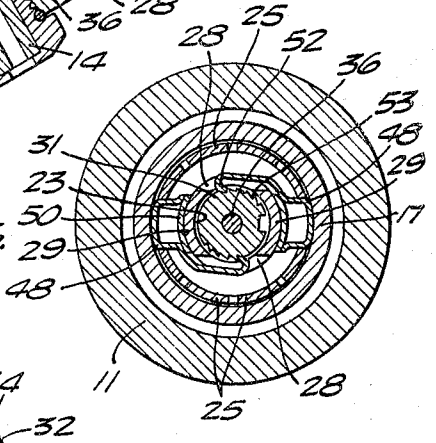


FIG. 6.

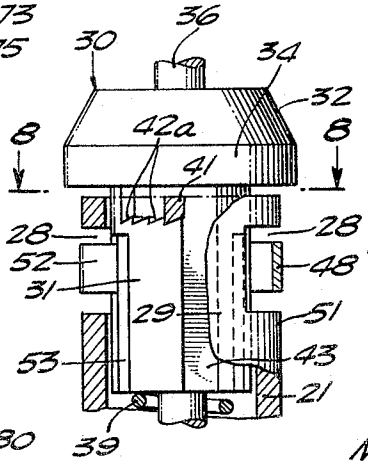


FIG. 7.

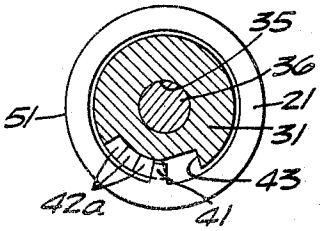


FIG. 8.

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ACTUATING DEVICE FOR VALVES IN A WELL PIPE

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Filed May 14, 1962, Ser. No. 194,513
7 Claims. (Cl. 166—154)

This invention relates to valves for controlling flow of fluids within a well, and is particularly directed to an actuating device for selectively operating one of a series of sleeve valves mounted within a well pipe. It is desirable in order to perform certain operations in a well, to provide a well pipe with a series of longitudinally spaced sleeve valves constructed so that downward movement of each sleeve results in opening one or more lateral ports in the well pipe. The present invention relates to such construction and to apparatus for selectively opening any one of the sleeve valves without opening the others, and characterized by full bore opening through all of the sleeves.

The principal object of this invention is to provide a plug device which may pass downward through the interior of the well pipe and which cooperates with the series of full bore valve sleeves in a maner so that a predetermined sleeve only is moved to open position. Another object is to provide a plug assembly having novel construction which enables it to pass through a predetermined number of valve sleeves without opening them and then to seat with respect to a predetermined valve sleeve so that pressure in the well pipe may be employed to move the sleeve downward to open position and thereby permit flow through one or more lateral ports in the wall of the well pipe.

In a preferred form of the invention the plug assembly is provided with a plurality of spring fingers which may be deflected inwardly to enable the plug assembly to pass through one or more valve sleeves, together with a movable member for blocking inward movement of the spring fingers to prevent passage of the plug assembly through one of the valve sleeves. Internal mechanism in the plug assembly operates to move the said movable member into blocking position only after the plug assembly has passed through a predetermined number of valve sleeves.

In a modified form of the invention, the valve sleeves in the well pipe are closely spaced and the distance between them is substantially the same. Duplicate plug assemblies having no movable parts may then pass downward through the interior of the well pipe to open the valve sleeves in sequence beginning with the lowermost valve sleeve.

Referring to the drawings:

FIGURE 1 is a longitudinal sectional view showing a preferred form of plug assembly embodying this invention.

FIGURE 2 is a continuation of the lower end of FIGURE 1 and shows the same plug assembly passing through one of a series of cylindrical sleeves mounted for axial movement within the well pipe.

FIGURE 3 is a continuation of the lower end of FIGURE 2 showing the same plug assembly fixed within one of the valve sleeves and showing the valve sleeve moved to open position.

FIGURE 4 is a transverse sectional view taken substantially on the lines 4—4 as shown in FIGURE 1.

FIGURE 5 is a transverse sectional view taken substantially on the lines 5—5 as shown in FIGURE 2.

FIGURE 6 is a transverse sectional view taken substantially on the lines 6—6 as shown in FIGURE 3.

FIGURE 7 is a sectional detail, partly broken away, and taken substantially on the lines 7—7 as shown in FIGURE 2.

FIGURE 8 is a transverse sectional detail taken substantially on the lines 8—8 as shown in FIGURE 7.

FIGURE 9 is a perspective view showing details of construction of the expander member.

FIGURE 10 is a longitudinal sectional view showing a modification.

Referring to the drawings, the casing generally designated 10 extends downward into the well hole. Sections of the casing are connected end to end by threaded joints at predetermined positions within the well. Valve housings 11 are interposed between adjacent casing sections. Each valve housing 11 is preferably formed with a noncircular portion 12 having a plurality of lateral ports 13 therein. A nozzle 14 is mounted at each of the ports 13 and held in position by means of a threaded retainer 15. Each housing 11 is provided with a cylindrical bore 16 which intersects the lateral ports 13. A valve sleeve 17 is slidably mounted within each bore 16 and normally closes off the ports 13 to prevent flow therethrough. Seal rings 18 are provided within the housing above and below the ports 13 and these seal rings 18 form a sliding seal with the outer cylindrical surface of the valve sleeve 17. A ring 19 mounted in a shallow groove 19*a* in the housing 11 projects into the path of downward movement of the valve sleeve 17 and thereby serves to maintain it in closed position, preventing lateral flow through the ports 13. Upon application of sufficient downward force to the valve sleeve 17, in the manner hereafter described, the lower end of the valve sleeve 17 shears the ring 19 and allows the valve sleeve 17 to move downward to another position in which the lateral ports 13 are placed in communication with the interior of the housing above the valve sleeve 17, thereby permitting lateral flow through the ports 13 and nozzles 14.

A plug assembly generally designated 20 is shaped to allow its passage downward through the interior of the casing 10 and this plug assembly includes a body 21 having an annular flange 22 and provided with a central cylindrical bore 23. A metal ring 24 is mounted on the body 21 and engages the flange 22 and this metal ring 24 has a plurality of axially extending circumferentially spaced spring fingers 25 at its upper end remote from the metal ring 24. Each spring finger is provided with a lug 26 which extends radially outward beyond the remainder of the spring finger. A lip type seal ring 27 encircles the body 21 adjacent the metal ring 24, and this seal ring 27 and metal ring 24 are held in position against the flange 22 by means of the nut 28*a*.

The upper portion of the body 21 is cut away on opposite sides to form windows 28 between upstanding curved walls 29. The expander generally designated 30 is provided with a shank portion 31 which extends between the curved walls 29 and into the cylindrical bore 23 in the body 21. The expander is provided with an enlarged head 32 having a tapered portion and a cylindrical portion 34. The expander 30 has an axial opening 35 which slidably receives the central stationary rod 36 connected to the body 21 by means of threads 37. The rod 36 is provided with an abutment 38 on its projecting end. A coil spring 39 within the bore 23 of the body 21 acts on the expander 30 to move it in a direction toward the abutment 38. This axial motion of the expander 30 relative to the body 21 is resisted by means of latch means generally designated 40.

As shown on the drawings, the latch means 40 includes a lug 41 fixed on the upper end of the body 21 and projecting into a groove 42 which extends for a limited arcuate distance circumferentially of the expander 30 at one end of the shank 31 adjacent the head 32. An axially extending groove 43 on the shank 31 intersects the arcuate groove 42. When the expander 30 is rotated about the rod 36 to bring the lug 41 into alignment with the axial

groove 43, the coil spring 39 moves the expander from the retracted position shown in FIGURES 1 and 2 to the extended position shown in FIGURE 3. So long as the lug 41 remains in the arcuate groove 42, however, the expander 30 is held in retracted position. When the expander 30 is in the extended position shown in FIGURE 3 the cylindrical surface 34 engages each of the enlarged ends 26 on the spring arms 25 and prevents inward movement thereof. The coil spring 39 holds the expander 30 in extended position with the abutment 38 on the stationary rod 36 received within a recess 44 provided in the head 32 of the expander 30.

Means are provided for turning the expander 30 with respect to the body 21 through a small angular increment each time that the plug assembly 20 passes through one of the valve sleeves 17. As shown in the drawings, this means includes a pair of spring mounted shoes 48, each carried at the end of a spring finger 49 having a mounting part 50 fixed on the curved outer surface 51 of the body 21. The shoes 48 are biased outwardly by the spring fingers 49 so that the shoes engage the inner surface of the valve sleeves 17 and are each moved radially inward thereby. Each shoe 48 is provided at one side with a claw 52 adapted to engage ratchet teeth 53 formed by longitudinal grooves on the shank 31 of the expander 30. Each time the plug assembly 20 passes through a valve sleeve 17, the shoes 48 are depressed, and upon re-expansion after the plug assembly has passed completely through the particular valve sleeve 17, the claws 52 each engage the next ratchet tooth 53 and thus turn the expander 30 through a small arc relative to the body lug 41. This action of the shoes 48 and claws 52 repeats the next time that the plug assembly 20 passes through another valve sleeve 17. The initial movement of the claws 52 in a direction radially inward does not serve to turn the expander 30 because the ratchet teeth 42*a* on one side of the arcuate groove 42 engage the lug 41, under action of the spring 39. This construction serves to resist the turning movement of the expander in a counterclockwise direction as viewed in FIGURE 4.

When the plug assembly passes through the next to the last valve sleeve 17 the claws 52 complete the turning movement of the expander 30 relative to the body 21 and thus bring the axial groove 43 on the expander shank 31 into alignment with the lug 41 on the body. The compression spring 39 then moves the expander 30 to the extended position shown in FIGURE 3, thereby contacting the enlargements 26 on the ends of the spring arms 25 to prevent inward movement of the lugs. The lugs then project radially beyond the inner surface of the valve sleeve 17, with the result that the plug assembly 20 cannot pass through the next valve sleeve 17 which it enters. The seal ring 27 slidably engages the inner surface of the valve sleeve 17 to prevent leakage, and fluid pressure within the casing 10 above the plug assembly 20, then acts on the full effective area of the outer surface of the valve sleeve 17. The force developed by this pressure is sufficient to shear the retainer ring 19 and allow the plug assembly 20 and valve sleeve 17 to move to the fully open position shown in FIGURE 3. Fluid under pressure within the casing above the plug assembly 20 then passes outward through the lateral ports 13 and nozzles 14.

In operation, the plug assembly 20 is first adjusted so that the parts are in the position shown in FIGURE 1 and so that the angular position of the expander 30 with respect to the body lug 41 is such that the desired number of strokes of the shoes 48 must be accomplished before the expander moves to extended position under action of the spring 39. For example, if the plug assembly is to pass through two valves sleeves 17 and then to seat within the third valve sleeve and move it to open position, the expander 30 is initially positioned so that two strokes of the claws 52 are required to align the axial groove 43 with the lug 41. The plug assembly 20 is then pumped down through the interior of the well casing 10 or lowered therein on a wire line equipped with a sinker bar. An oil filled plastic bag 60 may enclose the major portion of the plug assembly 20, if desired, in order to prevent entry of sand or other foreign matter into the working parts of the plug assembly. This plastic bag remains in position on the plug assembly as it passes downward through the interior of the casing 10 and until it passes through the first valve sleeve 17. Sliding contact of the shoes 48 within the interior of the valve sleeve 17 may or may not destroy the plastic bag. When the latch means is released by means of the claws 52 following passage of the plug assembly 20 through the second valve sleeve 17, the spring 39 moves the expander 30 into position within the enlargements 26 which then prevent passage of the plug assembly 20 completely through the next valve sleeve which is encountered. The plug assembly 20 and valve sleeve 17 then move downward as a unit under applied fluid pressure, shearing the retainer ring 19 and permitting flow of fluid through the lateral ports 13 and nozzles 14.

In the modified form of the invention shown in FIGURE 10 a series of valve sleeve housings 70 are connected end-to-end at the lower end of the well pipe 10*a*. While only two valve housings are shown in FIGURE 10, it will be understood that any number may be employed. Each valve housing has a sleeve 71 mounted to slide axially within a bore 72 to open lateral ports in the housing. The ports, nozzles, and retainers are the same as previously described. Downward movement of the valve sleeve 71 shears the retainer ring 73 and connects the interior of the tubing 10*a* to the lateral ports which are positioned between the seal rings 74. The plugs 75 are duplicates and each is provided with a sealing ring 76 at the upper end of a solid cylindrical body 77. A conical recess 78 in the lower forward end of each body 77 is shaped to receive the conical projection 79 on the upper end of an adjoining plug 75. The lowermost plug in the series abuts the shoulder 80 within the footpiece 81.

In operation, the valve sleeves 71 are all initially in closed position and when the first plug 75 is lowered through the interior of the tubing 10*a* it passes through all of the valve sleeves in the series except for the lowermost valve sleeve 71. The plug 75 strikes the abutment 80 and comes to rest with its seal ring 76 in sealing engagement with the interior of the lowermost valve sleeve 71. Fluid pressure in the interior of the tubing and housing assemblies acts to move the lowermost valve sleeve downward, shearing the ring 73 and establishing communication from the interior of the lowermost housing 70 to the space outside the housing via the lateral ports in the housing. When the second plug 75 passes downward through the tubing 10*a*, it comes to rest when it engages the upper end of the plug 75 previously lowered. The second plug 75 serves to permit fluid pressure to open the second valve sleeve 71. It will be observed that the length of each plug 75 is equal to the spacing of the valve sleeves 71 so that any desired number of valve sleeves may be opened in sequence, using one plug 75 for each valve sleeve.

Having fully described my invention, it is to be understood that I am not to be limited to the details herein set forth but that my invention is of the full scope of the appended claims.

I claim:

1. For use within a well pipe having a plurality of longitudinally spaced lateral ports therein each closed by a longitudinally movable cylindrical sleeve within the well pipe, the improvement comprising, in combination: a plug assembly adapted to move through the well pipe and to pass through at least one of the sleeves, said plug assembly having a body, a seal ring on the body for sliding contact with the interior of said sleeves, a series of movable parts on the body each having an element extending radially outward, an expander mounted for axial movement on said body between a retracted position in which each said element may move radially inward to permit passage through the interior of a sleeve, to an extended

position contacting said elements to prevent their movement radially inward, means on the body acting to move said expander toward extended position, latch means including interengaging parts on said body and said expander for retaining said expander in retracted position, and means on the body actuated by contact with a sleeve for releasing said latch means.

2. For use within a well pipe having a plurality of longitudinally spaced lateral ports therein each closed by a longitudinally movable cylindrical sleeve within the well pipe, the improvement comprising, in combination: a plug device adapted to move through the well pipe and to pass through at least one of the sleeves, said plug assembly having a body, a seal ring on the body for sliding contact with the interior of said sleeves, a series of axially extending spring arms each fixed at one end relative to the body, each spring arm having an element at the other end extending radially outward, an expander mounted for axial movement on said body between a retracted position in which each said element may move radially inward to permit passage of the spring arms through the interior of a sleeve, to an extended position contacting said elements to prevent their movement radially inward, resilient means on the body acting to move said expander toward extended position, latch means including interengaging parts on said body and said expander for retaining said expander in retracted position, and means on the body actuated by contact with a sleeve for releasing said latch means.

3. For use within a well pipe having a plurality of longitudinally spaced lateral ports therein each closed by a longitudinally movable cylindrical sleeve within the well pipe, the improvement comprising, in combination: a plug assembly adapted to move through the well pipe and to pass through at least one of the sleeves, said plug assembly having a body, a seal ring on the body for sliding contact with the interior of said sleeves, a series of axially extending parts each attached at one end relative to the body, each spring arm having an element at the other end extending radially outward, an expander mounted for axial movement on said body between a retracted position in which each said element may move radially inward to permit passage of the said parts through the interior of a sleeve, to an extended position contacting said parts to prevent their movement radially inward, resilient means on the body acting to move said expander toward extended position, latch means including interengaging parts on said body and said expander for retaining said expander in retracted position and ratchet means on the body actuated by contact with a sleeve for releasing said latch means.

4. For use within a well pipe having a plurality of longitudinally spaced lateral ports therein each closed by a longitudinally movable cylindrical sleeve within the well pipe, the improvement comprising, in combination: a plug assembly adapted to move downward through the well pipe and to pass through at least one of the sleeves, said

plug assembly having a body, a seal ring on the body for sliding contact with the interior of said sleeves, expansible means on the body movable outwardly to prevent passage of the plug assembly through a sleeve, an expander movably mounted on said body for selectively holding said expansible means in expanded position, means on the body acting to move said expander toward operative position, latch means including interengaging parts on said body and said expander for retaining said expander in retracted position, and ratchet means on the body including at least one shoe actuated by contact with a sleeve for releasing said latch means.

5. For use within a well pipe having a plurality of longitudinally spaced lateral ports therein, each closed by a longitudinally movable cylindrical sleeve within the well pipe, the improvement comprising in combination:

a plug assembly adapted to move through the well pipe and through said sleeves,

said plug assembly including a detent means operable to engage a sleeve and lock said plug assembly and such a sleeve together for simultaneous movement longitudinally of said well pipe,

said detent means being normally inoperative,

means for operating said detent means,

said operating means including means engageable with a sleeve upon passage through a sleeve for causing said detent means to so lock said plug assembly to another sleeve entered thereafter,

and fluid seal means for preventing passage of fluid through a sleeve to which said plug assembly is locked,

whereby fluid pressure can cause longitudinal movement of a sleeve to which said plug assembly is locked.

6. A device as recited in claim 5 in which

said operating means includes control means for causing actuation thereof upon passage through a predeterminel number of said sleeves.

7. A device as recited in claim 6 in which

said control means is adjustable for permitting selection of said predetermined number of said sleeves.

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