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[54] WELL FLOW CONTROLLING SYSTEMS, METHODS AND APPARATUS

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[58] **Field of Search** 166/115, 189, 224, 313

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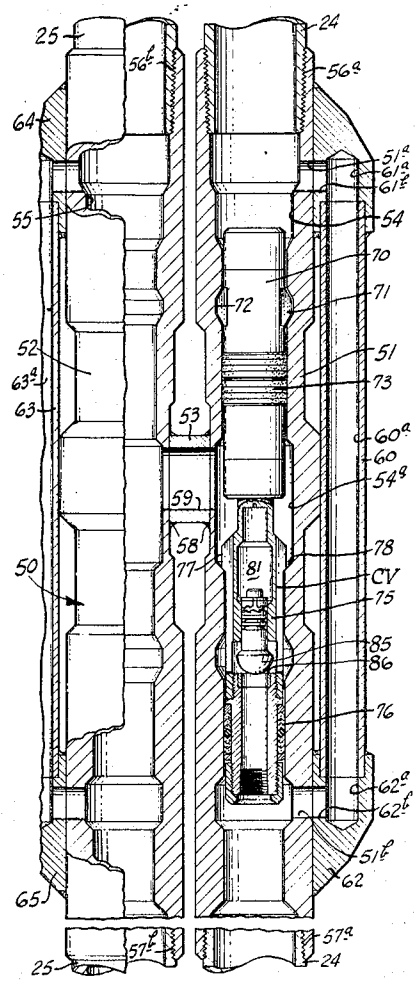
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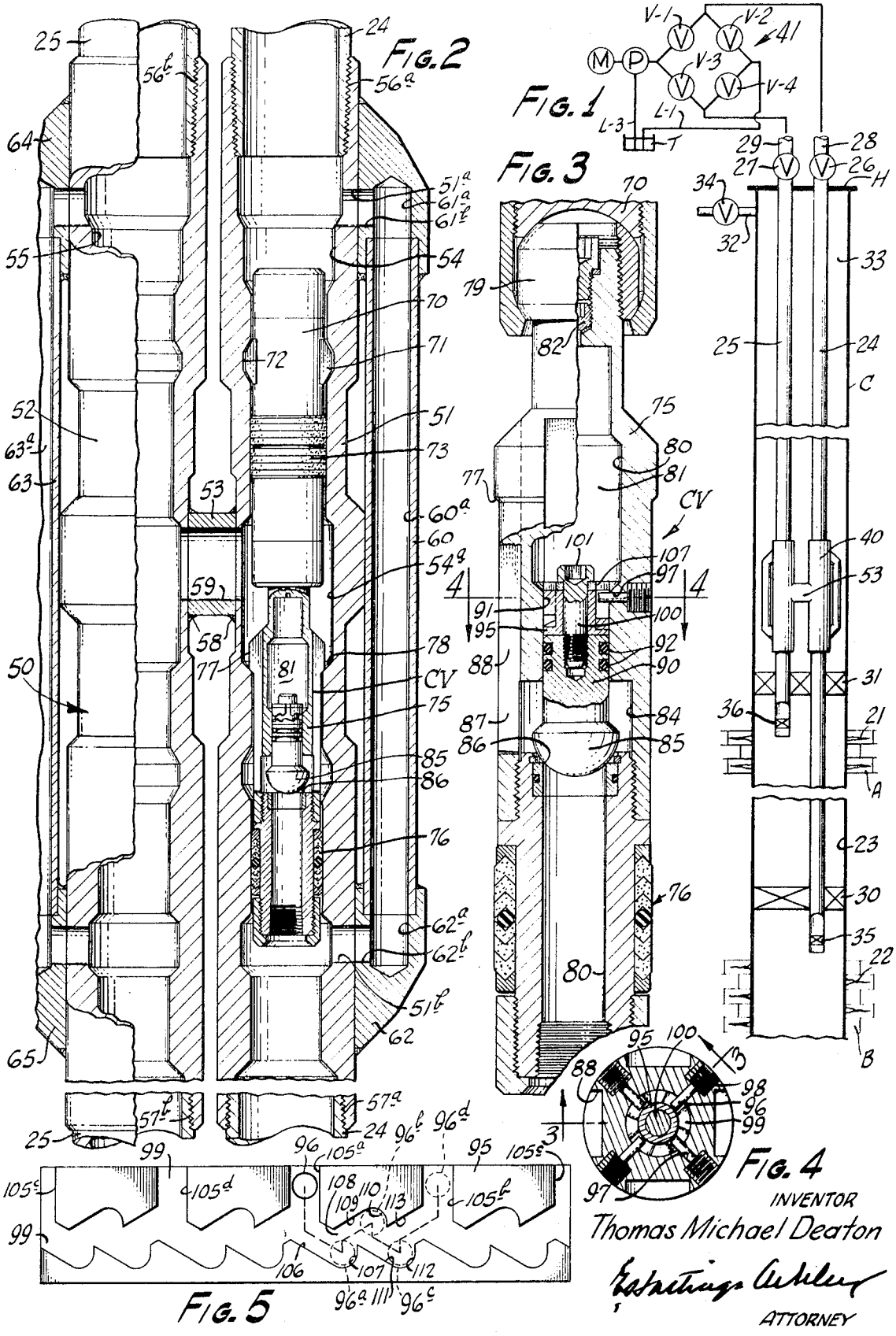
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[57] **ABSTRACT**

A well flow controlling system, method and apparatus for wells having a plurality of flow conductors therein for establishing flow communication between pairs of the flow conductors at a point down-hole in the well by opening normally closed valve means and positively holding the valve means open during operations of circulating or flowing fluids through the conductors in the well until it is desired to close the valve to shut off flow communication between the pairs of conductors. The valve is pressure operable to open position by pressure of fluids in the conduits and is held open mechanically to permit the flow or circulation of fluids at pressures lower than the pressure required to open the valve. The valve is also fluid pressure operable for movement to closed position. A pressure responsive valve for controlling fluid flow between a pair of well flow conduits connected together by a cross-flow passage at a subsurface point in a well to provide U-tube flow communication between the conduits to permit circulation of fluids through the conduits to move well tools into and out of the well through one or the other of the conduits or to perform other service or production operations in the well. The valve is positively mechanically held in open position when moved to such open position to permit circulation of fluids at pressures lower than the pressures required to move the valve to open or closed positions.

14 Claims, 5 Drawing Figures





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WELL FLOW CONTROLLING SYSTEMS, METHODS AND APPARATUS

This invention relates to well flow controlling systems and methods of operating a well for controlling fluid flow between pairs of flow conductors in place in the well at a point down-hole in the well bore; and, to a valve for controlling communication between the conductors operated in response to fluid pressure in the flow conductors for movement between open and closed positions and having means for positively mechanically holding the valve in open position to permit circulation of fluids therepast at pressures lower than the pressures required to move the valve to the open or closed position.

It is an object of the invention to provide a well flow control system and method and a valve assembly responsive to fluid pressure in one of a pair of flow conductors in a well for controlling flow of fluid through a cross-flow conduit connecting said pair of conductors at a down-hole point in the well.

It is a particular object of the invention to provide an improved flow control device for controlling fluid flow through a subsurface cross-flow passage connecting a pair of well flow conductors in place in a well, which device comprises a valve assembly operable by fluid pressure of fluids in the well flow conductors and provided with mechanical means for positively holding the valve in open position under predetermined conditions when desired.

A particular object of the invention is to provide a valve assembly of the character described which includes a pressure responsive valve operable in response to fluid pressures of fluids in one of the flow conductors, which fluid is controllable from the surface of the well to move the valve to open position or to closed position for controlling fluid flow through a cross-flow passage between two flow conductors; and, wherein latch means is provided on the valve assembly for positively holding the valve in the open position when the actuating fluid pressure used to operate the valve is reduced in value, whereby the cross-flow passage remains open after having been opened, so long as the fluid pressures in the flow conductors are lower than that required to cause actuation of the valve between open and closed positions.

A still further object of the invention is to provide a flow control valve of the character described which is designed to remain closed regardless of the pressure in the other of the pair of conductors than the conductor in which the operating fluid is present, whereby the valve will remain closed at all times regardless of the pressure in the other of said pair of conductors.

A further important object of the invention is to provide a method of operating a well having a pair of flow conductors therein with a cross-flow passage connecting the same in flow communication with each other at a down-hold point in the well which comprises providing a movable closure for the cross-flow passage between the two conductors; moving the closure to open position by means of fluid pressure in one of the conductors to permit flow between the conductors; positively holding the closure in open position for circulating fluids through the cross-flow conductor at pressures lower than the pressure required to move the closure to open position or to closed position; and subsequently closing the closure to cut off flow through the cross-flow passage.

A further object of the invention is to provide in a valve of the character described a latch mechanism operatively connected with the valve for positively holding the valve in open position and which is movable to a position permitting the valve to move to closed position when desired, such latch mechanism being operable by movement of the valve; and, wherein the valve is movable by operating fluid pressure in one of the flow conduits.

A still further object of the invention is to provide in a well system of the character set forth, a valve which is movable to open and closed positions by fluid pressure present in one of the flow conductors acting on the valve with a pressure substantially in excess of the normal operating pressures used in producing, servicing the well or operating well tools in the well conductors; and, wherein means is provided for positively

holding the valve in the open position for flow of fluids therepast at the normal operating pressures of fluids present in the conductors, and wherein the valve is movable from closed to open or from open to closed position by pressures in excess of such normal operating pressures; said valve being inoperable by normal operating pressures.

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 reference to the accompanying drawings thereof, wherein:

FIG. 1 is a schematic view of a well installation and a circulation control system for practicing the invention;

FIG. 2 is an enlarged fragmentary sectional view of the cross-flow control device showing a valve constructed in accordance with the invention removably locked in place therein, and showing the valve in open position;

FIG. 3 is an enlarged fragmentary longitudinal vertical sectional view of the valve of FIG. 2, showing the valve in closed position;

FIG. 4 is a horizontal crcorss-sectional view taken on the line 4—4 of FIG. 3; and,

FIG. 5 is a view showing a development of the slot and pin arrangement of the latching mechanism for positively holding the valve in open position and permitting it to move to closed position.

In the drawings, FIG. 1, well apparatus embodying the invention is shown schematically in the form of a well installation 20 having conventional casing C which extends downwardly in the well bore to the lower end thereof and is provided with a plurality of sets of perforations at 21 and 22 near its lower end providing flow communication with the producing earth formations A and B traversed by and surrounding the well bore at such depths to permit fluids from said formations to enter the bore 23 of the casing C.

The well installation as shown includes a pair of parallel side by side strings of tubing or flow conductors 24 and 25 which extend downwardly from a casinghead H at the surface of the well which seals between the upper end of the casing C and each of the tubing strings or flow conductors. Well head valves 26 and 27 are provided in the tubing strings or flow conductors 24 and 25, respectively, at the upper ends thereof for controlling flow through the tubing strings to and from the surface flow lines 28 and 29, respectively.

A lower single string packer 30 is disposed in the casing C between the sets of perforations 21 and 22 and seals between the casing and the long string of tubing or flow conductor 24 so that fluid flowing into the casing bore 23 through the lower perforations 22 will enter the open lower end of the tubing or flow conductor and flow upwardly therein. A dual string packer 31 is located in the well casing above the upper perforations 21 and seals between the casing and each of the strings of tubing or flow conductors 24 and 25. The short string or flow conductor 25 terminates below the dual packer 31 and above the lower packer 30 and fluids flowing through the upper perforations 21 into the bore 23 of the casing C will enter the open lower end of the tubing or flow conductor 25 and flow upwardly therein.

The bore 23 of the casing above the dual packer 31 may be and usually is filled with a loading fluid such as mud or water; unless, for instance, the well is equipped for gas lifting, in which case the casing annulus 33 above the dual packer 31 may be filled with lift gas. In either case, the well will normally be provided with a lateral flow line or conductor 32 connected to the upper end of the casing communicating with annular space 33 between the casing and the pair of tubing strings or flow conductors and having a valve 34 connected therein for controlling the admission and the withdrawal of fluids from the annular space above the dual packer in the usual manner.

The long tubing string 24 is provided at its lower end with a standing valve 35, which is preferably a removable type, for preventing the back flow of fluids from the tubing string into the casing therebelow. In a similar manner, the short tubing string 25 is provided at its lower end with a standing valve 36,

which may be identical to the standing valve **35**, for preventing the back flow of fluids from that tubing string into the casing between the packers **30** and **31**. The standing valves **35** and **36** will not preclude the upward flow of fluids therepast.

If desired, landing nipples and well tools may be connected at various vertically spaced elevations within one or both of the tubing strings in the usual manner of operating and flowing a well of this type, and, since such equipment is well known and is in common use, it will not be described in greater detail.

In order to permit installation and removal of the flow control devices in the tubing strings by means of a pump down train of tools (not shown), a crossover flow device or H-member assembly **40** is connected in the tubing strings **24** and **25** at an elevation above but near the dual packer **31**, as shown in FIG. **1**, to provide for fluid flow communication between the tubing strings at such point in the well.

The flow lines **28** and **29**, which are connected to the tubing strings **24** and **25**, respectively, have their opposite ends connected to a manifold **41** which is included in the surface facilities for supplying and circulating fluids in the well. The manifold **41** comprises valves V-**1**, V-**2**, V-**3** and V-**4** which are shown as connected together by conduits forming a closed series circuit. The flow line **28** is connected to the manifold conduit between valves V-**1** and V-**2** and flow line **29** is connected to the manifold conduit between valves V-**3** and V-**4**. A drain or discharge line L-**1** has one of its ends connected to the manifold conduit between valves V-**2** and V-**4** and its opposite end communicating with a tank T. An input line L-**2** has one of its ends connected to the manifold conduit between valves V-**1** and V-**3** and its opposite end connected to a pump P which is powered by a prime mover or motor M. A suction line L-**3** connects the pump P with the tank T.

When the motor M actuates the pump P, fluid from the tank T is sucked through suction line L-**3** into the pump and is discharged through the discharge line L-**2** to the manifold **41**. If the valves V-**2** and V-**3** are closed and the valves V-**1** and V-**4** are open, fluid will flow from discharge line L-**2** through the valve V-**1** to the flow line **28** and through the well head valve **26** and the tubing **24** down to the crossover device **40**. The fluid will then flow through the cross-flow passage **59** into the bore of tubing string **25** and thence back to the surface where it passes through the well head valve **27** and flows through the flow line **29** to the manifold where it passes through the open valve V-**4**, valves V-**2** and V-**3** being closed, to the drain line L-**1** and to the tank T. This flow pattern of fluid circulation may be reversed merely by changing the positions of the valves V-**1**, V-**2**, V-**3** and V-**4**, that is, by closing valves V-**1** and V-**4** and opening valves V-**2** and V-**3**, thus causing the pumped fluids to flow downwardly in the well through the tubing **25** and returning to the surface through the tubing **24**.

The crossover flow device or H-member assembly **40** is shown in enlarged greater detail in FIG. **2** and comprises a body assembly **50** formed of a pair of landing nipples **51** and **52** connected together intermediate their ends by a transverse flow connector member or cross-flow conductor **53** and having a pair of parallel longitudinal laterally spaced flow passages **54** and **55**, respectively, formed therein. The upper and lower ends of the bores of the landing nipples are provided with threads as at **56***a* and **56***b* at their upper ends and **57***a* and **57***b* at their lower ends, respectively, for attachment to the tubing strings **24** and **25**. The transverse flow connector member or cross-flow conductor **53** is secured at its opposite ends to each of the landing nipples as by welds **58** and is formed with a bore or cross-flow passage **59** communicating at its opposite ends with the bores of the landing nipples for conducting fluid from the bore of one landing nipple to the bore of the other.

An external longitudinal tubular bypass conductor **60** having a bore **60***a* is mounted exteriorly of the mandrel **51** between a pair of opposed upper and lower bosses **61** and **62**, respectively, which are secured by welding or the like to the exterior of the mandrel and which are provided with opposed longitudinal bores or flow passages **61***a* and **62***a*, respectively, which receive the end portions of the bypass conductor **60**. The bypass conductor is also welded at its opposite ends to the bosses in fluid tight relationship. Lateral passages **61***b* and **62***b* in the bosses connect the bores **61***a* and **62***a*, respectively, with upper and lower lateral ports **51***a* and **51***b*, respectively, formed in the wall of the landing nipple **51** which communicate at their inner ends with the bore **54** of the nipple. Thus, fluids may flow through the bypass member in either longitudinal direction out of and into the bore of the landing nipple above and below the cross-flow conductor **53**.

In similar manner, a longitudinal bypass conductor **63** having a bore **63***a* is attached to upper and lower flow conductor bosses **64** and **65** on the landing nipple **52** on the opposite end of the cross-flow conductor to provide for the flow of fluids through the bypass conductor in either direction out of and into the bore **55** of that landing nipple above and below the cross-flow passage **59**.

A circulation control valve assembly CV similar to that shown in the co-pending application of George Max Raulins, Ser. No. 65,425, filed Aug. 20, 1970, which is a continuation in part of application Ser. No. 80,477, filed Feb. 19, 1969, is releasably mounted in the bore **54** of the landing nipple **51** for controlling flow of fluids through the lateral flow passage **59** between the bore of the landing nipple **51** and the bore of the landing nipple **52**.

The bores **54** and **55** of the landing nipples **51** and **52**, respectively, are formed with a plurality of locking recesses and sealing surfaces and stop shoulders therein for receiving the valve assembly, as will be hereinafter more fully described, and as is set forth in greater detail in said co-pending application Ser. No. 65,425. The grooves, shoulders and surfaces above the lateral flow passageway **59** are adapted to be engaged to stop and seal and lock the locking and sealing mandrel **70** of the control valve assembly CV in place in the bore of the landing nipple **51**, with the locking elements **71** engaged in the locking recess **72** in the landing nipple and the sealing assembly **73** engaging the bore wall of the reduced portion of the bore **54** above the lateral flow passageway **59**, and with the valve body **75** disposed below the lateral passageway and the sealing assembly **76** thereon engaging the lower reduced portion of the bore **54** of the landing nipple below the lateral flow passage **59** and above the lower lateral port **51***b* which communicates with the bypass passage **60***a* of the bypass member **60**. An external annular flange or stop shoulder **77** on the valve body engages a shoulder **78** at the lower end of the enlarged central portion **54***a* of the bore **54** of the landing nipple **51** adjacent the lateral flow passage **59**. The valve body **75** is connected to the locking mandrel assembly **70** by means of a knuckle joint assembly **79** for permitting use of the assembly in pump-down well installations and the like, if desired.

The valve body is formed with a bore **80** which provides a chamber **81** closed at its upper end by a closure plug assembly **82** threaded into the bore of the valve body at the end thereof located in the knuckle joint assembly. A ball type closure valve member **85** engages an annular seat **86** at the lower end of the enlarged central portion **84** of the bore of the valve body **75** and lateral ports or passageways **87** communicate with said enlarged bore **84** of the valve body above the valve seat **86** and permits flow of fluids upwardly through the bore of the valve body past the valve seat and outwardly through the lateral ports **87**. In addition, the ports are extended longitudinally upwardly in the form of longitudinally extending external slots **88** which extend upwardly of the body past the shoulder or external annular flange **77** on the upper end of the valve body, so that fluids may flow readily upwardly therepast to the lateral cross-flow passage **59** when desired.

A piston **90** is formed integrally on the upper end of the ball valve closure member **85** and is slidable in the reduced portion **91** of the bore of the valve body above the enlarged bore **84** and below the chamber **81**. O-ring seal members **92** are disposed in external annular recesses formed in the piston and seal between the piston and the wall of the reduced bore **91** to confine a charge of gas in the chamber **81** for biasing the valve

closure member **85** toward the closed position in engagement with the seat **86**.

The valve is moved to open position by fluid pressure entering the bore of the valve body below the seat **86** and the valve closure member and acting on the valve closure member to move the piston upwardly in the cylinder against the pressure in the chamber **81** in the manner set forth in said co-pending application, Ser. No 65,425.

In carrying out the invention, it is desired that the valve closure member be moved by fluid pressure to the open position and that a latch member be provided to hold the valve closure member in the open position when the fluid pressure in the tubing string **24** and in the bore **54** of the landing nipple **51** beneath the valve closure member is reduced below the pressure required to move the valve to the fully open position.

To accomplish this result, a ratchet latching mechanism is provided comprising a slot carrying latch member **95** and a latching pin **96** which extends inwardly through a lateral opening **97** in the side wall of the valve body **75** and into the upper portion of the reduced bore **91** of the valve body above the piston, as clearly seen in FIG. **3**. The latch pin **96** is held in place in the lateral opening by means of an enlarged integral threaded body portion **98** which is screwed into the body and abuts the shoulder in the lateral opening **97** to position the projecting pin **96** at the proper position to engage in a latching groove or slot **99** formed in the exterior surface of the latch member **95**. A shoulder screw or bolt **100** extends through an axial bore in the latch member **95** and is threaded into the upper end of the piston **90** to secure the latch member to the piston. The shoulder of the bolt engages the piston to position the head **101** thereof at a distance above the upper end of the latch member **95** sufficient to accommodate the latch member and a washer **102** between the upper end of the latch member and the head of the bolt.

As shown in FIG. **5**, the exterior cylindrical surface of the latch member **95** is formed with a serpentine type slot **99** which has four vertical passageways or openings **105***a*, **105***b*, **105***c* and **105***d* extending downwardly from the upper surface or end of the latch member and communicating or opening into the serpentine path **99**. The vertical openings **105***a*, **105***b*, **105***c* and **105***d* receive the inner ends of the latch pins **96**, which are equally spaced about the periphery of the body of the valve as shown in FIG. **4**, when the valve is in the closed position.

As shown in FIG. **5**, the serpentine groove **99** extends downwardly and to the right or in a counterclockwise direction from the lower end of each vertical groove segment, and the downwardly and counterclockwise portion provides a downwardly inclined cam surface **106** which terminates at a point **107** below the lower end of the downwardly facing cam surface **109** of an upwardly and counterclockwise inclined slot or groove **108**, whereby the pin **96** will move downwardly in the slot **105***a* to engage the upwardly facing cam surface **106** of the slot **99** therebelow and be directed in a downward counterclockwise direction to the lower end **107** of the cam surface **106** below the upwardly inclined downwardly facing cam surface **109** of the upwardly inclined slot **108**. The pin will move upwardly in the slot **99** upon axial downward movement of the latch member **95** to engage and ride upwardly on the upward and counterclockwise inclined cam surface **109** of the slot **108** to the upper end **110** thereof located at a point above the upper end of a downwardly and counterclockwise inclined cam surface **111** therebelow in the slot **99**. The downwardly inclined cam surface **111** terminates at a point **112** below the lower end of an upwardly and counterclockwise inclined cam surface **115** which extends upwardly in a counterclockwise direction to the lower end of the next adjacent vertical slot **105***b*.

Each of the camming surfaces of the serpentine groove **99** between the other vertical sections **105***b* and **105***c*, and **105***c* and **105***d*, and **105***d* and **105***a*, is identical in configuration to that just described between the vertical sections **105***a* and **105***b*. As a result, the ends of the pins **96** engaged in the serpentine slot **99** will cause the latch member **95** to be rotated as the piston moves the latch member axially longitudinally upwardly when the valve is moved toward the upper position, and downwardly when the valve is returned to its lower closed position, to cause each of the pins to move through the path indicated in dotted lines in FIG. **5**. When the piston **90** is moved upwardly, the latch member **95** is moved upwardly therewith, and the pin **96** is moved downwardly in the slot **105***a* to engage the cam surface **106** and be cammed to the right along the path indicated in dotted lines to the position shown as **96***a* in FIG. **5**. Relieving the pressure on the valve piston will permit the piston and the latch member **95** to move downwardly with respect to the pin until the pin engages the downwardly facing cam surface **109** which causes the pin to move upwardly along such cam surface to the right to the position shown as **96***b*, in which position the valve closure member **85** is positively held in open position. Pressure on the valve moving the piston upwardly then moves the latch member upwardly and the pin downwardly relative thereto in the slot **99** until the pin engages the upwardly facing cam surface **111** which move the pin downwardly and to the right to the lower end **112** of that inclined surface, at the position shown as **96***c*. Subsequent further upward reciprocating movement of the valve member and latch member moves the pin into engagement with the downwardly facing cam surface **113** and guides the pin into the lower open end of the vertical section **105***b*.

It will readily be seen that when the latch pins are in the upper portions of the vertical sections **105***a*, **105***b*, **105***c* and **105***d*, the valve is permitted to move downwardly to the closed position shown in FIG. **3**. However, when the valve is moved upwardly and then downwardly as illustrated in FIG. **5**, until the pins **96** are moved to the positions **96***b* in the serpentine slot **99**, the valve member is positively held latched in the upper open position by the engagement of the latch pins **96** in the upper end portions **110** of the slot **99** intermediate the adjacent vertical sections. The biasing force of the gas charge in the chamber **81** maintains the latching member in engagement with the pin to hold the pin in the position **96***b* in engagement with the surface **110** at the upper end of the mid-portion of the serpentine groove to positively mechanically latch the valve in the open position. The valve will remain in the open position until the pressure below the valve closure member and the piston **90** is sufficient to move the piston upwardly to move the latch pin downwardly along the cam surface **111** into the position **96***c*, whereupon downward movement of the valve member and the latch member caused by reducing the pressure below the piston will cam the pin into the vertical slot **105***b* and permit the valve to move to fully closed position.

So long as the pressures present in the bore of the valve body below the valve closure member and the piston **90** are below the pressure required to move the piston upwardly sufficiently to move the latch pin downwardly in the serpentine slot toward the position **96***c*, the valve will be held positively in the open position. When the pressure acting on the piston acting from below becomes sufficiently great to move the piston and the latch member upwardly to displace the latch pin **96** to the position **96***c*, and pressure is thereafter reduced, the pins will be moved along the cam surface **113** into the vertical slots **105***a*–**105***d*, to permit the valve closure to be moved to the closed position automatically by the pressure charge in the chamber **81**.

It will thus be seen that the valve assembly provides a means for positively controlling flow through the cross-flow passage **59** between the bores **54** and **55** of the landing nipples or tubular nipples **51** and **52**, respectively.

It will particularly be noted that the latching member **95** having the serpentine slot **99** formed therein engaged by the projecting latch pins **96** provides means for positively mechanically latching the valve closure member **85** in the upper open position to permit flow of fluid through the latching flow passage **59** even though the pressure of the fluids in the bore of the valve below the piston **90** is lower than that required to move the valve closure to the open position. The

check valves 35 and 36 prevent intercommunication between the producing formations A and B.

It will also be seen that the valve assembly including the marking mandrel assembly is insertable into and removable from the cross-flow or H-member 40 so that it may be installed or removed by wire line operating tools or by fluid circulating pump down tools as desired. The principal advantage of the valve assembly is that the latching means positively holds the valve closure in the open position so long as the fluid pressure in the bore of the valve body acting on the piston 90 is lower than that pressure required to move the piston and the latch member relative to the pin sufficiently to release the latching engagement thereof. A higher pressure charge may be confined within the chamber 81 for positively resiliently biasing the valve closure member to closed position than would be the case should it be impossible to latch the valve closure member in the open position, and this permits a wider range of pressure utilization and production and flow past the valve through the cross-flow passage 59. This also permits flow of the fluids through the cross-flow passage at lower rates and lower pressures while the valve is positively held in fully opened position.

The valve positively prevents cross-flow through the cross-flow passage until it is opened by fluid pressure within the bore of the landing nipple below the valve closure member. There the valve assembly and cross-flow passage member provide means for effecting the methods and utilization of the systems described herein.

The foregoing description of the invention is explanatory only, and changes in the details of the 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.

What is claimed and desired to be secured by Letters Patent is:

1. A method of operating a well having a pair of flow conductors therein with a cross-flow passage means connecting the conductors in flow communication with each other at a down-hole point in the well, comprising: disposing a movable closure for the cross-flow passage means between the two conductors in one of said flow conductors; moving the closure means to open position by means of fluid pressure in one of the flow conductors to permit flow through the cross-flow passage members between the conductors; positively holding the closure means in open position for circulating fluids through the cross-flow passage means at pressures lower than the pressure required to move the closure means to open position or to closed position; and subsequently closing the closure means to cut off flow through the cross-flow passage means.

2. A method of the character set forth in claim 1 wherein the step of holding the closure in open position comprises: positively latching the closure means in said open position by mechanical latching means; then releasing the mechanical latch by the pressures in both said flow conductors for moving the closure means to closed position.

3. A method of operating a well having a pair of side-by-side flow conductors disposed therein and connected by cross-flow passage means at a position down-hole in the well which includes: installing pressure responsive closure means in one of the conductors adjacent the cross-flow passage means for controlling flow of fluids through said crossflow passage means; moving said closure means to open position by means of fluid pressure in the flow conductor in which the closure means is disposed; and mechanically latching the closure means in open position for permitting fluids to be circulated through the cross-flow passage means at pressures lower than the pressure required to move the closure means to open position.

4. A method of operating a well of the character set forth in claim 3 including the step of: circulating fluids through the flow conductors and the cross-flow passage means while the closure means is in open position to move well tools into or out of one of the flow conductors or to perform other well service operations on the well.

5. A method of the character set forth in claim 4 which includes the additional step of releasing the mechanical latch for the closure means, and moving the closure means to closed position by fluid pressure present in the flow conductors.

6. A well operating system for a well in which a plurality of flow conductors are disposed in parallel side-by-side relationship therein and wherein a pair of said conductors are connected together in flow communication by cross-flow passage means at a point down-hole in the well, including: pressure responsive valve means disposed in one of the flow conductors adjacent the cross-flow passage means for controlling flow through said cross-flow passage means; means for conducting fluid pressure through said one flow conductor to said pressure responsive valve means to move the same to open position to establish flow through said cross-flow passage means; mechanical latching means connected with said valve means engageable when said valve means is moved from closed to open position to latch said valve in open position; and means for releasing said latching means in response to fluid pressure present in the flow conductors to permit said valve to move to closed position.

7. A system of the character set forth in claim 6 wherein the cross-flow passage means includes: a pair of tubular nipples having longitudinal by-pass means communicating the upper and lower ends thereof with the bores thereof above and below the lateral flow passage connecting the tubular nipples; locking and sealing surfaces in at least one of said tubular nipples for seating the pressure responsive valve means in sealed flow controlling position in the nipple; and sealing means on said valve means for sealing between said valve means and the locking and sealing surfaces of said tubular nipple to direct flow from said flow conductor through the valve to the passage of the cross-flow passage means, whereby the valve means controls flow through the cross-flow passage means.

8. A system of the character set forth in claim 6 wherein said valve means includes: latching means connected with the valve means and engageable for positively holding the valve means in open position and releasable to permit the valve means to move to closed position.

9. A system of the character set forth in claim 6 wherein the valve means has means resiliently biasing the valve means to closed position, and the valve means is movable to open position against said means resiliently biasing the valve to closed position; and said latching means comprises mechanical latching means engageable for positively mechanically holding the valve means in open position.

10. A circulation control valve assembly adapted to be connected to a pair of side-by-side flow conductors for establishing flow communication therebetween and controlling flow of fluids through said flow conductors by means of said flow communication between said conductors including: a cross-flow passage member having a pair of side-by-side tubular members adapted to be connected at their opposite ends to the pair of flow conductors in flow communication with said flow conductors; said cross-flow passage means having a flow conductor joining said pair of tubular members and providing a cross-flow passage between the bores of the tubular members for conducting fluids between the bores of said members; pressure responsive valve means disposed in one of said tubular members adjacent the cross-flow passage means for controlling flow through said cross-flow conductor between the tubular members; means on the tubular member in which the valve means is disposed for conducting fluids to said valve means to act on said valve means to move the same to open position to establish flow communication through the cross-flow conductor between the tubular members; and latching means on said valve means engageable to positively hold said valve assembly in open position and releasable to permit said valve assembly to move to closed position to shut off flow through the cross-flow conductor.

11. A circulation control valve assembly of the character set forth in claim 10 wherein one of the tubular members is provided with locking and sealing surfaces in its bore for receiving

the valve means therein in sealing position; means is provided on said valve means for releasably anchoring and sealing said valve means in position in said tubular member in position controlling flow through the cross-flow conductor between the tubular members; and means is provided on the tubular member in which said valve means is disposed for conducting fluids from one end of said bore of said tubular member to the valve means locked therein to move the valve means to open position.

12. A circulating valve assembly of the character set forth in claim 11 wherein the latching means on the valve assembly comprises: means operable by longitudinal reciprocating movement of the valve means between open and closed positions for engagement for mechanically holding the valve means in open position, and operable by further reciprocating movement of the valve means to release the latching means to permit the valve to move to closed position.

12. A device of the character set forth in claim 11 wherein the valve means is biased to open position by a fluid pressure charge confined in the valve means.

14. A device of the character set forth in claim 11 wherein the means for conducting fluid from one end of the tubular member to the valve means to act thereon to open the same comprises: by-pass flow passage means communicating with the bore of the tubular member at the opposite ends thereof for conducting fluid between the ends of the tubular member to the valve means to act on the valve means.

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