

March 31, 1964

G. C. DICKENS

3,126,908

WELL TOOLS

Filed Oct. 3, 1960

2 Sheets-Sheet 1

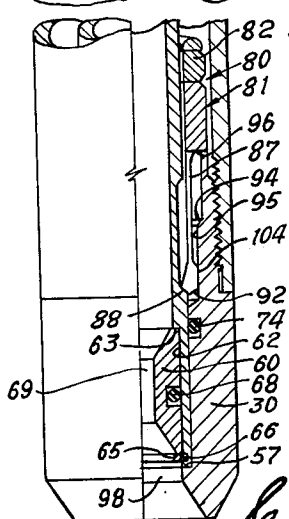
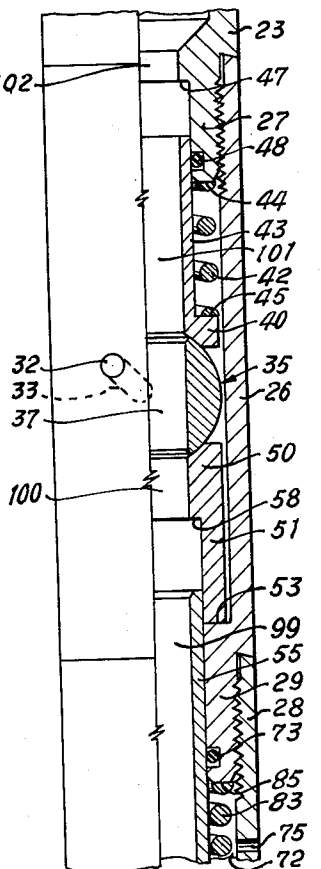
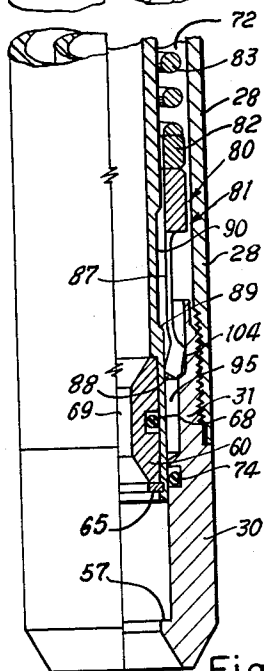
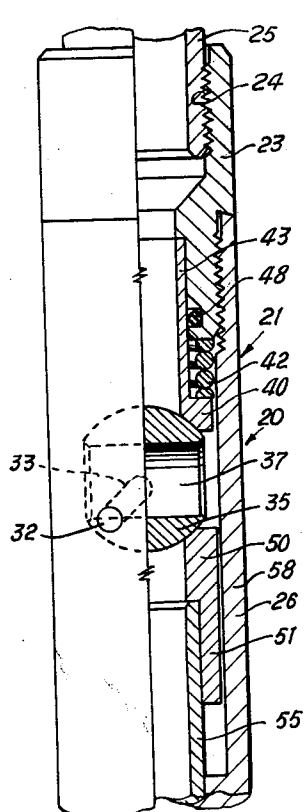


Fig. 1

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Fig. 2

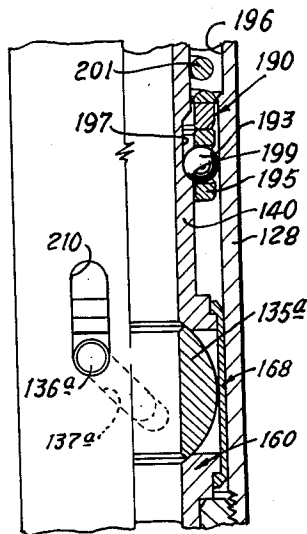


Fig. 6

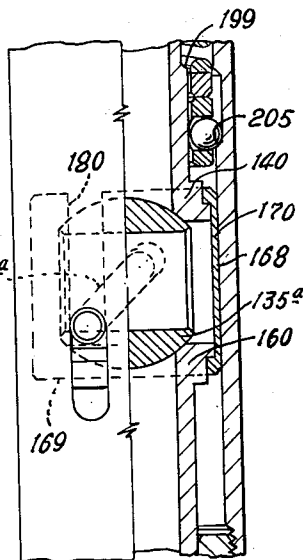


Fig. 7

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2 Sheets-Sheet 2

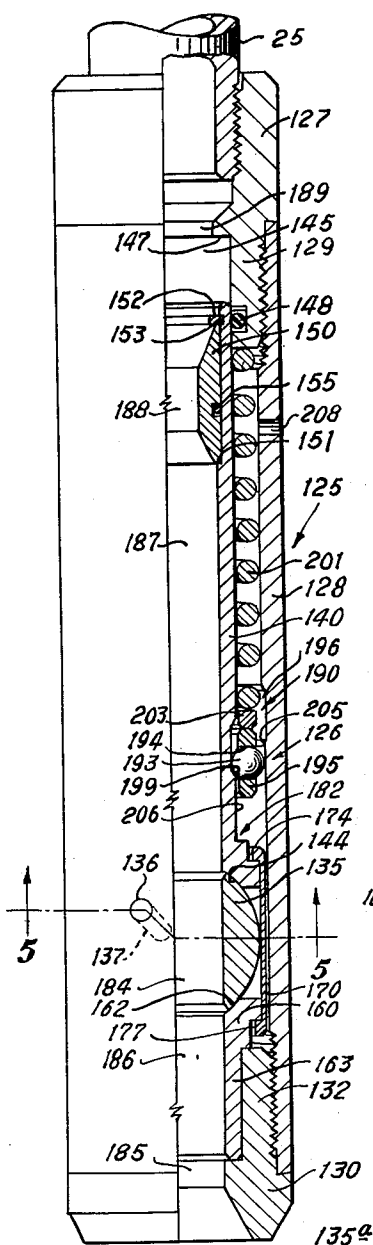


Fig. 3

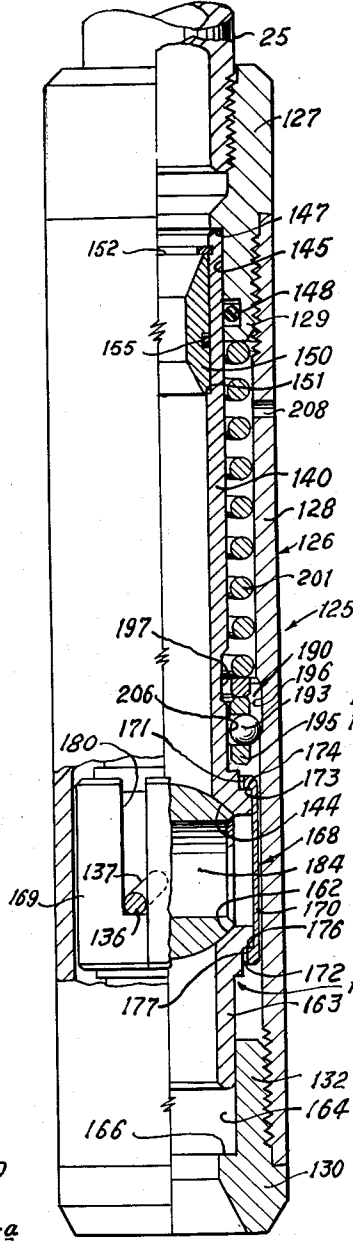


Fig. 4

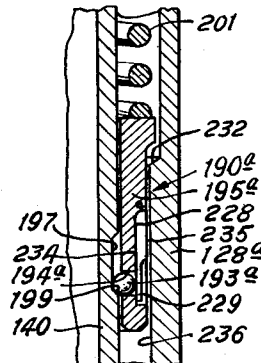


Fig. 9

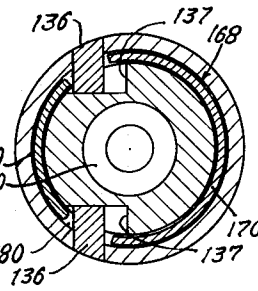


Fig. 5

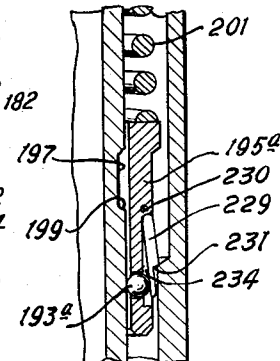


Fig. 10

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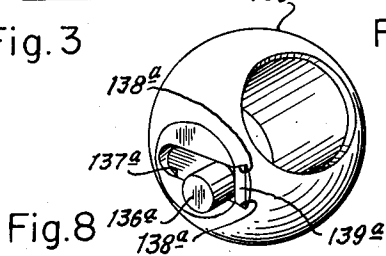


Fig. 8

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3,126,908

WELL TOOLS

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16 Claims. (Cl. 137-460)

This invention relates to well tools and more particularly to pressure operated means for controlling the flow of fluids through a well flow conductor.

One object of the invention is to provide a new and improved automatic pressure operated valve assembly for controlling the flow of well fluids through a well flow conductor.

Another object is to provide a pressure operated valve assembly which is adjustable to shut off the flow of fluids through the well flow conductor when the rate of flow of the fluids reaches a predetermined value.

Still another object is to provide a pressure operated valve assembly for controlling the flow of fluids through a well flow conductor which both closes and opens with a snap action thus preventing flow cutting of the valve and valve seat by preventing gradual throttling of the fluid flow during opening and closing movement of the valve.

A further object is to provide a valve assembly for controlling the flow of well fluids through a well flow conductor having a ball valve with a flow passage there-through which is rotatable to an open position wherein its flow passage is in communication with the flow passage of the well flow conductor and a closed position wherein its flow passage is removed from communication with the flow passage of the well flow conductor, the ball valve moving to its closed position when the pressure differential across the valve assembly attains a predetermined value and not moving back to its open position when the pressure differential across the valve assembly merely equalizes but only when the pressure differential across the valve assembly is reversed.

A still further object is to provide a valve assembly for controlling the flow of fluids through a well conductor having a straight through non-tortuous flow passage.

Still another object is to provide a valve assembly for controlling the flow of fluids through a well flow conductor which shuts off the flow of well fluids through the well flow conductor when the rate of flow through the valve assembly attains a predetermined rate and which will not close prematurely due to momentary surges in the rate of flow of well fluids or due to slugs or columns of liquids passing therethrough.

Still another object is to provide a ball valve assembly for controlling the flow of fluids through a well flow conductor which is provided with biasing means for yieldably holding the ball valve in open position, which holding means becomes inoperative to urge the ball valve toward its open position once the ball valve has been moved to its closed position due to the attainment of a predetermined pressure differential across the valve assembly.

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:

FIGURE 1 is a view, partly in elevation and partly in section, showing a well tool embodying the automatic pressure controlling valve assembly of the invention with its ball valve in open position permitting flow of fluids therethrough;

FIGURE 2 is a view similar to FIGURE 1 showing the ball valve of the valve assembly in closed position;

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FIGURE 3 is a view, partly in elevation and partly in section, showing a modified form of the pressure controlling valve assembly of the invention with the ball valve thereof in open position;

FIGURE 4 is a view, partly in elevation and partly in section, with some parts broken away, of the valve assembly of FIGURE 3 showing the ball valve in closed position;

FIGURE 5 is a horizontal sectional view taken on line 5-5 of FIGURE 3;

FIGURE 6 is a fragmentary view, partly in elevation and partly in section, showing a modified form of the valve assembly with the ball valve in open position;

FIGURE 7 is a view similar to FIGURE 6 showing the ball valve in closed position;

FIGURE 8 is a perspective view of the ball valve of the valve assembly illustrated in FIGURES 6 and 7;

FIGURE 9 is a vertical sectional view of a modified means for holding the ball valve in open position showing the elements of the holding assembly in the operative position for holding the ball valve of the valve assembly in open position;

FIGURE 10 is similar to FIGURE 9 showing the elements of the holding assembly in the position assumed when the ball valve is in closed position.

Referring now particularly to FIGURES 1 and 2 of the drawing, the well tool or valve assembly 20 includes a housing 21 having an upper sub section 23 having an enlarged threaded bore 24 at its upper end by means of which it may be secured to the lower threaded end of a locking and sealing device such as that illustrated and described in U.S. Patent No. 2,673,614 issued to I. A. Miller on March 30, 1954. The housing includes an upper barrel section 26 threaded on the lower end of the upper sub 23, a lower barrel section 28 threaded on the reduced externally threaded lower end 29 of the upper barrel section and a lower sub 30 having a reduced upper portion 31 threaded into the lower end of the lower barrel section of the housing 21.

The upper barrel section 26 is provided with a pair of stub shafts 32 which extend inwardly toward one another into the outwardly and oppositely facing slots 33 of the ball valve 35. The slots 33 extend angularly relative to the longitudinal and transverse axes of the ball valve whereby longitudinal movement of the ball valve in the upper barrel results in rotational movement of the ball valve between the open and closed positions illustrated in FIGURES 1 and 2, respectively. The ball valve 35 is provided with a flow passage 37 whose longitudinal axis is aligned with the longitudinal axis of the housing when the ball valve is in the lower position in the housing illustrated in FIGURE 1 and whose longitudinal axis is disposed perpendicularly relative to the longitudinal axis of the housing when the ball valve is moved to the upper position illustrated in FIGURE 2.

An upper annular valve seat 40 is disposed in the upper barrel section 26 above the ball valve and is yieldingly urged into engagement with the ball valve by a compression spring 42 disposed about the upward tubular extension 43 of the valve seat. The spring has its opposite ends bearing against the lower annular shoulder 44 of the upper sub 23 and the annular upwardly facing shoulder 45 of the valve seat. The upper portion of the tubular extension 43 of the upper valve seat 40 is received in the lower reduced section 27 of the upper sub. The upper sub has an internal annular flange 102 providing an annular downwardly facing shoulder 47 which limits upward movement of the tubular extension 43 in the upper sub. The lower reduced section 27 of the upper sub has an annular internal recess in which is disposed an O-ring 48 which

seals between the upper sub and the tubular extension 43.

A lower annular valve seat 50 is disposed in the upper barrel section 26 of the housing to engage the lower portions of the ball valve and has a tubular extension 51. The upper barrel section 26 has an upwardly facing internal annular shoulder 53 which limits downward movement of the lower seat 50 in the upper barrel section.

A tubular operator member 55 has its lower end disposed in the lower sub 30 and extends through the lower barrel section 28 of the housing into the upper tubular extension 51. Downward movement of the operator member 55 is limited by the internal upwardly facing shoulder 57 of the lower sub. The upper end of the operator member is adapted to engage the downwardly facing internal shoulder 58 of the lower seat 50.

An annular bean 60 is telescoped in the lower enlarged bore portion 62 of the operator member and is held against upward movement by engagement of its upper end with the downwardly facing shoulder 63 of the operator member and against downward movement of the engagement of its lower end with the split lock ring 65 which is received in the internal annular groove or recess 66 of the operator member. The bean 60 is provided with an external annular recess in which is disposed an O-ring 68, or other suitable sealing means, which seals between the bean and the operator member whereby all fluid flow through the housing to the flow passage 37 of the ball valve 35 must take place through the flow passage 69 of the bean.

A cylindrical chamber 72 is formed between the lower end of the upper barrel section and upper end of the lower sub and between the operator member and the lower barrel section 28. The reduced lower portion 29 of the upper barrel section has an internal annular recess in which an O-ring 73 or other suitable sealing means is disposed to seal between the operator member and the upper barrel section above the chamber 72 and a similar internal annular recess is provided in the lower sub 30 in which is disposed an O-ring 74 or other suitable packing means for sealing between the operator member 55 and the lower sub below the chamber. The lower barrel section 28 is provided with a port 75 through which fluid may flow into and out of the cylindrical chamber 72.

The operator member is yieldingly biased downwardly toward its lower position illustrated in FIGURE 1, when in such lower position, by biasing assembly 80 disposed in the chamber 72 which includes the collet 81, the spacer ring 82 and the biasing spring 83. The biasing spring has its opposite ends abutting the lower annular shoulder 85 of the upper barrel section and the upper annular shoulder of the spacer ring 82. The spacer ring 82 in turn has its lower annular shoulder resting upon the upper annular shoulder of the collet 81.

The collet 81 is provided with a plurality of circumferentially spaced dependent collet fingers 87 whose lower ends have bosses which provide downwardly and outwardly beveled or extending shoulders 88 adapted to engage the downwardly and outwardly extending shoulder 89 defining the lower end of the external annular groove or recess 90 of the operator member. The bosses also provide downwardly and inwardly extending shoulders 92 adapted to engage the annular shoulder 94 of the lower sub 30 above the lock surface 95 of the lower sub. Downward movement of the collet 81 is limited by the engagement of its downwardly facing shoulder 96 with the upper end of the lower sub. The collet fingers 87 are of resilient substance and tend to assume the positions illustrated in FIGURE 1.

In use, when it is desired to control the flow of well fluids through the well flow conductor 25, such as a locking and sealing device, the valve assembly 20 is connected to the lower end of the anchoring and sealing device 25

and installed at the desired depth in the well flow conductor. A spacer ring 82 of proper height is interposed between the collet 81 and the lower end of the biasing spring 83 to compress the biasing spring to the proper degree to insure that the ball valve 35 will not be moved to its upper closed position until the differential across the bean 60 attains a predetermined value. The ball valve 35 is now in its lower fully open position illustrated in FIGURE 1 so that well fluids produced by the well flow upwardly through the bore 98 of the lower sub, the restricted orifice 69 of the bean, the longitudinal flow passage 99 of the operator member, the passage 100 of the lower seat and its extension, the flow passage 37 of the ball valve, the flow passage 101 of the seat 40 and its tubular extension and the bore 102 of the upper sub 23 into the lower end of the locking and sealing device and thence through the well flow conductor to the surface. At this time the operator member is in the lower position illustrated in FIGURE 1 and the spring 83 yieldably biases the operator member downwardly due to the engagement of the shoulders 88 of the bosses of the collet fingers 87 with the upwardly facing shoulder 89 of the operator member, since the lower ends of the collet fingers may not move outwardly due to the engagement of the outer surfaces 104 of the bosses of the collet fingers with the cylindrical lock surface 95 of the lower sub. The spring 42 biases the upper valve seat 40 downwardly into engagement with the ball valve.

The operator member may move upwardly a predetermined distance from the position illustrated in FIGURE 1 until its upper end engages the downwardly facing shoulder 58 of the valve seat 50, without in any manner causing upward, and therefore closing movement of the ball valve 35. In the event that the pressure differential across the bean 60 increases for short periods of time, as when columns or slugs of liquid pass there-through, the operator member may move upwardly this short distance without causing closure of the ball valve 35. In the event, however, that the pressure differential across the bean increases to a predetermined value for a sustained period of time as would occur in the event that the surface controls at the upper end of the well flow conductor fail and permit an increased rate of flow of well fluids through the valve assembly and the well flow conductor, the operator member moves upwardly against the resistance offered by the biasing spring 83 until the shoulders 92 of the collet bosses at the end of the collet fingers 87 move above the shoulder 94 and out of engagement with the lock surface 95. When this occurs, the camming engagement of the shoulders 88 of the collet fingers with the shoulders 89 causes outward movement of the lower end of the collet fingers and the disengagement of the shoulders 88 of the collet fingers with the shoulder 89 of the operator member.

While the lower ends of the collet fingers now engage the cylindrical outer surface of the operator member below the shoulder 89 thereof and exert some frictional force which tends to prevent longitudinal movement of the operator member, the spring 83 is now ineffective to exert any downwardly acting force on the operator member. As a result, the operator member moves quickly upwardly through the valve housing and its upper end engages the downwardly facing shoulder 58 of the lower valve seat at substantially the same time that the collet fingers move out of engagement with the upwardly facing annular shoulder 89 thereof thereby causing upward movement of the lower valve seat, the ball valve and the upper valve seat until the upper end of the upper seat extension 43 engages the shoulder 47 of the upper sub. The spring 42 does not exert any appreciable downward force on the upper valve seat and is employed merely to maintain the upper valve seat in contact with the ball valve.

The pressure differential across the bean 60 is thus effective to move the valve seats and the ball valve

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from their lower positions illustrated in FIGURE 1 to their upper positions illustrated in FIGURE 2, the ball valve rotating during its upward movement due to the camming engagement between the shafts 32 and the slots 33 of the ball valve. This 90 degree rotational movement imparted to the ball valve now causes the flow passage 37 of the ball valve to be placed out of communication with the flow passages 100 and 101 of the valve seats and their extensions whereby flow of fluid through the well flow conductor is arrested.

The upward force exerted by the well fluids on the bean 60 is now communicated through the operator member to the lower valve seat and thence to the ball to cause a fluid tight sealing engagement between the valve seats and the ball valve. The spring 83 now does not exert any downwardly biasing force on the operator member but merely exerts a force tending to move the lower ends of the collet fingers into frictional engagement with the outer cylindrical surface of the operator member thereby tending to hold the operator member in its upper position and, therefore, the ball valve in its closed position. As a result, should the pressure differential across the ball valve now become equalized, the ball valve will remain in its upper closed positions since a downward force must be exerted thereon to cause it to move downwardly and rotate to its open position. The valve assembly will therefore prevent any flow of fluids through the well flow conductor once the ball valve has moved to closed position until some positive action is taken to move the valve to its open position.

When it is desired to move the ball valve 35 to its open position, fluid under pressure may be introduced into the well flow conductor 25 at the surface. When the pressure above the ball valve increases to a value which exceeds the pressure therebelow, the ball valve and the operator member are moved slightly downwardly. As the ball valve moves downward slightly, it also rotates towards its open position permitting fluids to flow through its flow passage. The increased fluid pressure above the ball valve is maintained to cause a pressure differential to be created across the bean 60 which moves the operator member downwardly and at the same time causes downward movement of the ball valve towards its fully open position. When the shoulder 89 of the operator member moves below the shoulders 88 of the collet fingers, both the resilient force of the now bent collet fingers 87 and the downwardly acting force of the spring 83 exerted through the camming engagement of the shoulder 94 of the lower sub and the shoulders 92 of the collet fingers cause the lower ends of the collet fingers to move inwardly into the recess 90 so that shoulders 88 of the collet fingers engage the shoulder 89 of the operator member. The force of the spring 83 is then effective to move the operator member 55 downwardly to the position illustrated in FIGURE 1. The spring 42 simultaneously causes the ball valve and the valve seats to move downwardly, the ball rotating in a clockwise direction until its flow passage 37 is aligned with the flow passages 100 and 101 of the valve seats. The force of the spring 83 is then effective to hold the operator member in its lowermost position until an upwardly acting differential pressure across the bean 60 again rises for a sustained period of time to a predetermined value when this cycle of operation is repeated. Since the pressure differential across the bean varies with the rate of flow of fluid through the well flow conductor, the valve remains open and permits production of well fluids therethrough so long as the rate of flow does not exceed the amount for which the valve assembly has been preset by the insertion of a spacer ring 82 of the proper thickness.

It will now be apparent that a new and improved automatic pressure operated valve assembly for controlling the flow of well fluids through a well flow conductor has been

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illustrated and described which remains open as long as the rate of flow of fluids through the well flow conductor through the valve assembly does not exceed a predetermined value for a sustained or predetermined period of time.

It will further be seen that when the valve has moved to closed position, it will remain in closed position until a positive action is taken, such as pumping fluids into the well flow conductor at the surface of the well to cause the pressure above the valve assembly to exceed the pressure therebelow.

It will now be seen that the new and improved valve assembly 20 includes a housing having a ball valve mounted therein for longitudinal and rotational movement in the housing between upper and lower valve seats and that the flow passage 37 of the ball valve 35 is in communication with the flow passages of the valve seats and their extensions when the ball valve is in a lower position in the valve housing.

It will further be seen that a spring 42 has been provided to bias the valve seats and the ball valve toward a lower position wherein the flow passage is in alignment with the flow passages of the valve seats.

It will further be seen that due to the frictional engagement of the lower ends of the collet fingers with the outer surface of the operator member below the annular shoulder 89 thereof when the operator member and the valve are in their upper positions illustrated in FIGURE 2, the force of the spring 42 is not sufficiently great to move the valve seats, the ball valve and the operator member downwardly even when the pressure differential thereacross is equalized and that it is necessary to provide a downwardly acting pressure differential across the ball valve before the ball valve, the valve seats and the operator member may be caused to move downwardly toward the positions illustrated in FIGURE 1.

It will further be seen that since the operator member must move a certain distance from the lowermost position before its upper end engages the downwardly facing annular shoulder 58 of the lower valve seat, the shoulders of the collet fingers move out of engagement with the annular shoulder 89 before any upward, and therefore rotational movement, is imparted to the ball valve. A quick or snap closing action is thus obtained since the spring 83 is rendered ineffective to slow down the movement of the operator member prior to or simultaneously with the engagement of the upper end of the operator member with the lower shoulder of the lower valve seat. As a result, the full force of the pressure differential across the bean 60 is effective to move the valve seats and the ball valve into their upper positions assuring the snap closing action of the ball valve and thus preventing the flow cutting of the valve and valve seats by preventing the gradual throttling of the fluid therebetween.

It will further be seen that since a clearance is provided between the internal surfaces of the upper barrel section and the external surfaces of the valve seats, fluid may flow therepast as the valve seats move upwardly and downwardly in the housing whereby no fluid is trapped therebetween which might prevent upward or downward movement of the valve seats. In addition, it will be noted that no seal means are provided between adjoining surfaces of the lower valve seat extension 51 and the upper portions of the operator member which are telescoped therein to permit fluid flow between the interior of the operator member and the exterior of the valve seats but that the seal means 48 prevents flow of such fluid upwardly past the ball valve when the ball valve is in closed position.

It will further be seen that since the shoulders 88 and 94 are spaced a substantial distance from one another when the operator member is in its lower position and the upper end of the operator member is spaced from the lower shoulder 58 of the lower valve seat, the operator member may move longitudinally upwardly a short distance against resistance of the biasing spring 83 to ac-

commodate momentary increases in the pressure differential across the bean 60 without causing any movement of the ball valve from its fully opened position and without causing disengagement of the collet fingers from the shoulder 39 so that the ball valve will remain in open position until the increase of the pressure differential across the bean 60, due to increased rate of flow of well fluids there-through, persists for a period of predetermined duration.

In FIGURES 3, 4 and 5 is illustrated a modified form of the valve assembly for controlling the flow of fluids through a well flow conductor. The valve assembly 125 includes a housing 126 having an upper sub 127, a barrel 128 whose upper end is threaded on the reduced lower end portion 129 of the upper sub and a lower sub 130 whose upper reduced end portion 132 is threaded in the lower end of the barrel. The upper sub 127 is internally threaded at its upper end to receive the lower end of the locking and sealing device.

A ball valve 135, which is similar in all respects to the ball valve 35, is mounted in the barrel for limited longitudinal and rotational movement relative thereto by means of the shafts or pins 136 rigid with the barrel which extend into the outwardly and oppositely facing slots 137 of the ball valve 135. A tubular operator member 140 is disposed in the housing above the ball valve and is provided at its lower end with a seat surface 144 which engages the spherical outer surface of the ball valve in sealing engagement therewith.

The upper end of the tubular operator member is received in the reduced lower bore portion 145 of the upper sub 127 and its upward movement therein is limited by the engagement of its upper annular end surface with the downwardly facing annular shoulder 147 of the upper sub. The reduced lower portion 129 of the upper sub has an internal annular recess in which is disposed an O-ring 148 or other suitable sealing means for sealing between the tubular operator member and the upper sub.

An annular bean 150 is mounted in the operator member adjacent the upper end thereof and is held against downward movement therein by the engagement of its lower annular shoulder with the upwardly facing internal annular shoulder 151 of the operator member and against upward movement therein by the engagement of its upper annular shoulder with the split lock ring 152 which is receivable in the internal annular groove or recess 153 of the operator member. The annular bean has an external annular recess in which is disposed an O-ring 155 which seals between the bean and the operator member.

A lower valve seat 160 is disposed in the barrel 128 below the ball valve 135 and has its arcuate seat surface 162 engaging the outer surface of the ball valve. The lower valve seat 160 is provided with a tubular downward extension 163 which telescopes into the bore 164 of the upper reduced portion 132 of the lower sub 130. Downward movement of the lower valve seat is limited by the engagement of the lower annular end of its extension 163 with the internal annular upwardly facing shoulder 166 of the lower sub. The operator member 140 and the lower seat 160 are securely attached to one another and held in engagement with the ball valve by a cage 168 having two sections 169 and 170 each of which is provided with an upper internal flange 171 and a lower internal flange 172. The upper internal flanges of the valve cage sections have lower surfaces 173 which engage the external upper shoulder 174 of the operator member. The internal flanges 172 of the valve cage sections provide upwardly facing shoulders 176 which engage a downwardly facing shoulder 177 provided by an external flange of the valve seat. Side portions of one of the valve cage sections 169 are removed to provide upwardly opening slots 180 through which the shafts 136 may extend into the grooves 137 of the ball valve thus permitting longitudinal movement of the ball valve.

The ball valve, the operator member and the lower valve seat and its extension move longitudinally in the

housing 126 as an assembly or unit 182 due to the connecting action of the cage 168. The provision of the slots 180 in the cage permits longitudinal movement of this assembly between the upper and lower positions illustrated in FIGURES 3 and 4.

The assembly 182 is releasably held in the lower position illustrated in FIGURE 3, wherein the flow passage 184 of the ball valve is in alignment and communication with the flow passage 185 of the lower sub, the flow passage 186 of the lower seat and its extension, the flow passage 187 of the operator member, the restricted flow passage 188 of the bean 150 and the flow passage 189 of the upper sub 127 by a holding or detent assembly or mechanism 190. The holding assembly includes a plurality of balls 193 disposed in the circumferentially spaced lateral apertures 194 of a ball carrier ring 195 disposed in the barrel 128 and about the operator member 140. The balls are of greater diameter than the thickness of the ball carrier ring so that portions of the balls at all times protrude either inwardly or outwardly of the inner or outer surfaces of the ball carrier ring.

When the balls are disposed below the internal annular recess 196 of the barrel 128, inner portions of the balls are received in the external annular recess 197 of the operator member and engage the upwardly facing shoulder 199. Outward movement of the balls out of engagement with the shoulder 199 is prevented by the engagement of the balls with the internal surface of the barrel below the internal annular recess 196 thereof.

The ball carrier ring 195 is biased downwardly by a spring 201 disposed in the barrel 128 and about the operator member. The upper end of the spring bears against the lower annular end of the upper sub 127 and its lower end bears against a spacer or compression adjusting ring 203 whose lower annular end bears on the upper annular end of the ball carrier ring.

When the operator member 140 is in its lower position holding the ball valve 135 in its open position, the engagement of the outer portions of the balls 193 with the internal surface of the barrel 128 below the recess causes the portions of the ball projecting inwardly of the ball carrier ring 195 to extend or project into the external recess 197 of the operator member and engage the downwardly and outwardly extending lower shoulder 199 defining the lower edge of the external recess. As a result, the force of the spring 201 is effective to act on the operator member through the balls 193 to yieldably hold the operator member in the lower position in the barrel illustrated in FIGURE 3.

When the operator member is moved upwardly in the barrel 128, from the position illustrated in FIGURE 3 toward the position illustrated in FIGURE 4, the engagement of the balls with the lower shoulder 199 of the operator member also causes upward movement of the balls and of the ball carrier ring until the outwardly projecting portions of the balls 193 move into alignment with the internal recess of the barrel and above the lower downwardly and inwardly projecting shoulder 205 defining the lower end of the internal recess of the barrel. At this time the camming action of the downwardly and outwardly extending lower shoulder 199 of the operator member causes the balls to move from their inner positions to the outer positions illustrated in FIGURE 4 wherein the outer portions of the balls extend into the internal recess 196 of the barrel and are held in such outer positions by the engagement of the inner portions of the balls with the surface 206 of the operator member below the shoulder 199.

When the shoulder 199 cams the balls outwardly into the internal recess of the barrel and out of engagement with the shoulder 199, the force of the spring 201 becomes ineffective to bias the operator member downwardly so that further upward movement of the operator member is no longer resisted by the force of the spring. The engagement of the lower shoulder 205 with the balls,

however, causes the balls to be cammed inwardly against the surface 206 of the operator member due to the force exerted by the spring. The carrier ring and the balls are then held in the position illustrated in FIGURE 4, the spring biasing the ball carrier ring and the balls to a lower position relative to the internal recess 196 of the barrel.

In use, when it is desired to control the flow of well fluids through the well flow conductor, the valve assembly 125 is connected to the lower end of the anchoring and sealing device 25 and is installed at the desired depth in the well flow conductor. A spacer ring 203 of the proper height or width is interposed between the ball carrier ring and the lower end of the biasing spring 201 to compress the biasing spring to the proper degree to insure that the ball valve 135 will not be moved to its upper closed position until the pressure differential across the bean 150 attains a predetermined value. The ball valve is now in its fully open position illustrated in FIGURE 3 so that well fluids produced by the well flow upwardly through the bore 185 of the lower sub, the bore 186 of the lower valve seat 160 and its extension 163, the passage 184 of the ball valve, the flow passage 187 of the operator member 140, the restricted orifice 188 of the bean 150 and the flow passage 189 of the upper sub to the lower end of the anchoring and sealing device and thence through the tubing string to the surface. At this time the operator member is in the lower position illustrated in FIGURE 3 and the biasing spring 201 yieldably biases the operator member downwardly due to the engagement of the inner portions of the balls, which project inwardly of the ball carrier ring into the external recess 197 of the operator member, with the shoulder 199 of the operator member. The arcuate seat surfaces 144 and 162 of the operator member and of the lower valve seat are thus held in engagement with the outer surface of the ball valve by the force exerted by the biasing spring since downward movement of the lower valve seat 160 is limited by the engagement of the lower end of its extension 163 with the internal upwardly facing shoulder 166 of the lower sub 130 of the housing.

The force exerted by the spring is of sufficient value to hold the ball valve 135 in its fully open position illustrated in FIGURE 3 during normal conditions of rate of flow of well fluids through the ball valve assembly 125. When the pressure differential across the bean 150 however, increases to a predetermined value due to the increased rate of flow of well fluids through the orifice 188 thereof, the operator member moves upwardly against the resistance offered by the biasing spring and causes the ball valve 135 and the lower valve seat 160 to move upwardly therewith since the operator member and the lower valve seat are connected by the cage 168. As the ball valve moves upwardly in the barrel it rotates in a counter clockwise direction. Upward movement of the assembly 182, comprising the operator member, the ball valve and the lower valve seat, is of course resisted by the force exerted by the spring until the operator member moves upwardly in the barrel a sufficient distance to cause the portions of the balls 193 projecting outwardly of their carrier ring 195 to move above the lower shoulder 205 provided by the internal recess 196 of the barrel 193. At this time the balls are cammed outwardly into the internal recess of the barrel due to the camming engagement of the lower shoulder 199 with the portions of the balls which project inwardly of the carrier ring. Since the disengagement of the balls from the lower shoulder 199 of the operator member occurs only after the operator member has moved a predetermined distance relative to the barrel, momentary surges or increases in the rate of flow of well fluids through the bean may occur and not cause complete closure of the ball valve since the force of the spring 201 is effective to move the operator member back to its lower position illustrated in FIGURE 3 if the operator member has not moved upwardly in the

barrel a sufficient distance to permit the balls to move into alignment with the internal recess 196 of the barrel.

When the rate of flow of well fluids through the bean 150 and therefore the increase in the pressure differential thereacross is sustained for a predetermined period of time of sufficient length to cause the operator member to move upwardly to a position where the balls are in alignment with the internal recess of the barrel, the balls are cammed outwardly into the internal recess of the barrel and out of engagement with the shoulder 199 of the operator member whereupon the force of the spring 201 is no longer exerted to resist further upward movement of the operator member. As a result the operator member, once the balls move out of engagement with the shoulder 199, moves rapidly upwardly until its upward movement is stopped by the engagement of its upper end with the downwardly facing stop shoulder 147 of the upper sub. During this upward movement of the operator member, the ball valve and the lower valve seat are also moved upwardly, the ball valve rotating in a counter clockwise direction from its fully opened position towards its fully closed position. As the ball moves from its open position to its fully closed position, the pressure of the upward force exerted upon the ball valve by the well fluids increases and imparts a further acceleration to the upward movement of the ball valve and the operator member and the lower valve seat.

When the ball valve is in closed position, it is held in its fully closed position by the pressure exerted by the well fluids below the ball valve. The upward force exerted on the ball valve and its lower seat causes a fluid tight seal engagement between the ball valve and its seats.

The balls 193 have their inner portions engaging the outer surface 206 of the operator member 140 below the external recess 197 thereof and are biased inwardly toward this surface due to the camming action between the outer portions of the balls and the shoulder 205 of the internal annular recess of the barrel due to the downward force exerted by the spring on the ball carrier ring. As a result, the frictional engagement of the balls with the surface 206 of the operator member will tend to hold the operator member in its upper position even should the pressure differential across the valve assembly be equalized. The valve will therefore remain closed until it is intentionally reopened.

The valve assembly may be reopened by pumping fluids downwardly through the tubing string whereby the fluid exerts a downward force on the closed ball valve which exceeds the force exerted by the pressure of the well fluids below the ball valve. As the ball valve moves downwardly due to the downward pressure exerted thereon by the fluids pumped downwardly through the tubing string, its flow passage 184 moves into communication with the flow passages 187 and 186 of the operator member and the lower valve seat, respectively, and the fluids begin to flow downwardly therethrough. The rate of the flow of the well fluids downwardly through the tubing string and through the now partly open ball valve is held at a sufficient level to achieve the necessary pressure differential across the flow bean to force the ball valve, the operator member and the lower valve seat downwardly and overcome the frictional forces exerted by the balls 193 as they are cammed inwardly by the cam shoulder 205. When the operator member has moved downwardly a sufficient distance to cause the external recess 197 of the operator member to move into alignment with the balls and the shoulder 199 thereof moves below the inwardly protruding portions of the balls, the balls enter into the external recess 197 due to the camming action of the shoulder 205 of the barrel. The engagement of the inner portions of the balls with the shoulder 199 then causes the spring to exert a downward force on the operator member and move it downwardly to its fully open position, shown in FIGURE 4. The valve assembly is then in its initial open position and will remain in the open position until the pressure

differential across the bean 150 again exceeds the value predetermined by the width or height of the spacer ring 203.

The barrel 123 is provided with a port 208 to permit flow of fluids into and out of the barrel below the upper sub.

If desired, of course, the valve assembly may be moved from its closed position to its open position by any suitable well tool lowered through the tubing string which is engageable with the closed ball valve or with the upper shoulder of the bean 150 to force the operator member and the ball valve downwardly and thus toward open position. Such well tool may be used in conjunction with a pressure equalizing tool, connected between the ball valve assembly and the packer device which seals between the tubing string and the well casing in which the tubing string is disposed, which may be employed to equalize the pressure across the valve assembly prior to the lowering of the well tool on a conventional flexible line to engage the ball valve or the bean to move the ball valve to open position.

It will be apparent that the valve assembly 125, like the valve assembly 20, is provided with an operator member which is held or biased toward its ball valve opening position by a spring which is rendered ineffective through a holding or detent assembly or mechanism which renders the spring ineffective to resist movement of the ball valve and the operator member toward closed position after the operator member and the ball valve have moved a predetermined distance toward closed positions from open positions whereby snap closing action of the ball valve is achieved.

It will also be seen that since the ball valve and the operator member may move toward closed positions to a predetermined degree before the holding assembly renders the spring ineffective to resist movement of the operator member and the ball valve toward closed position, momentary surges in the flow of well fluids through the bean are resisted by the force of the spring and do not cause movement of the ball valve to fully closed position but any increases in the rate of flow of well fluids and therefore the pressure differential across the bean, which persist for a predetermined period of time cause closure of the ball valve with a snap action due to the disengagement of the balls 193 with the cam shoulder of the operator member when the operator member has moved a predetermined distance toward closing position, which renders the spring ineffective to bias the operator member downwardly toward opening position.

In FIGURES 6, 7 and 8 is illustrated a modified form of the means for mounting a ball valve of the type illustrated in FIGURES 3 and 4 in the barrel 128 between the operator member 140 and the lower valve seat 160. The ball valve 135a has grooves 137a which have undercut shoulders providing dovetailed slots 138a on opposite sides of the grooves in which is received a rectangular base 139a whose outer sides correspond in configuration to the undercut sides of the dovetailed slots whereby the base is slidable longitudinally in the grooves. The trunnions or pins 136a are rigid with the bases 139a and extend outwardly through the slots 180 of the cage 168 and through longitudinal aligned slots 210 provided in the barrel 128. The bases cause the pins 136a to be longitudinally and rotatably movable in the slots 210 but the dovetailed fit of the bases in the slots 138a prevent outward movement of the pins from the grooves 137 of the ball valve.

The valve assembly illustrated in FIGURES 6, 7 and 8 is provided with the same holding assembly 190 as the valve assembly 125 illustrated in FIGURES 3 through 5. The assembly of the operator member 140, the ball valve 135a, the lower valve seat 160 and the cage 168 may move upwardly a considerable distance in the barrel 128 due to the provision of the longitudinal slots 210 in the barrel 128 before any rotational movement is imparted to

the ball valve 135a, since it is only after the pin 136a engages the end of the slot 210 that the rotative movement is imparted to the ball valve member 135a.

In use, when the pressure differential acting across the bean at the upper end of the operator member 140 attains a predetermined value, it exerts an upward force on the assembly of the lower valve seat, the ball valve and the operator member causing this assembly to move upwardly against the resistance exerted by the biasing spring 201. No rotational movement is imparted to the ball valve 135a during such upward movement until the pins 136a engage the upper ends of the slots 210 of the barrel 128 since the pins 136a are free to slide in the slots. As a result, no portion of the force exerted due to the pressure differential across the bean is needed to rotate the ball valve from its open to its closed position during this initial upward movement. At the time that the pins reach and engage the upper ends of the slots 210, the balls 193 of the holding assembly 190 are moved into alignment with the internal annular recess 196 of the barrel 128 thus permitting the cam shoulder 199 at the lower end of the external annular recess 197 of the operator member to cam the balls outwardly thereinto. At the time that further upward movement of the pins 136a relative to the barrel 128 is arrested, the spring is rendered ineffective to bias the operator member 140 downwardly whereby the full force of the pressure differential across the bean is utilized to raise and at the same time rotate the ball valve from open to closed position. The holding or detent mechanism 190 can therefore respond more readily to pressure differentials caused by the flow of fluids through the bean since no force is needed to revolve the ball valve during initial upward movement of the ball valve. When the spring 201 is rendered ineffective to bias the operator member 140 downwardly and the pins 136a engage the upper ends of the slots 210, further upward movement of the ball valve, operator member and the lower valve seat causes rotation of the ball valve from the open position illustrated in FIGURE 6 to the closed position illustrated in FIGURE 7. This rotation of the ball valve is with a fast snap action since the spring no longer biases the operator member downwardly.

An important advantage of the ball valve mounting illustrated in FIGURES 6, 7 and 8 lies in its ease of opening since fluid pumped into the tubing string and downwardly into the valve assembly, when the ball valve is in closed position, moves the ball valve together with the operator member and the lower valve seat downwardly until the pins 136a engage the lower ends of the slots 210 without moving the ball valve toward open position. Since the valve is closed during this initial downward movement of the ball valve, the operator member and the lower seat, no part of such fluid can flow downwardly through the valve assembly and the volume of fluids which must be pumped downwardly through the tubing string to move the ball valve downwardly is very small. At the time that the pins 136a engage the lower ends of the slots 210 so that further downward movement of the ball valve will result in the rotation thereof from its fully closed position towards its fully open position, the external annular recess 197 of the operator member again moves into alignment with the balls 193 which are then moved by the force of the spring 201 through the camming action of the lower shoulder 205 of the barrel 128 into the external recess 197 and into engagement with the shoulder 199 whereupon the spring 201 is effective to move the operator member, the ball valve and the lower valve seat to their lower positions, and to rotate the ball valve to its open position. As a result, a minimum volume of fluids must be pumped into the tubing string to move the ball valve to its open position and to render the valve assembly again operative.

It will now be seen that due to the provision of the longitudinally extending slots 210 in which the pivot pins or trunnions 136a of the ball valve are slidably and ro-

tatably mounted, the assembly of the operator member, the ball valve and the lower valve seat is made more sensitive or responsive to variations in the rate of flow of fluids through the orifice of the bean mounted in the upper end of the operator member since upward movement of this assembly need overcome only the downwardly acting force exerted by the spring 201 and no part thereof need be expended on rotating the ball valve from its open position towards its closed position until the spring 201 is rendered ineffective by the detent mechanism 190. This occurs at the time that the further upward movement of the pins in the slots 210 of the barrel is arrested by their engagement with the upper ends of the slots.

It will further be seen that when it is desired to move the ball valve from its closed position to its open position, a minimum volume of fluid need be pumped downwardly through the tubing string since the ball valve remains in closed position and does not commence to rotate until the holding or detent mechanism 190 again renders the spring 201 effective to move the operator member downwardly at the time that the pins 136a engage the lower ends of the slots 210 whereby the force exerted by the spring causes rotation of the ball valve to its open position.

In FIGURES 9 and 10 is illustrated another modified form of the holding or detent mechanism 190 illustrated in FIGURES 3 and 4. The holding or detent assembly or mechanism 190a includes a ball carrier ring 195a having balls 193a disposed in circumferentially spaced apertures 194a. The apertures 194a in which the balls 193a are disposed communicate with an external annular recess 228 of the ball carrier ring 195a. The outer surfaces of the balls 193a are engageable by the lower end of the pawls 229 pivotally secured at their upper ends by any suitable means, such as the pins 230, to the ball carrier ring. The pawls 229 are receivable in the external annular recess 228 so that no portions thereof need protrude outwardly of the ball carrier ring. The pawls are provided with downwardly facing shoulders 231 which are engageable with an upwardly facing shoulder 232 of the barrel 128a, the lower portion of the bore of the barrel being reduced to provide the upwardly facing shoulder 232.

When the operator member is in the lower position illustrated in FIGURE 9, the spring 201 exerts a downwardly biasing force on the operator member since the inner portions of the balls 193a are in engagement with the upwardly facing shoulder 199 of the external recess 197 of the operator member 140, being held in such inwardly projecting positions by the engagement of their outer surfaces with the inner surfaces 234 of the pawls which are held within the external recess of the ball carrier ring by the engagement of their external shoulders 235 with the internal surface 236 of the barrel 128a below the shoulder 232. When the rate of flow through the bean of the operator member increases to a predetermined value, the pressure differential thereacross increases sufficiently to cause the operator member, the ball valve 135 and the lower seat 163 assembly, illustrated in FIGURES 3 and 4, to move upwardly against the resistance of the spring 201. When the operator member moves to the position wherein the shoulders 235 of the pawls move upwardly above the shoulders 232 the camming engagement between the shoulder 199 and the balls 193 cams the ball outwardly causing the pawls to pivot outwardly also. A portion of the downward force exerted by the spring 201 is then utilized to hold the shoulders 231 of the pawls against the shoulder 232 of the barrel and a portion thereof is exerted against the balls 193a forcing them inwardly into engagement with the outer surface of the operator member below the shoulder 199. The camming action between the shoulders 231 of the pawls and the shoulder 232 tends to cam the balls inwardly due to their engagement with the shoulders 234 of the pawls.

When it is desired to open a valve assembly having the holding or detent mechanism 190a, the operator member is moved downwardly in the barrel either by pumping fluid downwardly through the tubing string or by the use of any suitable well tool lowered through the tubing string into the valve assembly. When the operator member moves downwardly to the position where its shoulder 199 moves below the balls 193a, the force of the spring 201 acting through the pawls 229, which are biased inwardly due to the camming engagement between the shoulders 231 of the pawls and the upwardly facing shoulder 232 of the barrel 128a, moves the balls 193a into the internal recess 197 of the operator member whereupon the engagement of the balls with the shoulder 199 causes the force of the biasing spring 201 to be applied to the operator member to move it downwardly to its lower most position illustrated in FIGURE 9. The operator member of course moves the ball valve to its open position in its movement toward its lowermost position.

It will be seen that by selecting proper angles or inclinations for the shoulders 231 of the pawls and the shoulder 232 of the barrel, only a small portion of the force exerted by the spring may be utilized to bias the balls 193 inwardly against the outer surface of the operator member below the shoulder 197. The holding or detent mechanism 190a therefore may be employed where it is desired to reduce the friction between the balls of the detent mechanism and the operator member and thus facilitate the opening or resetting of the valve. It will be seen that in the detent or holding mechanism 80 illustrated in FIGURES 1 and 2, the force of the spring 83 tends to bias the lower ends of the cam fingers into engagement with the outer surface of the operator member 55 when the operator member is in the upper position illustrated in FIGURE 2 and that similarly the force of the springs 201 of the detent or holding mechanisms illustrated in FIGURES 3 through 8, due to the camming engagement of the shoulder 205 of the barrel with the balls tends to hold the balls 193 in engagement with the outer surface of the operator member below the external recess 197 thereof. Employing a holding and detent mechanism having pawls 229 for releasably holding the ball carrier ring in raised position against the force or load of the spring 201, facilitates moving of the ball valve to open position since the outer surface of the operator member is thus reduced.

It will now be seen that in each form of the valve assembly the ball valve is biased towards an open position within the housing to permit the flow of fluids through a flow passage thereof and through a tubing string in which the valve assembly is installed and that the ball valve is biased towards its open position by a spring whose force is exerted through a holding or detent mechanism.

It will further be seen that the detent mechanism renders the spring ineffective to bias the ball valve towards its open position once the ball valve has moved in the housing a predetermined degree towards its closed position.

It will further be seen that the operator member is provided with a reduced orifice through which the well fluids flow into the tubing string which causes the operator member to move toward ball valve closing position when the rate of flow causes the pressure differential across the restricted orifice to increase to a predetermined value.

It will further be seen that the operator member 90 of the valve assembly illustrated in FIGURES 1 and 2 and the operator member 140 of the valve assembly illustrated in FIGURES 6 and 7 may move a predetermined distance toward ball valve closing position before rotational movement is imparted to the ball valve whereby the rotational movement of the ball valve from open to closed position does not commence until the spring biasing the operator member downwardly toward a position wherein it holds the ball valve in open position has been rendered ineffective to bias the operator member down-

wardly so that the ball valve closes with a quick or snap action.

It will further be seen that in the forms of the ball valve assembly illustrated in FIGURES 1 through 8, the detent mechanism is held in frictional engagement with the operator member under the force exerted by the biasing spring when the spring is rendered ineffective to bias the operator member downwardly and the force of the spring is then effective to tend to hold the operator member in its upper position wherein it holds the ball valve in closed position.

It will further be seen that the frictional force with which the detent or holding mechanism engages the operator member when the operator member has been moved towards the ball valve closing position may be decreased by the provision of the pawls 229 on the ball carrier ring 195a as illustrated in FIGURES 9 and 10 which are provided with shoulders 231 for engaging the upwardly facing shoulder 232 whereby only a portion of the force exerted by the biasing spring 201 tends to move the balls 193a into frictional engagement with the operator member 140.

It will now further be seen that in all forms of the valve assembly illustrated and described, the biasing spring which biases the ball valve towards its open position, through the engagement of its holding or detent mechanism with the operator member, is rendered ineffective to bias the ball valve and the associated operator member towards open position when the operator member and the valve have moved upwardly in the valve housing to closed position so that the valve assembly can be moved to open position only by a definite positive action and will not open even if the pressure thereacross is equalized.

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 valve assembly including: a housing having a longitudinal passage; a valve mounted in said longitudinal passage for movement longitudinally in said passage and rotationally about a transverse axis between open and closed positions, said valve having a flow passage; means operatively connecting said valve and said housing, whereby longitudinal movement of said valve relative to said housing causes rotational movement of said valve within said housing; an operator member for moving said valve longitudinally in said housing disposed in said longitudinal passage of said housing and having a flow passage communicating with the flow passage of the valve when said valve and said operator member are in one extreme longitudinal position in said longitudinal passage of said housing to permit flow through said valve assembly; means biasing said operator member toward said one extreme position in said housing; detent means engageable with said biasing means and said operator member for operatively connecting said biasing means and said operator member; relief means on said housing receiving said detent means upon longitudinal movement of said operator means in said housing a predetermined distance from said one extreme position toward said opposite extreme position in said housing to free the connection of said biasing means and said operator means provided by said detent means, whereby said biasing means is rendered ineffective to bias said operator member toward said one extreme position in said housing when said operator member is moved said predetermined distance from said one extreme position toward an opposite extreme position in said housing, said operator member moving said valve longitudinally in said housing to closed position to prevent flow through said valve assembly when said operator member is moved to said opposite extreme posi-

tion in said housing wherein said flow passage of said operator member and said valve are not in communication, said operator member having means responsive to the flow of fluid through said flow passage of said operator member for moving said operator member from said one extreme position toward said opposite extreme position.

2. A valve assembly of the character set forth in claim 1 wherein said housing is provided with means for holding said detent means in engagement with said operator member until said operator member is moved a predetermined distance toward said opposite extreme position, said housing having relief means thereon receiving said detent means to permit said detent means to move out of operative engagement with said operator member upon movement of said operator member a predetermined longitudinal distance in said housing from said one position toward said opposite extreme position whereby said biasing means continues to act on said operating means only until said detent means is released from operative engagement with said operator means.

3. A valve assembly of the character set forth in claim 1 wherein said detent means includes latch means engageable with said operator member to transmit the force of said biasing means to said operator member, and said housing has means thereon coengageable with said latch means for holding said latch means in operative engagement with said operator member until said operator member is moved said predetermined distance toward said opposite extreme position; said housing also being provided with relief means permitting said latch means to be released from operative engagement with said operator member to release said operator member for unbiased movement toward said opposite extreme position to cause said valve to be moved to closed position.

4. A valve assembly of the character set forth in claim 1 wherein said means connecting said valve and said housing for causing rotational movement of the valve in said housing as said housing is moved longitudinally includes a lost motion connection permitting movement of said operator member a predetermined longitudinal distance in said housing before rotational movement is imparted to said valve.

5. A valve assembly including: a housing having a longitudinal passage; a ball valve mounted in said longitudinal passage for longitudinal movement in said passage between upper and lower positions and for rotational movement about a transverse axis between an open position when said valve is in said lower position and a closed position when said valve is in said upper position; valve seat means movably mounted in said housing for limited longitudinal movement in said housing between an upper and lower position and having opposed seating surfaces engaging said ball valve, said ball valve and said valve seat means having flow passages which are in communication with one another when said ball valve is in said lower position in said housing and out of communication with one another when said ball valve is in said upper position in said housing; an operator member mounted in said longitudinal passage of said housing and movable into engagement with one of said valve seat members for moving said valve seat means and said ball valve upwardly in said longitudinal passage to move said ball valve towards its closed position; biasing means in said housing for biasing said operator member downwardly, said operator member having a flow passage communicating with said flow passages of said ball valve and said valve seat means when said ball valve is in open position, said operator member having means responsive to the rate of flow of fluids through said operator member for moving said operator member upwardly in said housing to move said valve seat means and said ball valve upwardly in said housing; and detent means engageable with said biasing means and said operator member which upon release renders said biasing means ineffective to urge said operator member downwardly in said housing when said op-

erator member is moved upwardly in said housing a predetermined distance from a lower position in said housing, said detent means including shoulders on said operator member and said detent means engageable with one another until said operator member has moved a predetermined distance upwardly in said housing, said housing having means coengageable with said detent means for holding said shoulders in engagement with one another only until said operator member has moved a predetermined distance upwardly in said housing from its lower position.

6. A valve assembly including: a housing having a longitudinal passage therethrough; a ball valve mounted in said longitudinal passage for longitudinal movement in said passage between upper and lower positions and for rotational movement about a transverse axis between an open position when said valve is in said lower position and a closed position when said valve is in said upper position; valve seat means movably mounted in said housing in sealing engagement therewith for limited longitudinal movement in said housing between upper and lower positions and having opposed seating surfaces engaging said ball valve, said ball valve and said valve seat means having flow passages which are in communication with one another when said ball valve is in said lower position in said housing and out of communication with one another when said ball valve is in said upper position in said housing; means operatively connecting said ball valve and said housing whereby longitudinal movement of said ball valve in said housing causes such rotational movement of said ball valve; a tubular operator member mounted in said longitudinal passage of said housing and movable into engagement with one of said valve seat members for moving said valve seat means and said ball valve upwardly in said longitudinal passage to move said ball valve towards its closed position; said operator member having a flow passage communicating with said flow passages of said ball valve and said valve seat means when said ball valve is in open position, said operator member having means responsive to the rate of flow of fluids through said operator member for moving said operator member upwardly in said housing to move said valve seat means and said ball valve upwardly in said housing; biasing means in said housing for biasing said operator member downwardly therein; and holding means releasably connecting said biasing means and said operator member, whereby said biasing means acts on said operator member to bias the same downwardly, said holding means being releasable from operative connection with said operator member to free said operator member for upward movement free of the action of said biasing means thereon to move said ball valve to closed position; and relief means on said housing releasing said holding means connection of said biasing means with said operator member upon predetermined upward movement of said operator member relative to said housing to render said biasing means ineffective to urge said operator member downwardly in said housing when said operator member is moved upwardly in said housing said predetermined distance from a lower position in said housing.

7. A valve assembly including: a housing having a longitudinal passage therethrough; a ball valve mounted in said longitudinal passage for longitudinal movement in said passage between upper and lower positions and for rotational movement about a transverse axis between an open position when said valve is in said lower position and a closed position when said valve is in said upper position; valve seat means movably mounted in said housing in sealing engagement therewith for limited longitudinal movement in said housing between upper and lower positions and having opposed seating surfaces engaging said ball valve, said ball valve and said valve seat means having flow passages which are in communication with one another when said ball valve is in said lower position in said housing and out of communication with

one another when said ball valve is in said upper position in said housing; means operatively connecting said ball valve and said housing whereby longitudinal movement of said ball valve in said housing causes such rotational movement of said ball valve; a tubular operator member mounted in said longitudinal passage of said housing and movable into engagement with one of said valve seat members for moving said valve seat means and said ball valve upwardly in said longitudinal passage to move said ball valve towards its closed position; said operator member having a flow passage communicating with said flow passages of said ball valve and said valve seat means when said ball valve is in open position, said operator member having means responsive to the rate of flow of fluids through said operator member for moving said operator member upwardly in said housing to move said valve seat means and said ball valve upwardly in said housing; biasing means in said housing for biasing said operator member downwardly; and latch means connecting said biasing means and said operator member for operatively applying the force of said biasing means to said operator member for biasing said operator member downwardly of said housing; said latch means being releasable from engagement with said operator member to render said biasing means ineffective to urge said operator member downwardly in said housing when said operator member is moved upwardly in said housing a predetermined distance from a lower position in said housing; and relief means on said housing releasing said latch means connection of said biasing means to said operator member upon said predetermined upward movement of said operator member relative to said housing, said operator member and said one of said valve seat means having means engageable with one another when said operator member has moved upwardly said predetermined distance from said lower position whereby further upward movement of said operator member causes upward movement of said valve seat means and said ball valve in said housing to rotate said ball valve between open and closed positions.

8. A valve assembly including: a housing having a longitudinal passage having a longitudinal axis; a ball valve mounted in said longitudinal passage for longitudinal movement in said passage between upper and lower positions and for rotational movement about a transverse axis between an open position when said ball valve is in said lower position and a closed position when said valve is in said upper position; valve seat means movably mounted in said housing for limited longitudinal movement in said housing between upper and lower positions and having opposed seating surfaces engaging said ball valve, said ball valve and said valve seat means having flow passages which are in communication with one another when said ball valve is in said lower position in said housing and out of communication with one another when said ball valve is in said upper position in said housing; an operator member connected to one of said valve seat means mounted in said longitudinal passage of said housing for moving said valve seat means and said ball valve upwardly in said longitudinal passage to move said ball valve towards its closed position; said operator member having a flow passage communicating with said flow passages of said ball valve and said valve seat means when said ball valve is in open position, said operator member having means responsive to the rate of flow of fluids through said operator member for moving said operator member upwardly in said housing to move said valve seat means and said valve upwardly in said housing when said rate of flow attains a predetermined value; biasing means in said housing for biasing said operator member downwardly; and detent means operatively connecting said biasing means and said operator member whereby said biasing means acts on said operator member to bias the same downwardly of said housing, said detent means being releasable from connect-

ing engagement with said operator member to render said biasing means ineffective to bias said operator member downwardly in said housing when said operator member is moved upwardly in said housing a predetermined distance from a lower position in said housing; said housing having relief means receiving said ball valve means upon upward movement of said operator through such predetermined distance and said housing to free said connection between said biasing means and said operator member; said ball valve having oppositely facing external angularly disposed groove means, said housing having pivot pins extending inwardly into said opposed grooves of said ball valve whereby upward movement of said ball valve causes rotational movement of said ball valve about an axis perpendicular to the longitudinal axis of said longitudinal passage of said housing.

9. A valve assembly including: a housing having a longitudinal passage therethrough having a longitudinal axis; a ball valve mounted in said longitudinal passage for longitudinal movement in said passage between upper and lower positions and for rotational movement about a transverse axis between an open position when said ball valve is in said lower position and a closed position when said valve is in said upper position; valve seat means movably mounted in said housing in sealing engagement therewith for limited longitudinal movement in said housing between upper and lower positions and having opposed seating surfaces engaging said ball valve, said ball valve and said valve seat means having flow passages which are in communication with one another when said ball valve is in said lower position in said housing and out of communication with one another when said ball valve is in said upper position in said housing; means operatively connecting said ball valve and said housing whereby longitudinal movement of said ball valve in said housing causes such rotational movement of said ball valve; a tubular operator member connected to one of said valve seat means mounted in said longitudinal passage of said housing for moving said valve seat means and said ball valve upwardly in said longitudinal passage to move said ball valve towards its closed position; said operator member having a flow passage communicating with said flow passages of said ball valve and said valve seat means when said ball valve is in open position, said operator member having means responsive to the rate of flow of fluids through said operator member for moving said operator member upwardly in said housing to move said valve seat means and said ball valve upwardly in said housing when said rate of flow attains a predetermined value; biasing means in said housing for biasing said operator member downwardly therein; detent means engageable with said biasing means and said operator member for operatively connecting said biasing means and said operator member for biasing said operator member downwardly in said housing, said detent means being releasable from connection with said operator member for rendering said biasing means ineffective to bias said operator member downwardly in said housing when said operator member is moved upwardly in said housing a predetermined distance from a lower position in said housing; relief means on said housing engageable with said detent means to free said detent means from operative connection between said biasing means and said operator member upon such predetermined upward movement of said operator member in said housing; said ball valve connection with said housing including pivot means extending transversely in opposite directions and movably mounted on said ball valve whereby said ball valve may move perpendicularly relative to said transverse axis and to the longitudinal axis of said longitudinal passage, said housing having longitudinal slots; said pivot means extending longitudinally outwardly into said slots whereby said ball valve may move upwardly from its lower open position towards its upper closed position a predetermined distance before said pivot means engages the ends of said slots, whereby upon further up-

ward movement of said ball valve rotational movement is imparted to said ball valve.

10. A valve assembly including: a housing having a longitudinal passage having a longitudinal axis; a ball valve mounted in said longitudinal passage for longitudinal movement in said passage between upper and lower positions and for rotational movement about a transverse axis between an open position when said ball valve is in said lower position and a closed position when said valve is in said upper position; valve seat means movably mounted in said housing on opposite sides of said ball valve for limited longitudinal movement in said housing between upper and lower positions and having opposed seating surfaces engaging said ball valve, said ball valve and said valve seat means having flow passages which are in communication with one another when said ball valve is in said lower position in said housing and out of communication with one another when said ball valve is in said upper position in said housing; an operator member connected to one of said valve seat means mounted in said longitudinal passage of said housing for moving said valve seat means and said ball valve upwardly in said longitudinal passage to move said ball valve towards its closed position; said operator member having a flow passage communicating with said flow passages of said ball valve and said valve seat means when said ball valve is in open position, said operator member having flow restricting means responsive to the rate of flow of fluids through said operator member for moving said operator member upwardly in said housing to move said valve seat means and said ball valve upwardly in said housing when said rate of flow attains a predetermined value; biasing means in said housing for biasing said operator member downwardly; and detent means releasably engageable with said biasing means and said operator member for applying the force of said biasing means to said operator member to bias said operator member downwardly in said housing; said detent means being releasable from operative engagement with said operator member for rendering said biasing means ineffective to bias said operator member downwardly in said housing when said operator member is moved upwardly in said housing a predetermined distance from a lower position in said housing; said ball valve and said housing having pivot means operatively connecting said housing and said ball valve whereby upward movement of said ball valve by said operator member causes rotational movement of said ball valve about an axis perpendicular to the longitudinal axis of said longitudinal passage of said housing, whereby said ball valve is moved to closed position; said detent means including a carrier disposed about said operator member in said housing; a plurality of balls mounted on said carrier, said operator member having an external upwardly facing shoulder thereon; said balls when moved inwardly of said carrier being engageable with said upwardly facing shoulder of said operator member, whereby said detent means operatively and releasably connects said biasing means with said operator member; said housing having an internal annular relief groove in the bore thereof adapted to receive said balls when said operator member has moved upwardly in said housing a predetermined distance to permit said balls to move into said annular relief groove of said housing out of operative engagement with the shoulder on said operator member to free said operator member from connection with said biasing means for upward movement of said operator member free of the force exerted thereon by said biasing means.

11. A valve assembly including: an elongate housing having a longitudinal bore therethrough; valve seat means movably mounted in said bore and having a flow passage therethrough in sealing engagement with said housing; a ball valve mounted in said longitudinal bore of said housing and engageable with said seat means, said ball valve and seat means being movable longitudinally of said housing; pivot means operatively connecting said ball valve and said housing whereby longitudinal movement of said

ball valve in said housing causes rotational movement of said ball valve about an axis transverse to the longitudinal axis of said housing bore; said ball valve having a flow passage therethrough communicating with the flow passage of the valve seat means when said ball valve is in a lower position in said housing and out of communication with said valve seat means flow passage when said ball valve is in an upper position in said housing; a tubular operator member longitudinally movably mounted in said housing bore and operatively acting on said ball valve to move said ball valve upwardly of said housing, said operator member having a flow passage therethrough; a flow restricting member disposed in the flow passage of said operator member for restricting fluid flow therethrough, whereby said operator member is moved in response to the fluid pressure of the fluids flowing through said flow restricting member to move said ball valve upwardly in said housing; biasing means in said housing for biasing said operator member downwardly; detent means releasably connecting said biasing means to said operator member whereby said biasing means acts on said operator member to bias the same downwardly, said detent means being releasable from operative connection with said operator member to free said operator member for upward movement free of the action of said biasing means thereon to move said ball valve to closed position; and relief means on said housing releasing said detent means connection of said biasing means to said operator member upon a predetermined upward movement of said operator member relative to said housing.

12. A valve assembly including: a housing having a longitudinal passage; a valve mounted in said longitudinal passage for movement longitudinally in said passage and rotationally about a transverse axis, said valve having a flow passage therethrough disposed at a right angle to said transverse axis and rotatable about said axis into and out of alignment with said longitudinal passage of said housing between an open position and a closed position; means operatively connecting said valve and said housing, whereby longitudinal movement of said valve relative to said housing causes rotational movement of said valve within said housing; an operator member disposed in said longitudinal passage of said housing having means thereon exposed to flow of fluids through said longitudinal passage for movement by the pressure of said fluids from one extreme position to an opposite extreme position in said housing for moving said valve longitudinally in said longitudinal passage of said housing; means in said housing engageable with said operator member for biasing said operator member toward one extreme position in said housing, said valve being disposed with the flow passage therethrough aligned with the longitudinal passage of said housing in open position and permitting flow through said valve assembly when said operator member is in said one extreme position; detent means releasably connecting said biasing means with said operator member for biasing said operator member toward said one extreme position; relief means on said housing receiving said detent means upon movement of said operator member longitudinally a predetermined distance from said one extreme position toward said opposite extreme position for freeing the detent means connection of said biasing means with said operator member whereby said biasing means is rendered ineffective to bias said operator member toward said one

extreme position in said housing when said operator member is moved a predetermined distance from said one extreme position toward an opposite extreme position in said housing, said operator member being movable longitudinally of said housing to said opposite extreme position when freed from connection with said biasing means, and such movement of said operator member moving said valve to closed position wherein the flow passage therethrough is out of alignment with the longitudinal passage of said housing to prevent flow through said valve assembly when said operator member is moved to said opposite extreme position in said housing.

13. A valve assembly of the character set forth in claim 12 wherein said operator member is tubular and has in its bore, means responsive to the rate of flow of fluid through said valve assembly for moving said operator member from one extreme position toward said opposite extreme position.

14. A valve assembly of the character set forth in claim 12 wherein said detent means and said housing have coengageable means holding said detent means in engagement with said operator member only until said operator member has been moved a predetermined distance from said one extreme position toward said opposite extreme position.

15. A valve assembly of the character set forth in claim 12 wherein said detent means includes: a carrier disposed in said housing surrounding said operator member; a plurality of balls mounted on said carrier, said operator member having an external annular shoulder thereon, said balls when moved inwardly of said carrier being engageable with said shoulder of said operator member, said balls being held in said inner positions by pawls pivotally mounted on and engageable with said housing when said operator member is in said one extreme position in said housing; said housing relief means comprising an internal enlargement of the bore of said housing receiving said pawls when said operator member has in said housing a predetermined distance from said one extreme position therein to permit said pawls to move outwardly to permit said balls to move out of engagement with said shoulder of said operator member when said operator member has moved said predetermined distance from said one extreme position in said housing toward said opposite extreme position therein.

16. A valve assembly of the character set forth in claim 15 wherein said housing is provided with an enlarged bore above an internal annular upwardly facing shoulder engageable by said pawls, said pawls being movable outwardly into such enlarged bore above said shoulder when said operator member has moved upwardly in said housing a predetermined distance to engage said pawls with said housing shoulder, whereby such engagement of said pawls and said housing shoulder holds said detent means in position rendering said biasing means ineffective to act on said operator member.

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