# United States Patent

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[54] **WELL TOOLS**
**20 Claims, 4 Drawing Figs.**


[52] **U.S. Cl.** ..... **137/614.2;** 166/224; 137/462, 137/517
[51] **Int. Cl.** ..... **E21b 33/00**
[50] **Field of Search** ..... 137/614.2, 513.3, 513.5, 460, 463, 625.28, 462, 517; 166/224



[56] **References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 1,311,642 | 7/1919 | Deinest | 137/614.2 |
| 2,630,326 | 3/1953 | Bryant | 137/614.2X |
| 2,651,319 | 9/1953 | Cummings | 251/75X |
| 2,785,272 | 3/1957 | Baby | 137/614.2X |
| 2,969,088 | 1/1961 | Kramer | 137/614.2 |
| 3,070,119 | 12/1962 | Kaulins | 137/460 |
| 3,126,908 | 3/1964 | Dickens | 137/460 |



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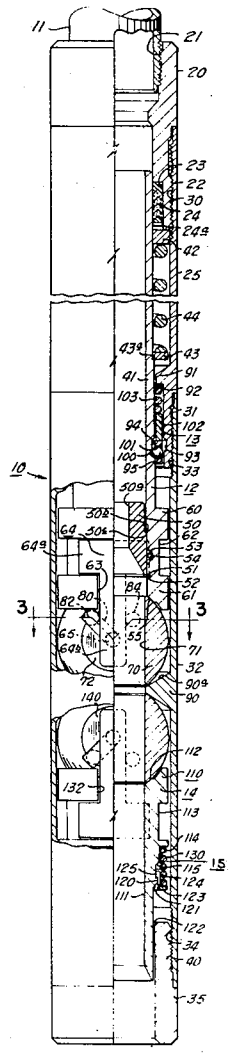
**ABSTRACT:** This invention relates to a fluid flow control device comprising a safety valve and a check valve including a bypass around the check valve to permit displacement of any fluid which may become trapped between the valves and prevent opening of the safety valve.

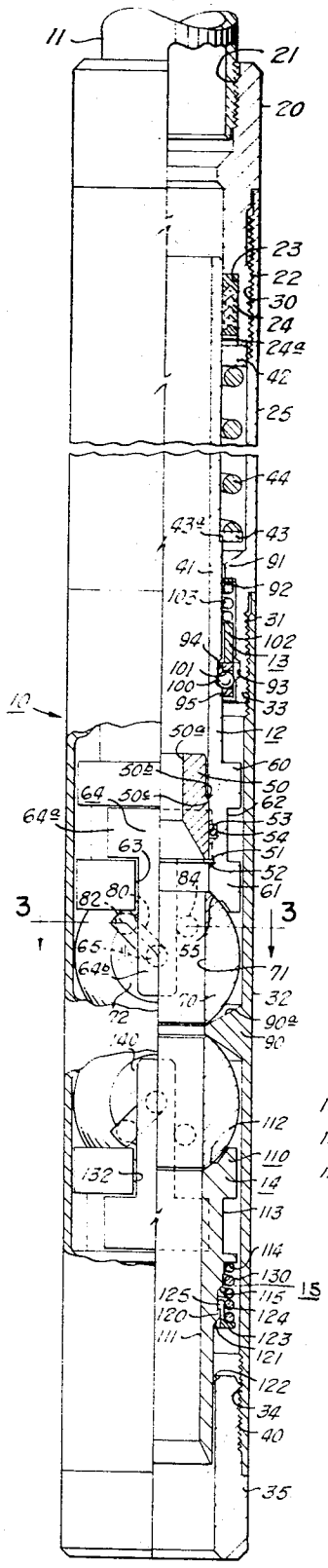


Fig. 1

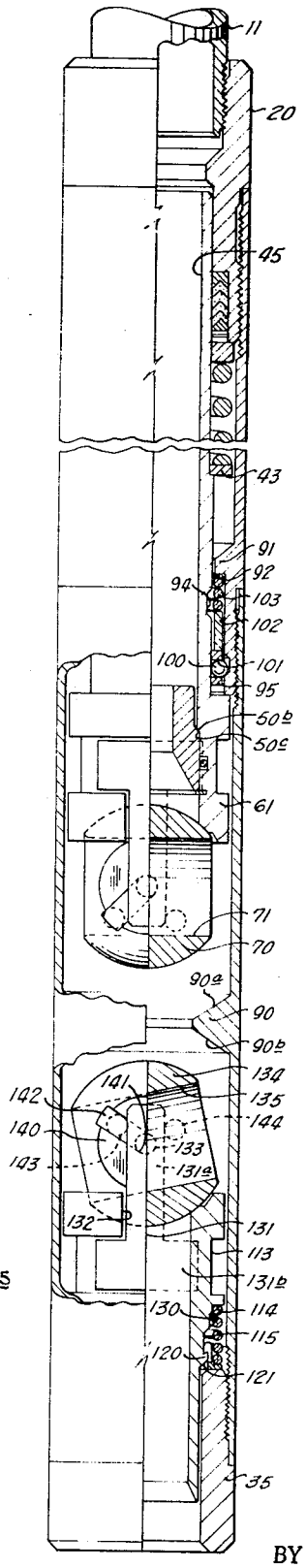


Fig. 2

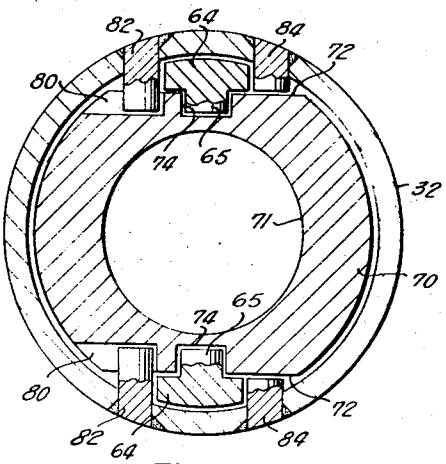


Fig. 3

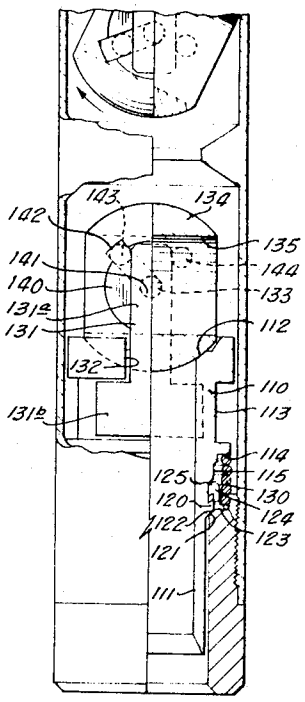


Fig. 4

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# WELL TOOLS

This application is a continuation-in-part of the copending application Ser. No. 328,157, filed Nov. 29, 1963, now abandoned.

This invention relates to well tools and more particularly to a flow control device for controlling the flow of fluids through a flow conductor, such as well tubing.

One object of this invention is to provide a new and improved control device for use in a well flow conductor which is responsive to fluid pressure within the conductor for controlling the flow of fluids therethrough.

Another object of the invention is to provide a new and improved valve for a flow conductor wherein the valve is responsive to a predetermined rate of flow of fluid within the conductor for controlling the flow of fluids therethrough.

A further object of the invention is to provide a new and improved pressure responsive device for controlling the flow of fluids through a fluid conductor including a valve mechanism wherein the valve is prevented from assuming any position between its fully opened and fully closed positions to preclude erosion or abrading of the valve parts by throttling the fluid stream or by making its path more tortuous.

An additional object of the invention is to provide a detent mechanism for a valve which controls the flow of fluids through a tubing or the like wherein the detent mechanism will hold the valve in fully opened position until a force of predetermined magnitude is exerted on the valve by the flow of fluids through the tubing to release the detent mechanism and move the valve to fully closed position.

It is another object of the invention to provide a detent mechanism for a valve adapted to control the flow of fluids through a tubing or the like wherein the detent mechanism will detain the valve in fully opened position and resist its being closed by temporary surges of fluid flow through the tubing.

It is a further object of the invention to provide a detent mechanism for use in a well tubing valve to detain the movement of the valve to a closed position until sufficient energy has been built up to move the valve to fully closed position upon release of the detent mechanism, such detent mechanism utilizing ball-type locking elements which minimize the frictional forces between the valve members engaged by the mechanism and which move relative to each other upon release of the mechanism.

It is a further object of the invention to provide a tubing safety valve employing a ball-type valve element biased to an open position by a spring and further utilizing a spring loaded detent mechanism adapted to retain the valve element in open position until the load resulting from fluid flow through the tubing is of a predetermined magnitude in excess of the force required to depress the valve element biasing spring.

It is a still further object of the invention to provide a fluid flow control device for use in a conductor such as a well tubing wherein a safety valve having a detent mechanism associated therewith is combined with a fluid check valve.

It is another object of the invention to provide a fluid flow control device comprising a safety valve and a check valve including a bypass around the check valve to permit displacement of any fluid which may become trapped between the valves and prevent opening of the safety valve.

It is a still further object of the invention to provide a combined well tubing safety and check valve utilizing ball-type valve elements for effecting both the safety and check valve functions and a spring loaded ball-type detent mechanism in association with the safety valve.

It is another object of the invention to provide a check valve assembly having means for biasing the valve toward open position.

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 longitudinal view partially in section and partially in elevation of a well tool in accordance with the invention illustrating both the safety valve and the check valve in full open positions;



FIG. 2 is a longitudinal view of the well tool partially in section and partially in elevation illustrating the safety valve in a fully closed position and the check valve assembly in a partially open position;

FIG. 3 is a view in section along the line 3–3 of FIG. 1 showing the safety valve in a full open position to allow fluid flow through the tubing; and,

FIG. 4 is a view partially in elevation and partially in section of the lower end of the well tool at a stage in its operation when the safety valve is beginning to open and the check valve is fully closed.

Referring to FIG. 1, a well tool 10 constructed in accordance with the invention is supported on a tubing string 11 to control fluid flow through the tubing string. The well tool includes a safety valve assembly 12, a detent mechanism 13 operatively associated with the safety valve assembly for detaining the safety valve in open position until a predetermined force is exerted on the valve, and a check valve assembly 14 which includes a spring unit 15 to prevent full closure of the check valve until a predetermined force is exerted on the valve. A top sub 20 which is internally threaded at 21 is engaged on the lower end of the tubing string. The top sub is externally threaded at 22 and is provided with an internal annular recess 23 in which a packing assembly 24 is positioned. An upper housing member 25 is internally threaded at 30 to permit its engagement with the lower end of the top sub and externally threaded at 31 to support the lower housing member 32. The lower housing member is internally threaded at 33 for engagement with the lower end of the upper housing member. The lower housing member is internally at 34 for engagement with the bottom sub 35 which is externally threaded at 40.

A safety valve seat body 41 is slidably positioned within the housing with the packing assembly 24 forming a substantially fluid tight seal around the seat body within the top sub. An annular-shaped spacer ring 42 is disposed around the seat body with the upper face of the spacer ring engaging the lower end of the top sub. A lock ring 43 is secured around the seat member in a shallow annular recess 43*a* in the seat body 41 to support the lower end of a spring 44 which is confined between the lock ring and the spacer ring 42 to provide a downward bias to the body. The valve seat body is provided with an internal bore 45 to allow fluid flow therethrough. A flow bean 50 with a bore 50*a* is secured within the lower portion of the seat body. The flow bean is held in the body against downward movement by a retaining ring 51 which is engaged in an annular recess 52 formed within the body. Upward movement of the flow bean is prevented by engagement of the external annular shoulder 50*b* on the flow bean with the internal annular shoulder 50*c* within the valve seat body. Above the slot 52 the body is provided with an internal annular recess 53 in which an O-ring 54 is positioned to form a seal between the flow bean and the body. The lower end of the body is provided with a conical valve seat surface 55. Annular external flanges 60 and 61 are formed around the lower portion of the valve seat body spaced apart from each other to provide an annular recess 62 around the body. The annular flange 61 is provided with two longitudinally extending slots 63 located on opposite sides of the valve seat body. While only one of the slots 63 is visible in FIG. 1 it is to be understood that an identical slot is formed in the back side of the body so that the slots will be spaced apart 180°. The T-shaped ball valve support members 64 are engaged on opposite sides of the safety valve seat body with the lateral portions 64*a* of the support members being positioned within the annular recess 62 and the longitudinal portions 64*b* of the support members extending downwardly through the slots 63. Referring to FIGS. 1 and 3, each of the arms 64 is provided with an inwardly projecting pin 65. The pins 65 cooperate to provide pivotal support for the ball valve 70.

The ball valve 70 is provided with a cylindrical bore 71 which when alined with the bore of the safety valve seat body, as shown in FIG. 1, permits fluid flow through the safety valve assembly. The flat surfaces or faces 72 are formed on opposite sides of the ball valve, see FIG. 3, in planes which extend parallel to each other and parallel to the axis of the bore 71 through the valve element. A blind hole recess 74 is formed at the center of each of the flat surfaces 72 of the ball valve to receive the pins 65 for supporting the ball valve from the safety valve seat body. The ball valve is provided with the slots 80 which are formed in the valve opening into the faces 72. The centerline of each of the slots 80 extends through the center of the recess 65 at an angle with the axis of the bore 71. The pins 82 are secured through opposite sides of the lower housing member 32 extending into the slots 80. The slots 80 are so located with respect to the recesses 74 that the ball valve rotated by longitudinal movement of the pins 65 relative to the pins 82. Since the ball valve is pivotally supported on the pins 65, upward and downward movement of the pins by raising and lowering the arms 64 raises and lowers the ball valve relative to the pins causing the fixed pins to slide in the slots to rotate the ball valve about its axis. The pins 84 are secured through opposite sides of the housing member 32, as shown in FIG. 3, so that the inward ends of the pins, each of which is flat, may cooperate with the faces 72 to aid in maintaining the alinement of the ball valve as it rotates. Each pin 84 is spaced apart from a pin 82 a distance which permits a ball valve support arm 64 to extend between the pins to guide and maintain the longitudinal alinement of the support arms.

The lower housing member 32 is provided with an internal annular flange 90 having an upper, downwardly and inwardly sloping face 90*a* and a lower upwardly and inwardly sloping face 90*b*. The face 90*a* functions to limit the downward movement of the safety ball valve 70 as the ball valve engages and is supported by the face of the flange when the valve is in full open position, as illustrated in FIG. 1. The lower face 90*b* of the flange performs a similar function with respect to limiting upward movement of the check valve, as will be explained hereinafter.

The detent assembly 13 is operatively engaged between the upper housing member 25 and the safety valve seat body 41. The upper housing member is provided with an internal annular flange 91 forming within the housing a downwardly facing shoulder 92. Below the shoulder 92 an internal annular recess 93 is formed adjacent to the lower end of the upper housing member. The valve seat body 41 is provided with an external annular recess 94. An annular cage or ring 95 is positioned around the valve seat body within the upper housing member. The cage is provided with a plurality of radially spaced apertures 100 to accommodate the balls 101. An annular spacer ring 102 is positioned around the valve seat body engaging the upper end of the cage 95. A coil spring 103 is confined between the shoulder 92 and the upper end of the spacer ring 102 around the valve seat body. The distance between external surface of the body 41 from the ring 43 to the flange 60 and the internal surface of the housing member 25 below the flange 91 is less than the diameter of the balls 101 thus requiring that the balls engage either or both of the recesses 94 and 93. The depth of either of the recesses plus the distance between the valve seat body and the housing member below the shoulder 92 is substantially equal to the diameter of the balls. The relative vertical positioning of the recesses 93 and 94 is such that when the safety valve is in open position, as illustrated in FIG. 1, the recess 93 will be sufficiently above the recess 94 that the balls 101 will engage the recess 94 in the seat body while contacting the inner surface of the upper housing member immediately below the recess 93. When the valve is positioned as shown in FIG. 2 the balls 101 engage the recess 93 while contacting the external surface of the upper valve seat member below the recess 94. The spring 103 acting through the spacer ring 102 biases the cage and balls in a downward direction. Upward movement of the safety valve assembly compresses the spring 103 to disengage the detent assembly in a manner which will be explained in more detail hereinafter in the discussion of the operation of the well tool of the invention.

The check valve assembly 14 is engaged within the lower housing member 32 so that the check valve will remain in open position, as shown in FIG. 1, while upward fluid flow is occurring through the tubing string, but when flow stops the valve closes as in FIG. 2 and with downflow moves to the position of FIG. 4. Check valve seat body 110 is a tubular-shaped member having a longitudinal bore 111 to permit fluid flow therethrough. The upper end of the check valve seat is an inwardly facing spherical face 112 providing a valve seat for the ball check valve. Near the upper end of the check valve seat body an annular external recess 113 is formed around the member. Below the recess 113 the seat body is reduced in external diameter to provide a downwardly facing shoulder 114. The valve seat body is further reduced in diameter at 115 at the lower end of which the body is provided with an external, upwardly sloping annular flange 120. Below the flange 120 the seat body has formed thereon an external, annular, downwardly and inwardly sloping seat 121 which conforms to the internal, annular, upwardly facing seat 122 formed on the upper end of the bottom sub 35. The check valve seat body below seat 121 is smaller in diameter than the internal diameter of the sub 35 thus providing a bypass for fluid flow around the seat body within the sub. The other external dimensions of the seat body are such that fluid may flow from between the two valves around the seat body. A collet ring 123 having upwardly extending fingers 124 provided with inwardly projecting bosses 125 is engaged around the valve seat body with the bosses 125 engaging the flange 120 to provide longitudinal support for the collet ring. A coil spring 130 is positioned around the seat member confined between the shoulder 114 and the collet ring.

The T-shaped ball check valve support arms 131 are engaged on opposite sides of the check valve seat body 110. The arms 131 are identical in shape and function to the arms 64 which support the ball safety valve. The arms 131 each comprises a longitudinal extending portion 131*a* and a lateral portion 131*b* which is engaged in the annular recess 113. The longitudinal portion 131*a* of each arm extends through a longitudinally oriented recess 132 formed in the valve seat body above the recess 113. A recess 132 is formed on each side of the body to accommodate the oppositely positioned arms 131. Each of the arms 131 is provided with an inwardly projecting pin 133. The ball check valve 134 is pivotally supported by the opposing pins 133. The ball check valve is identical in design to the previously described ball safety valve 70. The ball check valve is provided with a bore 135 which cooperates with the bore 111 in the valve seat to permit flow through the valve. The ball check valve is also provided with opposing flat surfaces 140 in the center of which circular recesses 141 are formed to receive the pins 133 for supporting the ball check valve. In each of the faces 141 a slot 142 is formed to receive the pins 143 which are secured to and through the lower housing member extending into the slots. Also secured through the lower housing member are the pins 144, the inward ends of which engage the flat surface 140 to prevent the ball check valve from rotating about the longitudinal axis of the housing member as the check valve is moved between open and closed positions. Upward and downward movement of the seat member 110 causes the ball check valve to be raised and lowered within the housing member and since the pins 143 are fixed through the housing member to engage the slots 142 the pins remain in a stationary position as the valve is raised and lowered causing the valve to rotate about the pins 133. As illustrated in FIG. 1, when the valve is up in fully open position the ball valve engages the downwardly facing surface 90*b* within the housing member. In addition to the pins 143 cooperating with the slots 142 to rotate the ball check valve, the pins 143 along with the pins 144 serve as guides for the portions 131*a* of the arms 131 as the arms are raised and lowered with the check valve body.

The well tool **10** is employed to control the flow of fluids from a well bore. The tool is secured by the threads **21** to the tubing string **11** which is introduced into the well bore with the tool being positioned at the desired level. The well tool controls the flow of the well fluid through the tubing string **11** shutting off flow when the pressure differential across the safety valve assembly exceeds a predetermined value. When the tool is positioned in the tubing string and before fluid flow occurs, the safety valve will be in open position and the check valve in closed position. Since at this stage the valves at the top of the well will be closed, no pressure differential will exist across the valves of the tool. The coil spring **44** around the safety valve seat body **41** acting against the lock ring **43** biases the safety valve seat body downwardly so that the safety valve **70** is in open position resting on the face **90***a* of the lower housing member **32**. Since the safety valve is supported on the arms **64** which are engaged on the valve seat body, the pins **65** on the arms are located, as illustrated in FIG. **1**, at a level below the fixed pins **82** which extend through the lower housing member. The detent mechanism **13** is engaged with the safety valve assembly. The recess **94** is at a level slightly below the recess **93**. The balls **101** are biased downwardly by the coil spring **103** and are cammed inwardly by the lower face of the recess **93** so that the balls engage the recess **94** in the safety valve seat body thus applying the downward bias of the coil spring **103** to the valve seat body. The balls **101** contact the inner wall of the upper housing member **25** immediately below the internal annular recess **93** within the upper housing member. Thus, the ball safety valve is held in open position by both the coil spring **44** and by the detent assembly spring **103**.

When the well tool is initially installed in the well bore, the surface valves are closed and no flow is occurring through the tool. The ball check valve **134** will, since no pressure differential exists across the valve assembly, assume the position illustrated in FIG. **2** as the weight of the assembly will cause the valve seat body to drop downwardly until the body is supported by the coil spring **130** pressing against the collet ring **123**. The downward pull of the arms **131** and thus the pins **133** will hold the check valve in the position illustrated since the pins **133** pull the ball check valve downwardly relative to the pins **143** which act in the slots **142** to rotate the check valve to the closed position. The spring **130** together with the collet mechanism keep the check valve seat slightly upward separating the surfaces **121** and **122** to allow slight fluid flow around the check valve body for purposes which will be explained. Thus, when the well tool is positioned within the well bore and before fluid is allowed to flow through it, the safety valve will be in the open position illustrated in FIG. **1** while the check valve will be in the partially closed position illustrated in the lower portion of FIG. **2**.

Upon completion of the positioning of the well tool in the well bore the necessary valves at the surface are opened to allow fluid flow through the well tool. The lower pressure at the surface due to opening the valves creates a pressure differential across the check valve assembly, both across the valve seat and the ball check valve. The pressure differential initiates upward movement of the check valve pushing it to the open position, illustrated in FIG. **1**. Upward movement of the body **110** carries the arms **131** upwardly and thus the pins **133** supporting the ball check valve move upwardly relative to the pins **143** which slide in the slots **142** of the ball check valve. The pins **143** cause the ball check valve to revolve about its axis to the open position illustrated. After the ball check valve is open, the pressure differential across the valve seat and the ball check valve will hold the valve assembly in open position. So long as fluid flow through the well tool remains within predetermined safe limits the various parts of the tool will be positioned, as illustrated in FIG. **1**, with both the safety valve and the check valve in open positions due to the pressure differentials effected across the elements. The fluid flows into the bottom sub, through the bore **111** of the check valve seat body, through the bores **135** and **71** of the check valve and safety valve, respectively, through the bore **50***a* of the flow bean into the bore **45**, and then into the tubing string **11**.

When the pressure within the well bore below the well tool exceeds what has been established as a safe limit the pressure differential across the flow bean will effect closure of the ball safety valve. The flow of fluids through the bore **57***a* of the flow bean **50** produces a pressure drop across the bean. The differential pressure acts upwardly against an area sealed by the packing **24** exclusive of the area of the bore **50***a* with the pressure differential tending to lift the flow bean along with the other members of the safety valve assembly including the seat body **41** and the ball safety valve **70**. The lifting force exerted against the safety valve assembly is opposed by the biasing force of the coil spring **103** in the detent assembly. When the difference in pressure across the flow bean exceeds the predetermined value necessary to overcome the resistance of the coil spring of the detent assembly, the lower surface of the recess **94** in the safety valve seat body lifts the balls **101** which raises the cage and spacer to depress the spring. When the balls have been lifted a short distance they are opposite the recess **93** within the upper housing member **25** and since the seat body is being urged upwardly the balls are cammed into the recess **93** by the outwardly facing lower surface of the recess **94** resulting in the complete disengagement of the safety valve seat body from the detent mechanism to free the body to be raised by the pressure differential. As the body is raised the arms **64** along with the pins **65** are lifted relative to the pins **82** which remain in their fixed locations through the lower housing member. As the pins **65** are lifted the safety valve **70** which is pivotally supported on the pins is rotated by the action of the pins **82** in the slots **80** until when the seat body is at its uppermost position the ball safety valve is fully closed, as illustrated in FIG. **2**. The pins **84** cooperate with the surfaces **72** to limit rotation of the valve to the axis through the pins **65**. Therefore, any twisting motion of the safety valve is precluded. When the safety valve is in closed position the surface of the valve engaged with the seat **55** seals off fluid flow through the well tool. The pressure within the tool below the safety valve maintains the surface of the valve in sealing engagement with the seat.

Once the detent assembly is disengaged from the valve seat body the closing of the ball safety valve is effected quickly and positively without the normal lingering and resultant throttling effect from a conventional type slow closing valve. The downward bias of the detent assembly is normally slightly greater than the force needed to depress the spring **44** so sufficiently to close the safety valve so that the detent assembly spring must first be compressed and the detent assembly disengaged before the safety valve may be moved to closed position. For example, the safety valve seat body may have to move upwardly three-quarters of an inch to close and if the spring **44** is initially loaded to 300 pounds and requires an additional 75 pounds per inch to depress it, the load of the spring when depressed three-quarters of an inch will be about 356 pounds. A coil spring **103** is chosen which requires a load slightly in excess of the additional load needed to depress the spring **44**, about 58 pounds, to disengage the detent mechanism from the safety valve seat body. Thus, it is necessary that an upward force of at least 358 pounds be exerted against the safety valve assembly to disengage the detent mechanism to allow the assembly to be urged in an upward direction against the force of the spring **44**. Since the spring **44** may be depressed the required distance by a force of about 56 pounds in excess of the load on the spring and an excess force of 58 pounds is exerted against the assembly to disengage the detent mechanism, the safety valve is fully and completely closed without lingering or chattering once the detent mechanism is disengaged. Since the force necessary to depress the coil spring of the detent assembly and thus disengage the assembly is greater than the force required to depress the coil spring **44** to the extent necessary to effect closing of the safety valve, the larger force being exerted upon the valve seat body immediately moves the valve seat body upwardly a sufficient distance to fully close the safety valve after the detent assembly is disengaged. In other words, when the detent assembly is disengaged, enough energy is available and is being

exerted upon the safety valve seat body to quickly and fully close the ball safety valve. It is unnecessary, therefore, to gradually build up the force required to fully close the valve and therefore the slow throttling effect resulting in the conventional type of safety valve not utilizing such a detent mechanism is avoided.

When the safety valve has been rotated to the closed position the pressure differential across the check valve and the valve seat **110** equalizes and the check valve closes due to the force of gravity upon the check valve assembly. The weight of the various members comprising the check valve assembly causes the assembly to drop downwardly. The arms **131** pull the check valve downwardly since the valve is pivotally supported on the pins **133**. As the valve seat body **110** drops downwardly pulling the arms and the check valve the pins **133** are moved in a downward direction relative to the pins **143** which remain fixed through the lower housing member. The check valve is rotated to the position shown in FIG. **2** due to the camming action of the pins in the slots **142**. The outer spherical surface of the valve cooperating with the seat **112** shuts off fluid flow through the bore **111** of the valve seat body. No pressure differential exists across the valve seat **110** due to the bypass space between the seat and the member **32** and the sub **35**. While it is evident from the position of the check valve in FIG. **2** that the valve has not rotated a full 90°, the seat **112** is sufficiently in contact with the surface of the valve to shut off flow through the bore of the valve seat. The valve seat body is retained in the slightly raised position illustrated by the spring engaged around the valve seat engaging the ring of the collet **123** which rests on the upper end of the sub **35**. The spring supports the valve seat body in an upward position sufficiently to prevent contact of the seats **121** and **122** whereby fluid may flow at a low rate downward around the check valve seat body from the space between the safety valve and check valve. A downwardly acting pressure differential across the check valve and valve seat body will, however, move the valve seat downwardly against the resistance of the spring and cause the seats **121** and **122** to close off fluid flow through the bypass space around the valve seat body.

The safety valve will remain in closed position, as illustrated in FIG. **2**, until the pressures above and below the valve are substantially equalized. The equalizing of the pressures may be effected by pumping fluid through the tubing string **11** into the well tool above the safety valve. Just before the pressure of the fluid being pumped in above the safety valve reaches the value of the pressure below the safety valve, the coil spring **44** begins to move the safety valve seat body **41** in a downward direction to initiate the opening of the safety valve. Movement of the pins **65** downwardly relative to the pins **82** effects rotation of the ball safety valve toward open position. If the check valve were fully closed, the fluid trapped between the safety valve and check valve could not be displaced and thus would prevent downward movement and opening of the safety valve. The spring **130** supports the faces **121** and **122** apart from each other to enable the fluid between the safety and check valves to be displaced downwardly around the check valve body thereby allowing the safety valve assembly to move in a downward direction toward open position. The spring **130** is chosen with sufficient strength to maintain the check valve seat in the upward position, illustrated in FIG. **2**, against the downward flow of fluid from between the valves to allow the safety valve to move to the position where it will start opening. When the safety valve opens the pressure differential across the valve will equalize. Further pumping of fluid downwardly may cause complete closing of the check valve assembly. Normally, however, the pumping of fluid downwardly will cease and the surface valves will be opened to permit the well to flow again. Upward flow will effect a pressure differential across the check valve which will move the check valve to open position. In opening the check valve seat body raises the pins **133** to effect rotation of the valve by the pins **143** acting in the slots **142**.

Once the pressure on either side of the safety valve is equalized the coil spring **44** around the safety valve seat body forces the body downwardly until the valve is again in full open position, as illustrated in FIG. **1**. In the course of the opening of the valve the external recess **94** around the valve seat body will move downward until the balls **101** move inwardly into the recess from the surrounding recess **93**. When the recess **94** arrives opposite the recess **93** the force of the spring **103** acting downwardly through the spacer **102** and the cage **100** against the balls causes the lower face of the recess **93** to cam the balls inwardly into the recess **94** where the balls engage the lower surface of the recess. The force of the spring **103** will then be added to the spring **44** to bias the safety valve assembly to full open position since the balls are again engaged with the upwardly facing bottom surface of the recess **94**. With fluid flow once again occurring upwardly through the well tool the check valve will be held in open position by a pressure differential across the valve and the safety valve will be held open by the coil springs **44** and **103** until the fluid flow through the flow bean reaches such a rate that the pressure drop across the flow bean will again exceed the predetermined limit to cause upward movement and closing of the safety valve.

It will be readily apparent that the characteristics of the spring **44** of the safety valve assembly, the spring **103** of the detent assembly, and the spring **130** around the check valve seat body are chosen to satisfy the particular requirements for which the well tool is designed. As previously pointed out, in order to insure that the safety valve will not linger between open and closed position the detent assembly requires a somewhat greater force to actuate it and disengage the safety valve seat body than is actually required to then lift the body and close the safety valve. The spring **103** is, therefore, chosen to require a somewhat greater load to depress it than the spring **44**. The effective force required to depress the spring **103** may be varied by changing the spacer **102** to effectively increase or decrease the preloading of the spring and thus vary the force necessary to depress it a sufficient distance to disengage the detent assembly.

The spring **130** around the check valve seat body is chosen based on the force required to hold the body upwardly a sufficient distance to allow fluid to flow between the surfaces **121** and **122** while the safety valve is moving downwardly toward open position. The spring must, however, be depressable by the force resulting from fluid flow in excess of that necessary to allow opening of the safety valve so that higher flow rates will completely close the check valve to permit it to fulfill its fundamental function.

It will be readily recognized that while the well tool has been described and illustrated as including both a safety valve and a check valve the safety valve assembly and its associated detent assembly may be employed independent of the check valve assembly. For example, the check valve and its associated parts may readily be removed from the well tool body by disengagement of the bottom sub **35** to allow the check valve seat body along with the check valve and the spring and collet assembly to be withdrawn as a unit from the lower housing member.

It will be seen that there has been described and illustrated a new and improved well tool for controlling fluid flow in a well conductor which is responsive to the fluid pressure within the conductor for controlling the fluid flow therethrough.

It will also be seen that there has been provided a well tool including a valve for a flow conductor wherein the valve is responsive to a predetermined fluid flow rate through the conductor.

It will be additionally seen that there has been provided a new and improved pressure responsive device for controlling fluid flow through a conductor which includes a valve mechanism which is prevented from assuming an intermediate position between open and closed positions to minimize erosion or abrasion of the valve parts by throttling of the fluid flow through the conductor.

It will be further seen that the well tool includes a detent mechanism associated with the safety valve to hold the valve in a fully open position until a force of predetermined magnitude is exerted on the valve by the flow of fluids through the tubing to release the detent mechanism and thus free the valve to move to a fully closed position.

It will also be seen that the well tool of the invention includes a detent mechanism which will hold a valve in fully open position and resist its being closed by temporary surges of fluid flow through a conductor.

It will also be seen that the detent mechanism of the well tool detains the valve with which it is associated in an open position until sufficient energy has been built up to move the valve to a fully closed position without the valves lingering between such open and closed positions.

It has also been shown that the detent mechanism employed with the well tool utilizes the ball-type locking elements between relatively movable members of tie tool to minimize the frictional forces involved.

It will be additionally seen that the well tool includes a spring loaded ball-type valve element and a detent mechanism associated therewith which also includes a spring in the detent mechanism which is independent of the spring employed to retain the valve element in open position until the load from the fluid flow through the valve exceeds a predetermined value in excess of the force required to depress the spring on the valve element.

It will also be seen that the well tool employs a safety valve and a check valve which includes bypass means for allowing fluid to be displaced from between the valves around the check valve seat body to permit closing of the safety valve.

It will also be seen that the well tool includes in combination a safety valve with a detent mechanism and a fluid check valve.

I claim:

1. A well tool including: housing means having a longitudinal flow passage extending therethrough; upper valve seat body means slidably positioned within said housing means, said body means having a longitudinal flow passage extending therethrough; ball valve means rotatably supported on the lower end of said body means, said valve means having a flow passage therethrough to cooperate with said flow passage through said body means when said valve means is in open position; the lower end of said body means being provided with a valve seat for cooperating with said valve means to prevent fluid flow through said well tool when said valve means is in closed position; said valve means being operably engaged with said housing means whereby movement of said body means between extreme positions effects opening and closing of said valve means by rotating said valve means about a transverse axis; spring means around said body means biasing said body means toward one extreme position in which said valve means is open; detent means between said body means and said housing means, said detent means being operably engageable with said body means when said body means is in said extreme position holding said valve means open, said detent means being disengageable from said body means in response to a force against said body means in excess of the force necessary to depress the spring means around said body means until said body means is moved to a second extreme position in which said valve means is closed, said detent means biasing said body means toward said first extreme position when engaged with said body means; lower valve seat body means having a longitudinal flow passage therethrough slidably positioned within said housing means below said upper valve seat body means; second ball valve means supported on the upper end of said lower body means, said second ball valve means having a passage therethrough for cooperating with said passage through said lower body means to permit fluid flow through said well tool; means interconnecting said second ball valve and said housing means for rotating said second ball valve between open and closed positions by relative longitudinal motion between said lower seat body means and said housing means, said lower seat body means assuming a downward position effecting closure of said second ball valve connected thereto when the fluid flow drops below a predetermined minimum through said well tool; and means operatively associated with said housing means and said lower seat body means for biasing said body means upwardly to permit fluid flow around said body means between said body means and said housing means.

2. A well tool for controlling fluid flow through a conductor including: a housing having a longitudinal passage therethrough; an upper ball valve disposed in said passage and adapted to be moved between open and closed positions; a spring operatively connected between said housing and said upper ball valve for biasing said ball valve toward open position; means operatively associated with said ball valve for effecting a pressure differential across said valve when fluid flow is occuring through said valve; a detent assembly operatively engaged between said ball valve and said housing for retaining said ball valve in open position until the pressure differential across said valve exceeds a predetermined value which disengages said detent assembly to permit said pressure differential to actuate said ball valve toward closed position; a lower ball valve disposed within said housing below said upper ball valve, said lower ball valve being operable between open and closed positions in response to fluid flow through said passage in said housing, said second valve being biased toward open position by upward flow through said passage; check valve seat means movably secured within said longitudinal passage and engageable with said lower ball valve for controlling fluid flow; and means operatively engaged between said housing and said check valve seat means for biasing said lower ball valve toward open position when downward flow around said lower ball valve is below a predetermined rate.

3. A well tool for controlling fluid flow through a conductor: a housing having a flow passage therethrough; an upper ball valve disposed in said housing and adapted to move longitudinally between lower open and upper closed positions, said upper ball valve being biased toward open position and being adapted to close in response to upward flow through said passage in excess of a predetermined rate; a detent mechanism operably engaged between said housing and said upper ball valve for retaining said ball valve in open position until the upward force on said ball valve exceeds the downward bias on said valve by a predetermined value; a lower ball valve disposed in said housing below said upper ball valve, said lower ball valve being movable between open and closed positions and being biased toward open position by upward flow through said passage; check valve seat means movable longitudinally in said flow passage and engageable with said lower ball valve for controlling fluid flow through said passage and means for biasing said lower ball valve and said check valve seat means toward open position for allowing downward flow around said lower ball valve below a predetermined minimum rate.

4. A well tool including: a housing having a longitudinal flow passage extending therethrough; a safety valve assembly disposed in said housing to shut off fluid flow through said passage when the fluid flow rate exceeds a predetermined value, means biasing said safety valve toward open position; a detent assembly operatively engaged between said housing and said safety valve for detaining said safety valve in open position until the closing force on said safety valve from fluid flow through said passage exceeds the biasing force on said valve by a predetermined value; a check valve assembly including a valve member and a seat member movably disposed in said flow passage, said check valve assembly being held in open position by fluid flow through said passage in one direction and moved to closed position by fluid flow through said passage in the other direction; and means operatively associated with said housing and said check valve seat member for biasing said check valve assembly toward open position when the fluid flow rate tending to close said check valve assembly is below a minimum value.

5. A valve assembly including: a housing having a longitudinal flow passage; a safety valve mounted in said passage for movement longitudinally and rotationally about a transverse axis in said housing between open and closed positions, said valve having a flow passage; means operatively connected to said valve and said housing whereby longitudinal movement of said valve relative to said housing causes rotational movement of said valve within said housing; means operatively associated with said safety valve for effecting a pressure differential in fluid flowing through said valve whereby a fluid flow rate in excess of a predetermined value biases said safety valve toward closed position; means operatively engaged between said safety valve and said housing biasing said safety valve toward open position; detent means engaged with said housing and operatively engageable with said safety valve to detain said valve in open position until the force tending to close said valve exceeds the biasing force holding said valve in open position by a predetermined value at which time said detent mechanism disengages from said valve; a check valve assembly mounted in said longitudinal passage for movement longitudinally in said passage and including a longitudinally movable seat member and a valve member engageable with said seat member and movable longitudinally and rotationally about a transverse axis between open and closed positions, said check valve assembly having a flow passage; means operatively connecting said valve member and said housing whereby longitudinal movement of said valve member relative to said housing causes rotational movement of said valve member within said housing; said check valve assembly being closable in response to fluid flow in a direction opposite to the direction in which said fluid closes said safety valve; and means for biasing said check valve assembly toward an open position to allow fluid flow past said valve member when the flow rate tending to close said check valve assembly is below a minimum predetermined value.

6. A tool for controlling fluid flow including: housing means having a longitudinal flow passage extending therethrough; safety valve means positioned within said flow passage, said safety valve means being biased toward open position and being adapted to close in response to a pressure differential across said safety valve in excess of a predetermined value; means operatively associated with said safety valve means and said housing means for retaining said safety valve means in open position until a force tending to close said safety valve means exceeds the force biasing said safety valve means toward open position by a predetermined value; check valve means positioned in said flow passage adjacent to said safety valve means, said check valve means including a valve member and seat member movable longitudinally in said flow passage and adapted to close in response to fluid flow opposite in direction to said flow tending to close said safety valve means; and means biasing said seat member of said check valve means longitudinally of said flow passage to move said check valve means toward open position to permit fluid flow past said means below a minimum flow rate.

7. A tool for controlling fluid flow including: housing means having a longitudinal flow passage extending therethrough; safety valve means positioned in said flow passage and adapted to close in response to fluid flow in excess of a predetermined rate; means operatively connected between said housing means and said safety valve means for biasing said safety valve means toward open position; means connected with said housing means and adapted to be connected with said safety valve means for detaining said safety valve means in open position until the fluid flow rate through said safety valve means exceeds a predetermined value; check valve means positioned within said flow passage upstream of said safety valve means, said check valve means including closure means and seat means movable in said flow passage adapted to close in response to fluid flow in an upstream direction; and means operatively connected between said housing means and said seat means of said check valve means for biasing said seat means and closure means of said check valve means toward open position to permit fluid flow below a minimum fluid flow rate to allow drainage of fluid from between said safety valve means and said check valve means when opening said safety valve means subsequent to closure.

8. A tool for controlling fluid flow including: housing means having a longitudinal flow passage extending therethrough; ball-type safety valve means positioned in said flow passage and adapted to close in response to fluid flow through said passage in excess of a predetermined rate, said safety valve means including means for effecting a fluid pressure differential across said valve means; means operatively connected between said safety valve means and said housing means for biasing said safety valve means toward open position; means engaged within said flow passage in said housing means and engageable with said safety valve means for detaining said safety valve means in open position until the fluid flow rate through said flow passage exceeds the force biasing said safety valve means toward open position by a predetermined value; check valve means including closure means and seat means positioned within said flow passage and movable longitudinally within said flow passage on the side of said safety valve means toward the source of fluid flow which closes said safety valve means; and biasing means operatively connected between said housing means and said seat means of said check valve means for biasing said seat means and closure means of said check valve means toward said safety valve means to permit a minimum fluid flow past said check valve means to allow fluid trapped between said safety valve means and said check valve means when both of said valve means are closed to be displaced past said check valve means upon subsequent opening of said safety valve means.

9. A tool for controlling fluid flow in a well including: a housing having a longitudinal flow passage extending therethrough; a safety valve seat body having a longitudinal flow passage slidably positioned within said flow passage of said housing; a ball-type safety valve rotatably secured on the lower end of said seat body, said safety valve being rotatable about an axis transverse to the longitudinal axis of said housing and having a flow passage therethrough to communicate with said flow passages of said housing and said safety valve seat body when said safety valve is in open position; the lower end of said safety valve seat body having a face adapted to cooperate with said ball safety valve for shutting off fluid flow through said tool when said flow passage through said safety valve is not in communication with said flow passages through said housing and said safety valve body; fluid flow restriction means secured within said flow passage through said safety valve body; means connected between said safety valve body and said housing for biasing said safety valve toward open position, said biasing means being adapted to hold said safety valve in open position when the fluid flow rate through said valve is below a minimum predetermined value; detent means connected to said housing around said safety valve seat body and engageable with said body for holding said safety valve in open position until the fluid flow rate through said safety valve exceeds by a predetermined value the force biasing said safety valve toward open position; a check valve body having a longitudinal flow passage extending therethrough slidably positioned within said flow passage through said housing below said safety valve; a ball-type check valve rotatably secured on the upper end of said check valve body and adapted to rotate about an axis transverse to the longitudinal axis of said housing, said check valve having a flow passage therethrough to communicate with said flow passage through said check valve body to permit fluid flow through said tool; the upper end of said check valve body having a seat surface adapted to cooperate with the surface of said check valve to prevent fluid flow through said check valve when said check valve is rotated to a position where the flow passage through said check valve is not in communication with the flow passage through said body; and means biasing said check valve body toward said safety valve to allow a minimum fluid flow past said check valve body from between said check valve and said safety valve during opening of said safety valve.

10. A fluid flow control assembly including: a housing having a longitudinal flow passage extending along the longitudinal axis of said housing; a valve seat movably positioned within said flow passage, said valve seat being provided with a flow passage communicating with said flow passage of said housing; a flow bean secured within said flow passage of said valve seat for effecting a pressure differential across said valve seat responsive to fluid flow through said flow passage in said valve seat; a ball valve rotatably secured to one end of said valve seat along an axis transverse to the longitudinal axis of said flow passage through said housing, said ball valve having a flow passage therethrough adapted to communicate with said flow passage through said valve seat when said ball valve is in open position; the end of said valve seat adjacent to said ball valve having a seat surface adapted to cooperate with the surface of said ball valve for preventing fluid flow through said flow passage in said valve seat when said ball valve is in closed position; means interconnecting said ball valve and said housing for rotating said ball valve between open and closed positions responsive to longitudinal movement of said valve seat within said housing; a spring positioned around said valve seat and engaged between said valve seat and said housing biasing said valve seat in a direction to urge said ball valve toward open position; means secured within said housing around said valve seat for releasably engaging said valve seat to hold said ball valve in open position until the pressure differential effected by said flow bean exceeds a predetermined value; a second valve seat movably positioned within said housing adjacent to and spaced apart from said ball valve on said first mentioned valve seat, said second valve seat having a fluid flow passage extending therethrough communicating with said fluid flow passage through said housing; a second ball valve rotatably secured to the end of said second valve seat adjacent to said first mentioned ball valve along an axis extending transverse to the longitudinal axis through said housing, said second ball valve having a fluid flow passage therethrough communicating with said flow passage through said second valve seat when said ball valve is in open position; the end of said second valve seat adjacent to said second ball valve having a seat surface engageable with the surface of said second ball valve for preventing fluid flow through said second valve seat when said ball valve is in closed position; means interconnecting said second ball valve and said housing for effecting rotation of said ball valve between closed and open positions responsive to longitudinal movement of said second valve seat relative to said housing; said second valve seat and said housing having cooperating surfaces adapted to control fluid flow around said valve seat within said housing; and means engaged between said second valve seat and said housing biasing said cooperating surfaces apart to permit fluid flow below a predetermined rate around said second valve seat from between said second valve seat and said first mentioned valve seat.

11. A tool for controlling fluid flow including: a housing having a flow passage extending therethrough along the longitudinal axis of said housing; a safety valve seat movably secured within said flow passage of said housing, said safety valve seat having a longitudinal flow passage therethrough communicating with the flow passage of said housing; a flow bean secured within the flow passage through said safety valve seat for effecting a pressure differential in fluid flowing through said flow passage; a ball safety valve rotatably secured on the lower end of said safety valve seat along an axis transverse to the longitudinal axis of said seat, said valve having a flow passage therethrough adapted to cooperate with said flow passage through said seat to permit fluid flow through said safety valve; the lower end of said valve seat having a face thereon to cooperate with the surface of said safety valve to control flow therethrough; means operatively connecting said safety valve and said housing whereby longitudinal movement of said safety valve seat relative to said housing effects rotation of said safety valve between open and closed positions; first spring means engaged at one end with said housing and at the other end with said safety valve seat for biasing said seat downwardly to open said safety valve; second spring means operatively engaged at one end with said housing and engageable at the other end with said safety valve seat for retaining said safety valve in closed position until the force of a pressure differential resulting from fluid flow through said safety valve exceeds the biasing force of said first spring means by a predetermined amount; a check valve seat movably positioned within said housing below said safety valve, said check valve seat having a longitudinal flow passage extending therethrough; a ball check valve rotatably engageable with the upper end of said check valve seat on an axis transverse to said longitudinal flow passage through said check valve seat; said ball check valve having a flow passage adapted to cooperate with said flow passage through said check valve seat when said ball check valve is in open position to permit fluid flow through said tool; the upper end of said check valve seat having a face thereon adapted to cooperate with said ball check valve for controlling fluid flow through said ball check valve; means operatively connecting said ball check valve with said housing whereby longitudinal movement of said check valve seat relative to said housing effects rotation of said ball check valve between open and closed positions; said check valve seat having an external annular surface adapted to cooperate with an internal annular surface within said housing for controlling fluid flow along the outer surface of said check valve seat within said housing; and spring means engaged between said check valve seat and said housing for biasing said seat in an upward direction whereby said annular surfaces are held in spaced apart relationship until fluid flow downwardly around said check valve seat from between said ball safety valve and said ball check valve exceeds a predetermined rate.

12. A tool for controlling fluid flow including: a housing having a longitudinal flow passage extending therethrough; a safety valve seat movably positioned within said flow passage; said safety valve seat having a longitudinal flow passage extending therethrough in communication with said flow passage through said housing, the lower end of said safety valve seat having an annular face thereon adapted to cooperate with a ball-type valve for controlling fluid flow through said safety valve seat; a flow bean secured within said safety valve seat for effecting a pressure differential within fluid flowing through said seat; arm means engaged around said safety valve seat and extending downwardly from the lower end thereof; a ball safety valve rotatably secured to said arm means along an axis extending transverse to said passage through said housing; said ball safety valve having a fluid flow passage therethrough adapted to cooperate with said flow passage through said valve seat to permit fluid flow through said tool; means engaged between said housing and said ball safety valve whereby longitudinal movement of said safety valve seat effects rotation of said ball safety valve between open and closed positions; a first coil spring positioned around said safety valve seat within said passage through said housing, the upper end of said coil spring being engageable with said housing and the lower end of said spring being engageable with said safety valve seat whereby said safety valve seat is biased downwardly to effect rotation of said ball safety valve toward open position; a second coil spring positioned around said safety valve seat within said housing, the upper end of said second coil spring being engageable with said housing; annular locking means disposed within said housing around said safety valve seat below said second coil spring and engageable with the lower end of said second coil spring; said safety valve seat being provided with an annular external groove located to be engaged by said locking means for releasably locking said safety valve seat in a downward position whereby said ball safety valve is held in open position until the pressure differential across said safety valve seat exceeds a predetermined value; said housing having an internal annular groove for receiving said locking means when said locking means is disengaged from said safety valve seat; a check valve seat movably secured within said flow passage through said housing below said safety valve, said check valve seat having a lon-

gitudinal flow passage extending therethrough to communicate with said flow passage through said housing for permitting fluid flow through said tool, the upper end of said check valve seat having an annular face adapted to cooperate with a ball valve for controlling fluid flow through said passage in said check valve seat; arm means engaged on said check valve seat and extending upwardly therefrom; a ball check valve rotatably secured to said arm means to rotate about an axis extending transverse to the flow passage through said housing, said check valve having a flow passage therethrough adapted to cooperate with said flow passage through said check valve seat to permit fluid flow through said tool; means engaged between said housing and said ball check valve for rotating said ball check valve in response to longitudinal movement of said check valve seat relative to said housing whereby said ball check valve is rotated about its axis between open and closed positions; said housing being provided with an internal annular flange between said ball safety valve and said ball check valve, said flange having an upper face and a lower face adapted to be contacted by and limit, respectively, the downward movement of said safety valve and the upward movement of said check valve; said check valve seat being provided with an external annular surface adapted to cooperate with an internal annular surface provided within said housing to control fluid flow within said housing around said check valve seat whereby any fluid trapped between said safety valve and said check valve when each of said valves is closed may be displaced around said check valve seat when said check valve is in closed position and said safety valve is being urged toward open position; and spring means engaged between said housing and said check valve seat for biasing said check valve seat toward said safety valve to maintain a spaced apart relationship between said annular surface around said check valve seat and said annular surface within said housing when the fluid flow around said check valve seat is below a predetermined rate.

13. A tool for controlling fluid flow including: a housing having a longitudinal passage having a longitudinal axis; a safety valve seat movably engaged within said passage through said housing, said safety valve seat having a passage having a longitudinal axis adapted to cooperate with said passage through said housing for permitting fluid flow through said tool, the lower end of said safety valve seat being provided with an annular valve face adapted to cooperate with a ball valve for controlling fluid flow through said passage through said seat; a flow bean secured within said flow passage within said safety valve seat for effecting a pressure differential in fluid flowing through said seat; arm means engaged around said safety valve seat and extending downwardly therefrom; a ball safety valve rotatably secured to said arm means along an axis extending transverse to the longitudinal axis through said housing; said ball safety valve being provided with a flow passage therethrough to cooperate with said flow passage through said safety valve seat for controlling fluid flow through said safety valve; said ball safety valve being provided with external slots on opposite sides thereof, the center line of each of said slots being coincident with a line intersecting the axis of rotation of said ball safety valve; pin means secured through said housing engaging said slots of said safety valve whereby longitudinal movement of said safety valve seat relative to said housing effects movement of said pin means in said slots to rotate said ball safety valve between open and closed positions; a first coil spring disposed within said flow passage through said housing around said safety valve seat, said coil spring being engaged with said housing at the upper end thereof and secured to said safety valve seat at the lower end thereof whereby said safety valve seat is biased downwardly to urge said ball safety valve toward open position; a second coil spring disposed around said safety valve seat within said flow passage through said housing, said spring being engageable at the upper end thereof with said housing; an annular cage having a plurality of radially spaced holes therethrough positioned around said safety valve seat within said housing below said second coil spring; a plurality of ball shaped locking elements carried by said cage; the upper end of said cage being urged downwardly by said second coil spring; said safety valve seat being provided with an external annular recess for receiving said ball shaped locking elements to releasably lock said safety valve seat in a downward position whereby said safety valve is held in open position until the fluid rate through said valve exceeds a predetermined value in excess of the biasing force of said first mentioned coil spring; said housing being provided with an internal annular recess adapted to receive said ball shaped locking elements when said elements are disengaged from said safety valve seat; a check valve seat movably positioned within said flow passage through said housing below said safety valve, said check valve seat having a flow passage extending longitudinally thereof to provide communication with said flow passage through said housing, the upper end of said check valve seat being provided with a spherical annular face adapted to cooperate with a ball shaped valve for controlling flow through said flow passage through said check valve seat; arm means engaged around said check valve seat and extending upwardly therefrom; a ball check valve rotatably secured to said arm means along an axis extending transverse to said longitudinal axis through said housing; said ball check valve having slots on opposite sides thereof, the center line of each of said slots being coincident with a line intersecting the axis of rotation of said ball check valve; pin means extending through said housing engaging said slots in said ball check valve whereby longitudinal movement of said check valve seat causes said pin means to rotate said ball check valve between open and closed positions; said check valve seat being provided with a downwardly facing external annular face to cooperate with an upwardly facing internal annular face within said flow passage through said housing for controlling fluid flow within said housing around said check valve seat; a coil spring disposed within said flow passage around said check valve seat, said coil spring being engageable with said housing at the lower end thereof to bias said check valve seat in an upward direction to maintain a spaced relationship between said annular face around said check valve seat and said annular face within said flow passage through said housing whereby fluid trapped between said check valve and said safety valve may be displaced around said check valve seat when said check valve is closed and said safety valve is being moved downwardly when the fluid flow is around said valve seat exceeds a predetermined limit; and an internal annular flange formed within said housing between said safety valve and said check valve to limit the downward movement of said safety valve and the upward movement of said check valve.

14. A tool for controlling fluid flow in accordance with claim 13 including: a first external annular flange around said check valve seat body to engage the upper end of said coil spring around said seat body; a second external annular flange around said check valve seat body below and spaced apart from said first annular flange; a collet ring positioned around said check valve seat body engaged with the lower end of said coil spring, said collet ring having upwardly extending fingers provided with inwardly projecting bosses, said inwardly projecting bosses engaging said second external annular flange for supporting the lower end of said coil spring from said flange; and said external annular flanges and said collet ring being so spaced to maintain said annular face around said check valve seat and said annular face within said housing in a spaced apart relationship when said collet bosses are engaged with the upper surface of said second external annular flange.

15. A tool for controlling fluid flow including: housing means having a longitudinal flow passage extending therethrough; safety valve means positioned within said flow passage and biased toward open position; said safety valve means being adapted to close in response to a fluid pressure differential across said valve means in excess of a predetermined value; and means operatively associated with said safety valve means and said housing means for retaining said

safety valve means in open position until a force effected by a pressure differential across said safety valve means tending to close said safety valve means exceeds by a predetermined value the force biasing said safety valve means toward open position; check valve means positioned in said flow passage adjacent to said safety valve means, said check valve means including a valve member and seat member movable longitudinally in said flow passage and adapted to close in response to fluid flow opposite in direction to said flow tending to close said safety valve means; and means biasing said seat member of said check valve means longitudinally of said flow passage to move said check valve means toward open position to permit fluid flow past said means below a minimum flow rate.

16. A tool for controlling fluid flow including: a housing having a longitudinal flow passage having a longitudinal axis; a check valve seat movably secured within said flow passage through said housing, said check valve seat having a longitudinal flow passage extending therethrough to communicate with said flow passage through said housing, the upper end of said check valve seat being provided with an annular face adapted to cooperate with a ball valve for controlling fluid flow through said passage in said valve seat; arm means engaged on said check valve seat and extending outwardly therefrom; a ball check valve rotatably secured to said arm means to rotate about an axis extending transverse to the flow passage through said valve seat, said ball check valve having a flow passage therethrough adapted to cooperate with said flow passage through said valve seat; means engaged between said housing and said ball check valve for rotating said ball check valve in response to longitudinal movement of said check valve seat relative to said housing whereby said ball check valve is rotated about its axis between open and closed positions; means providing a bypass flow passage around said check valve seat within said housing; and means engaged between said housing and said check valve seat biasing said check valve seat in a direction to permit fluid flow through said bypass flow passage when the fluid flow rate through said tool tending to close said check valve is below a predetermined value.

17. A check valve for use in a well conduit including: a housing having a longitudinal flow passage therethrough; a valve seat movably positioned within said flow passage through said housing, said valve seat having a flow passage extending longitudinally thereof to provide communication with said flow passage through said housing, the upper end of said valve seat being provided with a spherical annular face adapted to cooperate with a ball shaped valve for controlling fluid flow through said flow passage through said seat; arm means engaged around said valve seat and extending outwardly therefrom; a ball check valve rotatably secured to said arm means along an axis extending transverse to the axis of said flow passage through said valve seat; said ball check valve having slots on opposite sides thereof, the center line of each of said slots being coincident with a line intersecting the axis of rotation of said ball check valve; pin means extending through said housing and engaging said slots in said ball check valve whereby longitudinal movement of said check valve seat causes said pin means to rotate about said ball check valve between open and closed positions; said valve seat being provided with an external annular face adapted to cooperate with an internal annular face formed within said housing for controlling fluid flow within said housing around said valve seat; said valve seat and said housing being sized to provide space therebetween to form a bypass around said valve seat; and a coil spring disposed in said flow passage around said valve seat, said coil spring being engageable with said housing at one end thereof and with said valve seat at the other end thereof to bias said valve seat toward said ball check valve to maintain said annular face around said valve seat and said annular seat within said housing in a spaced apart relationship until the fluid flow rate past said ball check valve around said valve seat through said bypass exceeds a predetermined value.

18. A tool for controlling fluid flow including: housing means having a longitudinal flow passage extending therethrough; safety valve means positioned within said flow passage and biased toward open position; said safety valve means being adapted to close in response to a fluid pressure differential across said safety valve means in excess of a predetermined value; means operatively associated with said safety valve means and said housing means for retaining said safety valve means in open position until a force effected by a pressure differential across said safety valve means tending to close said safety valve means exceeds by a predetermined value the force biasing said safety valve means toward open position; and check valve means including a valve closure member and valve seat means comprising a tubular seat member engageable with said closure member and movable longitudinally between open and closed positions in said flow passage in said housing spaced from said safety valve means and responsive to fluid flow in a reverse direction through said housing to close off flow therethrough, and means biasing said tubular seat member of said check valve means toward open position to permit fluid flow around said check valve means below a minimum flow rate.

19. A tool for controlling fluid flow including: housing means having a longitudinal flow passage extending therethrough; ball-type safety valve means positioned in said flow passage, said safety valve means including means for effecting a pressure differential across said safety valve means to move said safety valve means to closed position in response to fluid flow through said flow passage in excess of a predetermined rate; means operatively connected between said safety valve means and said housing means biasing said safety valve means toward open position; means engaged within said flow passage through said housing means and engageable with said safety valve means for detaining said safety valve means in open position until the pressure differential across said safety valve means in response to the flow through said safety valve means effects a force in excess of the force biasing said safety valve means toward open position by a predetermined value; and check valve means including a valve closure member and a seat means coacting therewith and movable longitudinally in said flow passage in said housing normally open to permit flow in one direction through said housing and movable responsive to reverse flow at a rate above a predetermined rate to shut off flow in said reverse direction through said housing.

20. A well tool for controlling fluid flow through a conductor including: a housing having a longitudinal flow passage therethrough; first valve means positioned in said flow passage and movable between open and closed positions therein and biased toward open position and movable by pressure of fluids flowing through said housing to closed position when the pressure of said fluids exceeds a predetermined value; second valve means including a valve closure member and a seat member movable longitudinally in said flow passage in said housing spaced from said first valve means; said seat member normally biased open and movable in response to pressure of fluid flowing through said housing and coacting with said closure member for controlling flow in a reverse direction through said housing; said second valve means being movable to closed position by flow of fluids through said housing in said reverse direction at a rate in excess of a predetermined value.