PATENT SPECIFICATION

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(54) SAFETY VALVES AND TRIGGERS THEREFOR

(71) We, BAKER CAC, INC., a corporation organised and existing under the laws of the State of Louisiana, United States of America, of 2102 Belle Chasse Highway South, Belle Chasse, Louisiana, 70037, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us and the method by which it is to be performed, to be particularly described in and by the following statement:—

During the drilling, completion and production of off-shore oil and gas wells, it has become prudent practice to utilise fluid operated safety mechanisms which isolate the wells in the event of a blow-out or other catastrophe.

Many of the known safety mechanism are hydraulically activatable, the hydraulic fluid being hydrocarbon-based and thus inflammable. The safety mechanisms are normally maintained in an open position by pressure within a hydraulic control line extending from the mechanism and/or an actuator therefor located adjacent the well, to a hydraulic control panel or console on a rig platform or other structure. In the event of a blowout, pressure within the control line is bled off and the mechanism is manipulated to a closed position. The distance from the control panel to the safety mechanism or its actuator can often be several hundred feet. Since the hydraulic fluid is highly inflammable, the fluid within the control line can be of considerable volume and could act as additional fuel for a fire. It would thus be desirable to provide a means for reducing this additional source of fuel for a fire resulting from a blowout or other catastrophe around a well or platform or the like.

According to the present invention, in a safety valve for controlled isolation of two or more fluid transmission lines normally kept in open communication with one another, the safety valve comprises trigger means which actuates in response to predetermined thermal conditions to operate valve means closing at least one of the lines, the activation of the trigger means itself actuating a timing assembly which eventually operates further valve means to close the or each of the other lines.

Preferably, however, there are only two lines of which, in use, one can be regarded as an input leading from a control panel, and the other as an output leading to a safety mechanism or an actuator therefor. Activation of the trigger means therefore isolates the input line from the valve to the control panel, from the output line downstream of the valve to the actuator or safety mechanism. In fact, activation of the trigger means preferably puts said output line into communication with a drain whereby hydraulic fluid contained therein may be transmitted away from a potential source of fire i.e. the well area. The timing assembly in the safety valve defined above is preferably pre-settable to isolate said output line from the drain after dumping of the hydraulic fluid has been completed.

A safety valve trigger assembly forming part of the present disclosure is the subject of our co-pending patent application Serial No 1 562 830 21282/77.

A safety valve according to the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:—

Figure 1 is a schematic drawing generally showing an off-shore platform with a safety valve, control line and safety mechanism actuator;

Figure 1*a* is a schematic drawing showing the actuator, safety valve and control line of Figure 1 as well as a control panel;

Figure 2 is a longitudinal section through the safety valve according to the present invention showing the trigger means in place during normal operation and prior to activation by heat source;

Figure 3 is a cross-section taken along the line 3-3 of Figure 2;

Figure 4 is a partial longitudinal section showing the safety valve of the present invention in operating mode, that is immediately after activation of the trigger means;

Figure 5 is a cross-section taken along the line 5-5 of Figure 4 showing the locking mechanism of the further valve means;

Figure 6 is a partial longitudinal section showing the poppet head of the further valve means dropped to its seat for isolation of the fluid transmission line extending downstream to the actuator; and,

Figure 7 is a cross-section taken along the line 7-7 of Figure 6 showing the locking mechanism of the further valve means after release of the poppet mechanism.

A preferred safety valve includes a thermally activated trigger means which initiates control of fluid normally passing through the valve from an inlet to an outlet passage, and thence to safety mechanisms and/or actuators immediate the well and below the safety valve. The trigger assembly also activates the operation of a timing assembly which, after completion of sequence, activates a further valve mechanism to close off the passage within the safety valve normally transmitting fluid to the safety mechanisms and the like.

The safety valve V basically includes an upper timing chamber housing 1 to which at its lower end is threadedly or otherwise appropriately secured at 1*a* an outwardly and lowerly extending central housing 2. In addition to engaging the timing chamber housing 1, the central housing 2 receives a thermally activated trigger assembly 100 at its lower end. Additionally, the central housing 2 contains an inlet valve assembly 3 which is communicably associated with an inlet flowline 4 extending from the central housing 2 to an hydraulic control panel C-P on the well platform or the like. The central housing 2 also receives at its uppermost end and interiorally of the timing chamber housing 1, a timing valve assembly 5 for control of fluid through and within the timing chamber housing 1. The central housing 2 also provides a control fluid outlet assembly 6 normally in communication with the inlet valve assembly 3 and selectively communicable with the interior of the timing chamber housing 1.

Referring now to Figs. 2 to 6, the thermally activated trigger assembly 100 has an exteriorly and circumferentially extending housing 101 having at its upper end 102 an opening 103 therethrough for insertion of a longitudinally extending blocking pin 104. The blocking pin 104 is initially inserted through the housing 101 by means of a companion opening 105 in lower end 106 of the housing 101. The pin 104 is locked into set position against further upward travel through the housing 101 by means of an outwardly protruding, circumferentially extending snap ring 107 housed within its companion grooveway 108 on the exterior of the pin 104, the snap ring 107 abutting the lower end 106 of the housing 101. The pin 104 is held stable against lower longitudinal movement by means of utilization of a plurality of locking balls 109 normally set against exterior 110 of the pin 104, and within a companion grooveway 113 partly formed along the exterior 110 of the pin 104 by means of the exterior 110 and a lowerly facing, outwardly extending shoulder 111 along a ring element 112 of the pin 104 thereabove. Thus, the snap ring 107 and its operatively associated parts, together with the locking balls 109 and their operatively associated parts, prevent longitudinal movement of the pin 104 within the housing 101.

An upper ball retainer portion 114*a* has a plurality of exteriorally extending ball passageways 109*a* therethrough for selective latitudinal movement of the respective locking balls 109. However, the locking balls 109 are prevented from moving through the companion ball passageways during normal operation of the valve V by means of a locking collar 116 longitudinally slidable along the interior smooth surface 117 of the housing 101, and having an outwardly protruding portion 118 for coverage of the ball passages 109*a* and contact with the exterior surface of the locking balls 109, to prevent movement of the locking balls 109 away from the exterior surface 110 of the pin 104. The locking collar 116 is held in locked position against longitudinal movement by means of a eutectic alloy 119 housed within an alloy chamber 120 immediately below the lower end 121 of the locking collar 116, the alloy chamber 120 having a plurality of ports 122 extending through the housing 101. The locking collar 116 is prevented from moving longitudinally upwardly within the housing 101 by means of the force exerted on the upper end 123 of the locking collar 116 as the result of the compressive force expressed through a spring element 124 circumferentially extending around the pin 104. The lower end 125 of the spring 124 abuts its companion spring seat 126, which, in turn, directly contacts the upper end 123 of the locking collar 116. The upper end 127 of the spring 124 abuts a companion support washer 127*a* and is held in position within the housing 101 by means of a circumferentially extending snap ring 128 extending partly within and partly away from its companion grooveway 128*a* formed within the housing 101. The pin 104 also has an exteriorally encircling O-ring 129 housed within its companion grooveway 129*a*, to prevent fluid communication between the interior of housing 101 and the portions of the valve assembly V thereabove, as hereinafter described. The trigger assembly 100 is threadedly or otherwise appropriately secured within the lower end 7 of the central housing 2, through an opening therein.

The upper end 102 of the housing 101 will abut, upon engagement of the trigger assembly 100 within the housing 2, a valve control seat 9 housed within a central chamber 10 within the control housing 2. The valve control seat 9 provides an opening 11 through its center for receipt of the upper portion of the pin 104 of the trigger assembly 100, the O-ring 129 abutting the interior wall 12 which defines the opening 11 of the valve control seat 9. A plurality of O-rings 13 within companion grooveways 13*a* are provided on the valve control seat 9 to prevent fluid communication between the valve control seat 9 and the central housing 2. The valve control seat 9 also has defined therein portal means 14, the port 14 normally receiving the end 16 of an extending pin 17 protruding from the head 18 of the inlet valve assembly 3. A bore at the immediate opposite side of the port 14 on the valve control seat 9 is functionally inoperable during activation of the valve V and is created only as a function of the manufacture of the valve V.

To one side of the valve control seat 9 and within the central housing 2 is the inlet valve assembly 3 for control of fluid entering the valve V from the control panel C-P at the platform or other surface. The inlet valve assembly 3 is communicable with the control panel C-P by means of the control line 4 extending from the control panel C-P and engageable with the central housing 2, a socket 19 therein receiving threaded end 19*a* of the control line 4, and the socket 19 terminating interiorally by means of a stop element 20 having a port 20*a* therethrough for fluid transmission. Formed interiorly of the stop element 20 is the inlet valve assembly 3, basically comprised of inlet poppet valve member 21 slidable in outer chamber 22, and having an inlet chamber 23 for transmission of fluid within the valve 21 and for housing of a control spring element 24, one end of the spring 24 abutting an inward shoulder 25 of the valve 21 and the other end of the spring 24 abutting an outward spring support 26, the spring support abutting the stop element 20 and protruding outwardly from the stop element 20. The head 18 of the inlet valve assembly 3 has a plurality of fluid passages 28 extending therethrough in communication with the interior chamber 23 of the valve 21, the fluid passages 28 providing communication of fluid between the interior 23 of the valve 21 and the exterior thereof. The head 18 also receives at its tip the valve control pin 17, the end 16 of which normally abuts against the exterior of the pin 104 of the thermally activated trigger assembly 100. The pin 17 passes through the control housing 2 by means of and within a chamber 30, the chamber 30 also serving to transmit fluid therethrough from the fluid passages 28 in the head 18 of the inlet valve assembly 3. The chamber 30 communicates with the port 14 in the valve control seat 9 and is in fluid communication with central fluid chamber 31.

The central housing 2 receives through an upwardly facing receiving groove 32 the timing valve assembly 5. The receiving groove 32 communicates with a longitudinally extending bore wall within the central housing 2 for receipt of a longitudinally extending poppet member 34 having at its lower end a mushroom shaped head element 35. The poppet member 34 has at its lower end within its head 35 an orifice opening 39 communicating with fluid passageway 36 thereabove and also with the central chamber 31 of the central housing 2 therebelow. The orifice opening 39 in the head element 35 normally is in communication with a companion duct 40 engrooved within the uppermost end of the pin 104.

The poppet member 34 is engageably secured through a support block 41 set within the receiving groove 32 and having a central bore with a wall 42 for receipt of the poppet member 34. The upper surface 43 of the support block 41 holds a selectively latitudinally movable locking plate, or blade disc, 44 which normally serves to engage the poppet member 34 to prevent its downward longitudinal movement. The blade disc 44 is designed with its outer edge 45 extending circularly away from the support block 41 therebelow, and an inner edge 46 defining an aperture which is eccentrically secured around the poppet member 34 by means of a spring element 47 holding the assembly in locked position by means of engaging disc shoulder 48 within its companion grooveway 49 defined along the outer surface of the poppet member 34. The spring element 47 is energizingly secured to the disc 44 by means of a pin element 50 secured within the support block 41, the eccentrically designed locking blade disc 44 being permitted to shift latitudinally, as hereinafter described, when the outwardly protruding edge 45 is shifted towards the poppet member 34, the disc 44 being movable within and across space 51 adjacent the member 34. A suitable O-ring 52 housed within its companion grooveway 53 in the central housing 2 prevents fluid communication between the central housing 2 and the exterior of the poppet member 34.

The timing valve assembly 5 as described above, functions to control ingres and egress of fluid within a timing chamber 38 which is defined by the timing chamber housing 1, the upwardly facing surface of the central housing 2, and head 55 of timing piston 54 within the timing chamber housing 1. The timing piston 54 normally is urged toward the timing valve assembly 5 by means of the force exerted by compressed spring element 56, the lower end 57 of which contacts a spring receptacle 58 on the timing piston 54, the other and upper end 59 of the spring 56 contacting the inwardly facing surface 1*c* of the top 1*b* of the timing chamber housing 1. The piston head 55 has a receptacle 60, the inside diameter (i.d.) of which is slightly greater than the outside diameter of the support block 41 of the timing valve assembly 5, and of a cover plate 61 located above the locking blade disc 44. However, although the i.d. of the receptacle 60 will permit a snug encapsulation over the cover plate 61 and the support block 41 of the timing valve assembly 5, the i.d. is not large enough to pass over the protruding exterior surface 45 of the locking blade disc 44. Consequently, a shoulder 62 on the piston head 55 engages the exterior surface 45 and shifts it latitudinally by overcoming the force exerted on the disc 44 by means of the spring element 47. When the locking blade disc 44 is latitudinally and interiorally shifted, the poppet member 34 will be disengaged and will drop onto the valve control seat 9, the pin 104 having previously been ejected from the trigger assembly 100. The lock position of the pin 104 and the locking engagement of the blade disc 44 normally prevent longitudinal movement of the poppet member 34.

Along the outer edge of the piston head 55 is a circumferentially extending Teflon (R.T.M.) seal 63 housed within its companion grooveway 64 defined within the piston head 55 to prevent communication of fluid between the timing chamber housing 1 and the timing piston 54. Teflon seals are preferable over elastomeric or rubber-like seals because of thermal stability.

The interior of the timing piston 54 is vented exteriorally of the valve assembly V by means of vent port 65 within the top 1*b* of the timing chamber housing 1, the vent port being covered by a mesh screen 66 to prevent entrapment or clogging of the vent port.

The timing piston 54 also has a threaded adjustment bore 68 for receipt of a companion tool (not shown) to manually cock the timing piston 54 during repair, check, or other maintenance operations.

In communication with the central chamber 31 of the central housing 2 is a latitudinally extending fluid passageway 69 for transmission of fluid to a receiving chamber 70 in association therewith, the receiving chamber 70 engaging one end of a fluid line F-L extending from the valve apparatus V to an actuator downstream of the valve V and operatively associated with the well safety mechanisms.

The trigger assembly 100 is secured to the central housing by threads or other appropriate means, and proper arrangement of the ports is assured by engagement of an adjustment pin 71 protruding outwardly at the top of the valve control seat 9 through its respective receiving groove 72 in the central housing 2.

OPERATION

Prior to hook up with pressure lines extending from the control panel C-P to the valve assembly V, and then from the assembly V through the actuator A to safety mechanisms downstream of the assembly V, the piston head 55 is in a position over the timing valve assembly 5 such that the receptacle 60 contacts the top 37 of the poppet valve 34. The spring 56 within the interior of the piston element 54 is in its expanded position, because pressure has not been exerted within the central fluid chamber 31 to cause contraction of the spring 56 and, hence, movement of the piston head 55 upwardly and away from the end of the poppet valve 34.

The valve mechanism 7 is connected to the flow line 4 extending from the control point C-P by attaching the flow line 4 within the control line socket 19. The fluid line F-L extending from the actuator A and/or safety mechanisms below and downstream of the valve V is engaged within the receiving chamber 70. As pressure is increased at the control panel C-P and through the flow line 4 to the valve assembly 3, fluid will pass through the inlet valve assembly 3 by means of the interior chamber 23, thence through the plurality of fluid passages 28 in the head 18 of the valve assembly 3. Thereafter, fluid communicates and is transmitted through the chamber 30, around the pin 17 in the head 18 of the inlet valve assembly 3, thence through the port 14 within the control seat 9. From this point, fluid enters the central chamber 10 immediate the upper end of pin 104. Fluid then is transmitted out of the central chamber 10 by means of the fluid passageway 69 and through the receiving chamber 70 exteriorally of the fluid passageway 69, thence out of the valve assembly V by means of the fluid line F-L connected thereto.

The flow path as above described is only partially modified by fluid flow which is permitted from the central chamber 10 through the orifice opening 39 at the bottom of the mushroom head 35 of and at the end of the poppet member 34. Fluid does continuously pass within the passageway afforded by the duct 40 at the top of the pin 104 and the orifice opening 39 until the piston 54 is appropriately contracted. Fluid thus passes through the fluid passageway 36 in the poppet member 34 and enters the fluid chamber 38 by means of the open end 37 in the top of the poppet valve member 34. As fluid pressure is increased within the fluid chamber 38, the head 55 of the piston element 54 is caused to retract away from the timing valve assembly 5 until the spring 56 is completely retracted within the interior of the piston 54. Varying pressures necessary to completely cock the piston 54 are capable of being utilized, the variances being only of particular design specifications. As shown in the Figs., the preferred construction is designed to permit pressuring the fluid chamber 38 to approximately 25 p.s.i. to completely cock the spring 56 and place the piston 54 in its completely contracted position. Even though the fluid chamber 38 has been completely pressurized, fluid will, of course, continue to pass through the fluid passageway as above described through the valve mechanism V, from the flow line 4 through the fluid line F-L for pressurization of the actuator A and/or safety mechanisms downstream of the valve mechanism V.

The thermally activated trigger assembly 100 contains the eutectic alloy 119, which may be a bismuth-lead-tin-alloy substance and which is capable of being supplied in varying mixtures to provide a material which will melt and become porable at varying but pre-selectable temperatures. The eutectic alloy being by its nature heat sensitive, it will melt in direct response to heat exposure. The temperature of initial melting can vary, but preferably is in the order of about 245° F, but can be varied considerably. In response to thermal activation, the eutectic alloy 119 will melt and bleed out of its alloy chamber 120 by means of the plurality of ports 122 within the housing 101 of the trigger assembly 100. As the alloy 119 melts and is deposited through the ports 122, the pressure afforded on the locking collar 116 by the expansion of the spring element 124 will cause the locking collar 116 to shift downwardly within the alloy chamber 120 in the space initially occupied by the eutectic alloy 119. As the locking collar 116 travels longitudinally downwardly, the ball passageways 109*a* are opened, thus permitting the locking balls to be moved latitudinally away by the ring 112 of the pin 104. As the locking balls 109 clear the ring 112, the pin 104 will be quickly ejected out of the trigger assembly 100 by means of and through the opening 105 at the lower end of the housing 101 because of the pressure variance afforded above and below the thermally activated trigger assembly 100. The differential pressure afforded between the pressure within the central fluid chamber 31 and the central chamber 10, and that of atmospheric pressure exteriorally of the valve assembly V, will cause the pin 104 to be ejected, as above described.

When the pin 104 is displaced out of the trigger assembly 100, the end 16 of the pin 17 within the head 18 of the inlet valve assembly 3 is no longer restricted in latitudinal movement, and, accordingly, the pressure afforded on the pin 17 and the head 18 of the inlet valve assembly 3 by means of the spring 24 in the chamber 23 will cause the poppet valve 21 to shift to closed position such that fluid cannot communicate with port 14 from the flow line 4. The pin 17 travels latitudinally within the central chamber 10 until the spring 24 permits the valve 21 to shift completely to closed position. When the inlet valve assembly 3 is in its closed position as above described, fluid in the control flow line 4 from the control panel C-P is prevented from being transmitted through the valve assembly V.

Additionally, also as the result of ejection of the pin 104 out of the trigger assembly 100, the fluid passage 69 and the receiving chamber 70 now are in direct communication with atmospheric pressure by means of the opening 105. Therefore, pressure within the fluid line F-L will be drained or dumped through the receiving chamber 70, its companion passageway 69, thence through the central chamber 10 downwardly through the opening 11 in the control seat 9, and thence through the interior of the thermally activated trigger assembly 100 and through the opening 105 at the lower end of the housing 101.

All of the physical and hydraulic parameters of fluid contained within fluid line F-L will be known, such that the time necessary to completely dump the pressure within the fluid line F-L will be known and calculable. Hence, given this time, a suitable orifice opening 39 may be constructed such that fluid within the central fluid chamber 38 in the timing chamber housing 1 can also be dumped in a time such that the receiving chamber 70 and its companion fluid passageway 69 are isolated from atmospheric pressure as the pressurized fluid within the fluid line F-L is completely dumped.

As the fluid within the fluid line F-L is dumped, as the result of the ejection of the pin 104, fluid within the central fluid chamber 38 will be exposed to atmospheric pressure as a result of exposure thereto of the orifice opening 39 within the mushroom head 35 of the poppet valve 34. Fluid will pass through the poppet valve 34 by means of the central passageway 36 therein and will slowly pass through the relatively small orifice opening 39 at the lower end thereof, thence within the central chamber 10 through the opening 11 of the control seat 9, and thence through the interior of the trigger assembly 100 and the opening 105 of the housing 101. As pressure is reduced within the central fluid chamber 38, the piston head 55 on the piston element 54 is caused to expand (i.e. move longitudinally downward) as the result of the pressure afforded on the piston 54 by the compressed spring element 56 within the interior of the piston element 54. As the head 55 travels downwardly, the receptacle 60 defined within the head 55 will pass over the cover 61 until the shoulder 62 of the head 55 engages the outer edge 45 of the locking blade disc 44. As the outer edge 45 of the locking blade disc 44 is encountered by the shoulder 62, additional loss of pressure within the central fluid chamber 38 will cause continued expansion of spring 56 until the resistance to lower movement of the head 55 is overcome by contraction of the spring element 47 holding the disc element 44 in place. The locking blade disc 44 then is permitted to shift latitudinally such that the eccentric disc 44 moves within the space 51, and the inner edge 46 of the blade disc 44 is moved out of the central bore 42 of the support block 41.

When the poppet valve 34 thus is unlocked, the poppet valve 34 will travel within the bore of the central housing 2 until the mushroom head 35 of the poppet member 34 comes to rest lowerly on the top of the control seat 9, thus isolating the central fluid chamber 10, the fluid passageway 69 and its companion receiving chamber 70 from atmospheric pressure. Any additional pressure within the fluid line F-L and/or the fluid passageway 69 and receiving chamber 70 then is permitted to pass upwardly of the mushroom head 35 of the poppet valve 34 and within the central chamber 10 to exert pressure on the top of the head 35 to maintain the head 35 in its locked and engaged position on control seat 9.

From the operational sequences described above, it can be seen that the valve assembly V affords unique protection in the event of a distaster which is accompanied by a thermal increase sufficient to cause melting of the eutectic alloy and thus activation of the valve assembly V. The valve assembly V as above described thus can be considered an important safety valve, because its thermal sensitivity will shut off fluid within the flow line 4 from the control panel C-P to the safety mechanisms downstream, thereby significantly reducing additional fuel to a fire or related hazard which would otherwise be dumped into the area of fire exposure. Additionally, the valve also permits dumping of fluid under pressure within the line downstream of the valve assembly V when the eutectic alloy melts in response to thermal increase or the like. This dumping sequence of pressure within the fluid line downstream of the valve V also prevents additional fuel being exposed to the thermal increase source. The fluid lines upstream and downstream of the valve assembly are completely isolated from one another and from atmospheric pressure as the result of the time delay sequence afforded by the operation of the timing valve assembly 5 as described above.

The trigger assembly 100 as shown in the Figs. can be replaced by a device which is tripped by means of a removable pin in place of the eutectic alloy, as preferably shown. This removable pin can be pulled to initiate the emergency operation sequence as described above. The pin may be pulled by using any number of known devices such as a lanyard or handle (also permitting manual operation for testing), an electric solenoid or motor or related device, a pneumatic actuator, a hydraulic actuator, or an explosive squib. All of the above devices would themselves be triggered by a remote sensing device or plurality of devices which is or are activated in response to predetermined thermal conditions, i.e. in response to any measurable state which will change in a known manner with a predetermined change in temperature.

Additionally, the timing chamber as shown may be replaced by any of several known timing devices. By eliminating the fluid passage through the outlet poppet stem, no fluid would flow into the timing chamber. Accordingly, the chamber could be removed and any of several self-contained timing devices installed in place of the apparatus as shown in the Figs. For example, the timing chamber could be replaced by a suitable actuator which could be remotely activated by the above-mentioned sensing device or plurality of devices forming part of the trigger means.

If desired, reversal of the valve entry and exit ports through flow lines upstream and downstream of the valve assembly can be achieved in a hydraulic system with the outlet port connected to the source of the pressurant while the inlet port is connected to the downstream system. In such event, upon tripping the trigger assembly, the downstream system would immediately be isolated while the pressurant supply would continue to flow through the vent port until the timing device was completely activated.

Although the valve as above described and shown in the Figs. is designed for use with hydraulic fluid as the pressurant, with proper sizing of the timing chamber orifice, spring and/or volume, the valve assembly can be easily adapted for successful utilization with pneumatic systems.

The safety valve as above described can control more than one downstream actuator and/or valve mechanism either directly or by means of external pilot-operated control valves. Sequential operation of such a downstream system can be achieved by proper sizing of the actuator or pilots. Mixed media operation (i.e., one downstream system hydraulically pressurized and another downstream system pneumatically pressurized) can be achieved by either direct or pilot control of one system and control of the pilot section of a pilot operated control valve in the other system.

WHAT WE CLAIM IS:

1. A safety valve for controlled isolation of two or more fluid transmission lines normally kept in open communication with one another, the safety valve comprising trigger means which actuates in response to predetermined thermal conditions to operate valve means closing at least one of the lines, the activation of the trigger means itself actuating a timing assembly which eventually operates further valve means to close the or each of the other lines.

2. A safety valve according to claim 1, in which there are only two lines, one of which can be regarded as an input and the other as an output.

3. A safety valve according to claim 2, in which activation of the trigger means puts that line which is eventually to be closed by said further valve means into communication with a drain.

4. A safety valve according to any preceding claim, in which the trigger means includes a blocking element which is not permitted to eject from a housing, within which it is held by a locking means, until release means responsive to thermal energy has been actuated.

5. A safety valve according to claim 4, in which said valve means includes, in each line to be closed thereby, a plunger which is continuously urged towards a valve seat, but is normally held away therefrom by the blocking element.

6. A safety valve according to claim 4 or claim 5, in which the locking means includes at least one ball which is normally held in locking engagement with the blocking element by a surrounding collar, activation of the release means allowing the collar to slide to a position in which it no longer restrains the ball or balls, which can then be moved aside during ejection of the blocking element.

7. A safety valve according to claim 6, in which the blocking element includes a rod formed with a shoulder against which a plurality of the balls are normally held, each of the balls being located by a respective aperture in a sleeve located concentrically between the rod and the collar.

8. A safety valve according to any one of claims 4 to 7, in which the release means is constituted by a eutectic material which melts when subjected to predetermined thermal conditions.

9. A safety valve according to claim 8, in which the eutectic material is an alloy of bismuth, lead and tin.

10. A safety valve according to any preceding claim, in which said further valve means includes a single poppet valve which is releasably secured in an inoperative position until operated upon by the timing assembly.

11. A safety valve according to any preceding claim, in which the timing assembly includes a piston which is slidably mounted in a chamber, the piston being continuously urged towards one end of the chamber by biasing means.

12. A safety valve according to claim 10 and claim 11, in which the poppet valve is formed with a bore therethrough, whereby any fluid in the lines can pass into the chamber and hold the piston against the force exerted by the biasing means.

13. A safety valve according to claim 12, in which fluid in the chamber escapes through the bore after activation of the trigger means, the piston thus being moved towards and eventually reaching said end wall of the chamber, whereupon the piston acts to release the poppet valve from its inoperative position.

14. A safety valve according to claim 13, in which the poppet valve is formed with a stem which is normally retained within an eccentric aperture formed in a slidable plate, the aperture releasing the stem when the plate is slid by contact with the piston.

15. A safety valve according to claim 1, and substantially as hereinbefore described with reference to the accompanying drawings.

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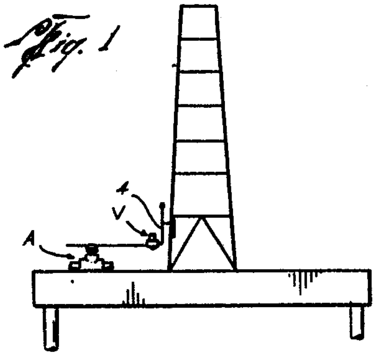


Fig. 1

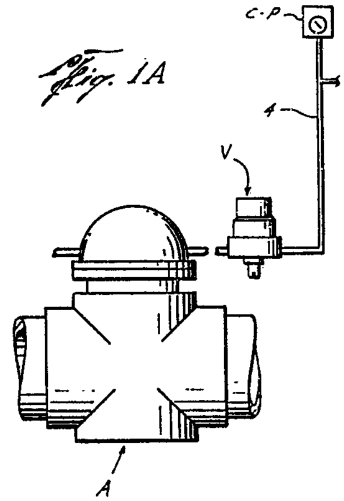


Fig. 1A

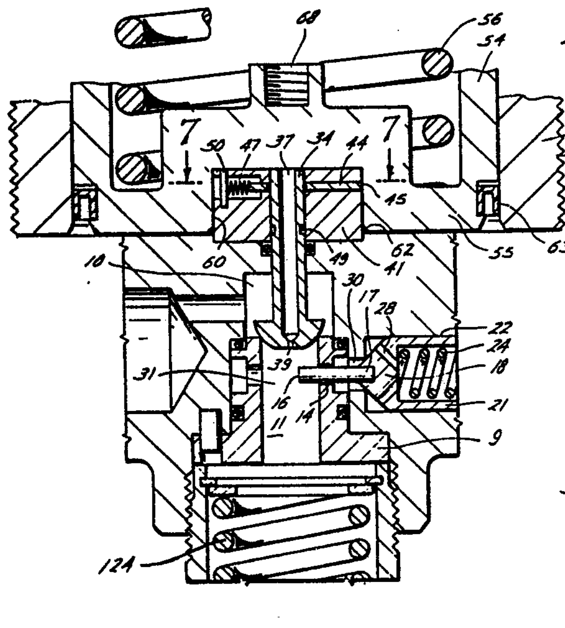


Fig. 6

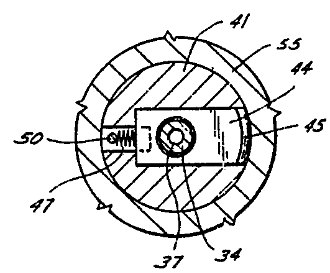
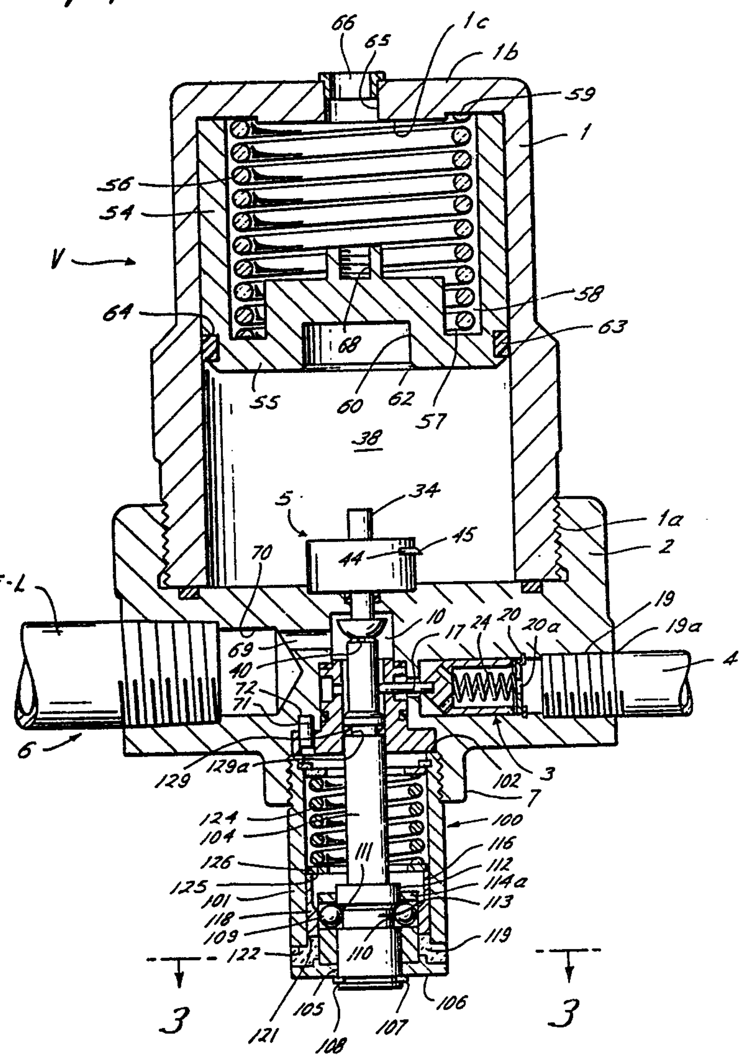


Fig. 7

Fig. 2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1562829 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

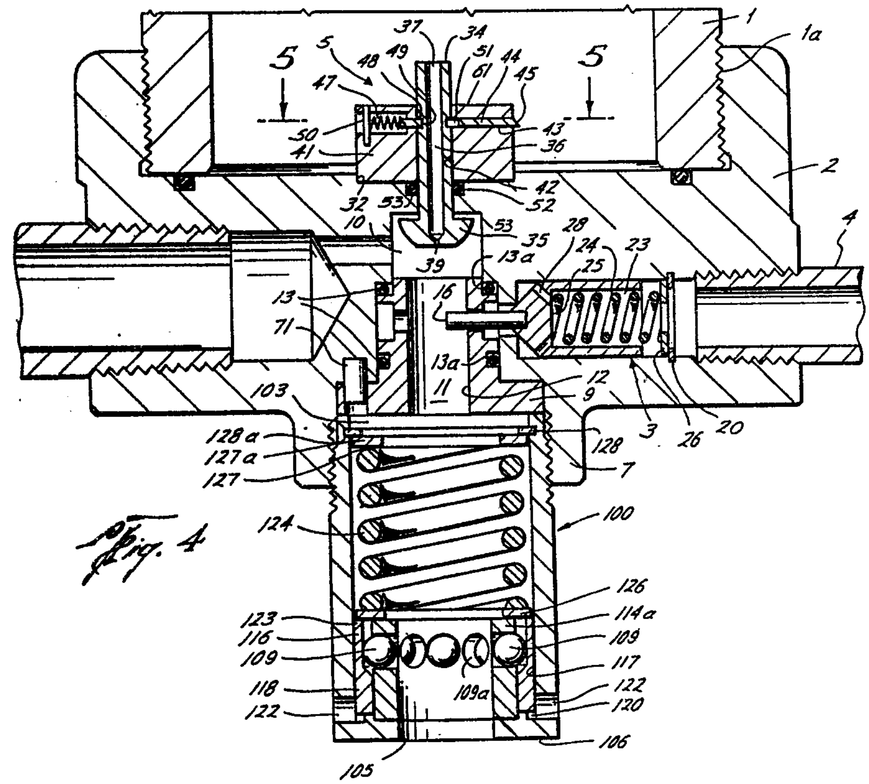

Fig. 4

Fig. 3

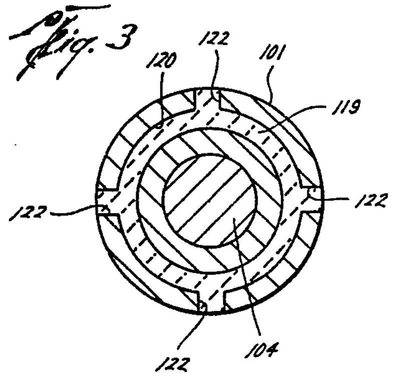

Fig. 5