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SNAP ACTION CONTROL MEANS

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3 Sheets-Sheet 1

Fig. 1.

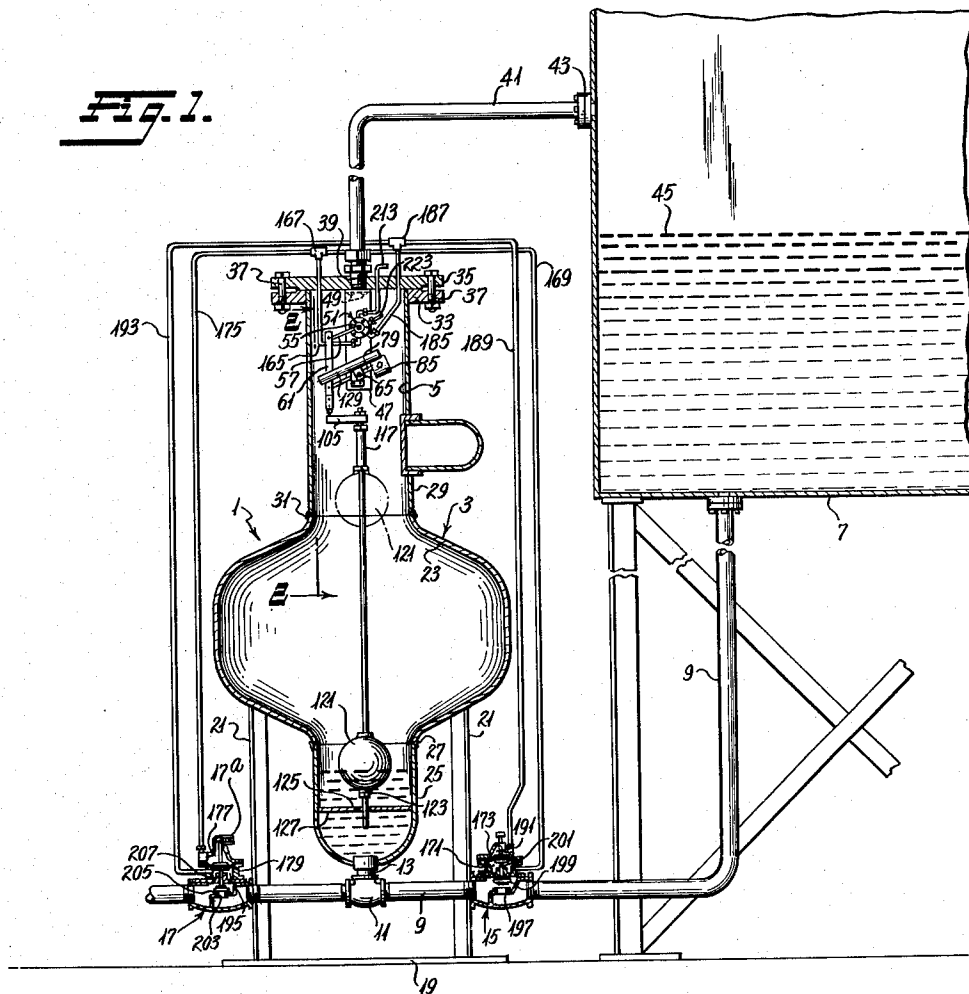
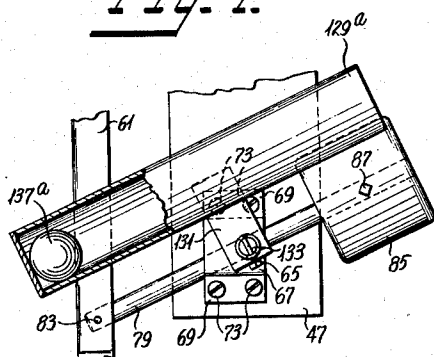


Fig. 2.



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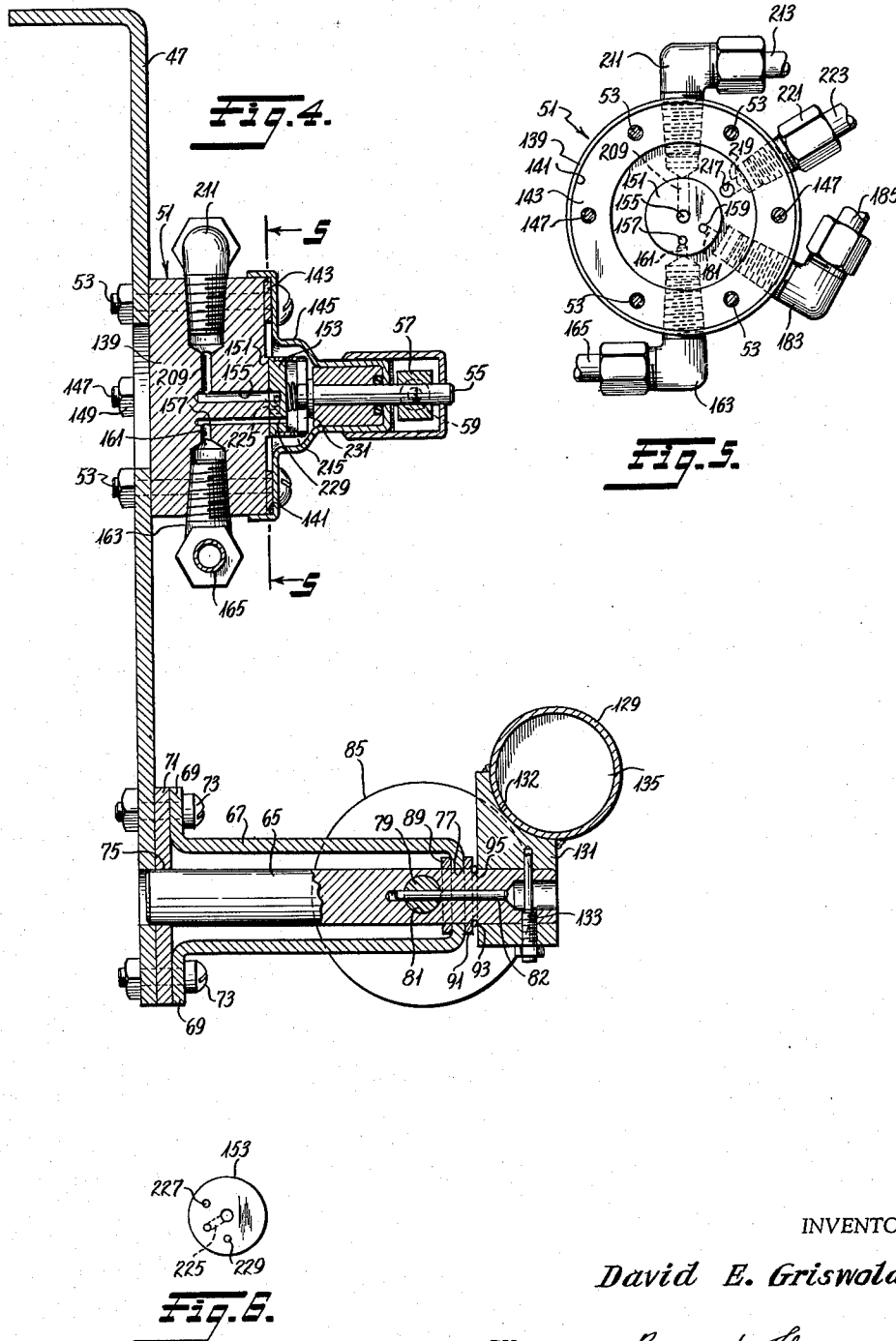
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SNAP ACTION CONTROL MEANS

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9 Claims. (Cl. 74-100)

The present invention relates to a snap action device and more particularly to a snap action device that is very sensitive and adapted for use generally with control apparatus requiring a rapid, rotary, snap action.

By way of illustration of one operative example of the use of the present snap action device, the same is described hereinafter in connection with the control of a float-operated rotary pilot valve associated with a liquid metering apparatus. It is to be understood, however, that the present snap action device is not limited to float actuation nor to use with a rotary pilot valve, but can be used with any control mechanism having a rotary member that must be turned with a snap action to move it through a predetermined angle.

The principal object of the invention is to provide a snap action device adapted for general use with apparatus including a rotary control element.

Another object is to provide a rotary snap action device that is very sensitive and rocks or tilts suddenly upon being turned clockwise or counterclockwise from a non-horizontal position past a true horizontal position.

Another object is to provide a snap action device which will prevent the control means with which it is associated from becoming locked or rendered ineffective in a "dead spot" position.

Still another object is to provide a rotary snap action device whose torque force can be predetermined to suit given control requirements and angles of rotary movement.

Other objects and features of the invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a sectional view of a liquid metering apparatus embodying the present snap action device for controlling the operation of a rotary pilot valve;

Fig. 2 is a left side elevational view of the snap action control device as viewed on the line 2-2 of Fig. 1;

Fig. 3 is a front elevational view of the same;

Fig. 4 is an enlarged vertical sectional view through the pilot valve and its support taken on the line 4-4 of Fig. 3;

Fig. 5 is a sectional view taken on the line 5-5 of Fig. 4 illustrating the porting in the fluid distribution base of the pilot valve;

Fig. 6 is a view of the face of the pilot disc showing the arrangement of the ports therein; and

Fig. 7 illustrates a modified form of snap action device.

Referring now to Fig. 1 of the drawings, the numeral 1 generally identifies a liquid metering apparatus including a housing 3 containing a chamber 5 to be successively filled and emptied. The housing 3 is connected with a liquid supply tank 7 by a pipe 9 containing a pipe T-fitting 11 connected with the lower end of the housing 3 by a pipe nipple 13. A fluid pressure operated valve 15 is connected in the pipe 9 between the pipe-T 11 and the tank 7 and serves as an inlet control valve for controlling the flow of liquid from the tank 7 into the chamber 5.

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A similar fluid pressure operated valve 17 is connected in the pipe 9 at a point beyond the pipe-T 11 and serves as an outlet control valve for controlling the discharge of liquid from the chamber 5.

The housing 3 is mounted upon a base 19 by legs 21 which may be conveniently welded to both said base and housing. The housing 3 comprises an intermediate bulbous section 23, a lower cuplike section 25 welded thereto, as indicated at 27, and an upper cylindrical section 29 welded at its lower end to said bulbous section, as indicated at 31. A ring 33 is welded to the upper end of the cylindrical section 29 and a cover 35 is secured to the ring by bolts 37. The cover 35 has a central threaded opening 39 to which one end of a vent pipe 41 is connected, the opposite end of said pipe being connected with the upper end of the tank 7, as indicated at 43. The tank 7 contains a liquid, such as fuel oil, whose level is indicated at 45. The space in the tank 7 above the liquid serves as a reservoir for gases vented from the housing 3 through the vent pipe 41 as the metering chamber 5 is filled to a desired predetermined height with the liquid.

The control means for the valves 15 and 17 is contained within the housing 3 and includes an angle bracket 47, which is secured to the underside of the cover 35 by screws 49. A pilot valve 51 is mounted upon the bracket 47 by bolts 53. The valve 51 contains a pilot shaft 55 and one end of an arm 57 is secured by a pin 59 to the outer end of said shaft. The opposite end of the arm 57 is connected to a link 61 by a pin 63. A shaft 65 is mounted upon the bracket 47, below the pilot valve 51 and in parallel relation to the pilot shaft 55, by a generally U-shaped horizontal bracket 67 having out-turned ends 69 overlying a plate 71, with bolts 73 extending through said out-turned ends, plate and bracket 47. One end of the shaft 65 is rotatably received in an opening 75 in the plate 71, and its opposite end is similarly received in an opening 77 in the base portion of the U-shaped bracket 67. A lever 79 extends through an opening 81 in the shaft 65 and is retained therein against longitudinal movement by an axially extending pin 82, Fig. 4. One end of the lever 79 is connected to the link 61 by a pin 83 and thus provides a parallel linkage interconnecting the shafts 55 and 65. A counterweight 85 is adjustably mounted upon the lever 79 by a set screw 87. A washer 89 is mounted on the shaft 65 between the lever 79 and the adjacent surface of the base of the bracket 67, and a second washer 91 is mounted upon said shaft on the opposite side of said base. The shaft 65 is held in place against longitudinal movement relative to the bracket 67 by a split-ring 93 engaging the washer 91 and mounted in a groove 95 in the shaft 65.

An internally threaded member 97, Figs. 1 to 3, is secured to the lower end of the link 61 by rivets 99. A pipe nipple 101 is threaded into the lower end of the member 97 and is locked against movement by a pin 103. A float arm 105 is threaded onto the other end of the pipe nipple 101 and is locked against turning relative thereto by a pin 107. The float arm 105 has an opening 111 through which the upper threaded end of a float rod 113 extends. The rod 113 is secured to the arm 105 by nuts 115 threaded thereon and tightened against opposite sides of the arm 105. A calibration sleeve 117 is threaded upon the rod 113 and maintained in adjusted position by a jam nut 119 threaded on the rod 113. A ball float 121 is slidably mounted upon the rod 113 and is adapted to be raised into abutting engagement with jam nut 119 on the lower end of the calibrating sleeve 117. A collar 123 is adjustably mounted upon the rod 113 below the float 121 and is engaged by said float as the liquid level in the chamber 5 drops during draining of said chamber. The lower end of the rod 113 extends through an opening 125

(Fig. 1) in a guide member 127 mounted in the housing section 25.

The float 121 is shown in full lines in Fig. 1 in its lowermost position, and is shown in dotted lines in the position along the rod 113 when it first engages the calibrating sleeve 117. This sleeve is adjusted so that the mechanism will be eventually tripped at the precise moment that a predetermined volume of liquid has been introduced into the chamber 5. It is to be understood that, as the liquid level in the chamber 5 continues to rise, the float 121 will correspondingly rise above its dotted line position and thus actuate the linkage associated with the arm 57 and lever 79 to rotate the pilot valve shaft 55 clockwise through the desired angle. In the present construction the angular movement of the pilot shaft 55 is 60°. The counterweight 85 is adjusted so that it approximately balances the weight of the link 61, float arm 105, etc., suspended from the arm 57 and lever 79, so that the buoyant effect on the float 121 can readily turn the linkage clockwise. A snap action device, described hereinafter, is connected with the linkage to trip it suddenly when the float 121 and liquid level reach a predetermined height in the chamber 5.

The shaft 65 extends beyond the base of the bracket 67 for a substantial distance, as shown in Figs. 2 and 4. A tube 129 has one end of a generally upright arm 131 brazed thereto medially of its length and the opposite end of said arm is secured to the extended portion of the shaft 65 by a set screw 133. The upper end of the arm 131 has an arcuate recess 132 corresponding to the outside diameter of the tube 129, as is best shown in Fig. 4. The opposite ends of the tube 129 are closed by circular discs 135 welded in place. The tube 129 contains a freely movable mass, in this case a predetermined weight of a heavy liquid 137, such as mercury. The manner in which the mercury-containing tube 129 functions to impart a rotary snap action to the pilot valve shaft 55 will be described in detail later.

Referring now to Figs. 4 and 5, the pilot valve 51 comprises a cylindrical fluid distributing base 139, one end of which seats against the bracket 47. The opposite end of the base 139 is provided with an annular groove or recess 141 to receive a gasket 143. A flanged pilot disc housing 145 overlies the gasket 143. Diametrically disposed bolts 147 extend through aligned openings in the housing 145, gasket 143 and base 139 and have nuts 149 threaded thereon for retaining the housing, gasket and base in assembled relation. The bolts 53, previously referred to, also extend through aligned openings in the housing 145, gasket 143 and base 139 and mount the pilot valve assembly 51 on the bracket 47.

The central portion 151 of the base 139 serves as a seat for a pilot disc 153. The seat is provided with a central exhaust port 155 and with two distributing ports 157 and 159, respectively, disposed on radii 60° apart. Distributing port 157 communicates with a radial passageway 161 having a fitting 163 mounted in the outer end thereof. One end of a tube 165 is connected to the fitting 163 and its opposite end is connected to the stem of a T-fitting 167, Fig. 1. One end of a tube 169 is connected to one side of the T-fitting 167 and its opposite end communicates with a pressure chamber 171 disposed below a diaphragm 173 in the valve 15. One end of a tube 175 is connected to the other side of the T-fitting 167, and the opposite end of said tube communicates with a chamber 177 above a diaphragm 179 in the valve 17.

The port 159, Fig. 5, communicates with a radial passageway 181 having a conventional fitting 183 mounted in its outer end. One end of a tube 185 is connected with the fitting 183 and its opposite end is connected with a conventional T-fitting 187, Fig. 1. One side of the T-fitting 187 is connected to one end of a tube 189 and the opposite end of said tube communicates with a pressure chamber 191 above the diaphragm 173 of the valve 15. The other side of the T-fitting 187 is connected to

one end of a tube 193, whose opposite end communicates with a pressure chamber 195 below the diaphragm 179 of the valve 17.

The valve 15, Fig. 1, has a seat 197 adapted to be engaged by a valve disc 199 connected to the lower end of a valve stem 201, the upper end of which is connected with the diaphragm 173 to be raised and lowered thereby to control flow through said valve, depending upon the pressure conditions in the chambers 171 and 191 at the opposite side of said diaphragm. The valve 17 also has a seat 203, a valve disc 205 and a stem 207 operatively secured to the diaphragm 179 for actuation in accordance with pressure conditions in the chambers 177 and 195 on the opposite sides of said diaphragm.

Referring now to Figs. 4 and 5, the exhaust port 155 communicates with a radial passageway 209 having a conventional fitting 211 mounted in the outer end thereof. One end of a vent or exhaust tube 213 is connected to the fitting 211 and its opposite end communicates with the atmosphere. The pilot housing 145 contains a chamber 215 for operating fluid under pressure supplied to the chamber 215 through a port 217 in the base 139. The port 217 communicates with a radial passageway 219 having a fitting 221 mounted in the outer end thereof. Operating fluid, such as air or gas under pressure, is supplied to the fitting 221 through a tube 223.

The distribution of operating fluid from the pressure chamber 215 is controlled by the pilot disc 153, Fig. 6, which is provided with a U-shaped exhaust port 225 having an axial leg in constant communication with the base part 155, and an outer leg which registers with either the port 157 or 159 of said base. The pilot disc 153 also has two pressure ports, 227 and 229, respectively, extending therethrough which are disposed on radii 60° to either side of the exhaust port 225.

The pilot disc 153 is drivingly interconnected with the pilot shaft 55 by a drive washer 231 non-rotatably secured to the shaft 55.

In one operative position of the pilot disc 153, corresponding to a filled condition of the metering chamber 5 (float 121 fully raised), the pressure port 227 is adapted to register with the base port 159 to supply operating fluid from the chamber 215 thereto at a time when the pilot disc exhaust port 225 is in registration with the base port 157. At such time operating fluid under pressure is supplied through tube 185 to the T-fitting 187 and thence through tube 189 to the chamber 191 of inlet valve 15 to close said valve, and through tube 193 to the chamber 195 of discharge valve 17 to open said valve; and spent operating fluid is exhausted from chamber 171 of inlet valve 15 through tube 169 and from chamber 177 of valve 17 through tube 175. Both of these tubes are in communication with the T-fitting 167 from whence the spent operating fluid flows through tube 165, fitting 163, base passage 161 and port 157, pilot exhaust port 225, base port 155 and radial passage 209, and fitting 211 for discharge through exhaust tube 213. Thus, the supply valve 15 is closed and the discharge valve 17 is simultaneously opened.

In the other operative position of the pilot valve 51, corresponding to a drained condition of the metering chamber 5 (float 121 down), the pressure port 229 registers with the base port 157 to supply operating fluid under pressure thereto from the chamber 215 and the pilot disc exhaust port 225 is in registration with the base port 159. The pressure and exhaust conditions are then reversed, as will be self-apparent, and the inlet valve 15 is caused to open and the discharge valve 17 is caused to close so that the metering chamber 5 is then refilled with a predetermined volume of liquid.

As the liquid flows by gravity from the tank 7 into the metering chamber 5, the float 121 moves upwardly along the rod 113 until it engages the jam nut 119 on calibrating sleeve 117. Any gas in the metering chamber 5 is displaced by the incoming liquid through the

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vent pipe 41 and collected in the upper portion of the supply tank 7.

It will be apparent from the foregoing that the device described can function as a meter for measuring fuel oil or other liquids, the principle of operation being that the valves 15 and 17 are controlled so as to alternately open and close to cause the chamber 5 to be successively filled to a calibrated volume of liquid and then drained. The number of cycles that the unit has completed and the volume of fluid that has flowed through the unit can be readily ascertained from a conventional counter 17^a mounted upon the discharge valve 17 so that it is actuated each time the valve stem 207 is raised to open said valve.

In the normal operation of the metering apparatus, as the float 121 reaches the position shown in dotted lines in Fig. 1, the float arm 105 moves upwardly at a very gradual rate so that the pilot valve operating arm 57 turns clockwise slowly at a corresponding rate. If, however, operating pressure is first applied to the upper chamber 191 of the inlet valve 15, causing said valve to close before the valve 17 is opened, or if a surface or some other liquid disturbance permits the float arm 105 to lower very slightly and the pilot valve operating arm 57 to return slightly in a counterclockwise direction sufficient to misalign the pilot disc ports with the seat ports, the pilot valve 51 would then be in a condition of stalemate and pressure would not be definitely applied to or vented from the control lines through the T-fittings 167 and 187. Accordingly, a neutral condition would then exist wherein both valves 15 and 17 would be closed, so that no change in level within the chamber 5 would occur and the liquid would then be in a trapped, stalled position.

The above difficulty is positively avoided by providing the pilot control mechanism with the snap action device comprising the mercury-containing tube 129, previously described. The presence of the mercury 137 in the tube 129 provides a condition of instability as the tube is rocked by the float mechanism from a non-horizontal position inclined in one direction past a true horizontal position. Once the condition of instability is established, the mercury will flow from one end of the tube to the opposite end and suddenly tilt the mechanism to a non-horizontal position inclined in the opposite direction, thereby causing the pilot valve operating arm 57 to complete its angular movement with a snap action and position the pilot disc 153 to effect positive closing of the inlet valve 15 and positive opening of the discharge valve 17. The same snap action occurs upon draining of the chamber 5, and the float 121 actuates the linkage to rock the tube 129 in a counterclockwise direction. The pilot valve is then positioned to positively open the inlet valve 15.

The condition of instability of the mercury-containing tube 129 is achieved in three ways.

First, since the mercury 137 is free to flow from one end of the tube to the other, the assembly is rendered unstable whenever the tube is moved past a truly horizontal position.

Second, the mercury-containing tube-assembly functions like an inverted pendulum, in that the center of mass of the tube 129 and mercury 137 is a substantial distance above the axis of rotation of the shaft 65. Therefore, as would be true of an inverted pendulum, as the center of mass crosses a vertical line passing through the axis of rotation, the downward gravitational pull tends to rotate the assembly in a direction corresponding to the direction in which the center of mass has shifted. The shifting of the mercury 137, as the tube 129 passes through the horizontal position, occurs abruptly or instantaneously and forces the assembly to rapidly tilt to one side or the other of the neutral position.

Third, as the mercury 137 abruptly flows from one extreme position to the other within the tube 129, an

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impact force results when the mercury flow is stopped by an end wall 135 of the tube. The inertia force thus produced supplements the force of gravity in producing the rapid or snap-action in the control device.

The turning torque that may be developed by the snap action mechanism can be varied, for example, by changing the quantity of mercury sealed within the tube 129. In the present case, the tube 129 is about 6 inches long and about 1½ inches in inside diameter, and contains 4¼ ounces of mercury. The tube 129 is inclined 30° to the horizontal, as shown in full lines in Fig. 3, when at rest in one position, and is shown in dot-and-dash when in its other position of rest. The dimensions of the tube 129 and the weight of mercury contained therein can be varied to suit the torque requirements and angular movement of any given control requiring actuation by rotary snap action.

Fig. 7 illustrates a modification of the invention in which a freely rolling ball 137^a of predetermined necessary mass is disposed in a tube 129^a in lieu of the mercury 137. The present snap action device, equipped with such ball, will provide the same sensitive control of the pilot valve 51, or other rotary control, as the mercury filled tube 129.

It will be understood that various changes may be made in the arrangement and in the details of construction of the snap action control disclosed herein without departing from the principles of the invention or the scope of the annexed claims. For example, the tube 129 could be mounted on either shaft 55 or 65 and the counterweight 85 could be associated with either shaft. Furthermore, the shaft 65 could be arranged above the shaft 55 and both shafts interconnected by the parallel linkage disclosed herein, if desired.

I claim:

1. A snap action device, comprising: a pair of parallel shafts, one of said shafts adapted for connection to an element to be operated; means having fixed axes rotatably supporting said shafts; a parallel linkage interconnecting said shafts for simultaneous equal angular rotation at all times; a tube disposed transversely of said shafts; a freely movable mass confined in said tube; an arm having one end thereof connected with said tube at a point approximately midway of the length of said tube and having its opposite end connected to the other of said shafts; and means, including a lost motion connection, actuating said parallel linkage to effect concurrent rotation of said shafts at all times through an angle sufficient to move said tube from a non-horizontal position inclined in one direction past a true horizontal position, so that said mass will rapidly move from one end of said tube to the opposite end of said tube and suddenly rock said tube, whereby to cause a rotary snap action movement to be imparted to both of said shafts.

2. A snap action device as defined in claim 1, wherein the arm connecting the tube to the other of said shafts is upright and of substantial length and the tube is mounted upon the upper end of said arm so that the tube swings like an inverted pendulum when rocked past a horizontal position.

3. A snap action device as defined in claim 1, wherein an arm having a counterweight is connected with one of the shafts for approximately counterbalancing the weight of the parallel linkage.

4. In combination, a control device having a horizontal rotatable shaft adapted for connection to an element to be operated; a second shaft disposed parallel with said first-mentioned shaft; means supporting said shafts for rotation about fixed axes; a radial arm connected to each of said shafts, said arms having substantially the same length; an upright link; means pivotally connecting said link to said arms to simultaneously rotate said arms equal angular distances at all times with said arms disposed at all times in substantially parallel relation to each other; a tube rigidly connected with the second shaft in sub-

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stantially parallel relation to the arm connected with said one shaft; a freely movable mass confined in said tube; and lost motion means operable to move said link vertically to rock said tube about the axis of said second shaft, whereby when said tube is rocked from a non-horizontal position inclined in one direction past a true horizontal position, said mass will rapidly move from one end of said tube to the opposite end of said tube and suddenly rock said tube into a position inclined in the opposite direction, whereby to cause a rotary snap action movement to be imparted to both of said shafts.

5. The combination defined in claim 4, wherein one of the arms projects radially from its associated shaft on the side thereof opposite to that upon which the link is disposed and has a counterweight mounted thereon to approximately counterbalance the weight of the link and arms.

6. The combination defined in claim 5, in which the lost motion means for moving the link vertically comprises a vertical rod connected with said link having spaced abutments thereon and a float ball slidably mounted upon said rod between said abutments.

7. In combination: a control device including a first rotatable shaft adapted for connection to an element to be operated; a snap action mechanism for actuating said first shaft comprising a tube, a freely movable mass confined in said tube, an arm having one end thereof connected to said tube at a point approximately midway of the length of said tube, a second shaft, means rotatably supporting said second shaft, and means securing the opposite end of said arm to said second shaft with said tube extending in a direction transversely of said second shaft; constant length means interconnecting said first shaft and said second shaft for simultaneous equal angular rotation at all times; and lost motion means for rotating said shafts through an angle sufficient to move said tube from a non-horizontal position inclined in one direction past a true horizontal position, so that said mass will rapidly move from one end of said tube to the opposite end of said tube and suddenly rock said tube into a position inclined in the opposite direction, whereby to cause a rotary snap action movement to be imparted to both of said shafts.

8. In combination: a support; a first shaft adapted for connection to an element to be operated; means mounting said shaft on said support for rotation about a horizontal axis; a second shaft; means mounting said second shaft on said support in parallel relation with said first shaft; a pair of radial arms of equal length, one arm connected to each of said shafts; an upright link; constant length means pivotally connecting said link to said arms to simultaneously rotate said arms for equal angular movements with said arms disposed at all times in substantially parallel relation to each other; a tube non-

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rotatably connected with said second shaft in substantially parallel relation to the arm connected with said second shaft for concurrent movement with said arm at all times; a freely movable mass confined in said tube; and lost motion means operable to move said link vertically to rock said tube about the axis of said second shaft so that when said tube is rocked from a non-horizontal position inclined in one direction past a true horizontal position, said mass will rapidly move from one end of said tube to the opposite end of said tube and suddenly rock said tube into a position inclined in the opposite direction, whereby to cause a rotary snap action movement to be imparted to both shafts.

9. In combination: a support; a first shaft adapted for connection to an element to be operated; means mounting said shaft on said support for rotation about a horizontal axis; a second shaft; means mounting said second shaft on said support below said first shaft and in parallel relation with said first shaft; a pair of radial arms of equal length, one arm connected to each of said shafts; an upright link; pivot pins connecting said link to said arms providing a constant length connection to simultaneously rotate said arms for equal angular movements with said arms disposed at all times in substantially parallel relation to each other; a tube non-rotatably connected with said second shaft in substantially parallel relation to the arm connected with said second shaft for concurrent movement with said arm at all times; a freely movable mass confined in said tube; and lost motion means operable to move said link vertically to rock said tube about the axis of said second shaft so that when said tube is rocked from a non-horizontal position inclined in one direction past a true horizontal position, said mass will rapidly move from one end of said tube to the opposite end of said tube and suddenly rock said tube into a position inclined in the opposite direction, whereby to cause a rotary snap action movement to be imparted to both of said shafts.

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