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VALVE MECHANISM AND CONTROL MEANS

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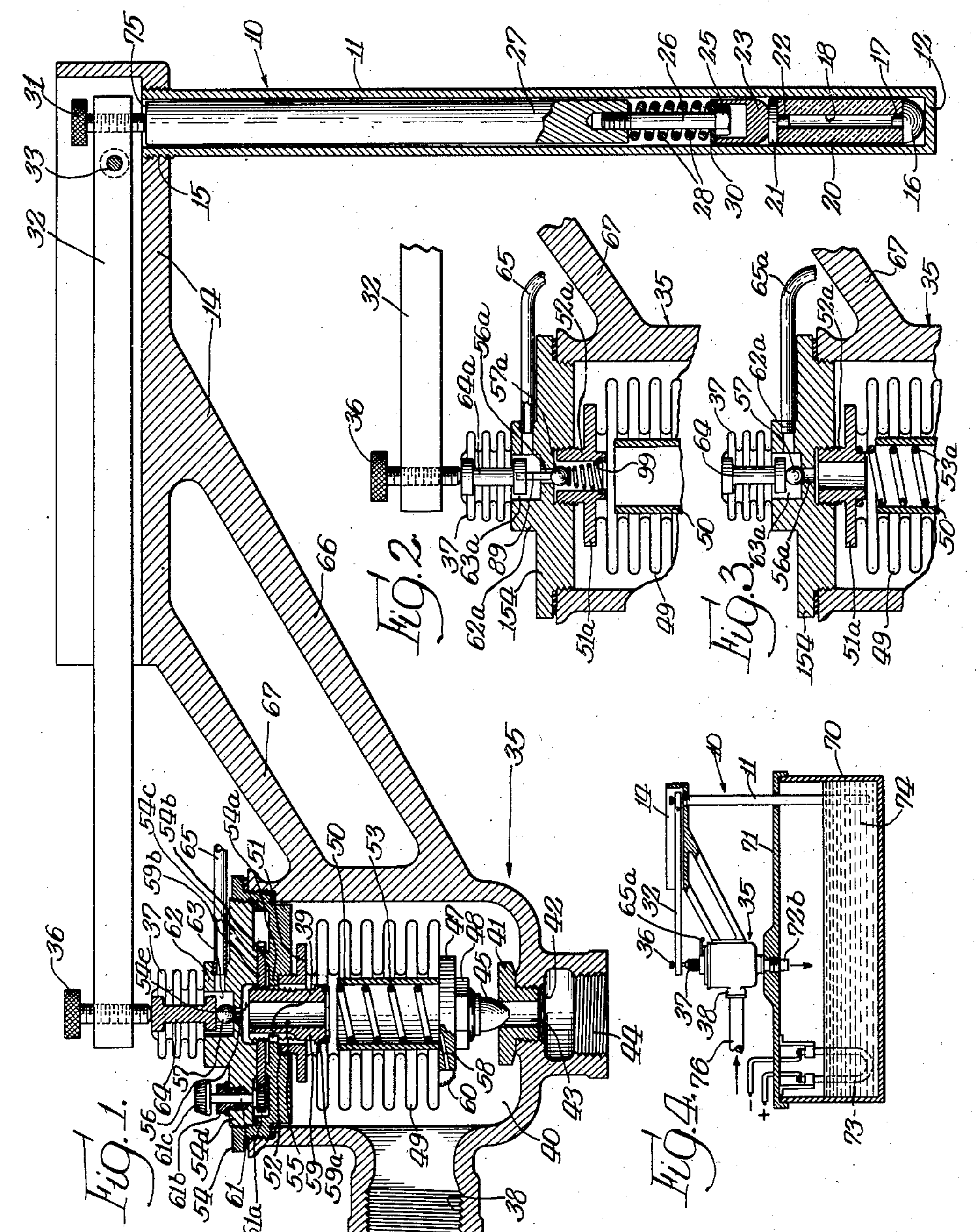

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VALVE MECHANISM AND CONTROL MEANS

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1 Claim. (Cl. 137—139)

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This invention relates to valve mechanism and has to do also with thermal responsive control means adapted for use with the valve mechanism.

My invention is directed to the provision of valve mechanism for controlling flow of fluid under pressure from a source of supply to a container or receptacle, responsive to conditions of temperature or pressure in the latter and in such manner as to maintain the temperature and pressure in the container or receptacle constant, maintain constant the pressure under which the fluid is delivered to the container or receptacle, or to deliver to the container or receptacle a measured amount of the fluid. I provide a valve mechanism of the character referred to which is of comparatively simple but rugged construction well suited to exacting conditions encountered in its use, and is capable, in certain of its forms, of accurate adjustment for assuring the desired pressure of delivery of the fluid.

My invention also includes thermo-responsive means and valve mechanism particularly suitable for use with such thermo-responsive means, the latter being capable of withstanding severe temperature conditions and cooperating with the valve mechanism for actuating the latter responsive to slight variations in temperature. Further objects and advantages of my invention will appear from the detail description:

In the drawings:

Figure 1 is a central vertical sectional view through valve mechanism and associated thermally responsive control means, embodying my invention, certain parts being shown in elevation and certain other parts being broken away;

Figure 2 is a fragmentary view, partly in section, of the valve mechanism and control means, showing a second modification of the valve mechanism;

Figure 3 is a view similar to Figure 2 but showing a third modified form of valve mechanism; and

Figure 4 is a diagrammatic view of the valve mechanism of Figure 3 and the thermally responsive control therefor mounted on a tank containing a solution adapted for bluing steel.

Referring first to Figure 1, I shall now describe the thermal actuated control, indicated generally by the reference numeral 10, for the valve mechanism. This control mechanism 10 has an outer cylindrical casing 11 which is closed at its lower end, as at 12, and open at its upper end. This casing 11 is preferably made of metal, preferably steel, stainless or otherwise. Conveniently, the upper end of this casing 11 has exterior threads

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15 and is screwed into a supporting frame 14, but it may be secured to frame 14 in any other suitable known manner.

Within the casing 11 and resting against its bottom is a spherical steel button or cap 16. This button or cap 16 has a short central shank 17 which fits loosely inside the cylindrical bore 18 of a ceramic tube 20, which is ground off square at its ends and fits loosely within the casing 11. A flat steel button or cap 21 seats on the upper end of tube 20 and is kept in place by its short shank 22 which fits loosely within the cylindrical bore 18. The purpose of this flat cap 21 is to distribute the load evenly upon the whole surface of the upper end of the tube 20, which distribution would not result ordinarily if the upper surface of tube 20 were not ground flat. The even distribution of the load reduces the danger of fracturing of the ceramic tube 20. Spherical button or cap 16 fitting against the bottom edge of tube 20 cooperates in the same manner as cap 21 in equalizing the distribution of the load on tube 20.

A steel cup 23 with a rounded bottom rests on the top of the flat cap 21. The inside diameter of the cup 23 is substantially larger than the head 25 of a cap screw 26 threaded into the lower end of a solid steel cylindrical thrust rod 27 which has a loose, sliding fit within the casing 11. A coiled steel compression spring 28, disposed about screw 26, is confined between the bottom of rod 27 and a washer 30 seating at its inner portion on head 25 of screw 26 and, at its outer portion, on the upper end of cup 23. Spring 28 is prestressed by means of the cap screw 26.

A screw 31 threaded through the right hand or short arm of a lever 32, for adjustment, bears against the upper end of thrust rod 27. While a lever of the first class is shown, and is preferable for the specific arrangement illustrated, a lever of the second class may equally well be employed with slight rearranging of the other parts. The lever 32 is pivoted close to screw 31 on bearing trunnion 33 which is supported at each end in the adjacent channel shaped part of the frame 14.

The casing 11, the rod 27 and the screw 26 are preferably all made of the same material which, for example, may be common steel which is both sturdy and inexpensive. Common steel has a coefficient of thermal expansion of approximately 11×10^{-6} per degree centigrade in the range of 0–100° C. The casing 11 and rod 27 may be of any desired length to fit the needs of the installation. In the present case the casing 11 and rod 27 are long enough to allow dissipation of heat sufficient to assure that the frame 14 and lever

32 remain at substantially room temperature. The overall length of these members has otherwise no practical effect on the operation of the control except as hereinafter described.

The ceramic tube 20 has a thermal coefficient of expansion of approximately 1.875×10^{-6} per degree centigrade which is about one-sixth that of common steel. It is to be understood that other materials than common steel may be used for the thrust rod 27, casing 11, and screw 26; the same may be said for tube 20—a ceramic tube is not the only usable material. The important factor is that there should be a substantial difference between the coefficient of expansion of the tube 20 and of the rod 27, casing 11 and screw 26. It is important, however, to choose the materials for durability and constancy of thermal coefficients of expansion within the range of the temperature involved. The caps 16 and 21, cap 23, adjusting screw 31, frame 14, bearing 33 and lever arm 32 may be of any suitable material and preferably are made of ordinary low carbon steel.

Any movement of rod 27 with respect to casing 11, and hence frame 14, acts to operate the lever 32, or to permit operation thereof, by pressure or release of pressure on screw 31. The movement is multiplied by the long arm of the lever 32 according to the laws of leverage; a mechanical advantage of 27–1 is illustrated in Figure 1. Adjustable engaging screw 36 at the left hand end (long arm) of lever 32 presses against a collapsible metal bellows 37 and reflects, on an increased scale, the motion of rod 27.

The valve housing, indicated generally at 35, has a threaded inlet 38 and a chamber 40. A valve seat member 41 is threaded into an opening 42 in the bottom of the housing 35 and has a passage 43. The threaded outlet 44 leads to an apparatus, container, or receptacle, for receiving the fluid from valve housing 35. A valve member 45 cooperates with seat member 41 and is secured to plate 47, conveniently by being screwed thereinto by means of an hexagonal portion 48. An expansible metal bellows 49 and a guide cylinder 50 are secured to the upper face of plate 47. The bellows 49 is secured, at its upper end, to the lower side of flange 51 of a tubular fitting 52 screwed into a stepped and dished cover 54 which screws into the upper end of housing 35.

Cylinder 50 houses a coil compression spring 53, of appropriate strength, confined between plate 47 and a flange 59a adjacent the lower end of an adjusting tube 59 extending through fitting 52 and defining a passage 55. Tube 59 extends upwardly through a flange 54a, of cover 54, which flange is at the upper end of fitting 52 and extends a slight distance radially inwardly beyond the fitting 52 so as to hold tube 59 out of contact, circumferentially, with fitting 52. A tongue and groove connection 39 between flange 54a and tube 59 holds the latter against rotation while permitting axial adjustment thereof. Tube 59 screws through a spur gear 59b mounted for rotation on an annular rib 54b on the upper face of cover 54, and confined against axial movement between rib 54b and an annular rib 54c, at the under face of a disc 54d screwed into the upper end of cover 54. Disc 54d is provided at its under face with a central recess 54e which opens through a port 56 into a chamber 63 defined by a hollow boss 62 on the top of disc 54d, to the upper end of which boss 62 the lower end of bellows 37 is suitably secured. A ball valve 57 normally seats in the upper end of port 56 and controls communication between bellows 49 and bellows 37, through passage 55 of adjusting tube 59, recess 54e and port 56. Suitable gaskets are disposed between cover 54 and the upper end of housing 35, and between an interior shoulder of cover 54 and disc 54c, as shown.

The interior of the large bellows 49 is connected to the chamber 40 of the housing 35 through a restricted inlet duct 58 in plate 47, provided with a strainer 60 at its outer end. The duct 58 may open into the interior of the bellows 49 at any other convenient place as, for example, through the fitting 52, but the location of duct 58 and screen 60 below the bellows allows impurities to drop away by gravity. Further, by being disposed in the line of liquid flow the tendency is to wash the screen free of impurities. A thrust member or post 64 rests at its lower end upon ball valve 57 and is secured at its top to the inside of the top of the smaller bellows 37. A drain tube 65 is threaded into a hole in the side of the hub 62 and serves to drain the bellows 37. As mentioned earlier, adjustable engaging screw 36 in lever arm 32 bears on the head of the thrust member 64 by way of the top of the collapsible bellows 37.

Gear 59b meshes with a pinion 61a secured on the lower end of a rod 61 mounted for rotation through a stuffing box 61b in disc 54d. A knob 61c is secured on the upper end of rod 61 and provides convenient means for rotating it and thereby rotating gear 59b for effecting axial adjustment of adjusting tube 59. Downward movement of tube 59 compresses spring 53 thereby increasing its effective resistance to contraction of bellows 49, and upward movement of tube 59, permitted by recess 54e, has the opposite effect. That provides simple and highly efficient means for controlling the opening of valve 45, as will be explained more fully presently.

The frame 14 is shown as being integrally connected to the valve housing 35 as by webs 66 and 67. This mode of construction is not essential. It is required that the frame hold the stationary parts rigidly in fixed relation to each other. The supporting frame 14 and the valve housing 35 may be separate parts so long as they remain in fixed positions with respect to one another.

Referring more particularly to Figure 1, the valve 45 is shown as closed against the seat of member 41, in which position it normally is held by compression spring 53 supplemented by the spring action of the bellows 49. Fluid which enters the housing fills the chamber 40 and passes through the strainer 60 and inlet duct 58 to the inside of the bellows 49. When the fluid pressure inside chamber 40 and bellows 49 is in equilibrium the valve 45 is closed. This condition exists when the passage 56 is closed by ball valve 57 and thrust bar 64, and when the main valve port 43 is closed by valve member 45. Since the pressure inside and outside of the bellows is then equal there is no tendency for the fluid pressure to collapse it.

When screw 31 is not subjected to pressure by the thermo-responsive control means, the long arm of lever 32 is free for upward movement. The pressure of the fluid inside the larger bellows raises the ball valve 57 from its seat and the fluid escapes from bellows 49 into and partially fills bellows 37, and flows out of the latter bellows through the drain tube 65. Since the duct 58 is quite restricted relative to port 56, the former having a diameter of about 1/64″ and the latter having a diameter of about 1/8″, for example, fluid escapes from bellows 49 at a considerably greater rate than fluid can enter that bellows through duct **58**. Consequently, the action of the fluid pressure on the exterior lower end surface of the bellows **49** causes it to contract lengthwise. Since the upper end of bellows **49** is fixed, the lower end thereof moves upwardly. Cylinder **50** within the bellows **49** cooperates with flange **51** to limit the maximum extent to which this bellows can be contracted. Contraction of the bellows **49** withdraws valve member **45** to a greater or less extent from its seat and permits the flow of fluid through the housing and out of the discharge outlet **44**. When the ball valve **57** has a diameter of approximately three-sixteenths ($\frac{3}{16}$) of an inch and the duct **58** and port **56** are respectively one-sixty-fourth ($1/64$) and one-eighth ($1/8$) inch in diameter, the thrust bar **64** needs to move less than five ten-thousandths of an inch to cause the main valve **45** to open.

When the thermal actuated control means again becomes effective for exerting pressure against screw **31**, it swings the left end of lever **32** downwardly, returning ball valve **57** to its closed position and holding it in that position so long as screw **31** is under pressure. Bellows **49** then fills with pressure fluid, the interior pressure and the exterior pressure to which this bellows is subjected become equalized and valve **45** is returned to its closed position by the action of spring **53**, supplemented by the spring action of bellows **49**, and is held there until ball valve **57** is again opened.

The form of valve mechanism of Figure 2 may also be used, in conjunction with lever **32** and the thermo-responsive unit **10** for supplying a relatively hot fluid or liquid, from a suitable source of supply, to a bath or body of fluid or liquid for maintaining the latter at a predetermined minimum temperature. In such case, the tube **65** may discharge to atmosphere or into the bath or body of fluid. When the temperature of the body of fluid or liquid tends to drop, the thermo-responsive unit **10** contracts slightly and causes downward movement of the long arm of lever **32**, by the resultant pressure exerted against screw **31** (Figure 1). That opens ball valve **57***a*, permitting escape of pressure fluid from bellows **49** with resultant opening of valve **45** and discharge of relatively hot fluid into the body of fluid in which unit **10** is immersed, raising the temperature thereof to the desired minimum, at which time unit **10** expands relieving the pressure on screw **31**, and spring **99** returns ball valve **57***a* to its closed position.

The valve mechanism of Figure 3 is similar to that of Figure 2, except that the thrust post **64** is in direct contact with ball valve **57**, which seats in the upper end of port **56***a*, as in Figure 1, and a light coil compression spring **53***a*, extending downward through cylinder **50**, is confined between plate **47** (shown in Figure 1) and flange **51***a* of fitting **52***a* screwed into cover **154**. The spring **53***a* is not essential and may be omitted in cases where the spring of bellows **49** is sufficient to hold valve **45** closed, and the tube **65***a* may discharge to atmosphere or to any other suitable point of discharge.

In Figure 4, the vat **70**, shown in section, has a frame **71** indicated as a cover. This illustration is largely diagrammatic. The cover **71** has a short section of pipe **72***b* threaded therein to which is threaded the valve housing **35** of a valve mechanism similar to that of Figure 5. The inlet of the valve housing **35** is connected by a pipe **76** to a source of supply of water under pressure, and the pipe **72***b* acts as a discharge duct from the valve housing to the bath. The thermal actuated control **10** is inserted through a hole in the cover **71** and extends at its lower end into the bath **74**. An electric heating element **73** projects into the salt solution **74** to heat the bath to the boiling point. Assume for illustrative purpose that it is a predetermined maximum temperature of the salt bath **74** which it is desired to control for bluing of steel articles immersed in the solution. This maximum temperature may be selected in the range of from 300° to 500° F. for example.

The operation of the thermal actuated control is as follows: As soon as a temperature greater than the predetermined maximum is reached, due to the heat input of heating element **73** and the increased boiling point being caused by increased concentration due to evaporation, the expansion of the tube **11** will cause it to lengthen in a downward direction since it is fixed at its upper end. This will permit the ceramic cylinder **20** and steel rod **27** to slide downwardly with the lowering bottom **12** of the tube **11**, since parts **20** and **27** have a sliding fit within tube **11**. The ceramic cylinder **20** has a much smaller coefficient of expansion than tube **11** and therefore expands less. Furthermore, cylinder **20** is heated principally by radiation of heat from tube **11** and by conduction through spherical cap **16** and a minor amount of contact with the wall of tube **11**. Hence it takes a short interval of time for the temperature to equalize the parts. Rod **27** and tube **11** will expand also because the region above the surface of the bath will be filled with water vapor.

Therefore, these various rates and degrees of expansion result in a lowering of the end surface **75** of rod **27** with respect to the upper end of the tube **11**. That means that the end surface **75** of rod **27** starts to move away from its contact with screw **31**. The fluid pressure against valve member **57**—as was above described when the valves **57** and **45** were closed—is such that it will then force up valve member **57**, thrust bar **64**, bellows **37**, screw **36** and lever **32** in such a manner as to cause screw **31** to follow the top surface **75** of rod **27** for at least a short distance. The degree of movement of screw **31** is determined by the amount of movement necessary for opening the valve **57**. Since the movement of valve **57** corresponds to that of the long arm of lever **32**, this movement of screw **31** needs to be only small. Consequently the rise in temperature of the salt solution will result in a slight lowering of the screw **31** with lowering of the upper surface **75** of rod **27**. The opening of valve **57** an amount less than five ten-thousandths ($5/10,000$) of an inch results in the opening of valve **45**. Therefore a change of temperature of around one-half a degree centigrade will cause valve **45** to be opened. Response to such a small change in temperature is obtained by the interaction of several factors —the difference in the coefficients of expansion of tube **11** and cylinder **20**, the length of cylinder **20**, the time differential in the heating of these tubes and the mechanical advantage of the lever **32**.

The ceramic cylinder **20** will, of course, expand. It does not start as soon, and has a much lower coefficient of expansion than tube **11**, but it will expand and thus raise end surface **75** of rod **27** upward toward the screw **31**. Since a considerable amount of cooling water may be let in past the valve 45, when the predetermined temperature is exceeded only by a small amount, there will be but a short space of time before tube 11 will begin to contract. The ceramic cylinder will subsequently contract also. The contraction of tube 11 will cause the cylinder 20 and rod 27 to rise again. When the temperature of the fluid is lowered to the proper operating temperature again, the tube will have so shrunk that the end surface 75 of rod 27 will have perforce contacted and forced up screw 31.

That means that the lever 32 at its left end will be forced down. Therefore screw 36 will press on the top of expansible bellows 37 and thrust rod 64 will force valve 57 shut. When valve 57 is shut, water will begin to fill up the inside of the large bellows 49 and the pressure inside and outside bellows 49 will become equal again. The spring action inherent in bellows 49, supplemented by the action of the compression spring 53*a*, if used, will expand bellows 49 and seat valve 45, thus shutting off the flow of water.

The more extensive and more rapid fluctuations in the length (expansion and contraction) of the tube 11 are always followed by a slower and less exaggerated expansion and contraction of the ceramic cylinder 20. Since the ceramic cylinder 20 is a factor, as is tube 11, in the positioning of surface 75 with respect to the fixed top of tube 11 and screw 31, surface 75 depends upon the interaction of both tube 11 and cylinder 20 to determine its location for a given situation.

The purpose of spring 28 which is prestressed by screw 26 is to act as a safety device. That is to say, it protects the instrument from rough handling and also provides against excessive stress on the ceramic cylinder or other parts due to excessive contraction of tube 11.

To illustrate this, consider the device shown in Figures 3 and 4. Assume that the water pressure in the main feeding valve housing 35 has a pressure of 40 pounds per square inch. Also assume that valves 57 and 45 are in closed position and that the salt solution is at, but not exceeding the predetermined maximum temperature. The adjusting screws 31 and 36 will have been adjusted earlier for just this condition of equilibrium. That is, they will be positioned in such a way that they will firmly bear on rod 27 and thrust rod 64 respectively—so that opening of valve 57 by the water pressure against it will be resisted at the right hand end of the lever which bears—by means of screw 31—against surface 75 of rod 27. (It is feasible if desired, to calibrate the thermal actuated control for action at various temperatures. Such calibration may be applied to the adjusting screw 31, for example, but preferably to screw 36.)

Now if tube 11 contracts further from any cause, that will mean that ceramic cylinder 20 and rod 27 will be compressed between lever arm 32 and the bottom end 12 of tube 11. The lever 32 cannot swing further about its bearing 33 since the left end of the lever arm is firmly pressed against thrust rod 64 and valve 57 which is firmly and solidly seated. In order to prevent the ceramic tube 20 from being crushed by excessive contraction, prestressed spring 28 is added between rod 27 and ceramic tube 20. Excessive contraction of tube 11 then will not crack ceramic cylinder 20 but will force spring 28 to compress. Spring 28 is prestressed sufficiently so that when all parts of the valve and thermal control are in an equilibrium or normal operating condition the fluid pressure acting against valve 57 will not cause it to open by compressing spring 28 through lever arm 32. With fluid pressure of 40 pounds per square inch in the mains, spring 28 of the illustrated device is preloaded to approximately 125 pounds.

If the control mechanism is to be used at high temperatures it is advisable to put the spring at the upper end of the rod 27 out of range of said heat. The rod 27 with its spring 28 and the cap 23 could be inverted to adapt the device quickly for use at higher temperatures.

Now the fact that my valve mechanism and thermal actuated control have been used in cooperation is not to indicate that that is the scope of their usefulness. The scope is greater and is not to be limited by the above specific illustrations. The pilot controlled valve mechanism of my invention is peculiarly adapted for thermostatic control or other control where the movement of the element responsive to the particular variable is small or minute. Thus a relatively large flow of fluid is turned on and off by a very minute motion of the valve 57. The dilution of a salt bath is but one example. The blending of fractions or ingredients in petroleum distillation is another example.

The valve mechanism, in its various forms disclosed herein, with or without the thermostatic control, may be applied to control of various fluids such as air or steam or other gases, vapors or liquids or mixtures of the same. The thermostatic element may be employed to operate switch contacts instead of a control valve. However, there is a particular relation between the valve mechanism shown herein and a positive expansion type of thermostat, in that the thermostat must hold the pilot valve 57 against the pressure of the liquid, when valve 45 is closed. Hence a positive force is required although a very small movement is involved. Damage to the parts under the conditions of abnormal movement in the closing direction is obviated by the prestressed spring 28 above described.

Briefly, the usefulness and applicability of my invention is extensive, and many modifications and changes are possible without departing from its scope and spirit as set out in the appended claim.

I claim:

In a valve mechanism, a housing having an inlet and an outlet, a bellows within said housing affixed at one end thereto having a constantly open restricted inlet and an outlet, a main valve carried by the other end of said bellows controlling said housing outlet, a tubular member extending into said one end of said bellows establishing communication between the latter and said bellows outlet, a compression spring within said bellows confined between said other end of said bellows and said tubular member, means operable exteriorly of said housing for adjusting said tubular member lengthwise thereby varying the extent of compression of said spring, and valve means controlling flow of fluid through said bellows outlet.

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