G. P. CARROLL.

DOUBLY ACTUATED EXPANSION VALVE.

APPLICATION FILED APR. 30, 1907.

959,458. **Patented May 31, 1910.**

Fig: 1

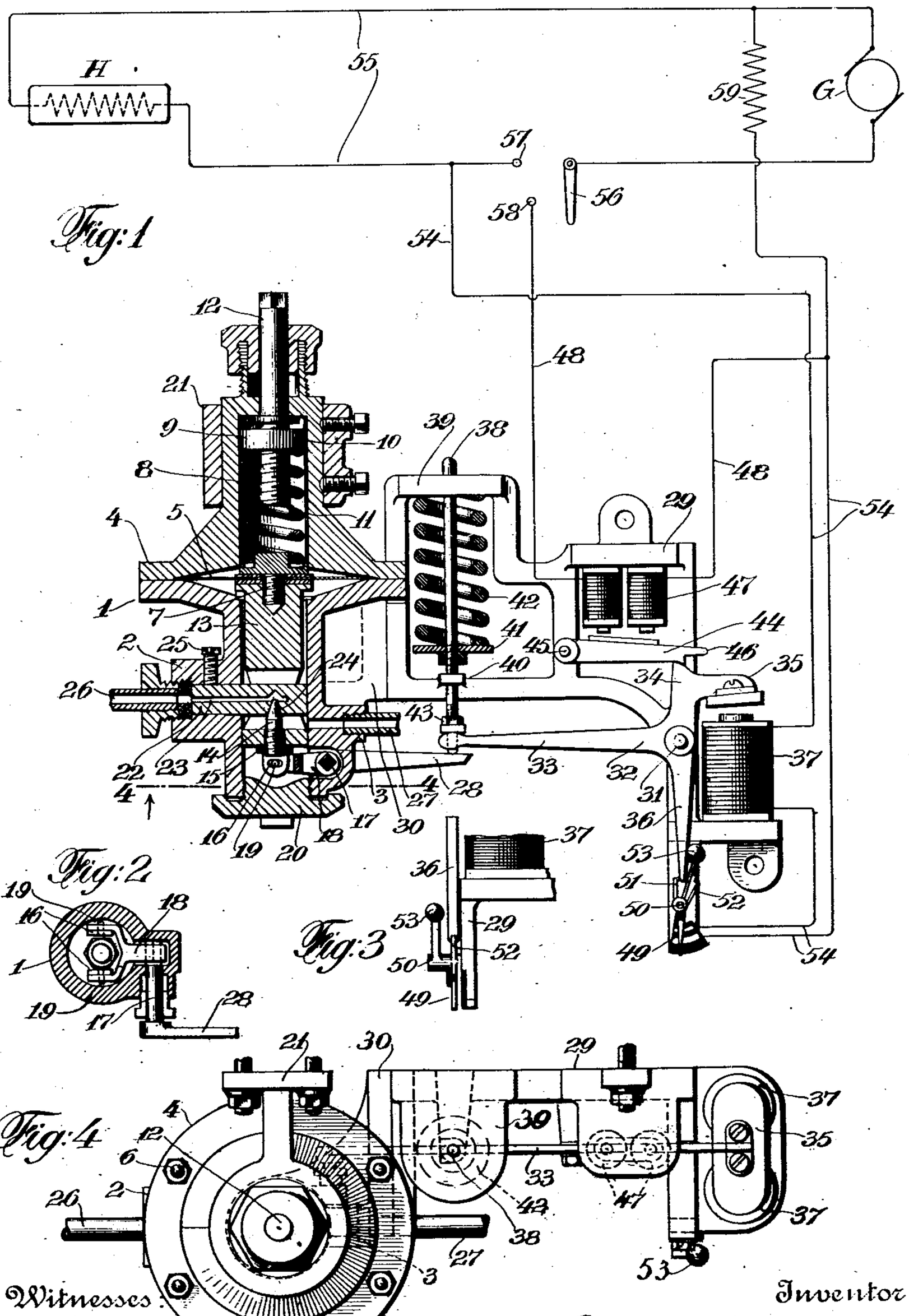

Fig: 2

Fig: 3

Fig: 4

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GEORGE P. CARROLL, OF BRIDGEPORT, CONNECTICUT.

DOUBLY-ACTUATED EXPANSION-VALVE.

959,458. Specification of Letters Patent. Patented May 31, 1910.

Application filed April 30, 1907. Serial No. 371,172.

To all whom it may concern:

Be it known that I, GEORGE P. CARROLL, a citizen of the United States, residing at Bridgeport, in the county of Fairfield and State of Connecticut, have invented a new and useful Doubly-Actuated Expansion-Valve, of which the following is a specification.

My invention relates in general to improvements in reducing valves doubly actuated so as to be opened and closed absolutely by the application of power from without the fluid circuit and, during the time when permitted to be open by such application of power, to be regulated according to the varying pressure of the fluid passing through the valve.

It especially relates to improvements in electrically operated automatic expansion valves placed between the high pressure and the low pressure sides of refrigerating systems whether of the compression or of the absorption type.

As ammonia is the refrigerant most commonly in use, it will be referred to in the following description as typical of all fluids.

The means employed are, with the addition of new elements, the combining in one valve of certain features and functions of the valves shown in my applications, Ser. No. 351,068, filed Jan. 7, 1907, entitled Automatic expansion valve; and Ser. No. 360,055, filed March 1, 1907, entitled Electric expansion valve. Said valves are also substantially shown as valves E and P in my application, Ser. No. 367,836, filed April 12, 1907, entitled Automatic compression refrigerating system.

In the drawings Figure 1 is a partial vertical section and a partial elevation of the valve structure and its diagrammatic connections. Fig. 2 is a horizontal section as seen from beneath the valve structure along the line 4—4 of the preceding figure. Fig. 3 is a side elevation of a switch and connected parts. And Fig. 4 is a plan view of the valve structure.

A lower casing 1 has cast as a part thereof a perforated lateral entrance boss 2 and a perforated lateral outlet 3, the axis of the outlet being preferably slightly below the axis of the entrance boss. The lower casing is flanged at its top and superimposed upon it is an upper casing 4 correspondingly flanged so as to hold a diaphragm 5 between the flanges clamped together by bolts 6. The diaphragm is so flexible or resilient that at the center it can be moved up or down while its periphery remains stationary. Extending centrally through the diaphragm is a screw 7, its top above the diaphragm being in the form of an annular pocket for receiving the lower end of a coiled spring 8. The thrust exerted by the spring is regulated by the elevation or depression above the spring of a collar 9, which is held from turning by a tongue 10 fitting into a vertical groove 11. Threaded into the collar 9 is an adjusting screw 12, which extends up through a suitable stuffing box and gland and is provided at its upper end with a wrench section for turning the screw when it is desired to adjust the thrust of the coiled spring 8 upon the diaphragm 5.

Threaded on to the screw 7 is a slotted bar 13; it is guided by the walls of the lower casing, but fits somewhat loosely therein. By this loose fit a sufficient space is left so that gas can pass up between the bar and the casing and impinge against the under side of the diaphragm 5. Threaded into the slotted bar 13 and extending upward into its slot is a valve 14, preferably of the conical or needle valve type, which is locked in place at its lower end by a lock nut 15. Lugs 16 depend from the slotted bar on each side of the lock nut and are horizontally slotted at their lower ends.

Near the bottom of the lower casing 1 below the outlet 3 is a recess perforated at the back and provided with a suitable stuffing box and gland for the passage of a lever shaft 17. The end of the shaft within the recess is squared for the securing thereto of an inner lever 18, extending horizontally. This lever has a forked extremity near the axis of the lower casing 1, each branch carrying a pin 19 which is extended into the corresponding slots of the lugs 16. A bottom cap 20 is screwed on to the lower end of the lower casing 1.

The upper casing 4 may be supported and fastened to an adjacent vertical surface by a bracket 21 provided with screw or bolt holes for attaching it to the vertical surface and with clamping bolts for securing the valve structure in place.

An entrance piece 22 rests in the perfora-

tion of the lateral entrance boss 2 for a part of its length so that its inner end abuts against the inner wall of the lower casing 1, preferably above the outlet 3. This entrance piece is preferably a solid rod of comparatively large diameter bored out centrally from its outer end up to a place that will be in the axial center of the casings, making a bore 23. Thence the piece has a downward bore at right angles to the other bore, ending in a conical valve seat 24 on its under side, upon which the valve 14 can be seated. The part of the entrance piece projecting inside the casing has its sides and bottom surface plane so as to loosely fit the slot of the bar 13 and so as to afford a suitable valve seat for the valve 14. The entrance piece may be kept in place by a set screw 25 or may be keyed in place. A high pressure pipe 26 enters the outer end of the lateral entrance boss 2 so as to lead into the bore 23 and is held in place and so as to prevent leakage by a suitable gland and packing. The inlet end of an expansion coil 27 is fitted into the lateral outlet 3 and may be similarly provided with a gland and packing.

To the outside end of the lever shaft 17 is secured an outer lever 28, extending in a horizontal direction opposite to that of the inner lever.

A frame 29 is provided with suitable screw or bolt holes for attaching it to the same vertical surface as the bracket; it is also made to abut against an extension 30 of the lower casing 1 and may be secured thereto by bolts or otherwise. Pivoted on the frame at 31 is a three-part lever 32 having its main arm 33 extending horizontally toward and terminating in a position just above the outer end of the outer lever 28. Substantially at right angles to the main arm an upper arm 34 extends upward having on the side opposite to the main arm a projecting arm 35 with an armature on its under side; and also a lower arm 36 extends downward from the pivot 31. Resting on a suitable projection from the frame 29 and immediately under the armature of the projecting arm 35 is an electro-magnet 37, which, when energized, depresses the projecting arm. A vertical rod 38 passes through annular guides 39 and 40 in the upper and lower parts of the frame 29; above the guide 40 it is threaded for the longitudinal adjustment of a disk and lock nut 41. A coiled spring 42 enspirals the rod 38 and abuts at its top against the under side of the guide 39 and at its bottom against the upper surface of the disk, which determines the thrusting force of the spring according to its longitudinal position. The coiled spring 42 is constructed so as to have a greater thrusting force than the coiled spring 8. The rod 38 is threaded below the lower guide 40 and near its lowest extremity for the longitudinal adjustment of a small disk and lock nut 43; and below the disk and lock nut its lower extremity passes through an eye in the outer extremity of the main arm 33 so as to bear upon the outer upper face of the outer lever 28. The longitudinal position of the disk and nut lock 41 determines, when the main arm 33 is depressed, the force of the depression of the outer lever 28 and the consequent force with which the inner lever 18 is elevated and the valve 14 is forced to its seat. The longitudinal position of the disk and nut 43 determines, when the main arm 33 is elevated, the lift of the rod 38 and the consequent lift of the valve 14 from off its seat 24. This adjustability of the lift of the valve makes it possible to use the same size of valve for systems of different capacities.

A dog 44, having an armature on its upper side, is pivoted at one end at 45 on the frame 29, has at its other end a tooth 46, and rests on top of the upper arm 34 when the main arm 33 is depressed and the upper arm is consequently rotated to the left. But when the main arm is elevated, the upper arm is rotated to the right and is engaged and locked by the tooth 46. An electro-magnet 47, connected by a line 48, is supported from above by a suitable projection from the frame 29 and, when energized, it lifts the dog 44 and thus disengages the upper arm 34.

A switch 49 is pivoted at 50, with proper insulation, on the frame 29; it has two limit arms 51 and 52 and also a weight arm intermediate between them and ending in a small globular weight 53. Both these limit arms are adapted in turn to be engaged by the lower end of the lower arm 36 as it is moved to the left by the elevation of the main arm 33 and to the right as it is depressed. A line 54 passes through and connects the electro-magnet 37 and the switch 49. As shown in Fig. 1, with the upper arm 34 unlocked and the main arm 33 depressed, the switch is closed.

An electric generator G, as at a central power station, has mains 55 leading to and through a heater H. A switch 56 is adapted to open and close the circuit between the generator and the heater by making contact at 57, and between its contact at 57 and its open position as shown it makes an intermediate contact at 58. The line 54 is connected at one end with the mains 55 between the contact point 57 and the heater and after passing through a resistance 59 is connected at its other end to the mains between the heater and the generator. The line 48 connects at one end with the contact point 58 and at its other end with the line 54 between the electro-magnet 37 and the resistance 59.

The method of operation is as follows:

When a slight current passes through the line 54, the electro-magnet 37 is energized and the several arms of the three-part lever 32 are rotated clockwise. Consequently the tooth 46 engages and locks the upper arm 34; the main arm 33 lifts the disks and lock nuts 43 and 41 and the rod 38 and thereby compresses the coiled spring 42; and the lower arm 36 engages and thrusts to the left the limit arm 51 and brings the weight 53 to the left of the vertical axis of the pivot 50. When the weight so gets past the vertical axis of the pivot it falls still farther until the limit arm 52 engages the lower arm 36 and the switch 49 is rotated so far to the right that the switch is opened and the current is broken. This breaking of current does not occur until the tooth 46 has locked the upper arm 34. The elevation of the rod 38 from off the outer lever 28 permits the coiled spring 8 to depress the diaphragm 5 and the bar 13 and to displace the valve 14 from off its seat 24. The valve is thus open and anhydrous liquid ammonia is free to pass from the high pressure pipe 26 through the bore 23, the valve seat 24, the slot of the bar 13 and the outlet 3 into the expansion coil 27, where it vaporizes, the quantity of the passing ammonia being determined by the adjustment of the disk and lock nut 43. But a part of the ammonia passing through the valve seat, as it vaporizes, rises between the bar 13 and the casings 1 and 4 and impinges against the diaphragm 5; and when its density and tension become sufficiently great it tends to overcome the force of the coiled spring 8, as determined by the position of the collar 9, to lift the diaphragm and bar so as to force the valve 14 to its seat, and thus to check the flow of ammonia. But as the gas in the expansion coil 27 is being at the same time drawn off by the absorber or compressor, as the case may be, the tension of the gas upon the diaphragm tends to diminish so as to permit the coiled spring to force the valve downward. These two opposing tendencies continue to regulate the position of the valve so long as the upper arm 34 is locked by the tooth 46. When it is desired to close the valve absolutely, a slight current is sent through the line 48. The consequent energization of the electro-magnet 47 lifts the dog 44 and unlocks the upper arm 34. The coiled spring 42 now is free and operative to depress the disk and lock nuts 41 and 43, the main arm 33 and the outer lever 28. The consequent rotation of the several arms of the three-part lever 32 counter-clockwise causes the lower arm 36 to engage and thrust to the right the limit arm 52 and to bring the weight 53 to the right of the vertical axis of the pivot 50. When the weight so gets past the vertical axis of the pivot it falls still farther until the limit arm 51 engages the lower arm 36 and the switch 49 is rotated so far to the left that the switch is closed. The depression of the rod 38 upon the outer lever 28 lifts the inner lever 18, the valve 14 to its seat, the bar 13 and the diaphragm 5 and compresses the coiled spring 8. The valve is now closed, the spring 42 having been assisted to this end by the tension of whatever vapor or gas there might be in the expansion coil. With the diagrammatic connections as shown, by the closing of the switch 56 by making contact at 57, a current passes from the generator G through the mains 55 to the heater H and thence back to the generator at the same time that the electro-magnet 37 is energized. And by making a slight intermediate contact at 58 as the switch is being opened, an instantaneous current energizes the electro-magnet 47 as the current is turned off from the heater. The valve is thus opened and closed simultaneously with the turning on of power through the mains for some other purpose and with the shutting off of the power so applied.

The heater H is intended especially to be used to heat the still of an automatic absorption refrigerating system. In its place may be substituted the compressor of an automatic compression refrigerating system. In other words this present valve may be substituted in place of valves E and P in my said application Ser. No. 367,836. While the valve is especially adapted for use as a part of an electrically operated automatic system, it can also be used with any kind of motive power for a compressor or with any kind of heat for a still. For the valve may be operated electrically although the plant itself is not so operated. That is to say, the valve may be used as a safety expansion valve in non-automatic plants in such a way as to prevent too dense vapor and especially liquid ammonia from passing into the compressor or still, as the case may be.

The construction of the present valve as one structure is not merely more simple and economical than that of the two valves E and P above referred to, but it also has the advantage that power is stored up by the compression of the coiled spring 42 for the subsequent closing of the valve at the very time when the plant is being started and when the motive power is of necessity adequate.

I claim:

1. In combination a chamber having a valve seat, a diaphragm forming one wall of said chamber, a valve adapted for seating on said seat, means operating upon a sufficient outward movement of said diaphragm to seat said valve, means tending to force said diaphragm inward and to unseat said valve, a device for applying power either to absolutely seat said valve or to permit it to be actuated independently of the device, and

means operating to shut off the power applied in such second alternative.

2. In combination a chamber having a valve seat, a diaphragm forming one wall of said chamber, a valve adapted for seating on said seat and so connected to said diaphragm as to be seated upon a sufficient outward movement of the diaphragm, means tending to force said diaphragm inward and to unseat said valve, a device for applying power either to absolutely seat said valve or to permit it to be actuated independently of the device, and means operating to shut off the power applied in such second alternative.

3. In combination a chamber having a valve seat, a diaphragm forming one wall of said chamber, a valve adapted for seating on said seat, means operating upon a sufficient outward movement of said diaphragm to seat said valve, means tending to force said diaphragm inward and to unseat said valve, a device penetrating a wall of said chamber and available for applying power either to absolutely seat said valve or to permit it to be actuated independently of the device, and means operating to shut off the power applied in such second alternative.

4. In combination a chamber having a valve seat, a diaphragm forming one wall of said chamber, a valve adapted for seating on said seat and so connected to said diaphragm as to be seated upon a sufficient outward movement of the diaphragm, means tending to force said diaphragm inward and to unseat said valve, a device penetrating a wall of said chamber and available for applying power either to absolutely seat said valve or to permit it to be actuated independently of the device, and means operating to shut off the power applied in such second alternative.

5. In combination a valve, mechanism operative upon being released to open said valve, a shaft, a lever connected to said shaft and adapted either to close said valve and to position said mechanism so that it may subsequently open said valve or else to release said mechanism, and means for applying power to rotate said shaft and lever so as to release said mechanism, for automatically shutting off such power and for subsequently applying power to rotate said shaft and lever so as to close said valve and to so position said mechanism.

6. In combination a valve, mechanism tending to open said valve, a shaft, a lever connected to said shaft and adapted either to close said valve and to position said mechanism so that it may subsequently act according to its tendency or else to permit said mechanism to act according to its tendency, and means for applying power to rotate said shaft and lever so as to permit said mechanism to act according to its tendency, for automatically shutting off such power and for subsequently applying power to rotate said shaft and lever so as to close said valve and to so position said mechanism.

7. In combination a chamber having a port, a valve adapted to open said port, a device adapted to open said port through said valve, a shaft partly within and partly without said chamber, a lever secured to said shaft and adapted to close said port through said valve and to position said device so that it may subsequently so open said port, and means for applying power so that said device so opens said port, for automatically shutting off such power and for subsequently applying power to so operate said lever through said shaft.

8. In combination a chamber having a port, a valve adapted to open said port, a device adapted to open said port through said valve, a shaft partly within and partly without said chamber, a lever secured to said shaft and adapted to close said port through said valve and to position said device so that it may subsequently open said port, and means for applying electric power so that said device so opens said port, for automatically shutting off such power and for subsequently applying electric power to so operate said lever through said shaft.

9. In combination a chamber having a port, a valve adapted to open said port, a first device adapted to open said port through said valve, a shaft partly within and partly without said chamber, an inner lever secured to said shaft and adapted to close said port through said valve and position said first device so that it may subsequently open said port, an outer lever secured to said shaft and adapted to so operate said inner lever through said shaft, a second device adapted to so operate said outer lever or to release it when it is itself rendered inactive, and means for applying power to render inactive said second device so that said first device becomes operative and to hold it inactive and for subsequently applying power to operate said second device to move said outer lever.

10. In combination a chamber having a port, a valve adapted to open said port, a first device adapted to open said port through said valve, a shaft partly within and partly without said chamber, an inner lever secured to said shaft and adapted to close said port through said valve and to act on said first device so that it may subsequently open said port, an outer lever secured to said shaft and adapted to so operate said inner lever through said shaft, a second device adapted to so operate said outer lever or to release it when it is itself rendered inactive, and means for applying electric power to render inactive said second

device so that said first device becomes operative and to hold it inactive and for subsequently applying electric power to operate said second device to move said outer lever.

11. In combination a valve, a first device normally tending to open said valve, an intermediate lever adapted to close said valve and to position said first device so that it may subsequently become operative, a second device normally tending to so operate said intermediate lever, a second lever adapted either to render said second device inactive or to permit is to so operate, a catch operative to lock said second lever in position when it renders said second device inactive, and means for applying power to said second lever so as to render said second device inactive and for subsequently applying power to release said second lever from said catch so as to permit said second device to so operate.

12. In combination a chamber having an inlet port, a diaphragm closing the top of said chamber, a valve connected to and movable with said diaphragm and adapted to close said port, a spring operative on said diaphragm and tending to keep said valve from off its seat except when opposed by a greater fluid pressure on the under side of said diaphragm, a lever connected to said valve, having an outer arm 28 and positionable to force said valve to its seat when its outer arm is engaged, a three-arm lever 32, a spring 42 tending after having been compressed to depress said three-arm lever into engagement with said outer arm, a dog 44, and means for rotating said three-arm lever into locking engagement with said dog and simultaneously compressing the spring 42 and for subsequently disengaging said dog so that said spring 42 may so operate.

13. In combination a chamber having an inlet port, a diaphragm closing the top of said chamber, a valve connected to and movable with said diaphragm and adapted to open or close said port, a spring operative on said diaphragm and tending to keep said valve from off its seat except when opposed by a greater fluid pressure on the under side of said diaphragm, a lever connected to said valve, having an outer arm 28 and positionable to force said valve to its seat when its outer arm is engaged, a three-arm lever 32, a spring 42 tending after having been compressed to depress said three-arm lever into engagement with said outer arm, a dog 44, electrical means for rotating said three-arm lever into locking engagement with said dog and simultaneously compressing the spring 42, automatic means for breaking the current that has actuated said electrical means, and electrical means subsequently operative to disengage said dog so that said spring 42 may so operate.

14. In combination a chamber having an entrance aperture and an outlet, a diaphragm closing the top of said chamber, a reciprocating slotted bar depending from said diaphragm, a valve supported by said bar and extending into its slot, an entrance piece inserted through said aperture and having a channel from its outer end emerging on its under side within said casing as a seat for said valve, a spring operative on said diaphragm and tending to keep said valve from off its seat except when opposed by a greater fluid pressure on the under side of said diaphragm, a lever connected to said valve, having an outer arm 28 and positionable to force said valve to its seat when its outer arm is engaged, a three-arm lever 32, a spring 42 tending after having been compressed to depress said three-arm lever into engagement with said outer arm, a dog 44, and means for rotating said three-arm lever into locking engagement with said dog and simultaneously compressing the spring 42 and for subsequently disengaging said dog so that said spring 42 may so operate.

15. In combination a chamber having an entrance aperture and an outlet, a diaphragm closing the top of said chamber, a reciprocating slotted bar depending from said diaphragm, a valve supported by said bar and extending into its slot, an entrance piece inserted through said aperture and having a channel from its outer end emerging on its under side within said casing as a seat for said valve, a spring operative on said diaphragm and tending to keep said valve from off its seat except when opposed by a greater fluid pressure on the under side of said diaphragm, a lever connected to said valve, having an outer arm 28 and positionable to force said valve into its seat when its outer arm is engaged, a three-arm lever 32; a spring 42 tending after having been compressed to depress said three-arm lever into engagement with said outer arm, a dog 44, electrical means for rotating said three-arm lever into locking engagement with said dog and simultaneously compressing the spring 42, automatic means for breaking the current that has actuated said electrical means, and electrical means subsequently operative to disengage said dog so that said spring 42 may so operate.

16. In combination a chamber having an inlet port, a valve adapted to open or close said port, a flexible wall of said chamber connected to said valve, normally tending to seat said valve, but tending when distended outward to close said port by seating said valve, a first device normally tending to position said diaphragm to so open said port, a second device normally tending to absolutely close said port through said valve or to permit said first device to act according to its tendency, and means for applying power so that said second device

permits said first device so to act, for automatically shutting off such power and for subsequently applying power so that said second device closes said port.

17. In combination a valve, means for applying power to open said valve, means for automatically shutting off the power so applied, means for subsequently applying power to close said valve, and means operative upon said valve between such opening and closing to regulate the flow of fluid from said valve according to its pressure.

18. In combination a valve, means for applying power to open said valve, means for automatically shutting off the power so applied, means for subsequently applying power to close said valve, and a diaphragm actuated by the pressure of fluid flowing from said valve between such opening and closing and operative upon said valve to regulate the flow of such fluid according to its pressure.

19. In combination a valve, means for applying power to open said valve, means controlled by electric power for automatically shutting off the power so applied, means for subsequently applying power to close said valve, and means operative upon said valve between such opening and closing to regulate the flow of fluid from said valve according to its pressure.

20. In combination a valve, means for applying power to open said valve, means controlled by electric power for automatically shutting off the power so applied, means for subsequently applying power to close said valve, and a diaphragm actuated by the pressure of fluid flowing from said valve between such opening and closing and operative upon said valve to regulate the flow of such fluid according to its pressure.

21. In combination a valve, a magnetizable device operative upon being magnetized to open said valve, a magnetizing coil operative upon the passage of an electric current through it to so magnetize said device, means controlled by electric power for automatically shutting off such current, means for subsequently applying power to close said valve, and means operative upon said valve between such opening and closing to regulate the flow of fluid from said valve according to its pressure.

22. In combination a valve, a magnetizable device movable through the segment of a circle only and operative when magnetized to open said valve, a magnet operative upon the passage of a current through it to so magnetize and to so move said device, means controlled by electric power for automatically shutting off such current, means for subsequently applying power to close said valve, and means operative upon said valve between such opening and closing to regulate the flow of fluid from said valve according to its pressure.

23. In combination a valve, a magnetizable device operative upon being magnetized to open said valve, a magnetizing coil operative upon the passage of an electric current through it to so magnetize said device, means controlled by electric power for automatically shutting off such current, means for subsequently applying power to close said valve, and a diaphragm actuated by the pressure of fluid flowing from said valve between such opening and closing and operative upon said valve to regulate the flow of such fluid according to its pressure.

24. In combination a valve, a magnetizable device movable through the segment of a circle only and operative when magnetized to open said valve, a magnet operative upon the passage of a current through it to so magnetize and to so move said device, means controlled by electric power for automatically shutting off such current, means for subsequently applying power to close said valve, and a diaphragm actuated by the pressure of fluid flowing from said valve between such opening and closing and operative upon said valve to regulate the flow of such fluid according to its pressure.

25. In combination a valve, a first device adapted to close said valve, a second device adapted to open said valve, means for applying power so that said second device opens said valve, means controlled by the power applied with such opening effect for automatically shutting off the power so applied, means for subsequently applying power so that said first device closes said valve, and means operative upon said valve between such opening and closing to regulate the flow of fluid from said valve according to its pressure.

26. In combination a valve, a first device adapted to close said valve, a second device adapted to open said valve, means for applying electric power so that said second device opens said valve, means controlled by electric power for automatically shutting off the power so applied, means for subsequently applying power so that said first device closes said valve, and means operative upon said valve between such opening and closing to regulate the flow of fluid from said valve according to its pressure.

27. In combination a valve, a first device adapted to close said valve, a second device adapted to open said valve, means for applying power so that said second device opens said valve, means controlled by the power applied with such opening effect for automatically shutting off the power so applied, means for subsequently applying power so that said first device closes said valve, and a diaphragm actuated by the pressure of fluid flowing from said valve

between such opening and closing and operative upon said valve to so regulate the flow of such fluid according to its pressure.

28. In combination a valve, a first device adapted to close said valve, a second device adapted to open said valve, means for applying electric power so that said second device opens said valve, means controlled by electric power for automatically shutting off the power so applied, means for subsequently applying power so that said first device closes said valve, and a diaphragm actuated by the pressure of fluid flowing from said valve between such opening and closing and operative upon said valve to regulate the flow of such fluid according to its pressure.

29. In combination a valve, a first device adapted to close said valve, a second device adapted to open said valve, a switch connected with a source of electric power for turning on such power so that said second device so opens said valve, means for automatically shutting off such power between said switch and the source of electric power, means to which power is subsequently applied so that said first device closes said valve, and means operative upon said valve between such opening and closing to regulate the flow of fluid from said valve according to its pressure.

30. In combination a valve, a first device adapted to close said valve, a second device adapted to open said valve, a switch connected with a source of electric power for turning on such power so that said second device so opens said valve, means for automatically shutting off such power between said switch and the source of electric power, means to which power is subsequently applied so that said first device closes said valve, and a diaphragm actuated by the pressure of fluid flowing from said valve between such opening and closing and operative upon said valve to regulate the flow of such fluid according to its pressure.

31. In combination a valve, a spring normally tending to close said valve, means adapted to open said valve by mechanical action and to store up energy in said spring, a device for mechanically acting upon said means to so open said valve and to so store up energy, means for applying power to said device with such effect, means for automatically shutting off the power so applied, means for subsequently releasing said spring, and means operative upon said valve between such opening and release to regulate the flow of fluid from said valve according to its pressure.

32. In combination a valve, a spring normally tending to close said valve, means adapted to open said valve by mechanical action and to store up energy in said spring, a device for mechanically acting upon said means to so open said valve and to so store up energy, means for applying power to said device with such effect, means for automatically shutting off the power so applied, means for subsequently releasing said spring, and a diaphragm actuated by the pressure of fluid flowing from said valve between such opening and release and operative upon said valve to regulate the flow of such fluid according to its pressure.

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