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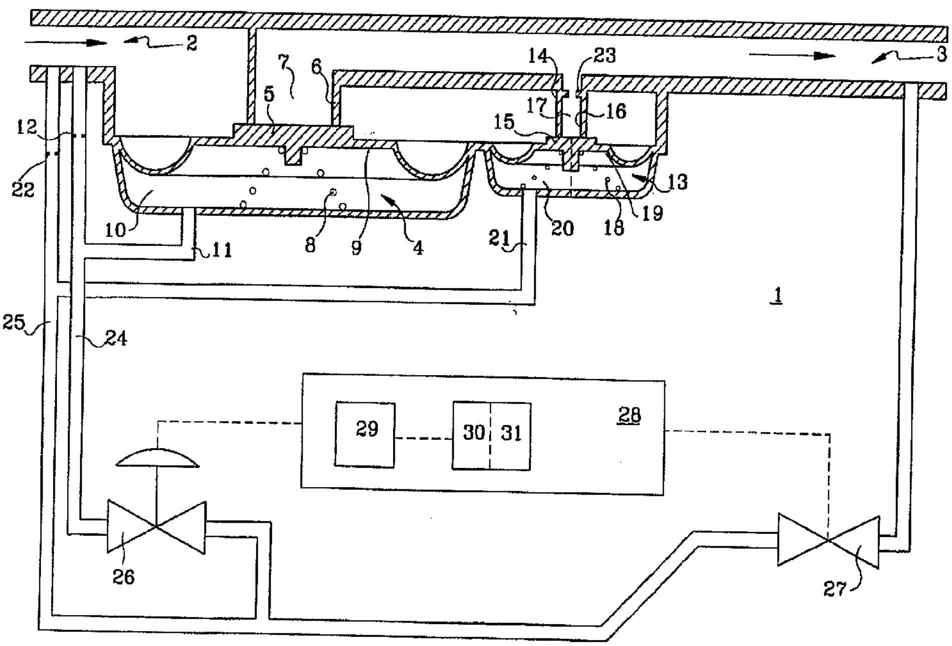
(54) **SOUPAPE A POIRE DE MODULATION DU DEBIT DE GAZ AVEC DERIVATION MINIMALE**

(54) **BULB-OPERATED MODULATING GAS VALVE WITH MINIMUM BYPASS**



(57) Un ensemble soupapes permettant un écoulement de gaz basse pression non régulé et un écoulement de gaz haute pression régulé dans un brûleur comprend une soupape principale à diaphragme (4) et une soupape de dérivation à diaphragme (13) s'ouvrant par un système à pression différentielle au niveau de leur diaphragme respectif (9, 19). Une soupape de régulation (26) et une soupape à enclenchement (27) modifient la pression de gaz appliquée au diaphragme de la soupape principale et au diaphragme de la soupape de dérivation, respectivement. Un mécanisme de commande (28) active la soupape de régulation et la soupape à

(57) A valve unit provides low pressure unregulated gas flow and high pressure regulated gas flow to a burner and comprises a main diaphragm valve (4) and a bypass diaphragm valve (13) which are opened by pressure differentials on their respective valve diaphragms (9, 19). A regulator valve (26) and a snap valve (27) modify gas pressure applied to the main and bypass valves diaphragms respectively. A control means (28) actuates the regulator and snap valves based on degree of temperature deficiency sensed in a monitored space. The control means opens the snap valve (27) to provide unregulated gas flow when low gas pressure is required,

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enclenchement en fonction du niveau d'insuffisance de température détecté dans un espace surveillé. Le mécanisme de commande ouvre la soupape à enclenchement (27) pour provoquer un écoulement de gaz non régulé lorsque du gaz basse pression est voulu, et ouvre la soupape de régulation (26) pour provoquer un écoulement de gaz régulé à grand débit lorsque du gaz haute pression est voulu.

and opens the regulator valve (26) to provide regulated high flow when high gas pressure is required.

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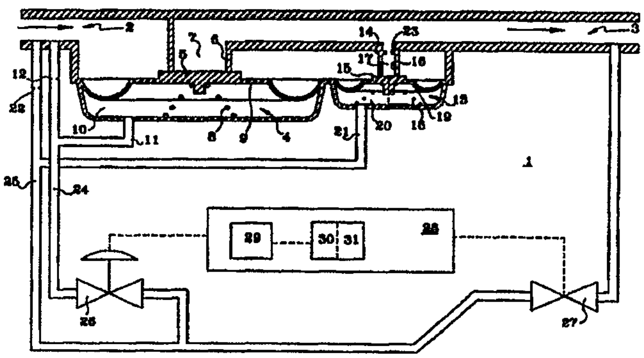
(57) Abstract

A valve unit provides low pressure unregulated gas flow and high pressure regulated gas flow to a burner and comprises a main diaphragm valve (4) and a bypass diaphragm valve (13) which are opened by pressure differentials on their respective valve diaphragms (9, 19). A regulator valve (26) and a snap valve (27) modify gas pressure applied to the main and bypass valves diaphragms respectively. A control means (28) actuates the regulator and snap valves based on degree of temperature deficiency sensed in a monitored space. The control means opens the snap valve (27) to provide unregulated gas flow when low gas pressure is required, and opens the regulator valve (26) to provide regulated high flow when high gas pressure is required.



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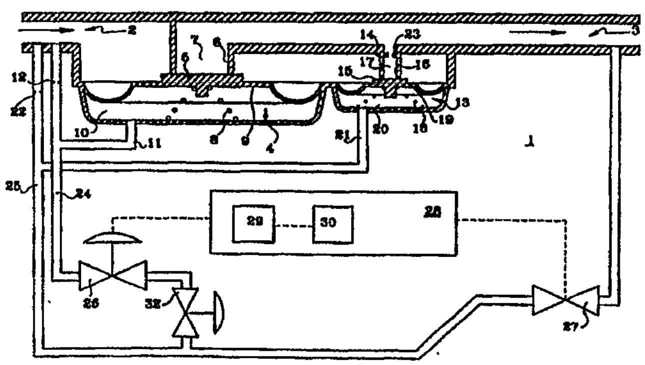

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BULB-OPERATED MODULATING GAS VALVE WITH MINIMUM BYPASS

The present invention relates to fluid handling systems, and more specifically to a multi-way valve unit having a regulated main valve, and an unregulated minimum bypass valve.

One common method of regulating gas flow is with a diaphragm valve. While many mechanisms exist to control the diaphragm valve, one popular method uses the inlet port pressure to control the position of a valve member relative to the valve seat, movement of the valve member being controlled by a valve diaphragm. Basically, this is accomplished by creating a pressure differential from one side of the valve diaphragm to the other sufficient to displace the diaphragm and the associated valve member. In simplest form, the valve member may be an integral part of the diaphragm. In more complicated systems, the valve diaphragm is mechanically linked to a separate valve member. The distance between the valve seat and the seat engaging member determines the valve opening, and thus the gas pressure at the outlet port.

A disadvantage of this control method is that any undesirable variations in the inlet pressure will be reflected in the outlet pressure, especially at low outlet pressures. For higher outlet gas pressures, these variations become negligible. Specifically, conventional diaphragm operated valves cannot provide acceptable characteristics under approximately 0,3" water column (w.c.). Thus the operating range of the diaphragm valve is substantially limited at low pressures by these inlet pressure variations.

Many popular gas control techniques would benefit from a valve system providing an extended operating pressure range at low pressures. One common example is so-called "on-demand" gas heating systems. In on-demand systems, fuel gas is provided only when there is a demand for heat. The demand is met by supplying only enough gas to exactly meet the needs of the application. For example, in a gas system for hot water supply, low gas pressure may be used to provide hot water to a sink, but high pressure will be provided if the shower is turned on. As a second example, in a space heating system, low gas pressure may be provided to raise the temperature by several degrees, but high gas pressure will be provided if the temperature in the controlled space is substantially below the desired temperature.

Valve systems providing both high and low controlled gas pressure also find application in slow-opening gas valve systems. Slow-opening gas valves have become a common means of improving the start-up characteristics of gas burner systems. In these applications, ramping to full gas pressure follows an initially low gas pressure period. In systems without improved start-up, initial full gas pressure may cause a dangerous gas flash to occur upon ignition. Although this flash is usually contained within the burner chamber, it also typically causes uncombusted gas to be propelled out of the burner chamber. By using low gas pressure on start-up, the initial start-up flash is essentially eliminated. This improves both the safety and the efficiency of the burner system.

Several workable slow-opening solutions exist which provide initial low gas pressure. U.S.-A-4,790,352 is one such patent. In this patent, gas pressure is ramped to full gas pressure, thus preventing the aforementioned flash problem. In U.S.-A-4,254,796 low gas pressure is only provided for a short initial period followed by full valve opening. Neither system however, can provide continuous regulated gas pressure control at low pressures.

Accordingly, it is desired to provide a gas valve system which smoothly integrates a diaphragm operated valve capable of over approximately 0,3" w.c. pressure regulation with a valve capable of controlled unregulated pressure under approximately 0,3" w.c. Furthermore, common control of the high and low gas pressures in a system is desirous which minimizes overall component count, and achieves a smooth transition from low pressure to high pressure operation.

SUMMARY OF THE INVENTION

The present invention as characterized in the independent claim is a multi-way valve system capable of providing high pressure regulated gas flow and low pressure unregulated gas flow in an integrated system. A main valve is provided, having a main valve seat and main valve member, which when in contact, separate the inlet port from the outlet port. The main valve also includes a main diaphragm which controls movement of the main valve member into and out of contact with the main valve seat. A main valve chamber is isolated from the flow path between the inlet and outlet ports by the main valve diaphragm. A first passage having a first flow restrictor, connects the main valve chamber and the inlet port.

A bypass conduit provides direct communication with the outlet port. The bypass conduit includes a bypass flow control element. A bypass valve, having a bypass valve seat and a bypass valve member, separates the inlet port and the bypass conduit when closed. The bypass valve also includes a bypass valve diaphragm which controls movement of the bypass valve member into and out of contact with the bypass valve seat. A bypass valve chamber is isolated from the flow path between the bypass conduit and the inlet port by the bypass valve diaphragm. A second passage having a second flow restrictor, connects the bypass valve chamber and the inlet port.

A third passage connects the main valve chamber and the outlet port. The third passage includes a regulator valve which obstructs flow through the third passage when closed. A fourth passage connects the bypass valve chamber and the outlet port. The fourth passage includes a snap valve which obstructs flow through the fourth passage when closed. Lastly, a primary control device is provided. The primary control device includes a temperature sensitive element, which causes the snap valve to open when the temperature sensitive element indicates a slightly lower than desired temperature, and causes the regulator valve in the third passage to open when the temperature sensitive element indicates a substantially lower than desired temperature. Preferred details and embodiments of the invention are described in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1A depicts a partial block diagram of one embodiment of the present invention.

FIGURE 1B depicts an embodiment using a separate valve as a maximum flow control element.

FIGURE 2 is a general representation of the temperature characteristic for the gas valve system.

FIGURE 3A shows one possible apparatus for controlling the gas valve system.

FIGURE 3B is an enlarged view of a snap element portion of mechanical control apparatus used in the gas valve embodiment of FIGURE 3A.

FIGURE 3C is a view of the snap element of FIGURE 3B taken along lines 3C-3C.

FIGURE 3D depicts a second possible apparatus for controlling the gas valve system.

DESCRIPTION OF PREFERRED EMBODIMENTS

In FIGURE 1A reference numeral 1 generally identifies the complete multi-way valve unit of the present invention. While the design in a single housing or casting is the preferred method of implementation, it would also be possible to perform the disclosed invention using discrete system components. An inlet port 2 and an outlet port 3, respectively, provide gas flow into and out of gas valve system 1. A main valve 4 in FIGURE 1A, controls the main gas flow from the inlet port to the outlet port. The main valve may be considered a first or primary diaphragm valve. A main valve member 5 generally lies adjacent inlet port 2, and is capable of sealably engaging a main valve seat 6. A main seat passage 7 through main valve seat 6, when open, connects the inlet and outlet ports. A spring 8, or other means urges the main valve member against main valve seat 6. When the main member does not engage the main valve, gas flows from the inlet port, through main valve passage 7 of the main valve to the outlet port.

Main valve member 5 in this embodiment is part of a main diaphragm 9, which separates a main chamber 10, from the inlet port. While this embodiment depicts the valve member as part of the main diaphragm, they may be separate. In systems where the main valve member is not part of the main valve diaphragm, a mechanical linkage connects the main valve diaphragm to the main valve member so that movements of the main valve diaphragm are reflected in the main valve member. The position of the main valve diaphragm reflects pressure differences between the main valve chamber and the inlet port. A pressure drop from the inlet port to the main valve chamber works against spring 8 to urge the main valve open. Equal pressure or a pressure rise from the inlet port to the main valve chamber will work in concert with spring 8 to hold the main valve in a closed position.

A first passage 11, provides gas flow between inlet port 2 and main valve chamber 10. A first flow restrictor 12 reduces the flow of gas from the inlet port through said first passage 11.

A bypass valve 13 controls bypass gas flow from inlet port 2 to a bypass conduit 14. The bypass valve may be considered as a second or secondary diaphragm valve. A bypass valve member 15 generally lies adjacent inlet port 2, and sealably engages a bypass valve seat 16. Bypass conduit 14 connects a bypass seat passage 17 through the bypass valve seat to outlet port 3. A bypass flow control element 23 restricts the flow through bypass valve 13. A spring 18 urges the bypass valve member against bypass valve seat 16. When the bypass valve member engages the bypass valve seat, gas flow from the inlet port to the bypass conduit is prevented.

The bypass valve member in this embodiment is part of a bypass valve diaphragm 19 which separates a bypass valve chamber 20 from the inlet port. In systems where the bypass seat-engaging member is not part of the bypass valve diaphragm, a mechanical linkage may be used to connect the bypass valve diaphragm to the bypass seat-engaging member so that movements of the bypass valve diaphragm are reflected in the bypass seat-engaging member. The position of the bypass valve diaphragm reflects pressure differences between the bypass valve chamber 20 and inlet port 2. A pressure drop from the inlet port to the bypass valve chamber works against spring 18 to cause bypass valve 13 to open. Equal pressure or a pressure rise from the inlet port to the bypass valve chamber will work in concert with spring 18 to hold the bypass valve in closed position. The bypass valve may be structurally smaller than the main valve, since it provides gas flow under low flow conditions, as will be described later.

A second passage 21 provides gas communication between the inlet port and the bypass valve chamber 20. A second flow restrictor 22 reduces the flow of gas through this second passage.

A third passage 24 and a fourth passage 25 provide controlled gas communication from the main and bypass valve chambers 10, 20 to the outlet port, respectively. A regulator valve 26 controls flow modulation in the third passage 24. The regulator valve may consist of any type of valve capable of controlling variable gas flow. For example, a cup valve and a needle valve are two common designs which may be used. A snap valve 27 controls gas flow in the fourth passage 25. The snap valve may be any type of valve providing fully closed or open control of gas flow through the valve. The regulator and snap valves may be referred to as first and second control valves, respectively. Since a small amount of leakage will occur with most types of regulator valves, the fourth passage connection 25 to the outlet port should include the snap valve, which will have no leakage when closed. The snap valve provides full-on or full-off control of the fourth passage. Both the regulator valve 26 and the snap valve 27 are normally closed.

A primary control device, generally indicated by block 28 in FIGURE 1A, provides control for regulator valve 26 and snap valve 27. The primary control device includes a temperature sensitive element 29 and a mechanical control apparatus 30, which can communicate temperature changes to the snap valve and regulator valve. Ideally, the mechanical control apparatus will include a maximum flow control element 31, which regulates the maximum gas flow to the outlet port. This maximum flow control element may also be implemented as a further diaphragm operated gas valve in series with regulator valve 26 as indicated by numeral 32 in FIGURE 1B. Maximum control in the mechanical control apparatus is the preferred method, however.

Primary control device 28 opens snap valve 27 when temperature sensitive element 29 registers a temperature in a small range below the desired temperature. The main valve will subsequently open if the temperature continues drop outside this small range. FIGURE 2 shows an illustration of the temperature/output pressure characteristics of the invention.

Operation of the multi-way valve unit is now described. Initially, it is assumed that temperature sensitive element 29 registers a temperature equal to the desired temperature. At this temperature, the primary control device 28 will not open regulator valve 26 or snap valve 27. Consequently, there will be no gas flow through either third passage 24 or fourth passage 25. The first 11 and second passages 21 will however allow the pressure in the main valve chamber 10 and the bypass valve chamber 20 to equalize with the inlet pressure. Equal pressure on either side of the main 9 and bypass valve diaphragms 19 results in both valves remaining closed. No gas will thus flow when a temperature drop is not registered.

If the temperature drops slightly below the desired temperature, primary control device 28 will open snap valve 27. As a result, the bypass valve chamber 20 and the outlet port 3 are essentially placed at equal pressure. Bypass valve diaphragm 19 will register a pressure drop from inlet port 2 to the bypass valve chamber 20 because second flow restrictor 22 prevents the outlet port 3 or the bypass valve chamber 20 from achieving the inlet pressure. The pressure differential between the bypass valve chamber 20 and the inlet port 2 causes bypass valve 13 to open. Gas will now flow from inlet port 2 to outlet port 3 via bypass conduit 14. Flow control may be modified by altering bypass flow control element 23.

Since snap valve 27 only provides on/off control of fourth passage 25, simple unregulated gas flow is provided to the outlet port in this temperature range.

If the temperature continues to drop, primary control device 28 will eventually open the regulator valve 27. The point at which the regulator valve opens will depend on the minimum usable flow rate for main valve 4. The regulator valve may, for example, be set to open when the gas pressure required to meet the current demand is twice the minimum output pressure of the main valve. For a main valve having 0.3" w.c. minimum output pressure for example, a demand requiring 0.6" w.c gas pressure would cause regulator valve 27 to begin to open. The main valve chamber 10 and the outlet port 3 will consequently approach equal pressure. The main valve diaphragm 9 will register a pressure drop from the inlet port 2 to the main valve chamber 10 because first flow restrictor 12 prevents the outlet port 3 or the bypass valve chamber 20 from achieving the inlet port pressure. This drop will cause main valve 4 to open. Gas will now flow directly from the inlet port 2 to the outlet port 3 via main seat passage 7 in the main valve seat 6. Unlike snap valve 27, regulator valve 26 is capable of temperature regulated control of the gas flow from the inlet port to the outlet port. A continued drop in temperature will thus increase the size of the main valve opening. The main valve will continue to open until outlet port 3 reaches the demanded pressure, or until maximum flow control element 31 prevents further gas pressure increase.

FIGURE 3A shows a bulb operator 40 for controlling the gas valve system. A liquid-filled bulb 41 is sealed from the atmosphere and a bulb passage 42 connects the bulb with a bellows 43 which expands and contracts with changes in temperature. Movement of the bellows causes the distance between a first and second engaging faces, located on opposite sides of bellows 43, to vary with temperature. A first lever 44 having a first end 45 and a second end 46 engages the bellows on one of the engaging faces near first end 45. Temperature changes reflected in bulb 41 are thus communicated to first lever 44 via bellows 43. A thermostat knob 47 contacts the remaining engaging face of bellows 43. The thermostat knob, upon rotation, varies the position of bellows 43 along a direction generally perpendicular to first lever 44.

A pivot point 48 is defined on first lever 44 between the first and second ends thereof. A second lever 49 has a first end 50 and a second end 51. The second end 46 of first lever 44 engages first end 50 of second lever 49. The first and second levers are arranged so that drops in temperature cause the first lever 44 to be urged in a direction away from second lever 49. A spring 52 urges second lever 49 toward first lever 44. As shown in the FIGURE 3A, spring 52 may be utilized as part of a maximum flow adjust means by employing a screw or other means which adjusts the tension of the spring. Second end 51 of second lever 49 engages regulator valve 26 via a spring 53 or other compressible means. Spring 53 absorbs movement of the second lever during the temperature range in which only the snap valve 27 should open. Spring 53 will generally act opposite means internal to the regulator valve 26 which urge the regulator valve closed. The placement of valve 26 and second lever 49 should cause the regulator valve to open when bulb 41 indicates a drop in temperature.

The first lever 44, at a position between second end 42 and pivot point 48, engages a snap element 54 near its first end 55. The first lever may directly engage snap element 54, or may engage the snap element via an adjustment screw, as depicted at numeral 57. The second end 56 of snap element 54 engages snap valve 27a.

As shown in FIGURES 3B and 3C, the snap element 54 of the applicants' invention. The snap element is constructed of three stiff but flexible, parallel members, joined at second end 56 and separate at first end 55. The first end of the outside members are fixed at a first pivot point 58. The first end of the inside member is attached to a second pivot point 59. Second end 56 of snap element 54 attaches to snap valve 27a. The first lever 44, directly or through adjustment screw 57, engages the middle member of snap element 54 at a point near its first end 55. For proper operation, the engaging point must be between the first pivot point 58 and the first end of the middle leg.

The location of the first pivot point 58 should be slightly below a straight line formed from the first end of the middle leg to the second end of the middle leg. The location of the first pivot point 58 should also place a stretching force on the middle leg, and a compressive force on the outside legs, causing the outside legs to bow away from the middle leg.

The mechanical stress in the snap element 54 provides an upward force on the snap valve 27a when the middle leg lies above the first pivot point 58. If on the other hand, the middle leg is bowed by the first lever 44 or the adjustment screw 57 below the first pivot point 58, downward force is applied to the snap valve 27a. Thus, by applying force to the snap element by the first lever or the adjustment screw, the snap element 54 is caused to snap from a rest position, which forces the snap valve 27a closed, to a depressed position in which the snap valve is forced open.

As the bulb operator 40 causes the first lever to rotate in a counter-clockwise direction, this motion is communicated to the snap element 54. If the temperature drops below the desired temperature, the middle leg of the snap element 54 will move below first pivot point 58, causing the second end 56 of snap element to rotate clockwise, thus opening the snap valve. If the temperature rises and the middle leg of the snap element moves above the first pivot 58 point again, the second end 56 of snap element 54 will rotate counter-clockwise, and snap valve 27a will close.

Full operation of primary control device 28 is now described. As the temperature in the monitored space drops, the pressure in bulb 41 drops. The monitored space may for example be a room to be heated. Alternatively, the monitored space may be a water pipe for an on-demand hot water supply system. Bulb passage 42 communicates the pressure drop to bellows 43, causing the bellows to contract. Contraction of the bellows causes the second end 45 of first lever 44 to drop. Initially, this drop forces the middle leg of snap element 54 to bow below first pivot point 58. This in turn causes the second end 56 of snap element 54 to snap downwardly, opening snap valve 27a.

Spring 53 absorbs movement of the first and second levers for small temperature changes, preventing opening of the regulator valve. As the temperature change increases, eventually spring 53 maximally compresses, and regulator valve 26 will begin to open. Once open, the first and second levers 44, 49 transmit the temperature changes reflected in bulb 41 to regulator valve 26 which will also track the temperature changes.

If the temperature change is sufficiently large, second end 46 of first lever 44 may drop enough to disengage from the second lever. Above this temperature, spring 52 will determine the gas flow which reaches the outlet port.

FIGURE 3D shows a second possible mechanical control apparatus for the applicants' invention. In this embodiment, an engaging member 60 replaces the second lever. Referring to FIGURE 3D, engaging member 60 includes first and second spring engaging surfaces, 61 and 62 respectively, and a lever engaging surface 63. The first and second spring engaging surfaces ideally lie parallel to each other, and are situated so that a perpendicular line bisects the midpoint of both surfaces. Spring engaging surfaces 61 and 62 face opposite directions. Lever engaging surface 63 lies generally parallel to the two spring engaging surfaces, and faces the same direction as first spring engaging surface 61. A first spring 64 is compressed between first spring engaging surface 61 and the regulator valve. First spring 53, first spring 64 absorbs movement of the first lever 44 and the engaging member 60 within the temperature range in which only the snap valve should open. First spring 64 will generally act opposite means internal to the regulator valve which urge the regulator valve closed. A second spring 65 presses against second spring engaging surface 62 of the engaging member. Second spring 65 may be compressed by a fixed member, such as a valve housing. Alternatively it may be compressed by a maximum adjustment screw 66. First lever 44, which engages lever engaging surface 63, generally acts against second spring 65, urging regulator valve 26 closed.

Initially, first lever 44 acts against spring 65 to hold the regulator valve closed. When snap valve 27 opens, spring 64 will absorb movement of first lever 44 in the downward direction, initially preventing regulator valve 26 from opening. When the lever 44 moves down sufficiently to maximally compress spring 64, the regulator valve will open. Temperature changes registered by the bulb are thereafter transmitted through the first lever to engaging member 60, causing it to vary the position of the regulator valve, through spring 64. If the temperature drops sufficiently below the desired temperature, the first lever will disengage engaging member 60, and maximum adjustment screw 66 will control flow of gas through the regulator above that temperature.

The invention provides an integrated valve unit capable of controlling unregulated flow at low pressures, and regulated flow at higher pressures.

CLAIMS

1. A valve system providing dual-mode gas flow control having first (4) and second (13) diaphragm valves defining a common inlet port (2) and outlet port (3) for providing gas into and out of the valve system, respectively, the valve diaphragms (9, 19) of said diaphragm valve (4, 13) separating said inlet port from the valve chamber (10, 20) of each diaphragm valve (4, 13), pressure differences from the valve chamber to said inlet port causing actuation of each diaphragm valve, characterized in that:
   a) said second diaphragm valve (13) provides substantially lower gas flow than said first diaphragm valve (4);
   b) a first control valve (26) is connected to the first diaphragm valve chamber (10) of said first diaphragm valve (4), said first control valve, when open, lowering the pressure in the first diaphragm valve chamber sufficient to cause said first diaphragm valve (4) to open, said first control valve being capable of regulated control of pressure in the first diaphragm valve chamber (10);
   c) a second control valve (27) is connected to the second diaphragm valve chamber (20) of said second diaphragm valve (13), said second control valve, when open, lowering the pressure in the second diaphragm valve chamber (20) sufficient to cause said second diaphragm valve (13) to open, said second control valve being capable of only fully opening or fully closing said second diaphragm valve; and,
   d) a primary control means (28) is provided for operating said first and second control valves (26, 27), causing said second control valve (27) to open under moderate gas demand, and causing said first control valve (26) to provide regulated gas flow under heavy gas demand.

2. The valve system of claim 1 wherein operation of said first and second control valves (26, 27) occurs over a continuous supply curve whereby as demand for gas increases from no gas demand to high gas demand, the valve system provides low unregulated pressure during low demand, and high regulated pressure when high demand is reached.

3. The valve system of claim 2 further comprising:
   a) first passage (11, 12) connecting said inlet port (2) to the first diaphragm valve chamber (10), said first passage communicating pressure changes at said inlet port to the first diaphragm valve chamber when said first control valve (26) is regulating, and

causing equalization of pressure at said inlet port (2) and in said first diaphragm valve chamber (10) when said first control valve (26) is closed;

b) a second passage (21, 22) connecting said inlet port (2) to the second diaphragm valve chamber (20), said second passage communicating pressure changes at said inlet port (2) to the second diaphragm valve chamber (20) when said second control valve (27) is open, and causing equalization of pressure at said inlet port and second diaphragm valve chamber (20) when said second control valve (26) is closed;

c) a third passage (24) connecting said first control valve (26) between the first diaphragm valve chamber and said outlet port (3), said third passage causing partial equalization of pressure between the first diaphragm valve chamber (10) and said outlet port (3), said first control valve (26) controlling the degree of regulation therebetween; and

d) a fourth passage connecting said second control valve (27) between the first diaphragm valve chamber (10) and said outlet port (3), said fourth passage causing full equalization of pressure between the second diaphragm valve chamber (20) and said outlet port, said second control valve (27) controlling equalization therebetween.

4. The valve system of claim 1, 2 or 3, wherein said primary control means (28) includes a temperature sensing means (40) for sensing temperature to be communicated to the valve system as an indication of gas demand, and a mechanical control means for communicating the sensed temperature to said first (26) and second (27) control valves, whereby the state of thc control valves reflects differences between the desired temperature and the sensed temperature.

5. The valve system of claim 4 wherein said primary control means (28) includes a maximum flow control means (31) for regulating the maximum gas pressure which can be delivered to said outlet port (3).

6. The valve system of claim 4 or 5 wherein the temperature sensing means (40) comprises a bulb operator including a bulb volume (41) with changes in the bulb volume being communicated to the mechanical control means (31).

7. The valve system of claim 4, 5 or 6, wherein the mechanical control means (31) includes snap means and lever means, the snap means (54) for forcing said second control valve

(27a) to define a fully closed state when there is no gas demand, and to define a fully open state at low or moderate gas demand, and the lever means (44, 49) for causing the first control valve (26) to define a closed state at low or moderate gas demand and to define a regulating state at high gas demand, movement of the snap means and lever means being controlled by the temperature sensitive means (40).

8. The valve system of claim 7, wherein:
   a) said mechanical control means (31) includes a first lever (44) having first (45) and second (46) ends, and a pivot point (48) located between the first and second ends, the first lever contacting the temperature sensitive means (40) at the first end (45), and contacting said snap means (54) between the pivot point (48) and the first end (45) of the first lever;
   b) the mechanical control means also includes a second lever (49) having a first end (50) contacting the second end (46) of the first lever (44), and having a second end (51) in communication with said first control valve (26) whereby temperature changes in the temperature sensitive means are communicated through the first and second levers to said first control valve, and through the first lever and snap means to said second control valve.

9. The valve system of claim 8 wherein the first lever (44) disengages from the second lever (49) when a maximum desired flow is reached.

10. The valve system of claim 8 or 9 wherein the second lever (49) is prevented from causing further opening of said first control valve (26) when a maximum desired flow is reached.

11. The valve system of claim 8, 9 or 10, wherein the second lever (49) engages said first control valve (26) through a spring (53), which absorbs movement of the second lever during periods of low or moderate gas demand.

12. The valve system of one of the preceding claims, comprising flow restrictors (12, 22) connected beween said inlet (2) and said first (11) and second (21) passages, respectively.

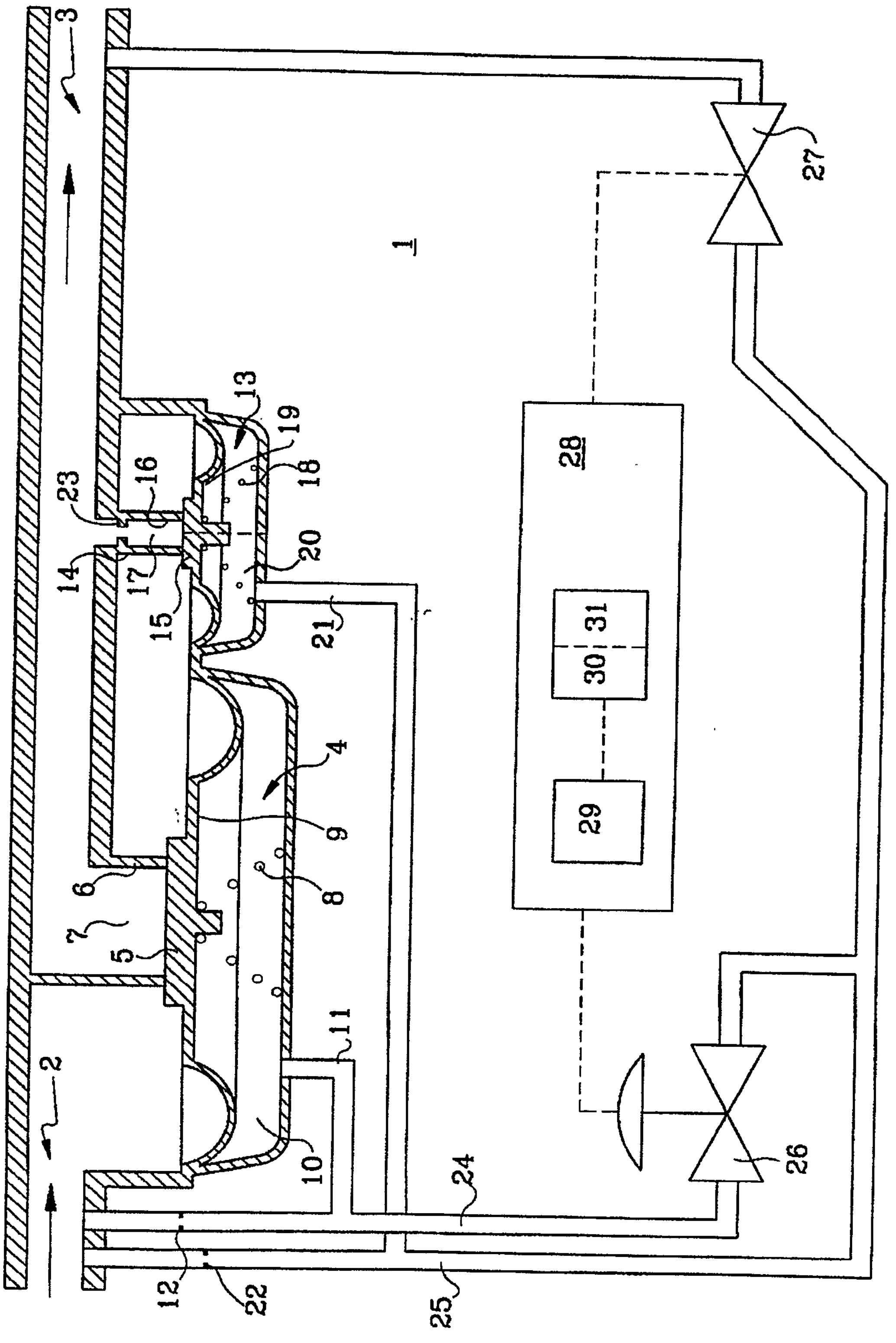
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Fig. 1A

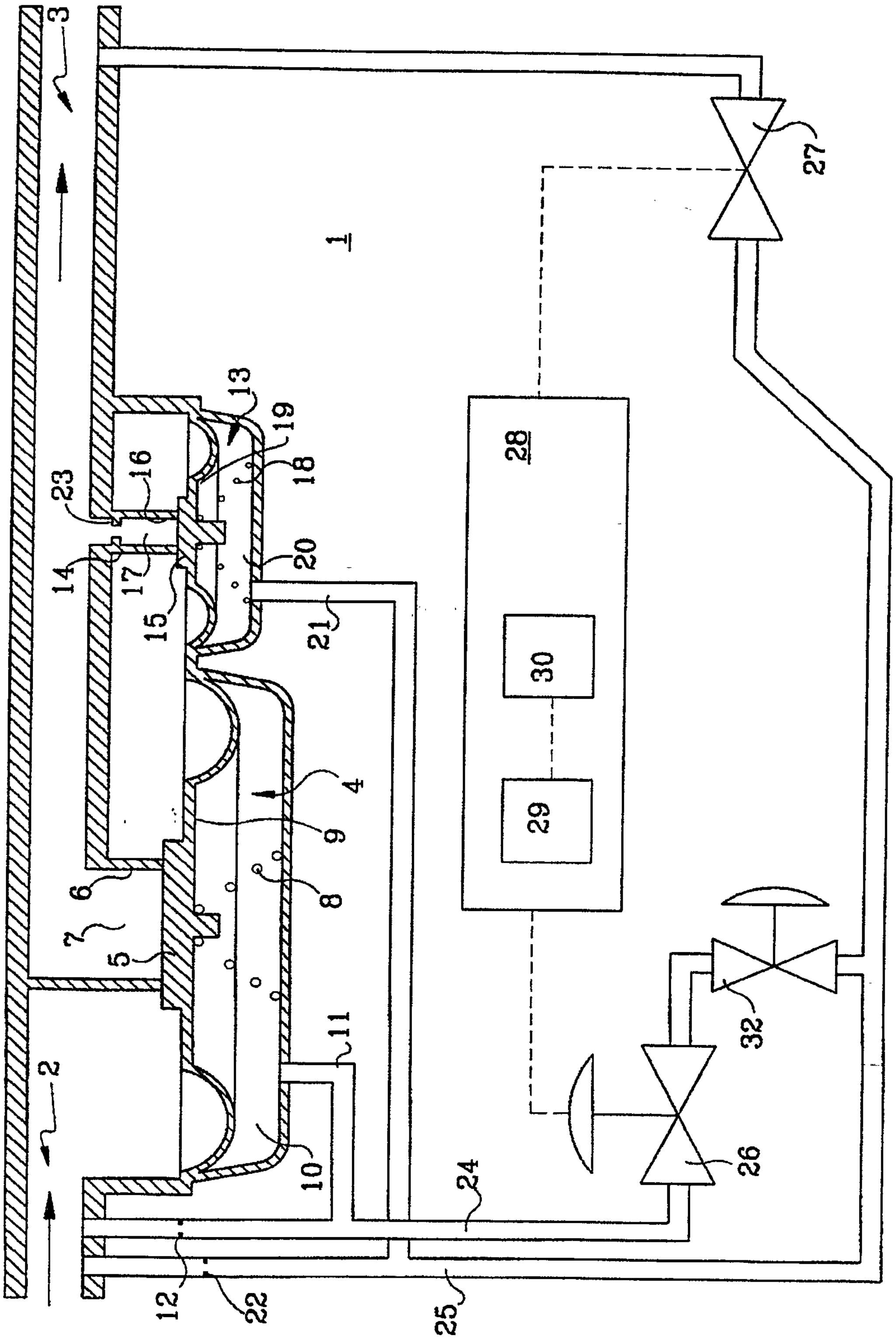
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Fig.1B

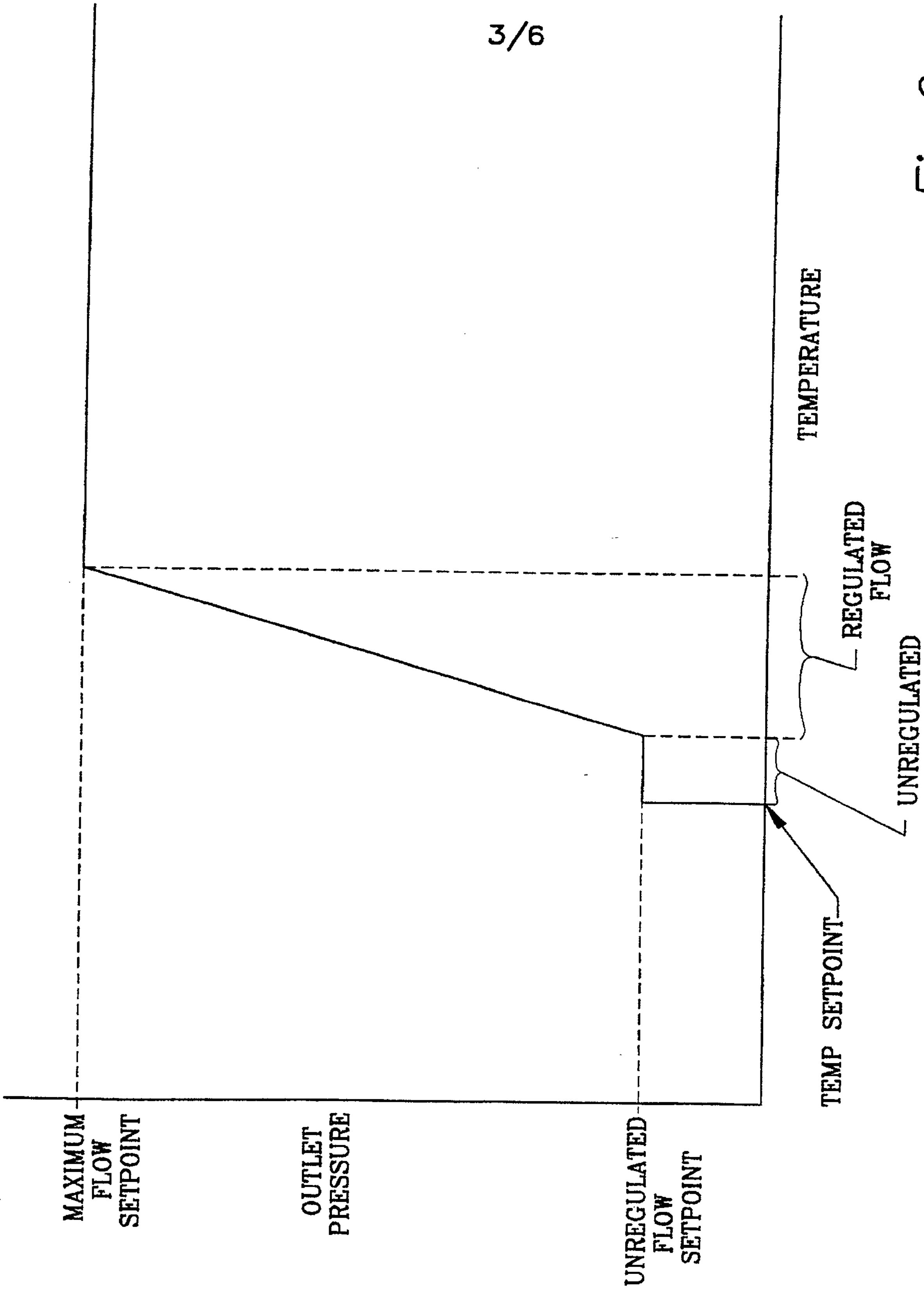

TEMPERATURE
REGULATED FLOW
UNREGULATED FLOW
TEMP SETPOINT
MAXIMUM FLOW SETPOINT
OUTLET PRESSURE
UNREGULATED FLOW SETPOINT

Fig. 2

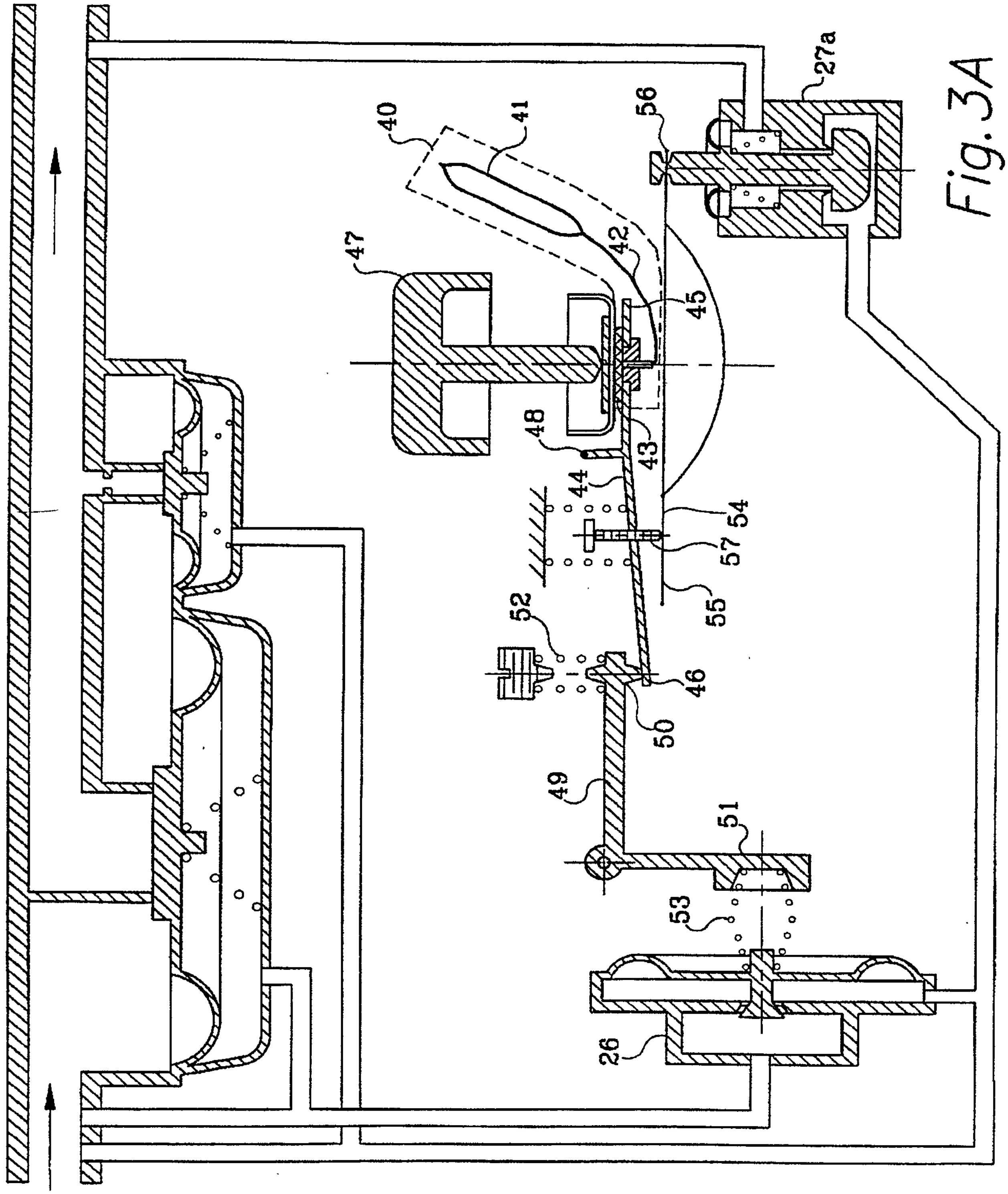


Fig. 3A

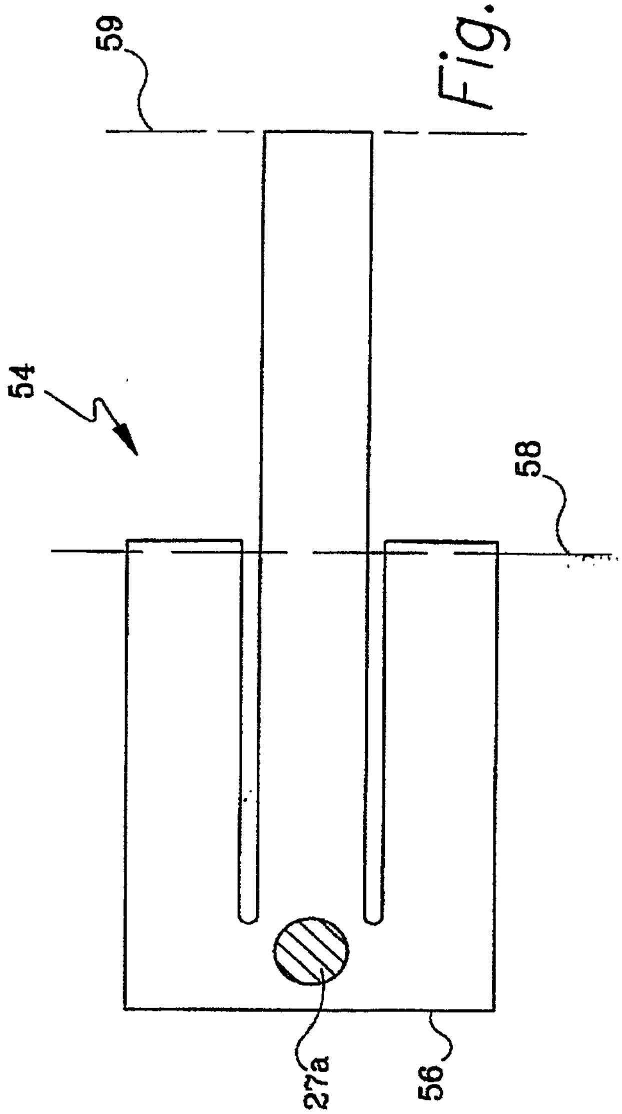


Fig. 3C

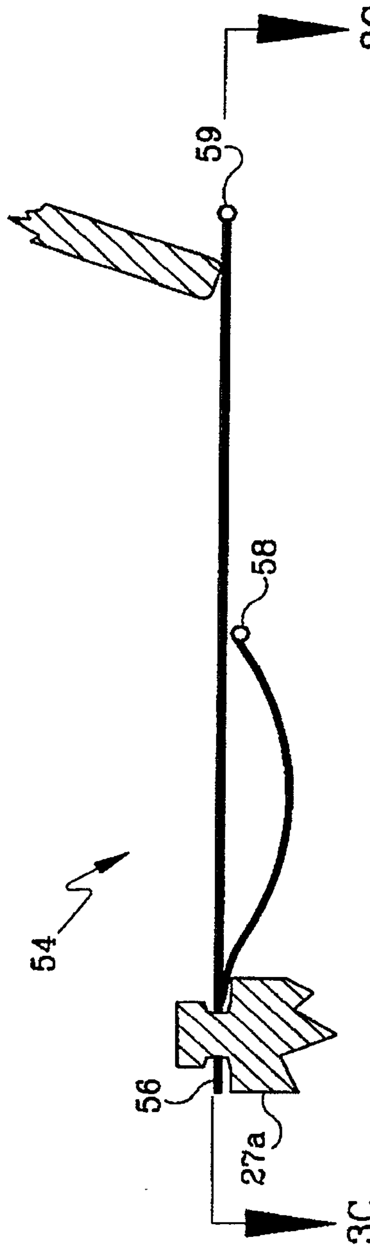


Fig. 3B

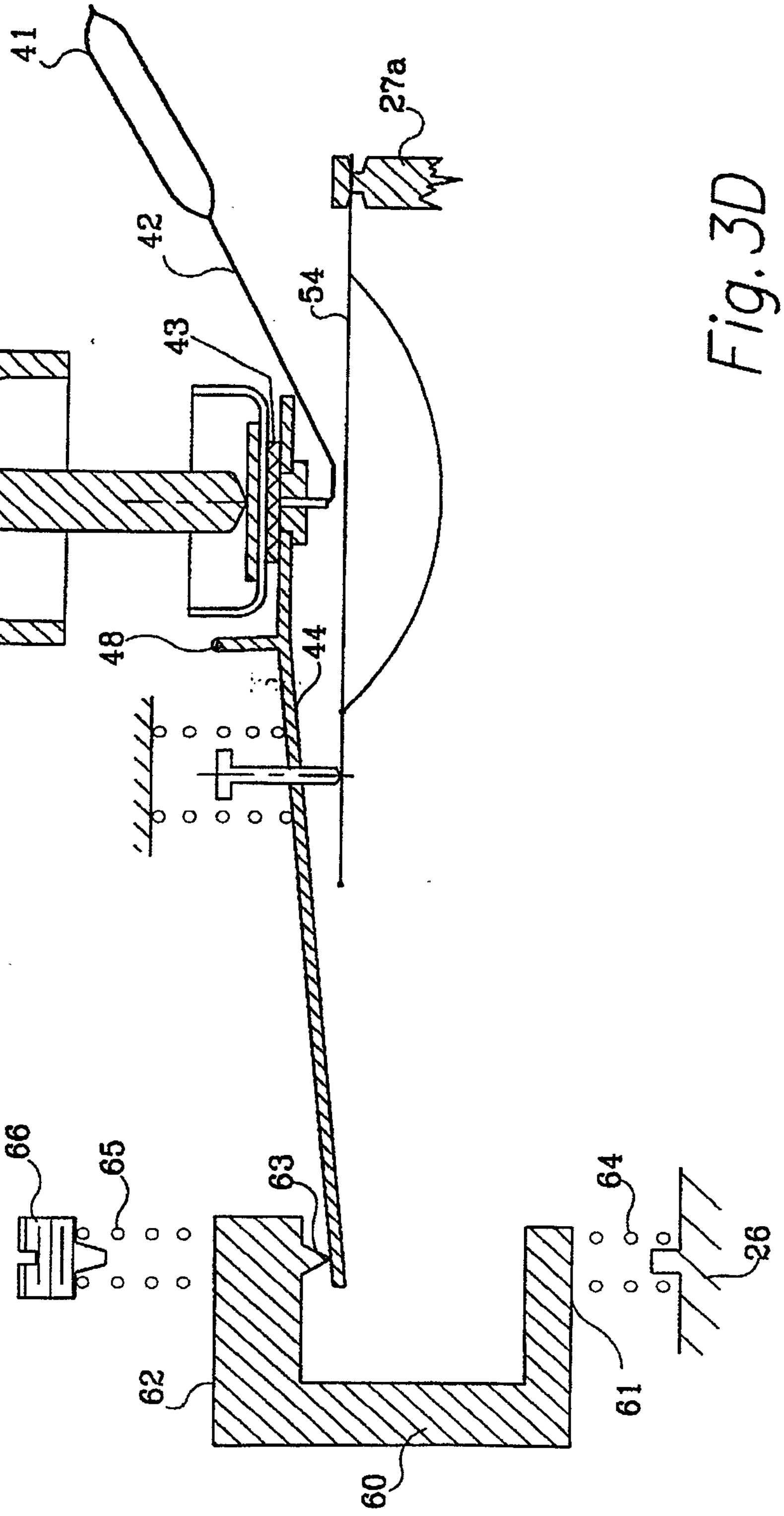
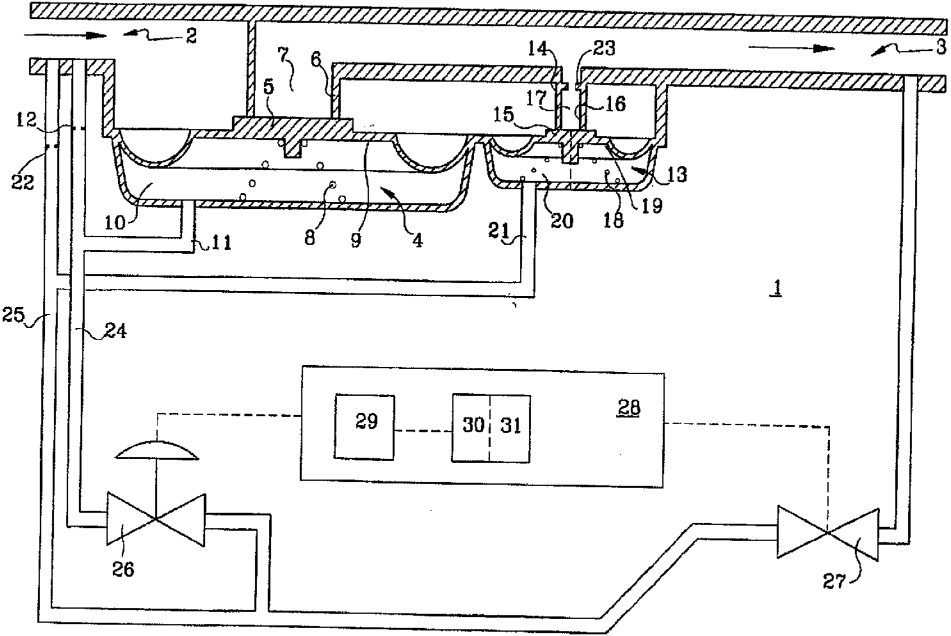


Fig. 3D



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