

[54] **CONTROL OF REFRIGERANT
MIGRATION TO COMPRESSOR
DURING SHUTDOWN**

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[22] Filed: **Oct. 12, 1971**

[21] Appl. No.: **188,132**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 112,942, Feb. 5,
1971, abandoned.

[52] U.S. Cl.62/206, 62/209, 62/215,
62/217

[51] Int. Cl.F25b 41/00

[58] Field of Search.....62/196, 206, 209, 217, 228,
62/215

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[57] **ABSTRACT**

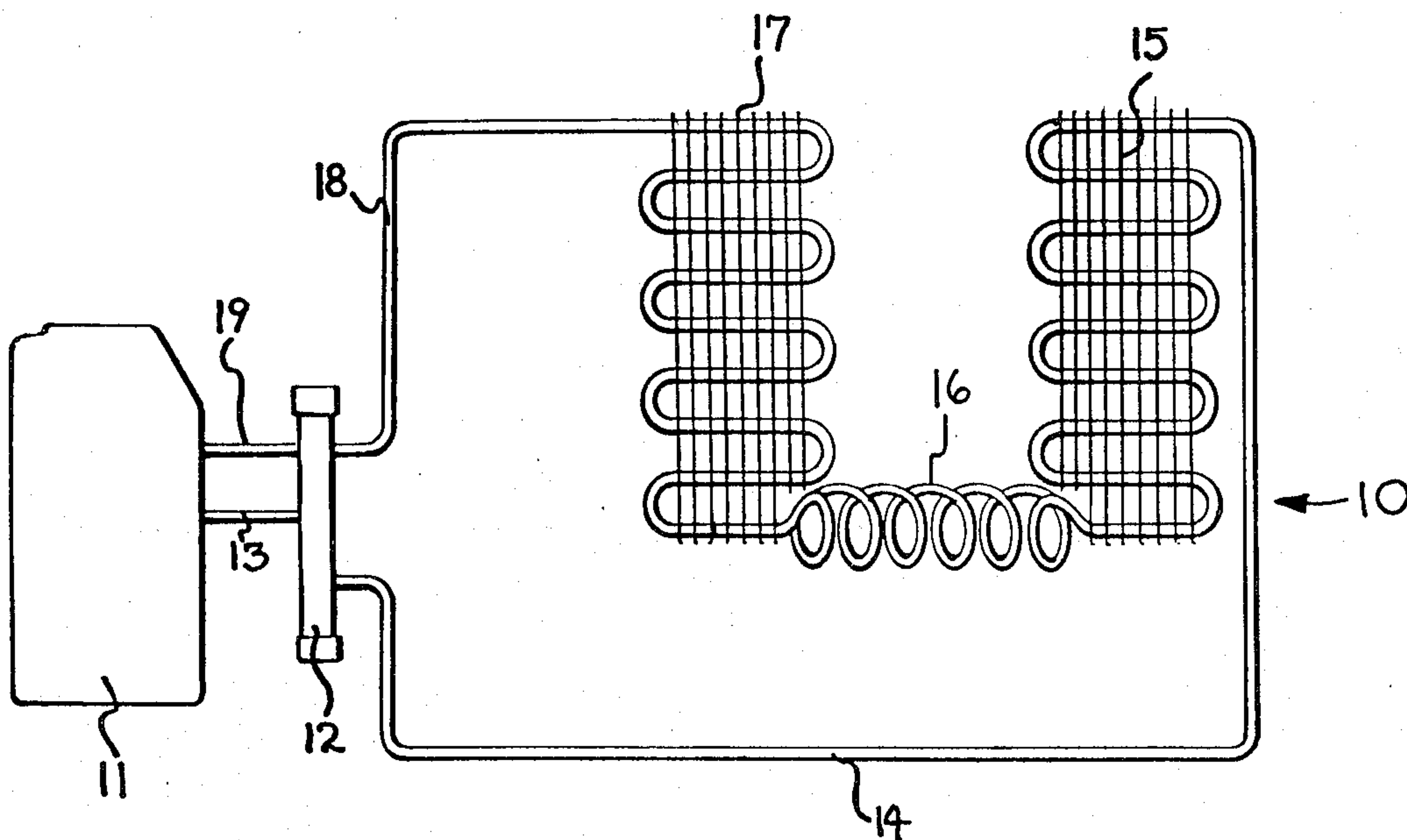
A control of refrigerant migration to the compressor during shutdown in a vapor compressor refrigeration cycle in which a compressor forces the vaporized refrigerant to a condenser from which it passes through an expansion device to an evaporator and then returns to the compressor. The control is such that the head pressure from the compressor opens the passage to the condenser and when the compressor is shut down, such passage automatically closes. Both the inlet to the compressor and outlet from it are automatically opened and closed. Thus, during the shutdown interval the vaporous refrigerant cannot migrate to the compressor.

[56] **References Cited**

10 Claims, 7 Drawing Figures

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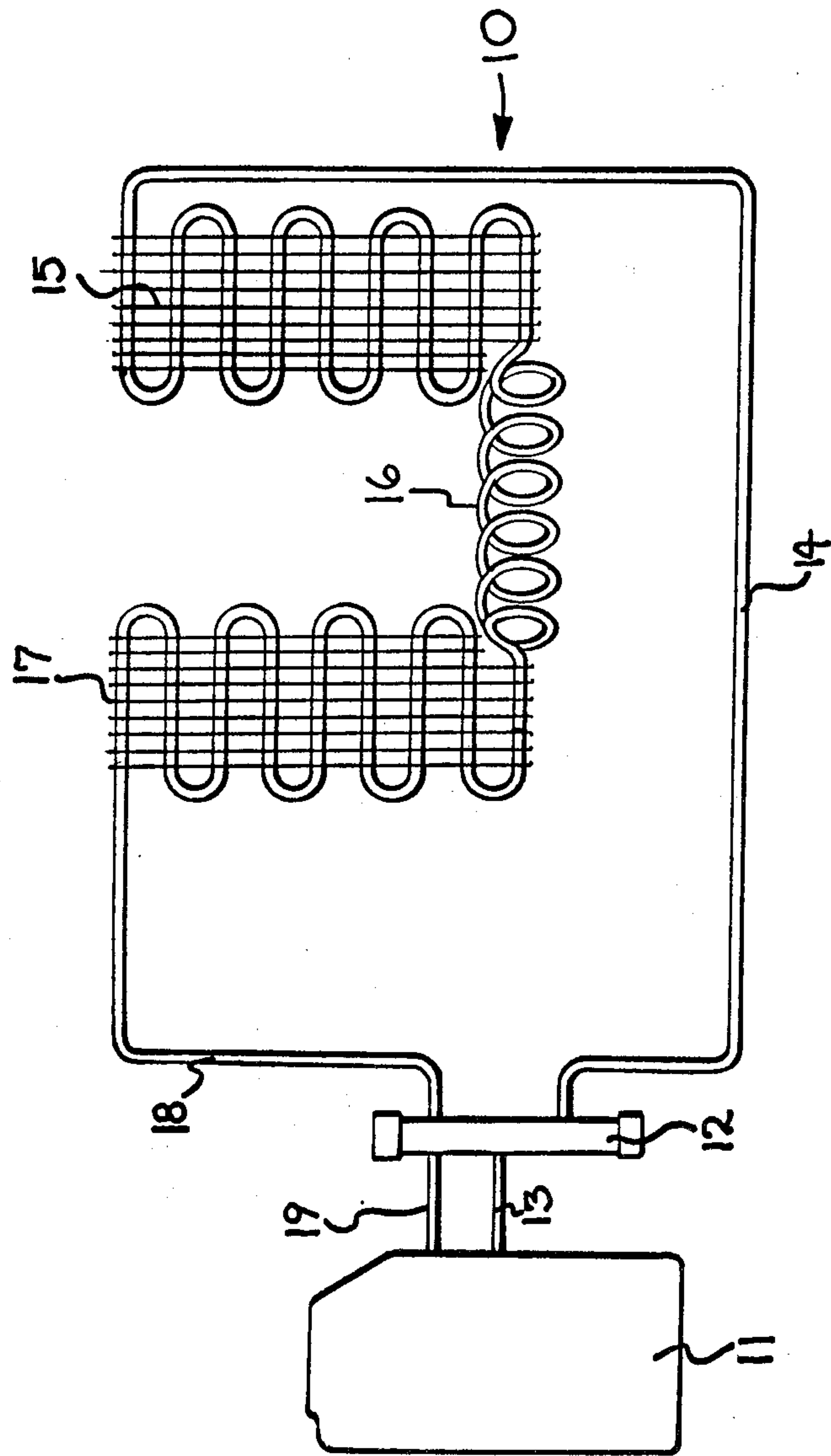
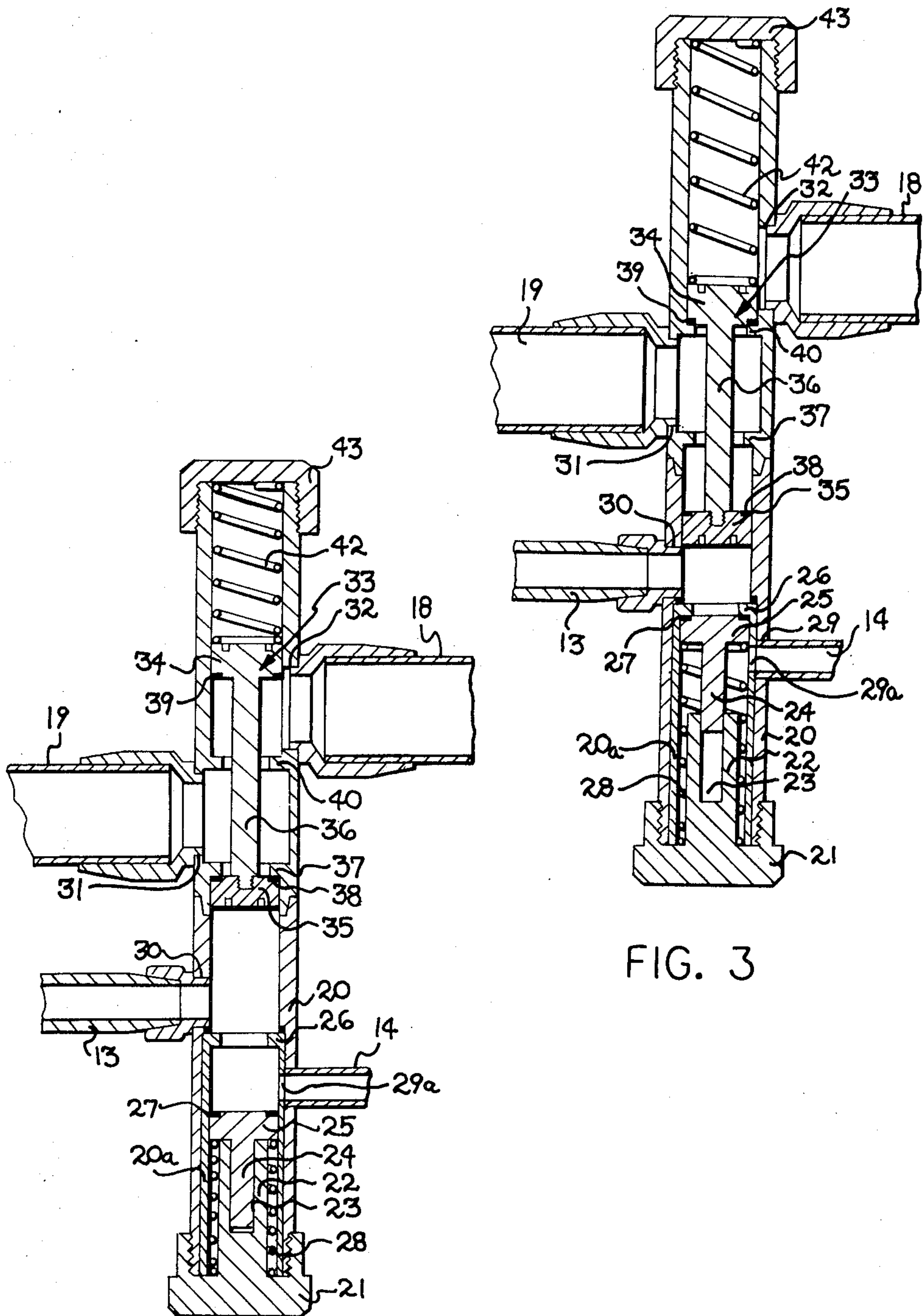


FIG. 1



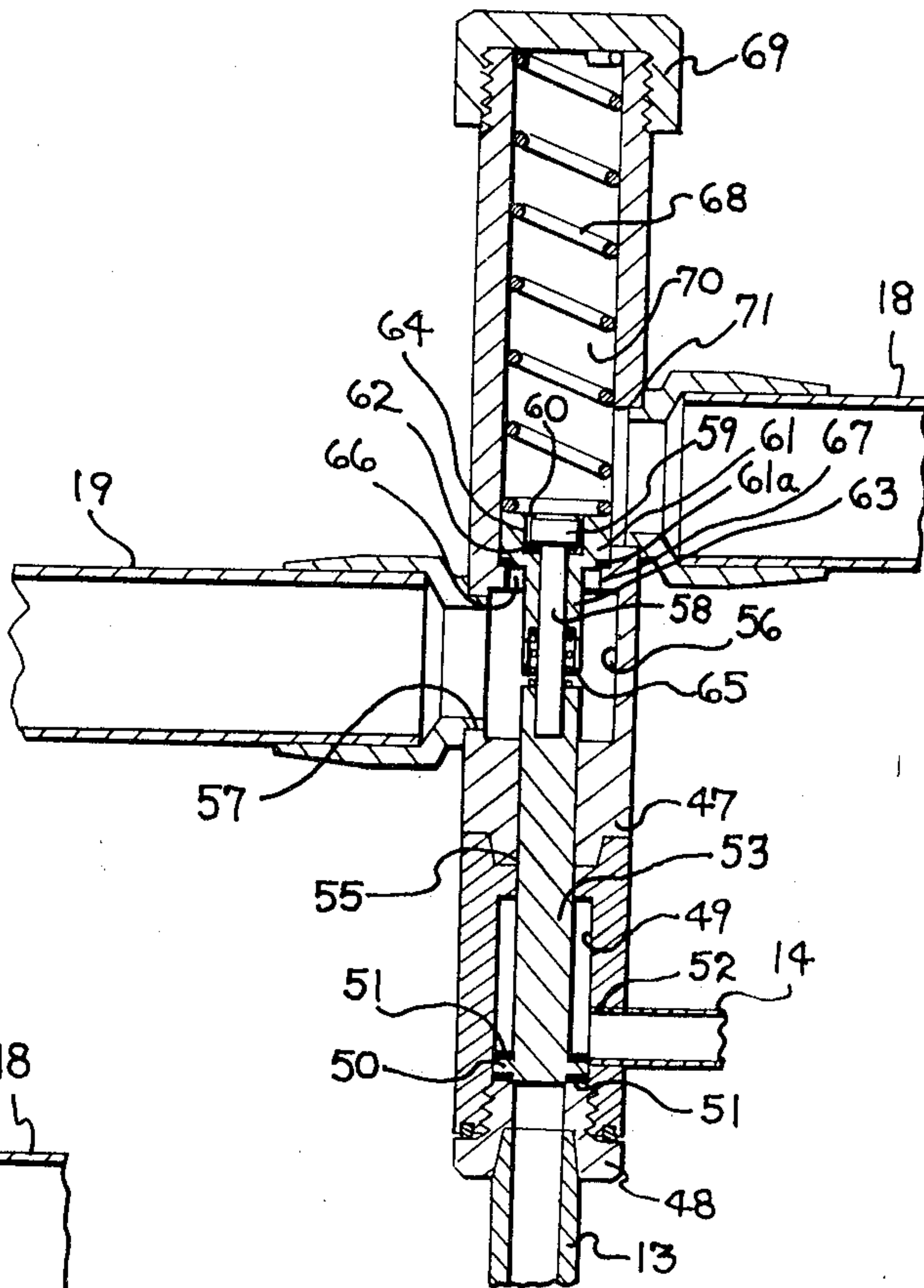


FIG. 4

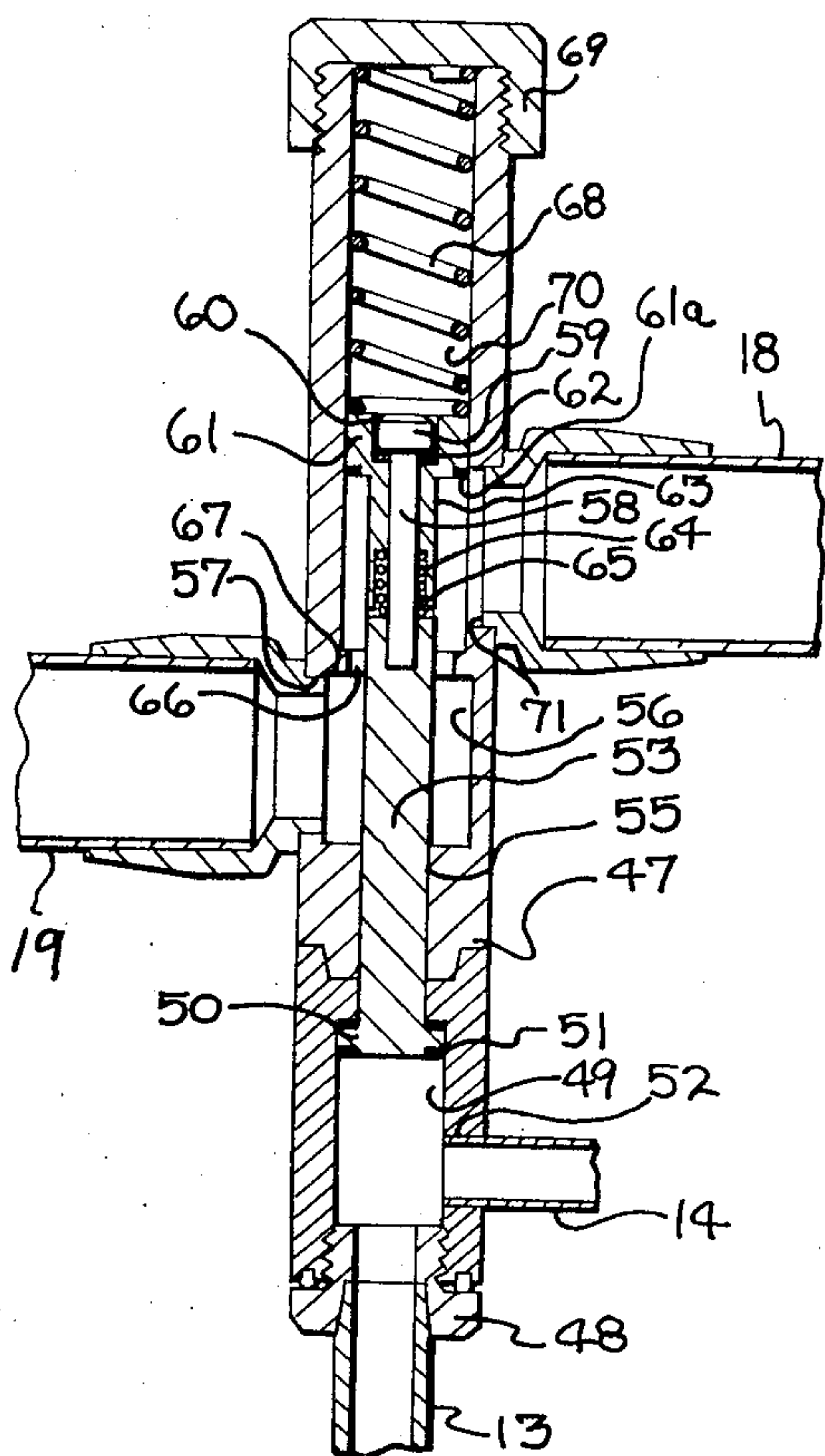


FIG. 5

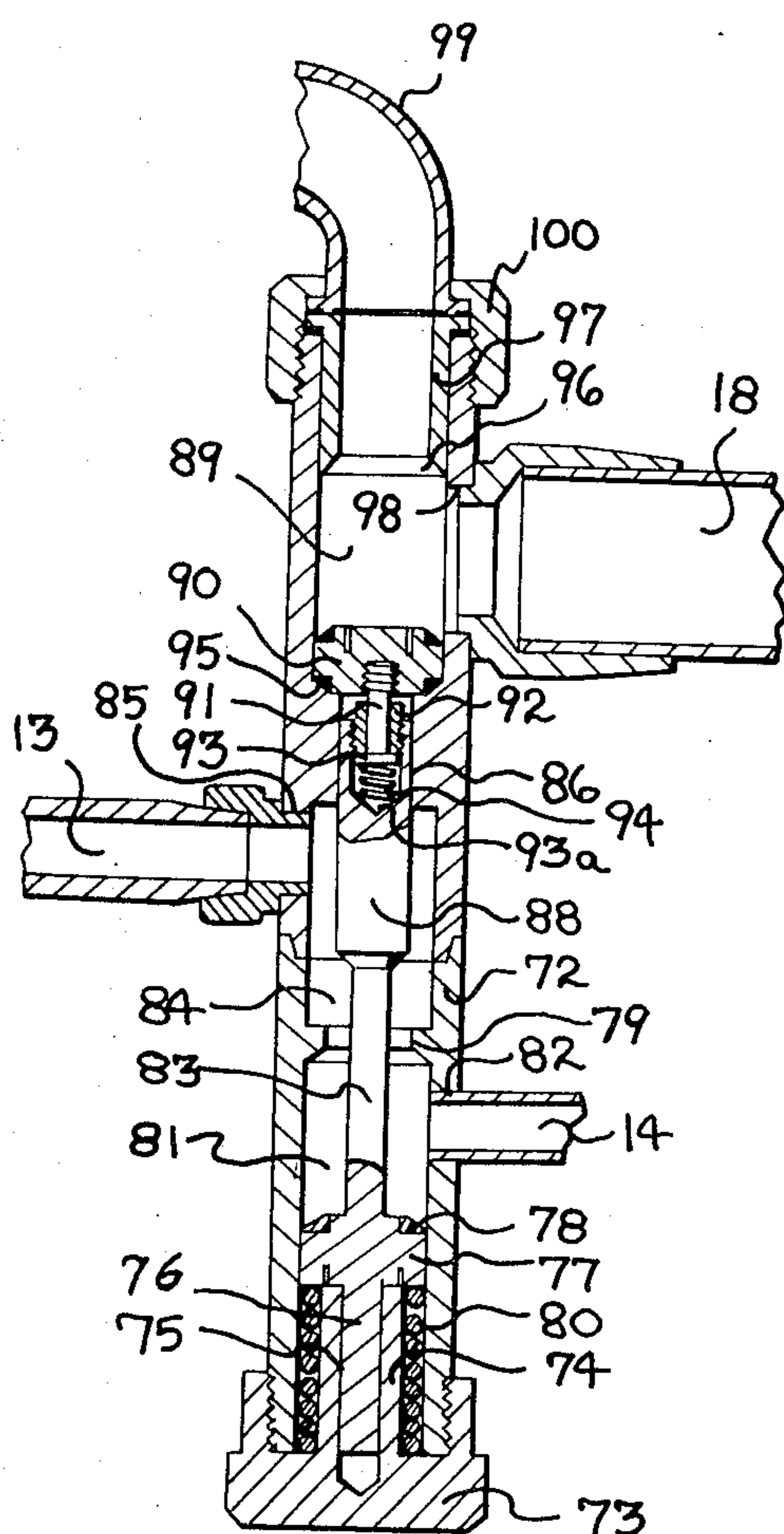


FIG 7

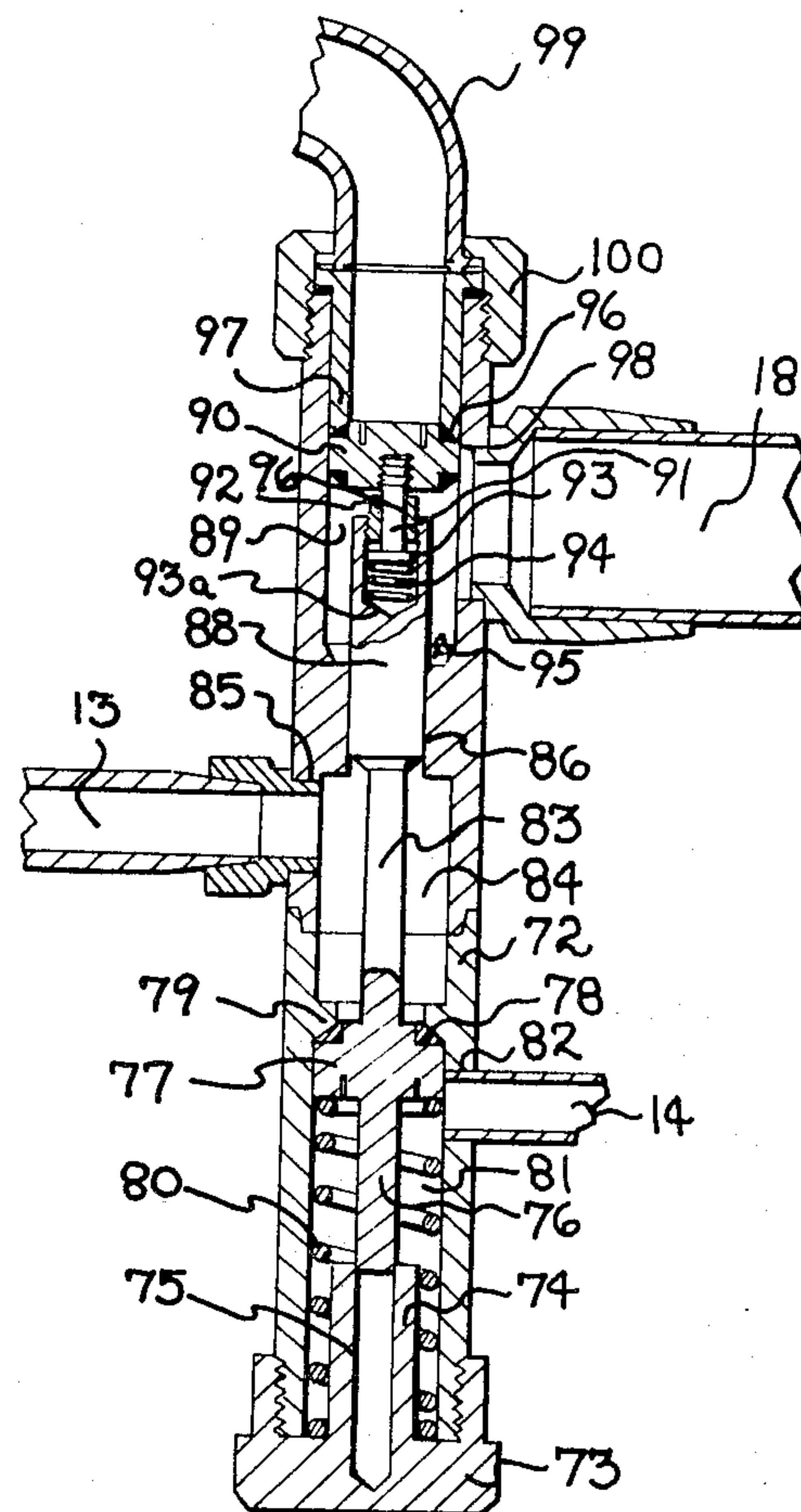


FIG 6

CONTROL OF REFRIGERANT MIGRATION TO COMPRESSOR DURING SHUTDOWN

This application constitutes a continuation-in-part of application, Ser. No. 112,942, filed Feb. 5, 1971, now abandoned, entitled CONTROL OF REFRIGERANT MIGRATION TO COMPRESSOR DURING SHUTDOWN, in the name of Russell T. Smith.

BACKGROUND OF THE INVENTION

Those skilled in the art are familiar with the ideal vapor compressor refrigeration cycle to which this invention relates. Suffice it to say, however, that in such cycle the refrigerant passes from the compressor at a high temperature and high pressure, and in the form of superheated vapor, and, thus, passes to the condenser where it is de-superheated and condensed reversibly at constant pressure. The refrigerant leaves the condenser under high pressure and at medium temperature in the form of saturated liquid, and as such enters the expansion device where the refrigerant is expanded irreversibly adiabatically at constant enthalpy. As it leaves the expansion device, the refrigerant is of relatively low pressure and temperature, and in the form of low quality vapor, and, thus, enters the evaporator where it evaporates reversibly at constant pressure to a dry saturated state and returns to the compressor in this state where it is compressed reversibly isentropically.

In such a cycle when shutdown occurs, the refrigerant migrates to the compressor. The refrigerant, which finds its way to the compressor, condenses and with the oil in the compressor there is an overabundance of liquid so that when the compressor is started, the oil does not have the opportunity to afford proper lubrication, and as a result, costly damage to the compressor parts not infrequently occurs.

SUMMARY OF THE INVENTION

An automatic control for refrigeration and air conditioning systems is provided so that upon shutdown migration of the vaporous refrigerant to the compressor is prevented. When the compressor is started again, free flow of refrigerant is afforded. This is achieved by spring biased valves, which yield when predetermined pressure is built up by the compressor and close when the compressor stops. Thus, in an extremely simple and reliable arrangement, excess refrigerant in the compressor is obviated and costly service problems are greatly reduced, if not entirely eliminated.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of a vapor compressor refrigeration system equipped with the new refrigerant migration control;

FIG. 2 is an enlarged vertical sectional view of the control device shown in FIG. 1 in closed position;

FIG. 3 is a vertical sectional view of the control according to FIG. 2, but with the device in open or operating position;

FIG. 4 is an enlarged vertical sectional view of an alternate form with the control in closed position;

FIG. 5 is a vertical sectional view of the control according to FIG. 4, but with the device open for operation of the system;

FIG. 6 is an enlarged vertical sectional view of a further alternate form with the control in closed position; and

FIG. 7 is a vertical sectional view of the control device according to FIG. 6, but with the control open for operation of the system.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, there is shown a vapor compressor refrigeration system 10 having an electric motor-compressor unit 11, adjacent to which is disposed a refrigerant migration control device 12, although it should be understood that the device 12 is not required to be located in such close proximity to the compressor unit 11. The lower portion of the control device 12 and the motor-compressor unit 11 are connected by an outlet duct 13, and arranged below the outlet duct 13 and leading from the control device 12 is a condenser duct 14 which extends to a condenser 15. The condenser 15 is connected to an evaporator 17 by a suitable expansion device 16, which, by way of example, is in the form of a capillary tube. From the evaporator 17 extends an outlet duct 18 which leads to the upper portion of the control device 12 substantially in alignment with a compressor inlet duct 19, which leads from the control device 12 to the upper portion of the compressor to enable the refrigerant to return to the compressor unit. This invention is of particular use where the condenser 15 is placed remote from the evaporator 17, usually outside of a building where air conditioning is required, but is not restricted to such arrangement. The evaporator 17 may be placed in the plenum chamber of the furnace from which the cooled air is circulated by a blower to the several rooms to be cooled, although in some instances self contained units are employed.

The above refrigeration system, except for the refrigerant migration control device 12, is conventional and well known to those well skilled in this art, so that more detailed description of the operation thereof is not considered necessary. Suffice it to say that when this system is shut down for a period of time, the refrigerant, in vapor state, migrates to the compressor. The amount of or severity of such migration depends on several things, such for example as the size of refrigerant and oil charge, climatic conditions, and the length of the shutdown interval. When shutdown occurs, there is a higher vapor pressure in the evaporator than the compressor. This difference in vapor pressure acts as a driving force for the refrigerant to migrate to the compressor and until the pressures are equalized and saturation has been reached, and even after that where there is a temperature difference. After migrating to the compressor, the refrigerant condenses, so that within the compressor is an overabundance of liquid consisting of condensed refrigerant and oil which is of such magnitude as to make starting up of the compressor difficult and oftentimes damaging. The refrigerant migration control device 12 obviates the difficulty above experienced.

The control device 12, according to FIGS. 2 and 3, comprises an elongate upright two part hollow housing 20, the bottom end of which is closed by a screwed-on closure cap 21. The two parts of the housing 20 are hydrogen braised to form a rigid structure. The cap 21 has an upwardly extending reduced axial extension 22 provided with a socket 23, which is open at its upper end. Reciprocable within the socket 23 is a valve stem 24 which has at its upper end a piston or valve head 25.

Formed in a sleeve 20a, fitting the lower portion of the housing 20, is an annular inwardly extending flange or shoulder 26 against which a sealing washer 27 on the upper end of the valve head 25 is adapted to seat. The sleeve 20a fits snugly against a sealing washer abutting an annular shoulder in the housing 20 and is held in place by the cap 21.

Engaging the underface of the valve head 25 is an helical coil spring 28, the bottom end of which seats against the closure cap 21 and the upper end against the valve head 25 to urge the latter towards the seat on the shoulder 26. Below the shoulder 26 and formed in the housing 20 is a lateral port or opening 29 with which a port 29a in the sleeve 20a registers. The condenser duct or tube 14 above mentioned is secured in the port 29. Above the shoulder 26 and on the opposite side of the housing 20 is a port or opening 30, which receives the adjacent end of the compressor outlet duct 13.

It will be understood that substantially when the underface of the valve head 25 contacts the upper end of the extension 22, the refrigerant gas from the compressor outlet duct 13 passes freely to the condenser duct 14. However, in the normal closed position of the valve 25, no liquid or gas can flow through these ducts since the valve head 25 is held snugly against its seat by the coil spring 28. Thus, sufficient head pressure must be built up by the compressor to unseat the valve 25 before refrigerant gas can flow to the condenser. Also, it will be manifest that when the system is shut down the valve 25 automatically closes and prevents passage of liquid or gas to or from the compressor unit 11. Both opening and closing of the valve takes place slowly and when closed the valve is held to its seat by both fluid or gaseous pressure and spring pressure.

Spaced above the port hole 30 in the housing 20 is a port hole 31 to which the adjacent end of the compressor inlet duct 19 is connected. Opposite the port hole 31 and arranged above it is a port hole 32 to which the adjacent end of the evaporator outlet duct 18 is connected. Disposed within the valve housing 20 and for controlling the flow of refrigerant from the duct 18 to the duct 19 is a valve unit 33 which has an upper head 34. Spaced downwardly from the head 34 is a valve head 35 and the two heads are connected integrally by a reduced neck 36. Within the valve housing 20 and just below the port hole 31 is an annular internal shoulder 37 against which the upper face of the valve head 35 is adapted to seat.

The valve head 35 is equipped with a sealing washer 38 on its upper face to seat against the inward annular flange 37, and the valve head 34 is equipped with a sealing washer 39 on its bottom face to seat against an inward annular flange 40 disposed between the ports 31 and 32. The valve 33 is normally urged to closed position to prevent the passage of refrigerant gas from the duct 18 to the duct 19 by an helical coil spring 42 which bears against the upper end of the valve 34 and the opposite end bears against a closure cap 43 screwed on to the upper end of the valve housing 20.

In operation, when the head pressure created by the compressor 11 is sufficient to compress the spring 28 and shift the valve 25 downwardly, refrigerant gas is allowed to flow from the duct 13 to the duct 14. The head pressure also pushes the valve 33 upwardly, com-

pressing the coil spring 42 sufficiently to enable gas to pass from the duct 18 about the reduced neck 36 to the duct 19. By predetermining the strength or tension of the coil springs 28 and 42, the valve 25 may open before the valve 33, or the valve 25 may open after the valve 33, or the valves 25 and 33 may open simultaneously. One or another of these valve movements will be selected according to operating conditions and the particular refrigerant employed. By causing the valve 33 to open at the same time as or slightly before the valve 25 opens, refrigerant can be drawn into the compressor from the evaporator at the start up and thus militate against a shortage of refrigerant in the compressor at that time. When shutdown occurs, it will be apparent that the coil springs 28 and 42 slowly shift the valves 25 and 33 to their closed positions, thereby overcoming the vapor pressure. The life of the valve seats is prolonged because of the relatively slow closing movement of the valves. Both valves are urged against their seats by the combined spring and gas refrigerant pressures.

It will be observed that the valve head 35 has a free fit with the walls of the housing 20 so that gas can pass from one side to the other in restricted manner, thereby equalizing the pressure on opposite sides of the valve head 35 in its lower position. When the compressor starts up, the only pressure required for valve unseating is that which will compress the respective coil springs.

The alternate form of the invention shown in FIGS. 4 and 5 comprises a two part hydrogen braised valve housing 47 which is similar to the valve housing 20 above described. It is shown in vertical position, and may be arranged, although not necessarily, in close juxtaposition to the motor compressor unit 11. In this instance, the lower end of the housing is internally threaded to receive a threaded end cap 48, which is axially apertured to receive the adjacent end of the compressor duct 13. The end cap 48 opens into a chamber or socket 49 in the valve housing, in which a piston-type valve head 50 is reciprocable, the latter having sealing washers 51 on opposite faces to provide sealing engagement respectively with the upper end of the sealing cap 48 and the upper end of the chamber 49. In the lower end portion of the chamber 49 is a lateral port 52 for the reception of the adjacent end of the condenser duct 14. Thus, when the piston head 50 is in its upper position, gas can pass through the duct 13 from the compressor into the chamber 49 and out from it through the duct 14.

The valve head 50 has an integral elongate stem 53, which extends slideably through a passage 55 in the valve housing, the upper end terminating in a chamber 56. From the chamber 56 extends a lateral port 57 which receives the adjacent end of the compressor inlet duct 19. Fixed to the upper end portion of the valve stem 53 is a pin 58 which projects upwardly in alignment with the center of the valve stem, and terminates in the head 59 which fits within a socket 60 formed in a valve head 61. The valve head 61 has on its lower face a sealing washer 61a, and an O-ring 62 encircles the pin 58 beneath the head 59 for providing a fluid seal. On the pin 58 is a sleeve 63, which is integral with the valve head 61. The lower end of the sleeve 63 is recessed at 64 to receive an helical coil spring 65, the outer end of which bears against the upper end of the valve stem 53.

Slightly above the lateral port 57 of the valve housing is an internal annular shoulder 67. The valve head 61, through the washer 61a, seats against the upper face of the shoulder 67, and urging the valve 61 to its seated position against the shoulder 67 is an helical coil spring 68, the upper end of which bears against a screwed-on cap 69 which closes the upper end of the valve housing. The opening 66 formed by the inner periphery of the shoulder 67 provides the opening from the chamber 56 to an elongate chamber 70 in which the coil spring 68 is arranged. Leading from the chamber 70 above the shoulder 67, and on the side of the valve housing opposite to the lateral port 56, is a lateral port 71 which receives the adjacent end of the evaporator duct 18.

In the operation of the control device shown in FIGS. 4 and 5, it will be apparent that when sufficient head pressure is built up by the compressor 11 against the underside of the valve head 50, the valve head 50 is forced upwardly compressing the spring 68 and uncovering the lateral port 52 to enable the gas to pass from the duct 13 to the duct 14. The valve head 61 uncovers the opening 66 enabling gas to flow from the duct 18 through a portion of the chamber 70 to the chamber 56 and then to the duct 19.

When the compressor 11 is shut down, the coil spring 68 is then able to shift the valve assembly downwardly so that the valve head 50 prevents communication between the ducts 13 and 14, and the valve head 61 closes the passage from the duct 18 to the duct 19. The lost motion made possible by the coil spring 65 insures the seating of the valve head 61 against its seat and the force of the coil spring 68 is transmitted to the valve stem 53 through the sleeve 63 and coil spring 65. The valve opening and closing movements are substantially simultaneous. Note that gas can flow from chamber 49 to 56 since there is no seal for the stem 53.

Another alternate form of the invention is shown on FIGS. 6 and 7, and this form bears a close similarity to that shown on FIGS. 4 and 5. As shown, there is an elongate two part hydrogen braided cylindrical valve housing 72, the lower end of which is closed by a screwed-on cap 73, which is formed on the inside with an upwardly extending axial extension 74 providing a socket 75. Reciprocable in the socket 75 is a valve stem 76 having at its upper end an integral valve head 77, the upper face of which is provided with a sealing ring 78. The sealing ring 78 is adapted to seat gas tightly against an integral annular shoulder 79 within the housing 72. An helical coil spring 80 bears respectively against the cap 73 and the valve head 77 to urge the latter to its seat. The valve head 77 is reciprocable within a chamber 81, which is provided near the shoulder 79 with a lateral port 82 for the duct 14.

Integral with the upper end of the valve head 77 is a stem extension 83 which extends through a chamber 84 in the valve housing. Near the upper end of the chamber 84 is a lateral port 85, on the side of the upper valve housing section opposite to the port 82. The lateral port 85 accommodates the duct 13 leading from the outlet of the compressor.

It will be manifest when the gaseous pressure from the compressor is sufficient to overcome the force of the coil spring 80, that the valve head 77 is shifted downwardly to permit gaseous fluid to pass from the duct 13 through the chamber 84 and to the condenser

through the duct 14. When the pressure is reduced so that the coil spring 80 can overcome the same, the valve head 77 will be shifted upwardly to its seat on the shoulder 79.

Leading from the upper end of the chamber 84 is a restricted guide channel 86 for slideably receiving a cylindrical guide extension 88, which is integral with the upper end of the stem extension 83. The guide extension projects into a chamber 89 in which a valve head 90 has a sliding fit for vertical reciprocation, there being sealing faces at the upper and lower ends of the valve head. The valve head 90 has a depending axially arranged stem 91, which has vertical movement in a guide sleeve 92 secured to the upper end of the guide extension 88. On the lower end of the stem 91 is an integral head 93, which is slideable in a socket 93a. Within the socket 93a is an helical coil spring 94, which bears against the head 93 at one end and at the bottom end of the socket at the opposite end. The lower sealing face of the valve head 90 is adapted to bear against a seat 95 formed in the lower end of the chamber 89. An upper valve seat 96 for the valve head 90 is formed on the bottom end of a sleeve 97, which is flanged at its upper end.

On the same side of the valve housing 72 as the port 82 and in the upper valve housing section, and leading from the chamber 89, is a lateral port 98, which accommodates the duct 18 leading from the evaporator. It will be seen that when the fluid pressure from the compressor is sufficient to shift the valve head 77 against the force of the spring 80 to uncover the duct 14, the valve head 90 will be moved downwardly through the connections, and in the manner hereinbefore described. When the compressor is shut down, the valve heads 77 and 90 are moved to their seats by the spring 80.

Cooperating with the flanged sleeve 97 is a flanged curved tube 99, and the flanges of the tube 99 and the sleeve 97 are tightened together by a collar 100, which is in screw threaded engagement with the upper end portion of the valve housing 72. The curved tube 99 receives the duct 19 as above described which extends to the upper end of the compressor.

It will be clear from an examination of FIG. 7 that when the valve head 90 is in its lower position against the seat 95, there is a free and unrestricted passage of refrigerant fluid from the evaporator to the compressor. The valve opening and closing movements as described in connection with the form shown in FIGS. 4 and 5, obtain with respect to this form.

It is to be understood that the above is by way of illustration and not limitation, and numerous changes in details of construction, arrangement, and choice of materials may be effected without departing from the spirit of the invention, especially as defined in the appended claims.

What I claim is:

1. In a vapor compressor refrigeration cycle having a refrigerant compressor, a condenser, an evaporator, an expansion device interposed between the condenser and evaporator and in communication therewith, and duct connections from the compressor to the condenser and from the evaporator to the compressor respectively, the improvement comprising a control for militating against migration of vapor refrigerant to said

compressor during shutdown, said control including a valve device entirely housed in a single casing for controlling refrigerant flow, operative connections respectively between said valve device and the duct connection from the compressor to the condenser and the duct connection from the evaporator to the compressor, and automatic means for normally retaining said valve device in closed position preventing refrigerant passage through either of said duct connections and operative selectively to effect opening and closing of said respective duct connections in a predetermined manner, said valve device being shiftable to open position in response to predetermined head pressure generated by said compressor for enabling refrigerant flow through its cycle during operation of the system.

2. The organization as claimed in claim 1, in which said valve device comprises a spring biased valve means interposed in each of said duct connections arranged to be unseated by head pressure.

3. The organization as claimed in claim 2, comprising means by which said valve means are seated and unseated successively.

4. The organization as claimed in claim 1, in which said valve device comprises a hollow housing, opposite end portions of which are in communication with said duct connections respectively, and interconnected spring biased valves shiftable in said casing for controlling gas flow through said duct connections and adapted to seat and unseat successively.

5. The organization as claimed in claim 4, in which said hollow housing is mounted in close juxtaposition to the compressor.

6. The organization as claimed in claim 1, in which said valve device comprises a hollow housing, a duct connection leading from the compressor to said housing, a duct connection adjacent said first duct and connection and leading from said housing to said condenser, a spring biased valve in said housing normally seated to close the passage from the compressor to the condenser but shiftable to open position in response to pressure from the compressor, a duct connection leading from the evaporator to said housing, a duct connection adjacent said last duct connection leading from

said valve housing to the compressor, a second spring biased valve shiftable in said valve housing for controlling said last two duct connections for recurrently placing them in communication with each other and placing them out of communication, and means to cause said valves to open and close, whereby said second spring biased valve opens and closes slightly in advance of or simultaneously with said first valve, or subsequent to said first valve.

7. The organization as claimed in claim 6, comprising passage means enabling the gaseous pressures between said valves to equalize when said valves are in closed position.

8. The organization as claimed in claim 1, comprising a valve member for each pair of ducts separate and distinct from each other and each arranged for actuation in response to gaseous pressure fluid from the compressor, and a spring individual to each valve for normally urging same to its seat.

9. The organization as claimed in claim 1, in which said valve device comprises a tubular housing, a duct connection leading from the compressor to said housing, a duct connection adjacent said first duct connection and leading from said housing to said condenser, a valve in said housing normally seated to close the passage from the compressor to the condenser but shiftable to open position in response to pressure from the compressor, a duct connection leading from the evaporator to said housing, a duct connection adjacent said last duct connection leading from said valve housing to the compressor, a second valve shiftable in said valve housing for controlling said last two duct connections for recurrently placing them in communication with each other and placing them out of communication, a connection between said valves enabling same to shift at about the same time, and spring means for said valves of such strength as to predetermine desired opening interval.

10. The organization as claimed in claim 9, in which said second valve includes a spring tensioned lost motion connection for insuring gas tight seating thereof when shifted to closed position.

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