United States Patent [19]
Smith
[11] 3,722,228
[45] Mar. 27, 1973

[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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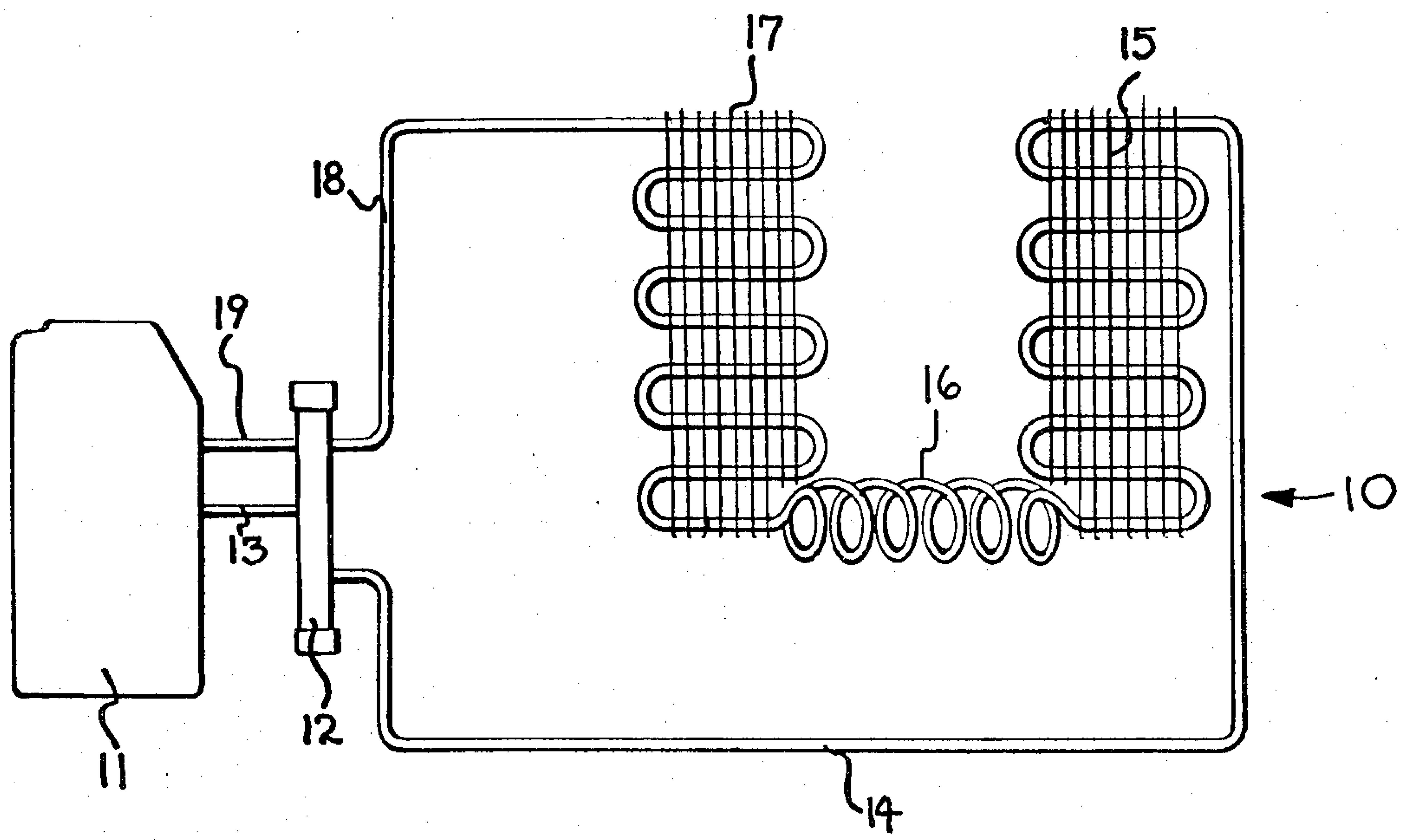
Primary Examiner—Meyer Perlin
Attorney—Malcolm W. Fraser

[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.

10 Claims, 7 Drawing Figures



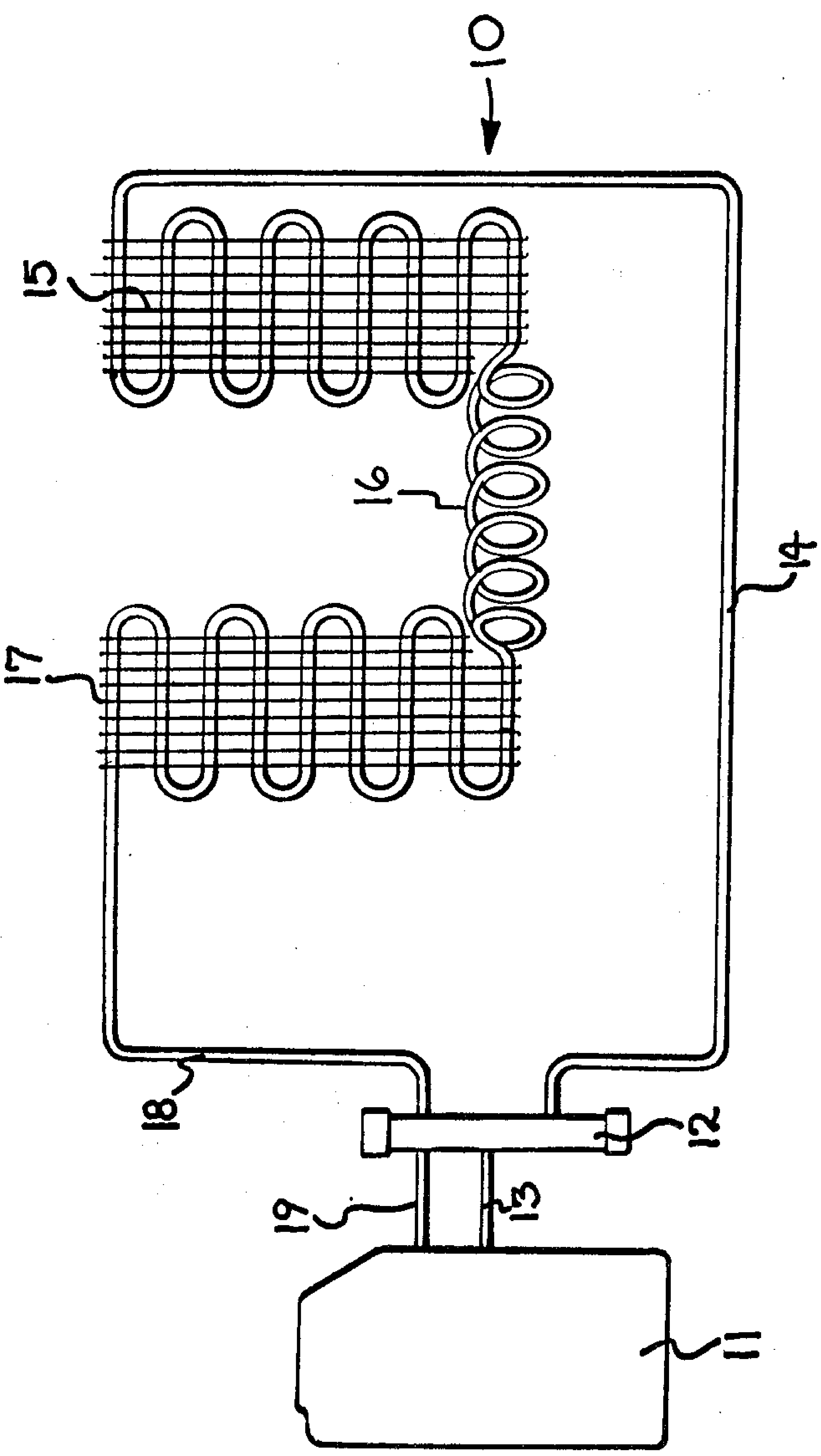


FIG. 1

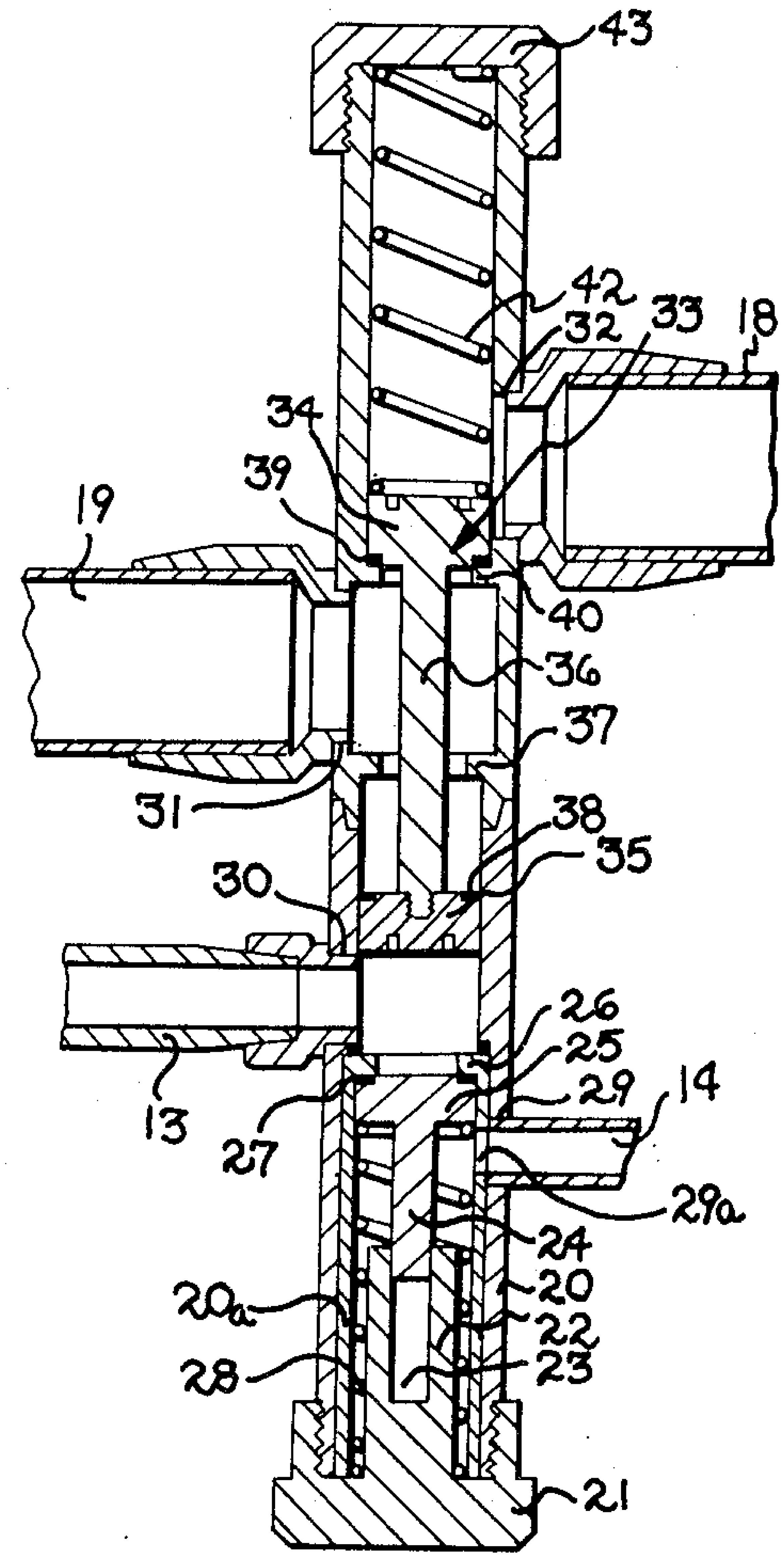

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FIG. 3

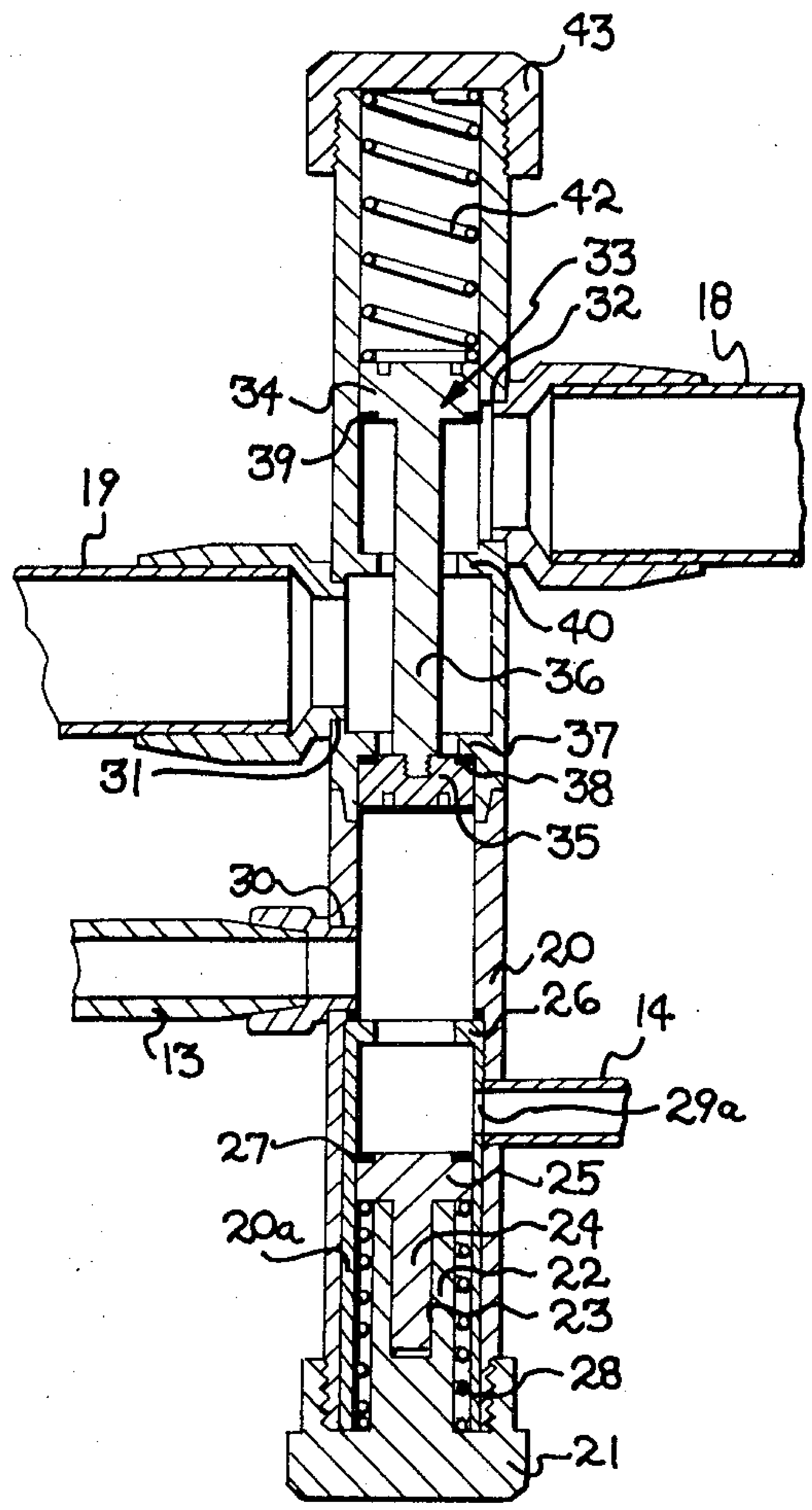
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FIG. 2

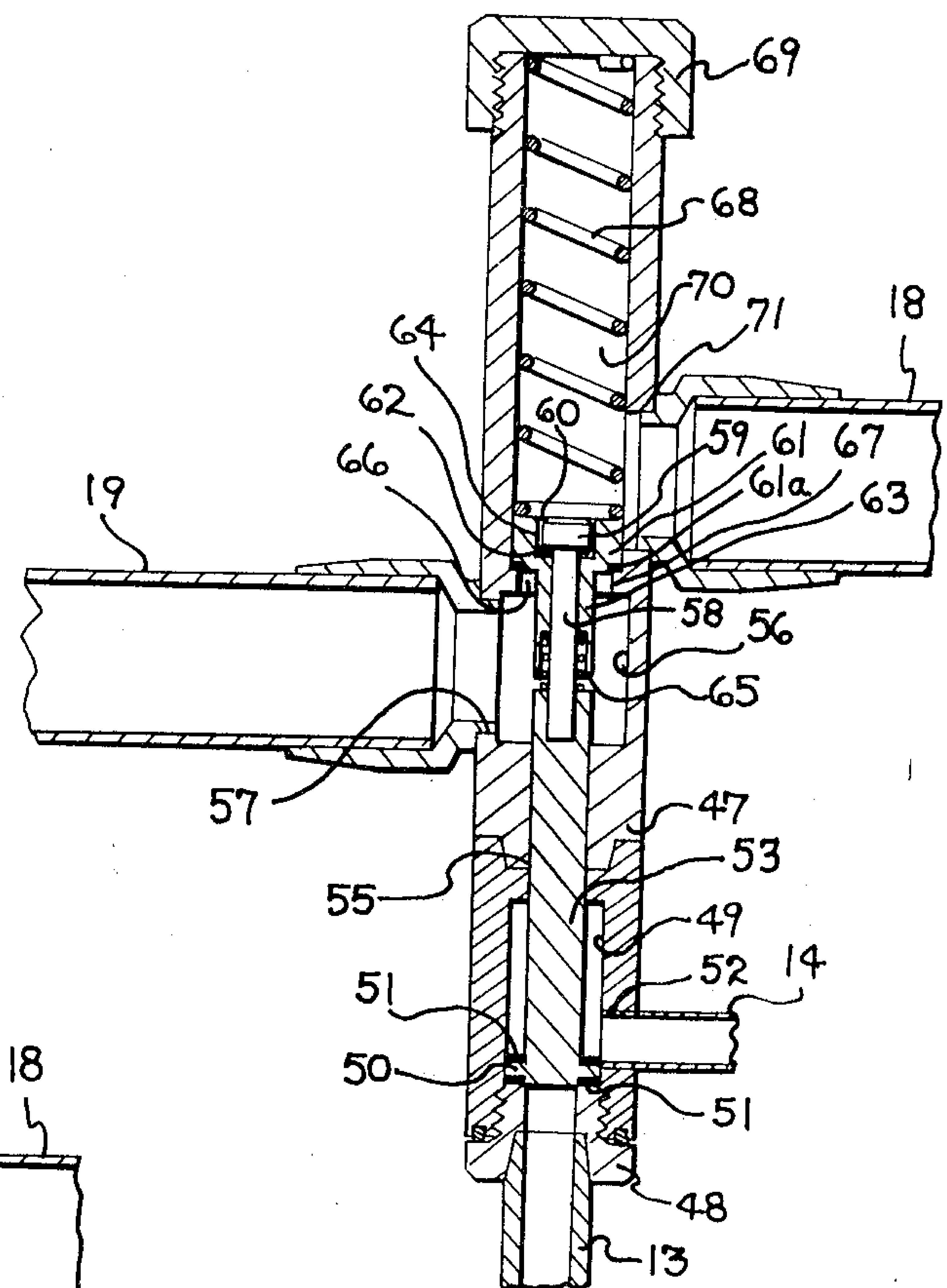
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FIG. 4

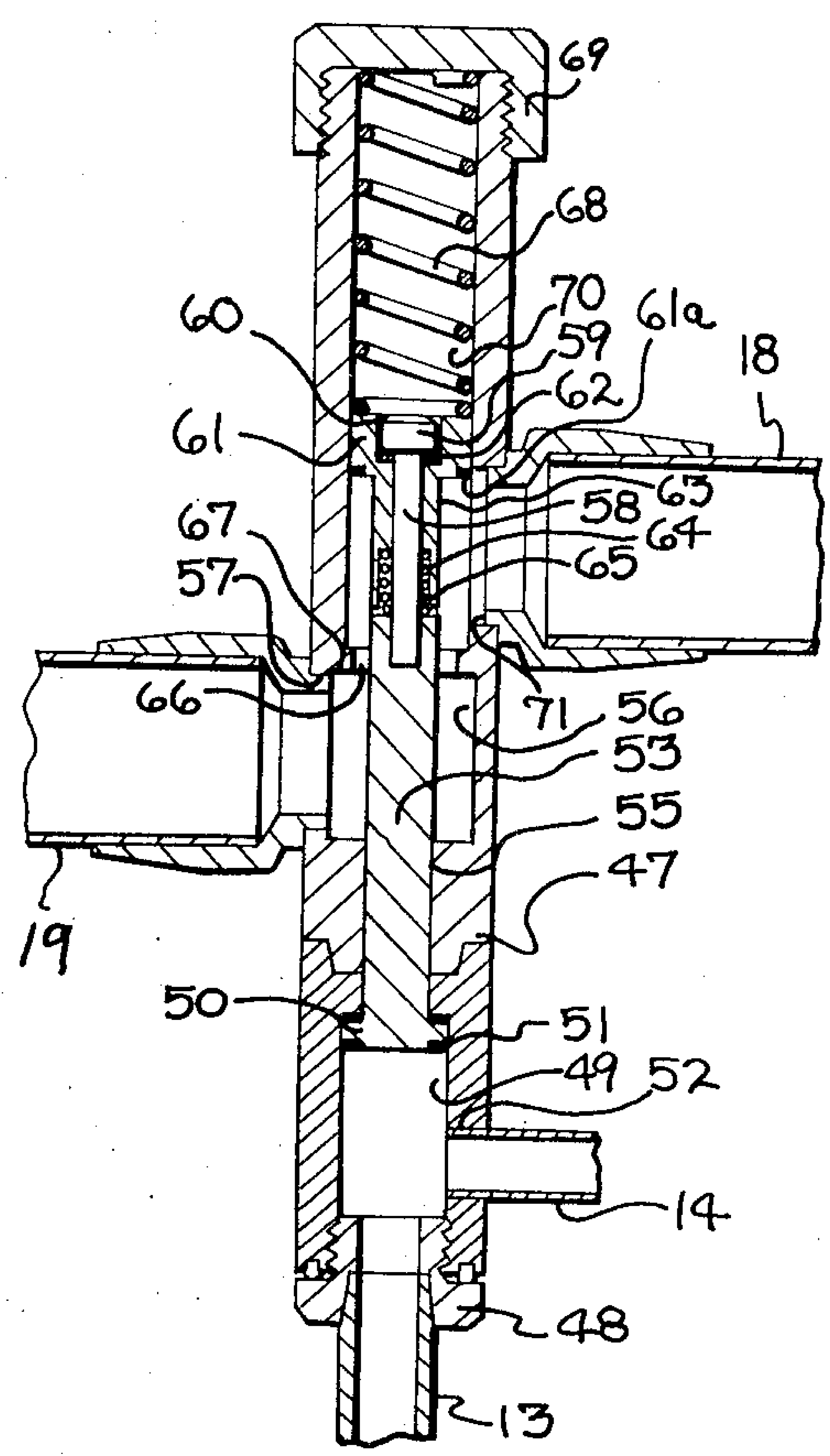
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FIG. 5

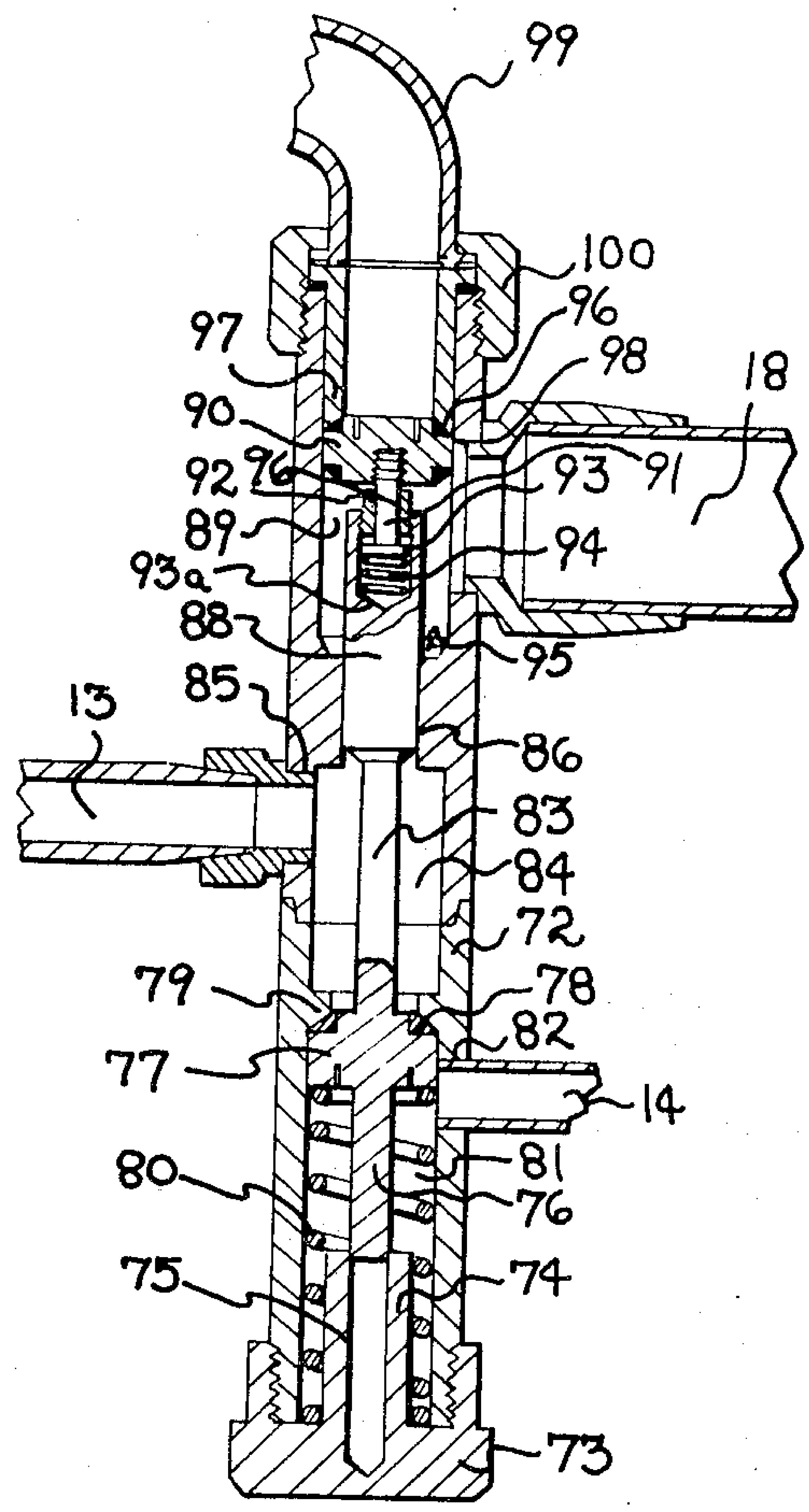
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FIG 6

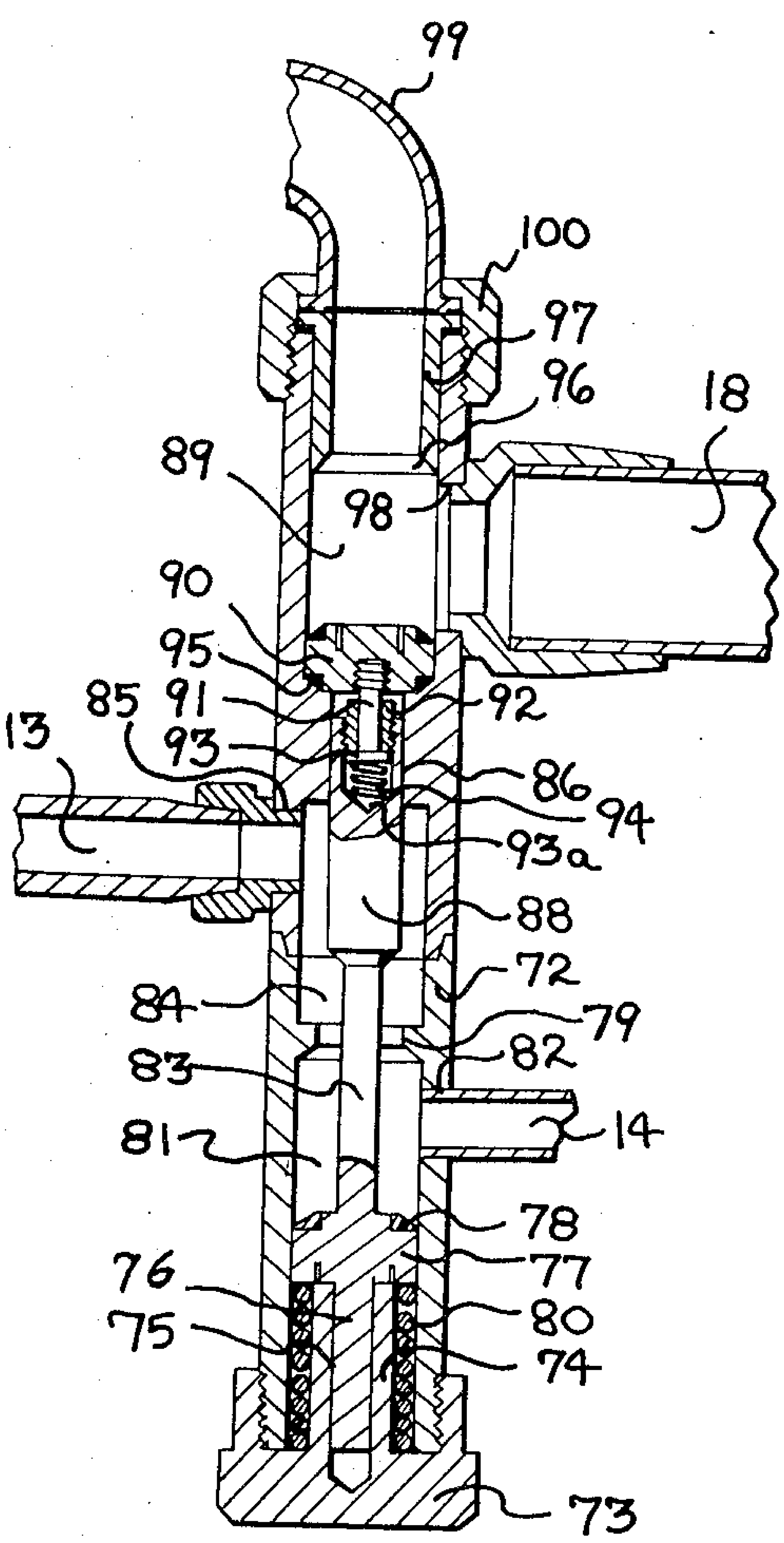
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FIG 7

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 **20***a*, 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 **20***a* 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 **29***a* in the sleeve **20***a* 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, compressing 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 **61**a, 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 braised 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 **93*a***. Within the socket **93*a*** 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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