

Jan. 6, 1953

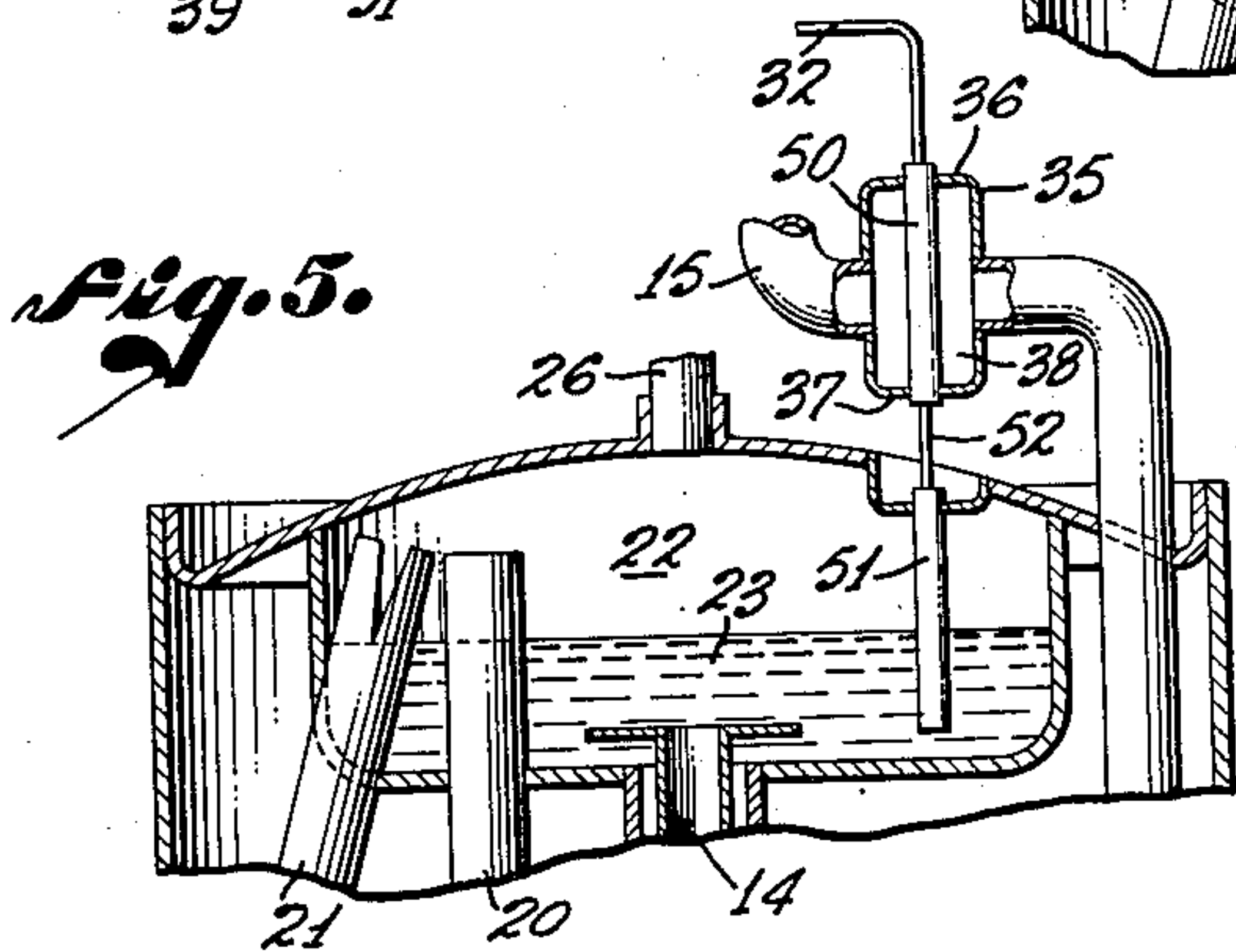
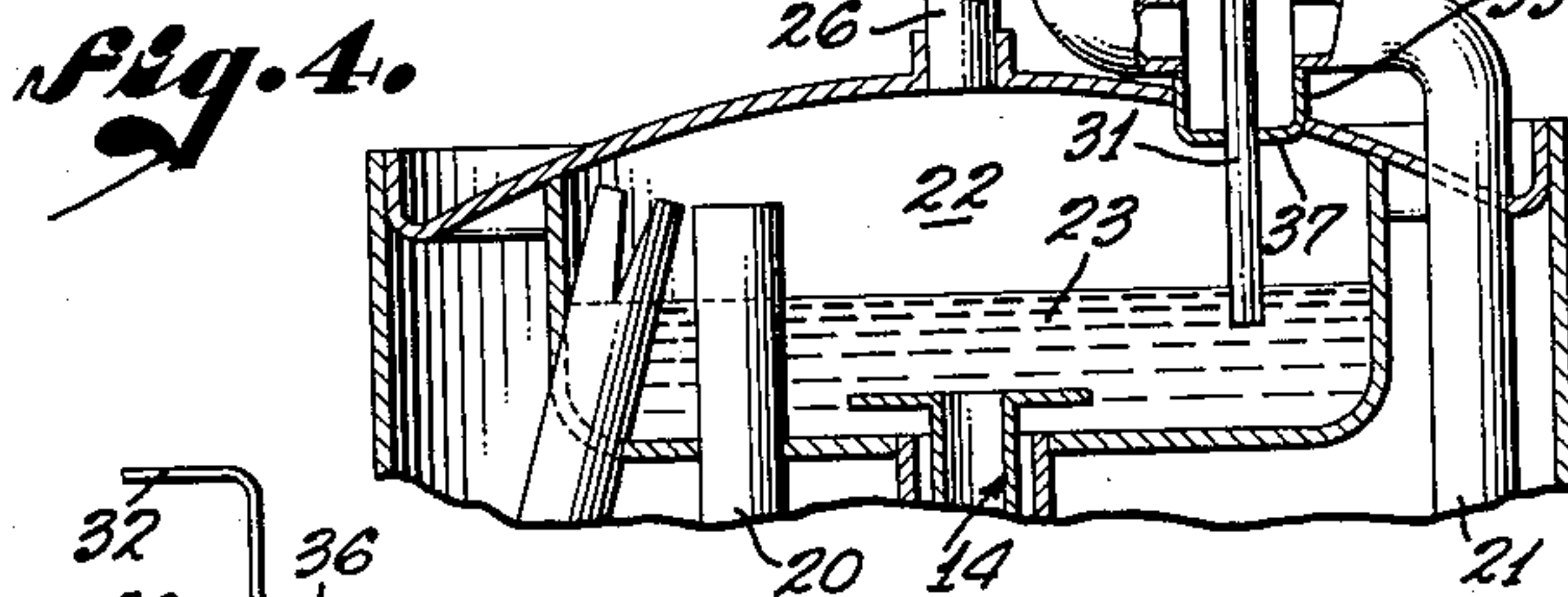
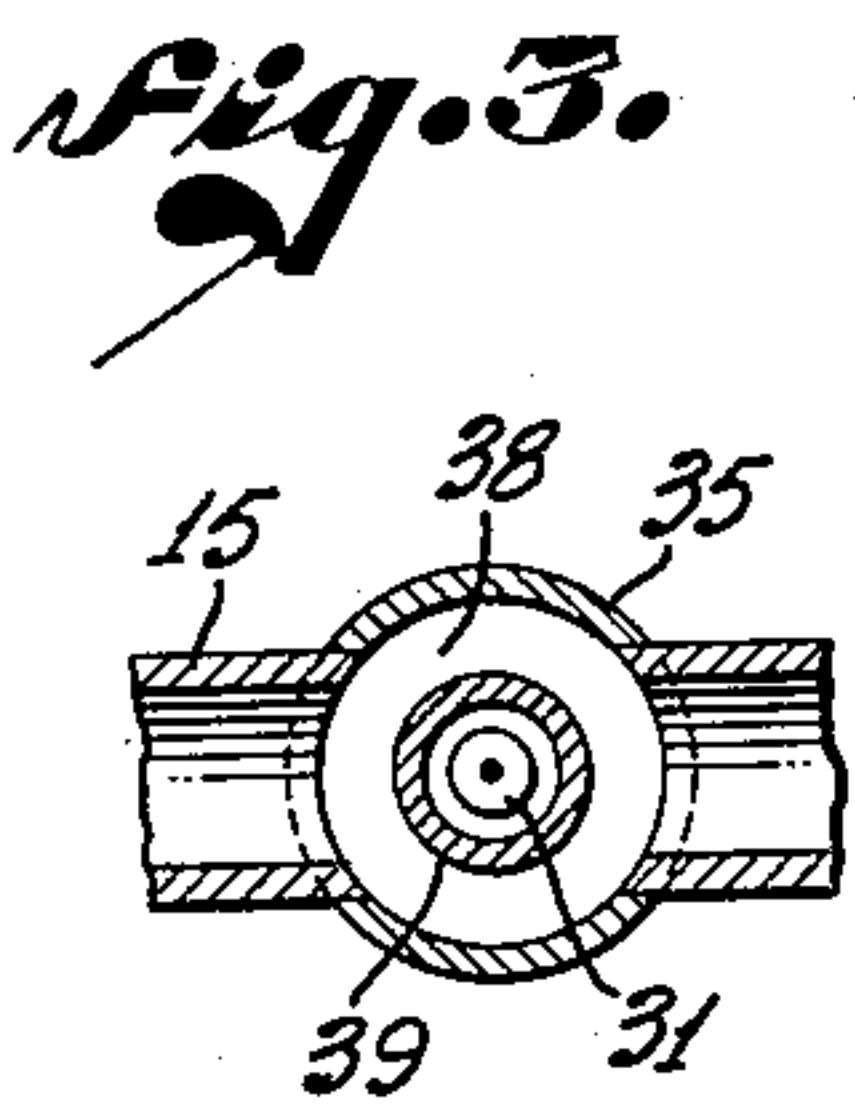
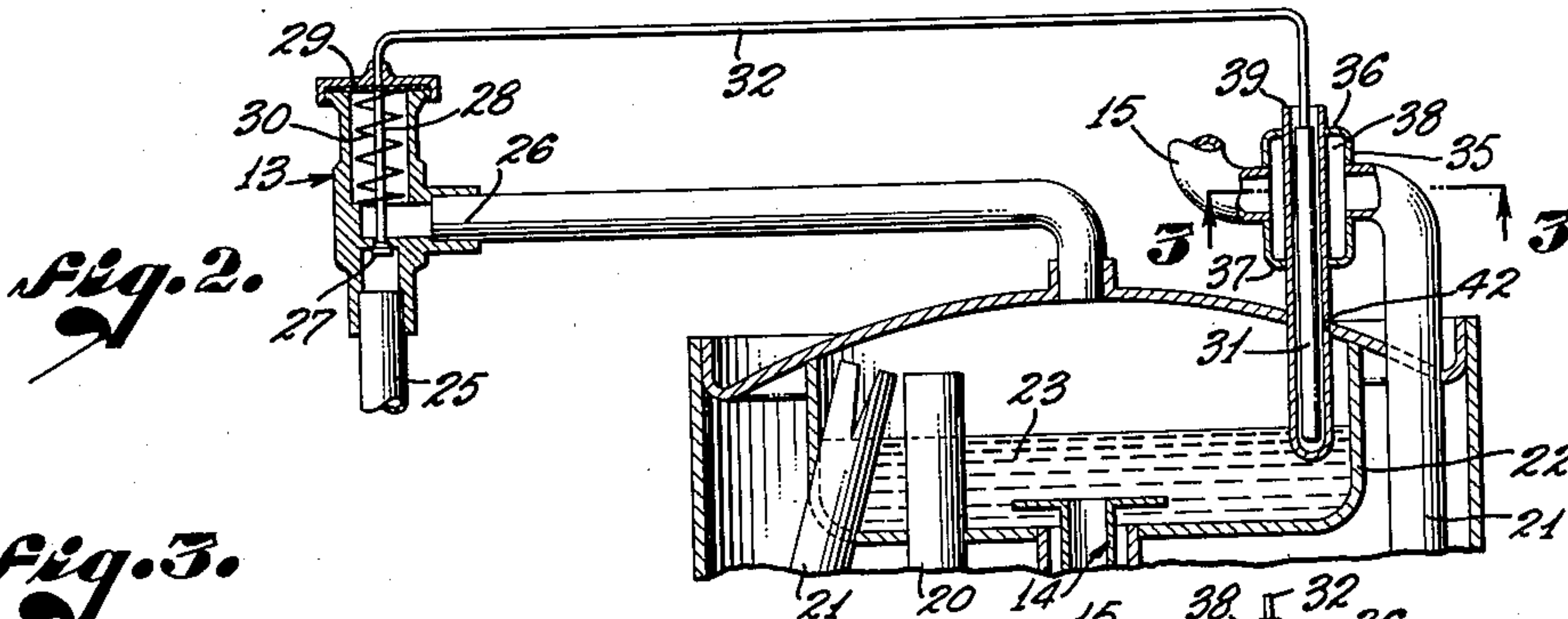
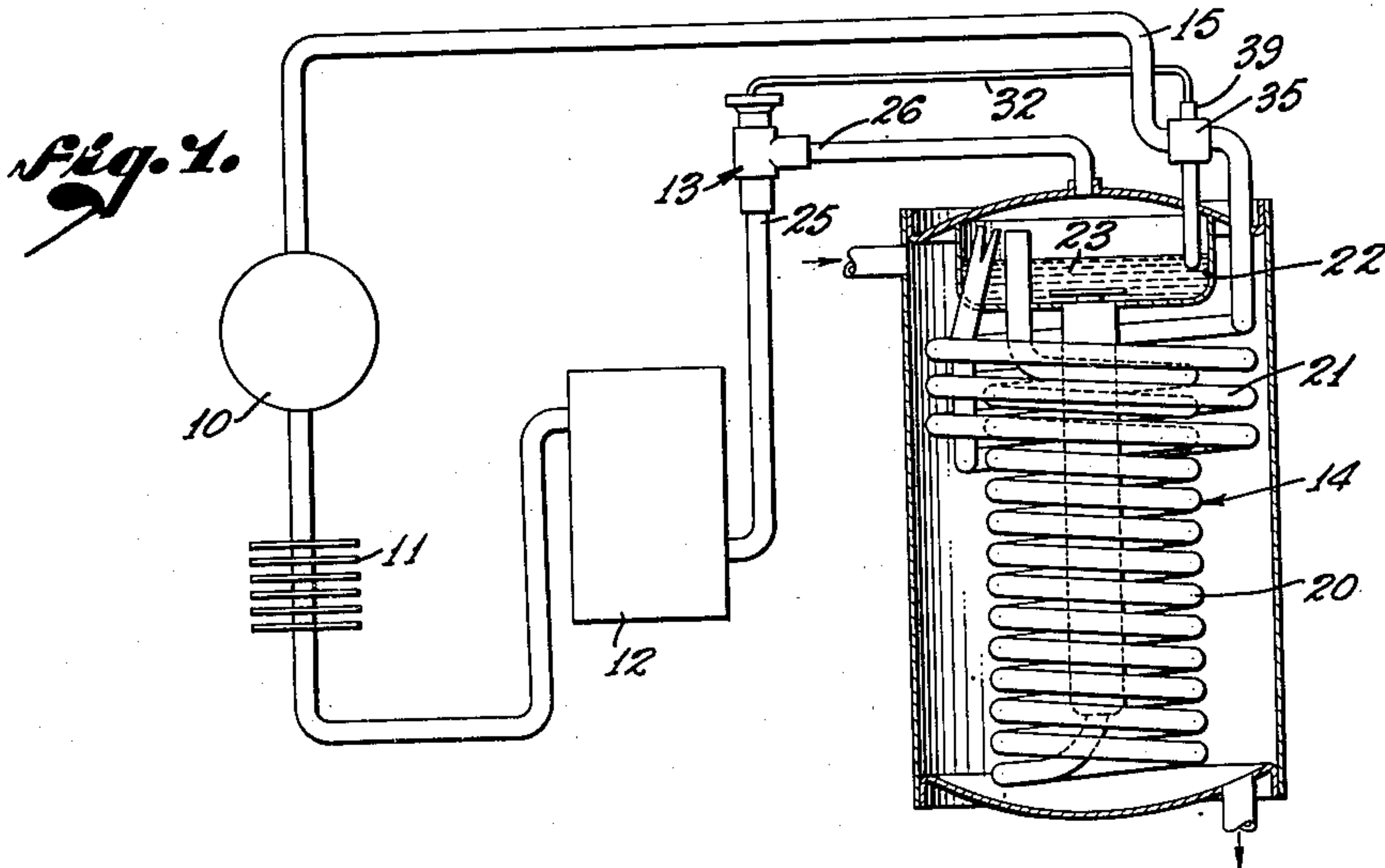
L. R. ERWIN ET AL

2,624,181

MEANS AND METHOD OF CONTROLLING REFRIGERATION SYSTEMS

Filed May 9, 1949

3 Sheets-Sheet 1



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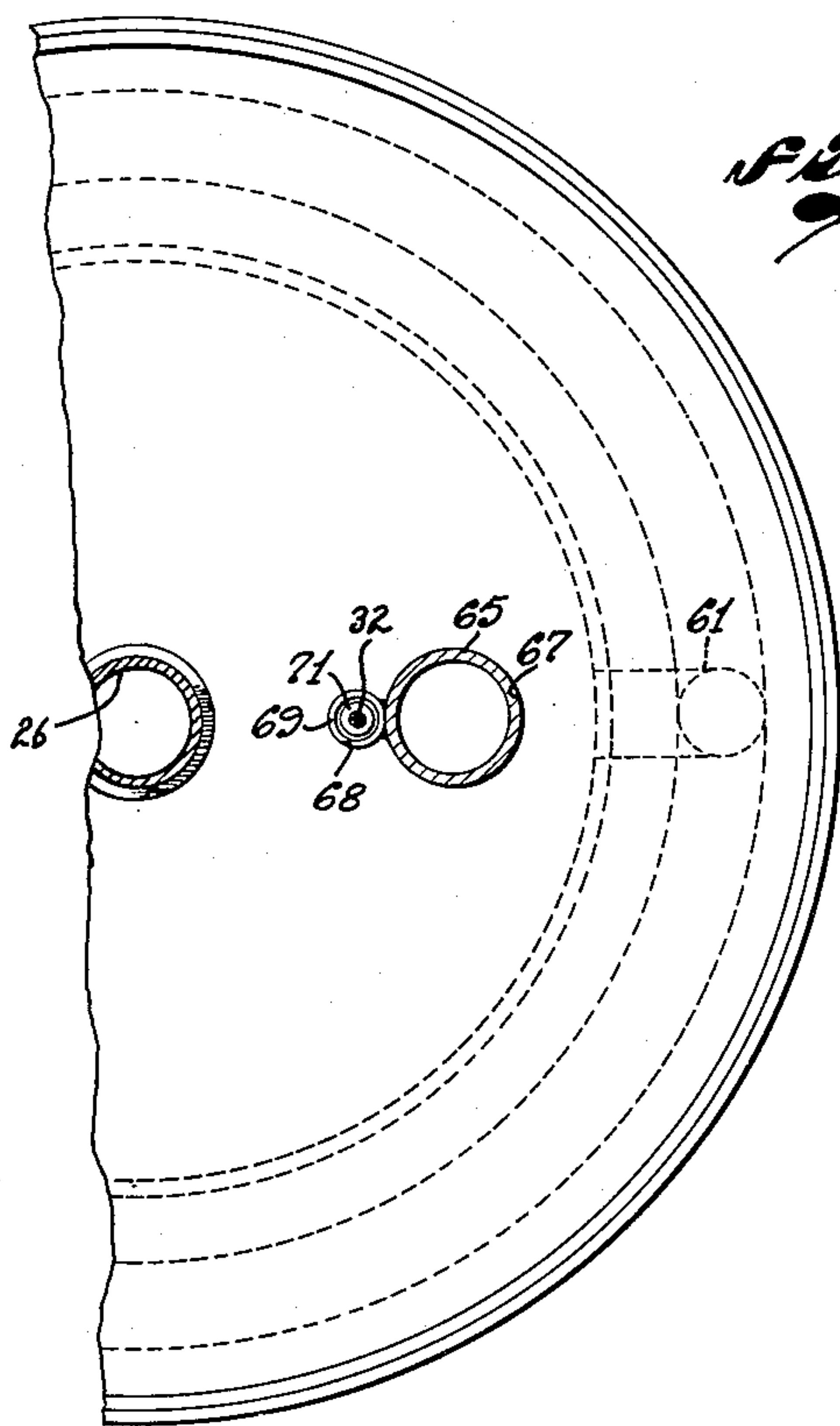
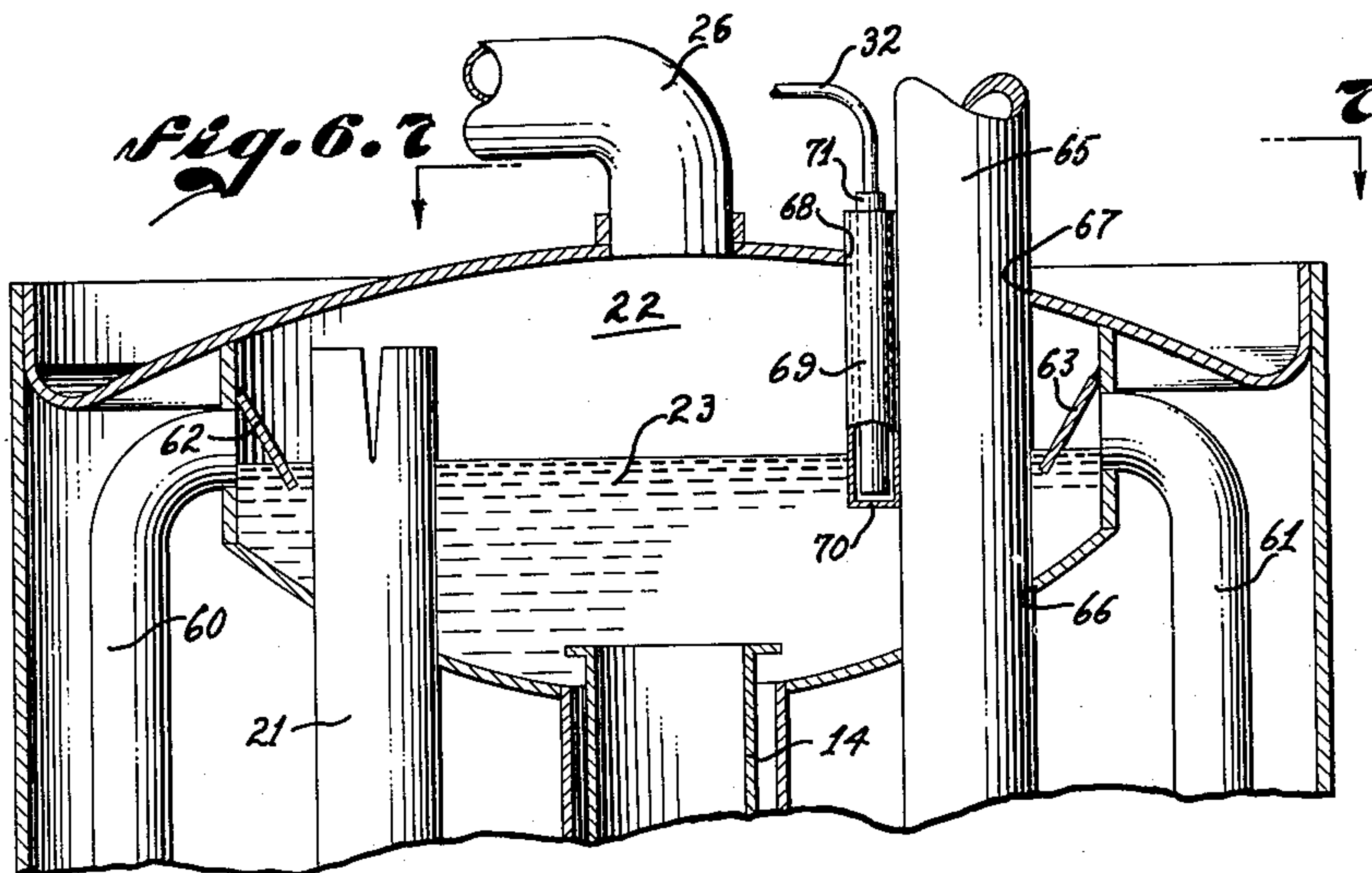
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MEANS AND METHOD OF CONTROLLING REFRIGERATION SYSTEMS

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3 Sheets-Sheet 2



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MEANS AND METHOD OF CONTROLLING REFRIGERATION SYSTEMS

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3 Sheets-Sheet 3

Fig. 8.

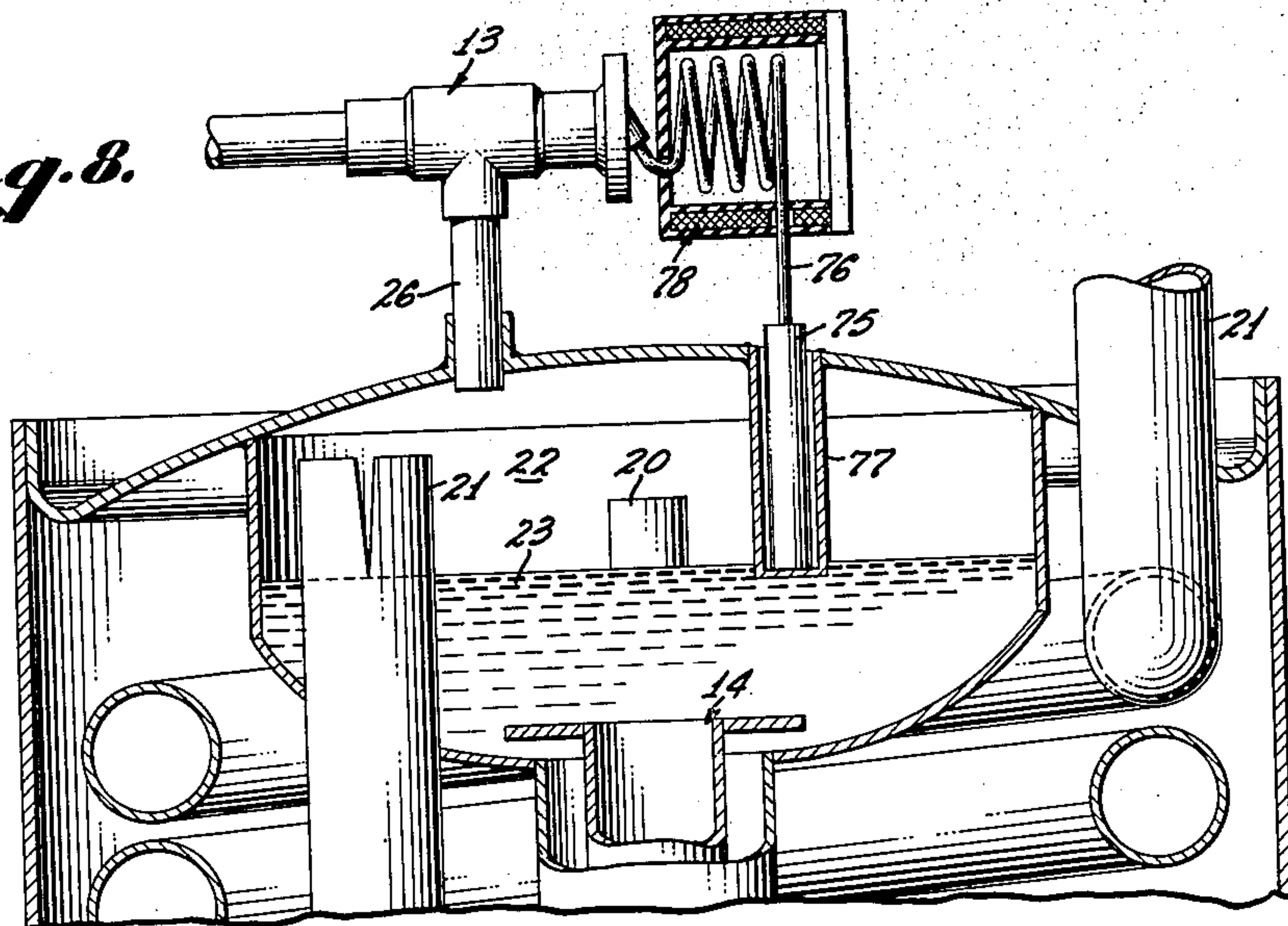
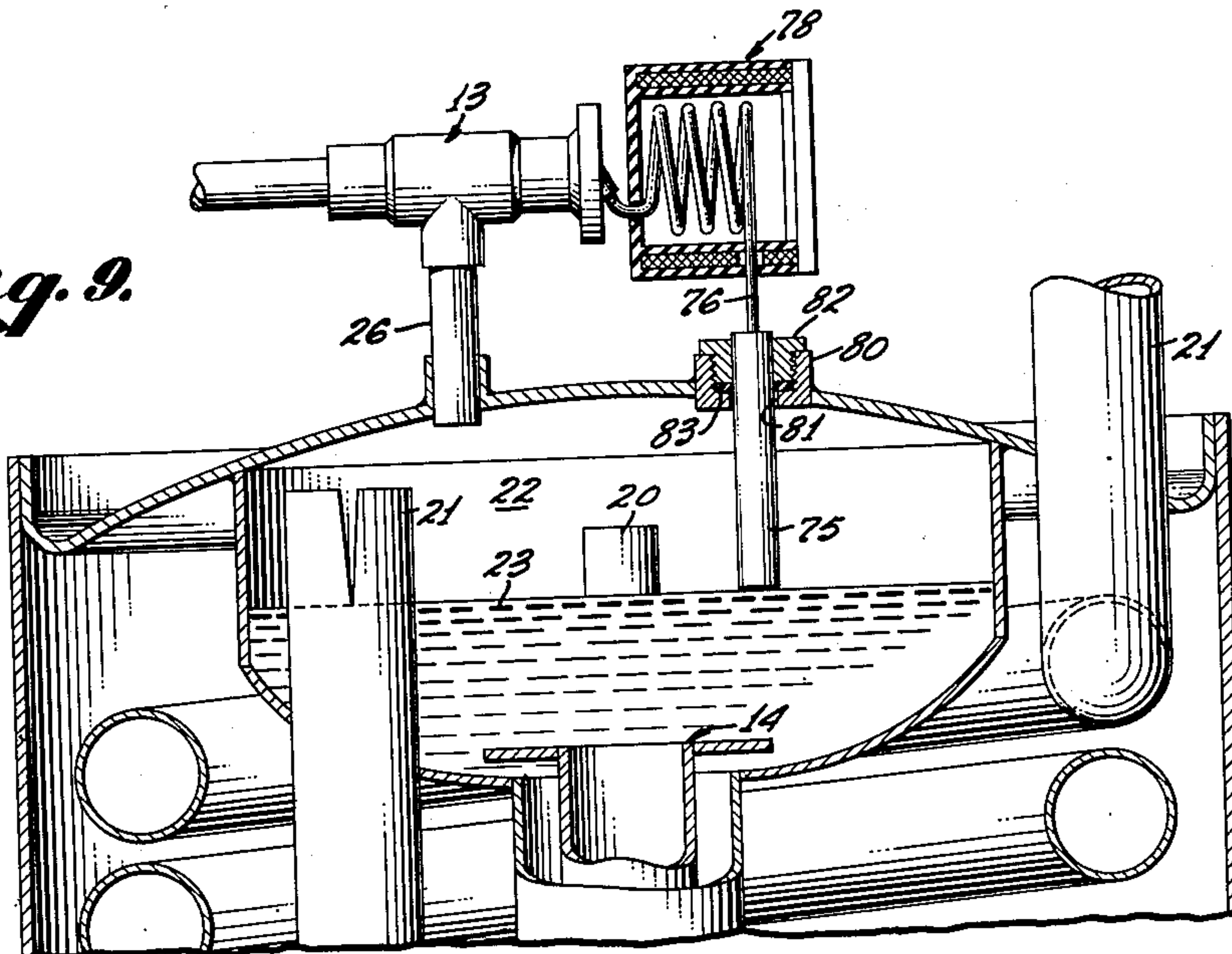


Fig. 9.



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2,624,181

MEANS AND METHOD OF CONTROLLING
REFRIGERATION SYSTEMS

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Application May 9, 1949, Serial No. 92,102

8 Claims. (Cl. 62-8)

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Our invention relates to the means and method for controlling refrigeration systems, and has particular reference to the means for controlling an expansion valve.

The standard-type compressor refrigerator system usually comprises a compressor, a condenser, a receiver and an evaporator coil having an expansion valve positioned between the receiver and the evaporator coil to control the flow of liquid refrigerant into the evaporator coil.

The expansion valve is essentially a diaphragm-operated valve which is responsive to differences in pressure on opposite faces of the diaphragm, one side of the diaphragm being responsive to the pressure in the refrigerant line; the other side being responsive to pressure from a temperature bulb positioned at some point in the refrigeration system which is used to control the admission of liquid refrigerant into the evaporator.

The usual position for the temperature bulb is adjacent the exhaust or suction line in heat transferring relation.

Due to the fact that the evaporator has a much lower pressure than the compressor side of the expansion valve, the refrigerant tends to boil at a relatively low temperature and in so doing, absorbs relatively large quantities of heat from the surrounding medium. As the boiling refrigerant progresses through the evaporator, it reaches a point of saturation, that is, where all liquid has boiled and become gas. From that point on, the gas begins to be superheated, that is, the temperature rises above the boiling point. It is usually this superheated exhaust gas that is applied to the temperature bulb to control the expansion valve.

In case of increasingly heavy demand, it will readily be seen that the point in the evaporator where saturation is reached, progresses upstream in the evaporator and the gases passing the point adjacent the temperature bulb are superheated to a greater degree, thereby causing the expansion valve to open and admit more liquid refrigerant into the system until the superheated gases are dropped back to the predetermined setting of the expansion valve, at which time the expansion valve closes.

Some systems are designed with a reservoir for liquid refrigerant between the expansion valve and the evaporator, and in such cases it is usually highly desirable to maintain a constant level of fluid therein. In such installations, the use of the standard-type control means is unsatisfactory. There is usually sufficient lag between the

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temperature of the superheated gases and the demand of the refrigeration system that the expansion valve either closes too slowly allowing the liquid level to run too high, or opens too slowly thereby allowing the reservoir to run dry.

One of the objects of our invention is to provide a control means which is modulated and subjected to a substantially instantaneous reaction upon a changing load demand for the refrigeration system.

Applicants are aware that others have attempted to maintain substantially constant liquid levels, but such endeavors have usually taken the form of mechanical float valves. Such valves are not entirely satisfactory because any piece of mechanical equipment is subject to failure, and being positioned inside of the evaporator unit, would be difficult to reach for repair and maintenance.

A further object of our invention is to provide a control unit which has no mechanical moving parts and which is readily available for maintenance and repair should the same be necessary.

We have found that a much more effective means for controlling the level of liquid refrigerant in the receiver consists in placing a temperature responsive bulb in contact with the liquid refrigerant in the receiver. A temperature responsive bulb in such position becomes immediately responsive to the level of the liquid refrigerant. It, however, becomes necessary to supply heat to the vapor system of the temperature responsive bulb from some source in order to operate the expansion valve. This can be done most conveniently by placing the temperature responsive bulb also in communication with the exhaust gases in the suction line or by subjecting the capillary tube connecting the expansion bulb to the expansion valve to some independent and constant source of heat. It is, therefore, among the objects of our invention to provide a means and method for controlling the level of liquid refrigerant in a flooded coil refrigeration system which is immediately responsive to the liquid refrigerant level and which actuates the expansion valve also in response to an independent source of heat or the superheat contained in the suction line.

It is also a further object of our invention to provide a control unit adapted to actuate the expansion valve in response to temperature changes in both the suction line and a refrigerant receiver between the expansion valve and the expansion or evaporator coil.

A further object of our invention is to provide

a method of controlling a pressure responsive expansion valve in a refrigeration system by subjecting said valve to the sum of the vapor pressures generated in response to the temperature of refrigerant entering the expansion coil and the refrigerant in the suction line being discharged from the coil.

Other and further objects and advantages of our invention will become apparent from the drawings and the specifications relative thereto.

In the drawings:

Figure 1 is a schematic illustration of a refrigerating system having a control embodying the principles of our invention.

Figure 2 is a partial sectional view showing the details of one form of our control.

Figure 3 is a sectional view taken on line 3—3 of Figure 2.

Figure 4 is a view similar to Figure 2 showing a modification of our invention.

Figure 5 is a similar view showing a further modification of our invention.

Figure 6 is an enlarged fragmentary sectional view of a further modification of our invention.

Figure 7 is a view taken on line 7—7 of Figure 6.

Figure 8 is an enlarged fragmentary sectional elevation of a further modification of our invention showing the capillary tube subjected to an independent source of heat.

Figure 9 is a similar view showing a modification in the details of inserting the temperature responsive bulb into the receiver.

We have illustrated our invention in connection with a refrigerator system, such as is disclosed in the co-pending application of William G. Cartter and J. Richard Ewell, filed on the 24th day of January, 1949, Serial No. 72,372. Whereas, we are illustrating our invention in connection with the system disclosed in said co-pending application, it is to be understood that such disclosure and explanation is by way of example only and not limitation. It shall be understood that our control system is applicable to any type of refrigeration wherein it is desired to maintain a fairly constant level of refrigeration liquid in a reservoir between the expansion valve and the evaporator coil.

The system comprises essentially a compressor 10, a condenser 11, a receiver 12, an expansion valve 13, and an evaporator unit, designated generally 14. A suction line 15 communicates between the exhaust of the evaporator unit and the compressor.

The evaporator unit 14 comprises essentially a primary coil 20, a superheat coil 21 and a cup or refrigerant reservoir 22.

For the purposes of explaining the present invention, it is necessary only to explain that in such a system as is illustrated herein it is highly desirable to maintain a substantially constant level for liquid refrigerant 23 in the reservoir 22.

As will be seen in Figure 2, we have provided an expansion valve, designated generally 13, having an inlet 25, a discharge 26 and a valve 27 adapted to interrupt the flow of refrigerant from the inlet 25 to the discharge 26. The valve 27 is mounted on a stem 28 and is controlled by a diaphragm 29. The valve is preloaded by means of a compression spring 30. It will, therefore, be apparent that the position of the valve 27 will be responsive to the force of the spring 30, the pressure in the discharge 26 and the pressure on top of the diaphragm 29.

Pressure on top of the diaphragm 29 is regu-

lated by means of a temperature responsive bulb 31 which is in communication with the upper surface of the diaphragm 29 by means of a capillary tube 32. The pressure system including the conduit or capillary tube 32 and the bulb 31, contains a vapor. The volume of the tube 32 is so small that the pressure in the conduit is determined almost entirely by the mean temperature of the vapor in the bulb 31. While under very cold operating conditions a portion of the vapor may condense on the walls and at the bottom of the bulb 31, the system is essentially a gas or vapor system.

The structure so far described is more or less standard. However, in a standard system, the temperature responsive bulb 31 is placed adjacent the suction line 15 and on the outer surface thereof. It has been noted that such standard placement of the temperature responsive bulb 31 is not entirely satisfactory because of the delayed action in response to varying refrigeration loads.

In order to overcome this objection, we have positioned the temperature responsive bulb 31 so that it is responsive to the temperature of the liquid refrigerant in the reservoir 22, as well as the temperature of the superheated gases in the suction line 15. In order to accomplish this, we have provided a cylindrical member 35 formed with inturned annular flanges 36 and 37 which defines an annular chamber 38 in direct communication with the passageway of the suction line 15.

The inturned flanges 36 and 37 define apertures in axial alignment through which a tube 39 is disposed in a gas-tight relation. It will readily be seen that the tube 39 will rapidly assume the temperature of the gases in the suction line 15 because the gases flow in intimate contact with the outer walls of the tube 39.

The top of the receiver 22 is formed with an aperture 42 through which the lower end of the tube 39 is disposed so that the lower end which is closed extends downwardly into the liquid refrigerant 23. The temperature responsive bulb 31 is disposed inside the tube 39 and extends substantially the full length thereof so that a portion of the bulb is responsive to the temperature of the suction line gases and also to the temperature of the liquid refrigerant in the accumulator 22. In this manner the pressure exerted on the diaphragm 29 is dependent on the sum or net value of the pressures created by the two temperature regions at the bottom and top of the bulb 31, respectively. For example, under normal operation the bottom portion of the bulb 31 in contact with the liquid refrigerant 23 is generally colder than is the upper portion which is in contact with the suction line 15. Should the level of liquid 23 drop, the bottom portion of the bulb 31 would become warmer, thereby increasing the pressure in the pressure system including the tube 32, even though the upper portion in contact with the pipe 15 remains unchanged in temperature. This increase in pressure creates a wider opening at the valve 27 admitting more liquid to the reservoir 22, thereby raising the level to its previous point.

In similar manner, should the temperature in the upper region of the bulb 31 which is responsive to the suction line 15 increase, the pressure in the tube 32 will go up as before, even though the liquid level in the reservoir 22 and hence the temperature in the bottom of the bulb 31 remains unchanged.

A similar although converse operation is ef-

ected upon drop in temperature in the suction line 15, or upon rise in liquid level 23.

It is thus seen that the valve 13 is made continually responsive to both the temperature at the inlet of the evaporator 14, in this case to the liquid level 23, and to the temperature at the outlet of the evaporator 14, i. e., the temperature in the suction line 15. Each of the two regions is effective to control the valve 13 independently of the temperature in the other region.

Due to the fact that the temperature of the gases in the suction line 15 tends to lag behind the load demand of the refrigeration system, the expansion valve lags behind such loads when it is dependent solely upon the temperature of the suction line for its control. By making the temperature responsive bulb 31 responsive to the temperature of the suction line gases and to the temperature in the accumulator 22, a modulating action is obtained.

As the demand for refrigeration is increased, the level of the liquid refrigerant 23 in the reservoir 22 tends to fall thereby exposing more of the tube 39 to contact with the gases in the reservoir 22 rather than the liquid refrigerant. Such action has an immediate effect on the expansion valve because of the slower rate of heat transfer between gases and metals as compared with liquid to metal and the consequent effect on the expansion bulb, which permits the discharge of more liquid refrigerant into the reservoir 22, thereby tending to raise the level of the liquid 23, and in raising the liquid subjects the tube to the temperature of the liquid refrigerant, thereby tending to close the valve 27. However, the temperature of the gases in the suction line 15 increases when the load on the refrigerating system increases so that the action of the temperature of the liquid 23 tending to close the valve and the action of the superheated gases in the suction line 15 tending to open the valve, create a stable condition and result in the valve finding a balance point. This arrangement not only results in an immediate response to load changes, but also results in a modulating action which tends to balance the valve at the correct open setting rather than having it either full open or full closed, as is usually the case where the temperature responsive bulb is merely responsive by conduction to the heat in the suction line.

Our invention involves a method of controlling a pressure responsive expansion valve of a refrigeration system, which comprises the steps of placing a quantity of vapor in heat-communicating relation with refrigerant entering the expansion coil of said refrigerating system, placing a second quantity of vapor in heat-communicating relation with the refrigerant being exhausted from said coil, and communicating the sum of the pressures of said vapors to said pressure responsive expansion valve for actuation thereof.

Figure 4 illustrates a modification of the control system shown in Figure 2. In the modification shown in Figure 4, we have eliminated the tube 39 and have disposed the cylindrical member 35 through the top of the receiver 22 and have extended the temperature responsive bulb 31 through the annular chamber 38 and into the reservoir 22.

It will be apparent that such an arrangement results in a more immediate response to temperature changes than is the case in the structure shown in Figure 2. However, the structure shown in Figure 2 is preferred because of the simplicity of sealing the engagement between the tube 39

and the annular flanges 36 and 37 and between the tube 39 and the aperture 42. These parts can readily be welded together in such a manner that gas cannot escape therefrom. It has been found that even a slight air gap between the tube 31 and the walls of the tube 39 does not materially affect the temperature response, so that even though the response of the bulb pressure to temperature changes is slower in the first embodiment, the difference is not sufficient to warrant the use of the modification of Figure 4 except in special circumstances where a highly sensitive response is essential.

Figure 5 illustrates a further modification in that we have substituted the temperature responsive bulbs 50 and 51 in place of the single temperature responsive bulb 31. The temperature responsive bulb 50 is directly in communication with the gases in the suction line 15 and immediately responds thereto. The bulb 51 is inserted inside of the reservoir 22 and is in direct contact with the liquid 23 and the gases in the reservoir 22 and, therefore, is immediately responsive to changes in temperature therein. The two bulbs 50 and 51 are connected in series by means of a capillary tube 52.

The type of construction illustrated in Figure 5 has certain disadvantages over the structure shown in Figure 2, namely, in the problem of sealing the parts against leakage of air and yet so arranging the assembly that the parts may be readily removed for repair and maintenance.

However, the structure shown in Figure 5 may be preferred in some installations because, as will be readily apparent, the chamber 35 and the bulb 50 need not be placed immediately adjacent the reservoir 22 as is the case of Figure 2.

The structure shown in Figure 5 illustrates the basic principles of our invention; namely, that the diaphragm of the expansion valve 32 is responsive to the sum of the pressures in the bulbs 50 and 51 which are controlled by the temperature of the surrounding medium. Therefore, the expansion valve is responsive to temperature both in the reservoir and in the suction line, which, as has been heretofore explained, gives a modulating action to the valve tending to stabilize it and to give an immediate response to load demand.

In Figures 8 and 9, we have illustrated a further modification of our invention wherein the temperature responsive bulb is positioned in heat-transferring relation with the liquid refrigerant contained in the receiver and showing the capillary tube connecting the temperature responsive bulb to the expansion valve but subjected to an independent source of heat rather than the superheat of the suction line. Like reference numerals indicate like parts of the other forms.

In the modification illustrated in Figure 8, we have illustrated a temperature responsive bulb 75 connected to the expansion valve 13 by means of a capillary tube 76. A well 77 extends downwardly to approximately the surface of the liquid refrigerant 23 and the temperature responsive bulb 75 is disposed therein. A source of heat, such as an electric coil 78, is placed in heat-transferring relation with the capillary tube 76.

Upon rising of the liquid level, the heat transfer between the well 77 containing the temperature responsive bulb 75 becomes faster and the temperature in the bulb 75 and, consequently, the vapor pressure contained therein decreases to permit closing of the expansion valve 13. When the liquid level again falls below a critical

point, the rate of heat transference from the temperature responsive bulb becomes insufficient to overcome the rate of heat application from the source of heat 73, thereby raising the vapor pressure affecting the expansion valve to open the expansion valve and permit the flow of liquid refrigerant into the receiver.

In this modification the valve 13 is responsive only to the level of liquid 23 in the reservoir 22, the outlet temperature in the suction line 21 having no effect on the valve. The purpose of the coil 78 is to maintain substantially constant temperature in the tube 76 thereby protecting it from temperature change of the ambient air which would, even though the volume of the tube 76 is small, tend to introduce a pressure change upon the valve 13. It has been found desirable to make the tube 76 in the form of a coil so as to lengthen the travel distance between bulb 75 and valve 13, thereby giving a cushioning effect to any sudden changes in temperature resulting from rapid rise or fall of the liquid level 23. The cushioning effect introduces a slight time lag in the response of the valve 13 and tends to prevent hunting thereof.

Figure 9 illustrates a further modification insofar as the details of construction are concerned, namely, the well 77 has been eliminated and a packing gland 80 substituted therefor having an aperture 81 through which the expansion bulb 75 is disposed. A packing nut 82 is in threaded engagement with the packing gland 80 and has a resilient gasket 83 positioned therebetween. Such a construction gives a more intimate contact between the temperature responsive bulb 77 and the liquid refrigerant 23, which results in a more rapid reaction. Such a construction, however, may not always be desirable in that the bulb may not be replaced without first removing the refrigerant and releasing the pressure inside the receiver 22.

While we have herein shown and described our invention in what we have conceived to be the most practical and preferred embodiment, it is recognized that departures may be made therefrom within the scope of our invention, which is not to be limited to the details disclosed herein, but is to be accorded the full scope of the claims so as to embrace any and all equivalent devices.

Having described our invention, what we claim as new and desire to secure by Letters Patent is:

1. In a refrigeration system having an expansion valve, a reservoir adapted to receive liquid refrigerant, an expansion coil in communication with said reservoir and a suction line adapted to exhaust gaseous refrigerant from said expansion coil, means responsive to temperature variations adapted to actuate said expansion valve, said means comprising means defining a chamber in series in said suction line, a tubular member extending through said chamber and into said reservoir, a bulb containing a vapor adapted to vary the pressure in said bulb in response to temperature variations disposed in said tubular member, and a capillary tube communicating the pressure from said bulb into said expansion valve for actuation thereof.

2. In a refrigeration system having an expansion valve, a reservoir adapted to receive liquid refrigerant, an expansion coil in communication with said reservoir and a suction line adapted to exhaust gaseous refrigerant from said expansion coil, means responsive to temperature variations adapted to actuate said expansion valve, said means comprising means defining a

chamber in series in said suction line, a tubular member extending through said chamber and into said reservoir, said tubular member having a closed bottom and an open top, a bulb containing a vapor adapted to vary the pressure in said bulb in response to temperature variations disposed in said tubular member, and means communicating the pressure from said bulb into said expansion valve for actuation thereof.

3. In a refrigeration system having an expansion valve, a reservoir adapted to receive liquid refrigerant, an expansion coil in communication with said reservoir and a suction line adapted to exhaust gaseous refrigerant from said expansion coil, means responsive to temperature variations adapted to actuate said expansion valve, said means comprising means defining a chamber in series in said suction line, temperature responsive pressure generating means disposed through said chamber and into said liquid refrigerant reservoir and responsive to the respective temperatures thereof, and means communicating the pressure from said pressure generating means into said expansion valve for actuation thereof.

4. In a refrigeration system having an expansion valve, a liquid refrigerant reservoir adapted to receive liquid refrigerant from said expansion valve and a suction line adapted to exhaust gaseous refrigerant from said system, said expansion valve being formed with a diaphragm actuable by pressure differentials across its face to control said expansion valve, temperature responsive pressure generating means in heat transferring relation with said gaseous refrigerant in said suction line, and temperature responsive pressure generating means in heat transferring relationship with the interior of said reservoir, the diaphragm of said expansion valve being responsive to the sum of the pressures in each of said pressure generating means.

5. A method of controlling a pressure responsive expansion valve, which is responsive to vapor pressure, of a refrigeration system in which there is an expansion coil having an inlet in communication with said expansion valve for the introduction of refrigerant into said coil and a discharge comprising the steps of placing a quantity of vapor in heat-communicating relation with refrigerant entering said coil, placing a second quantity of said vapor in heat-communicating relation with the refrigerant being discharged from said coil, and communicating the sum of said vapor pressures generated by said vapors to said expansion valve for actuation thereof.

6. Refrigeration control apparatus comprising, in combination in a refrigerant system, an expansion valve, a liquid refrigerant reservoir connected to said valve to receive liquid refrigerant therefrom, an evaporator communicating with said reservoir to receive refrigerant therefrom, a suction line connected to said evaporator to withdraw vaporized refrigerant therefrom, and a vapor-containing conduit having a portion thereof disposed in said reservoir adjacent the surface of the liquid therein and having a portion disposed in heat transfer relation with said suction line, said conduit communicating with said valve to actuate the same in response to vapor pressure in said conduit, whereby the position of said valve is determined both by the liquid level in said reservoir and by the temperature of refrigerant withdrawn through said suction line.

7. Refrigeration control apparatus comprising,

in combination in a refrigerant system, an expansion valve, a reservoir connected to receive liquid refrigerant from said valve, an evaporator communicating with said reservoir to receive refrigerant therefrom, and a vapor-containing conduit disposed vertically, partially in and partially out of the liquid refrigerant in said reservoir and connected to said valve to actuate the same in response to vapor pressure in the conduit, whereby the position of said valve is made sensitive to liquid level in said reservoir. 5 10

8. Refrigeration control apparatus comprising, in combination in a refrigerant system, an expansion valve, an evaporator having an inlet communicating with said valve and an outlet, 15 a pressure conduit containing fluid completely in vapor phase connected to said valve to actuate the same in response to vapor pressure in the conduit, a portion of said conduit being disposed in heat transfer relation with said inlet, and another portion of said conduit being disposed in heat transfer relation with said outlet whereby the pressure in said conduit is a func-

tion of refrigerant temperature both at said inlet and at said outlet.

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