

[54] REFRIGERANT CHARGING APPARATUS

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 430,182, Jan. 2,
1974, abandoned.

[52] U.S. Cl. 62/77; 62/149; 62/292;
62/125

[51] Int. Cl.² **F25D 45/00**

[58] Field of Search 62/77, 149, 292, 125

[56] References Cited

UNITED STATES PATENTS

2,055,780	9/1936	Zwickl	62/149
3,303,663	2/1967	Miller	62/149
3,400,552	9/1968	Johnson	62/149
3,686,954	8/1972	Inotl.	62/125
3,753,356	8/1973	Kramer	62/125
3,785,163	1/1974	Wagner	62/77
3,791,165	2/1974	Honnold	62/77
3,813,893	6/1974	Gemender	62/292

Primary Examiner—William J. Wye

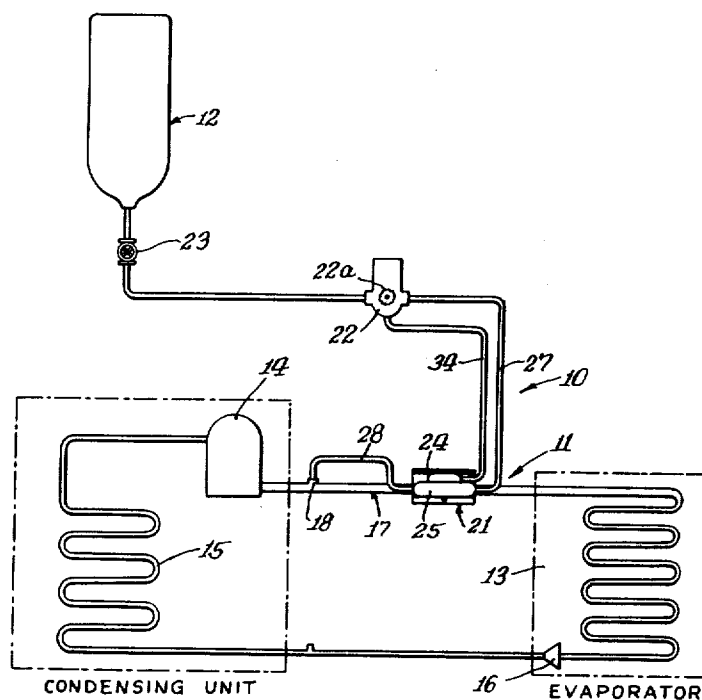
Attorney, Agent, or Firm—Wegner, Stellman, McCord,
Wiles & Wood

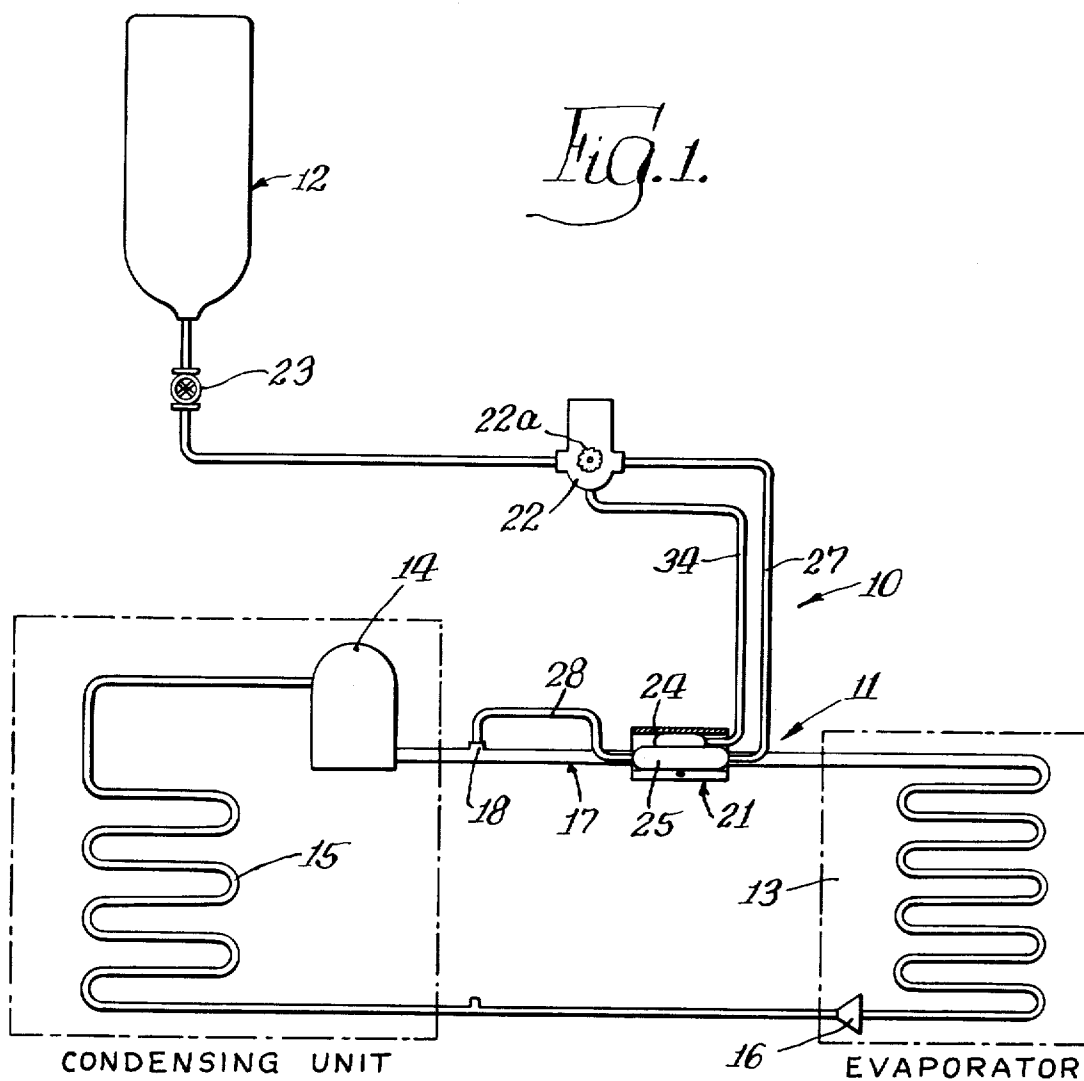
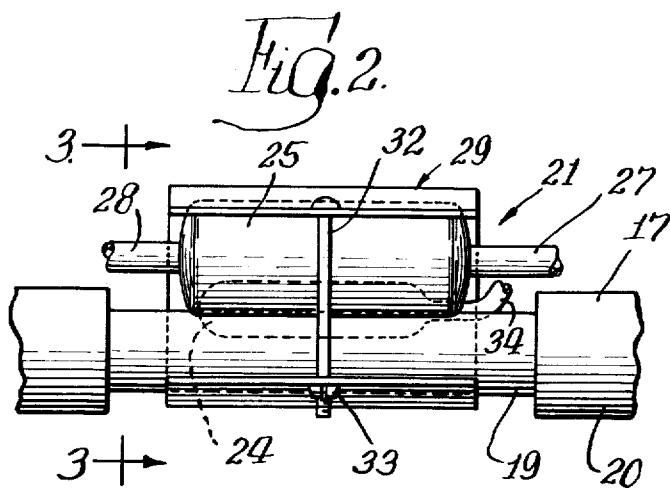
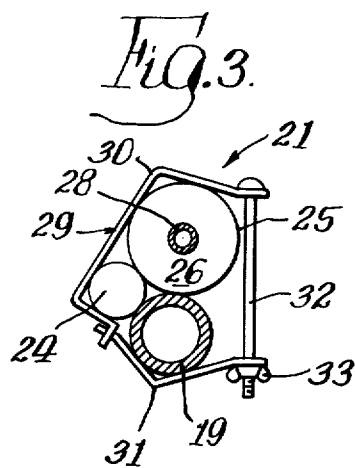
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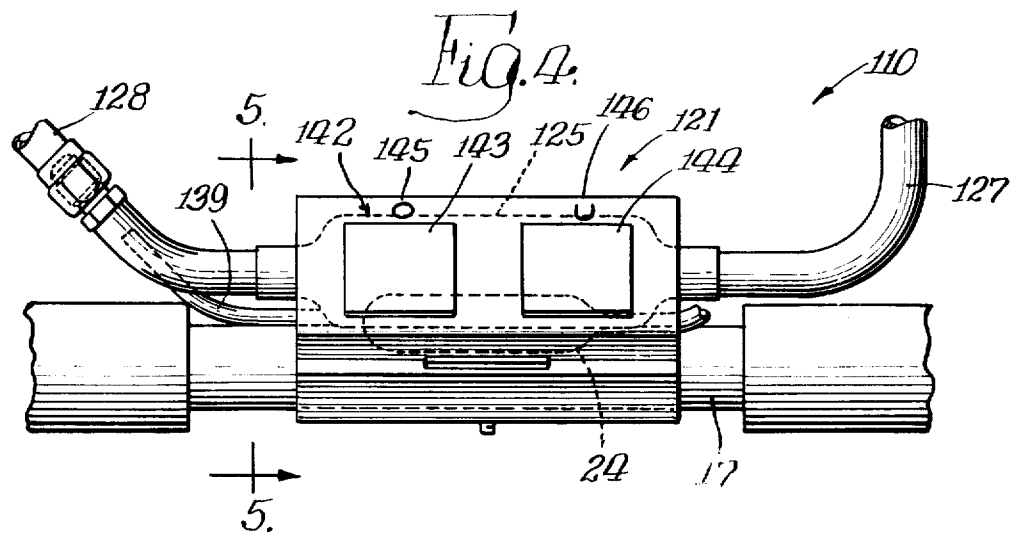
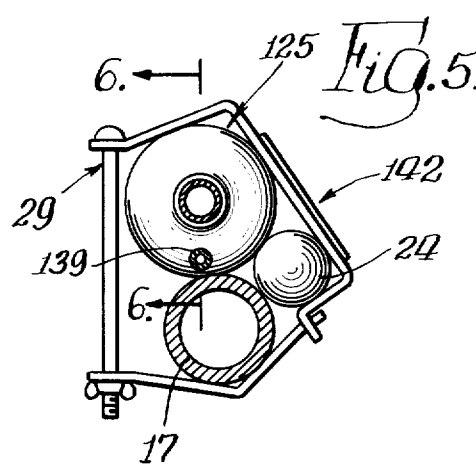
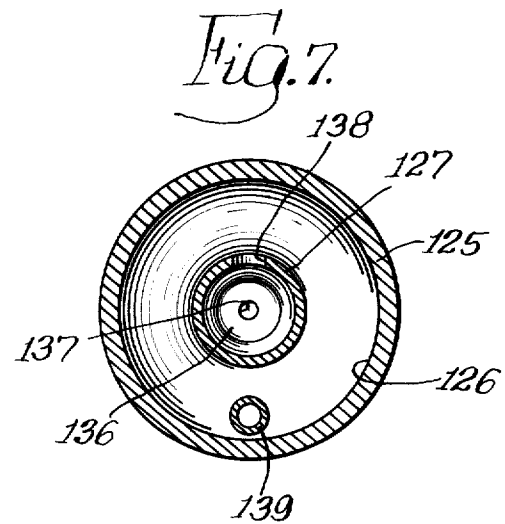
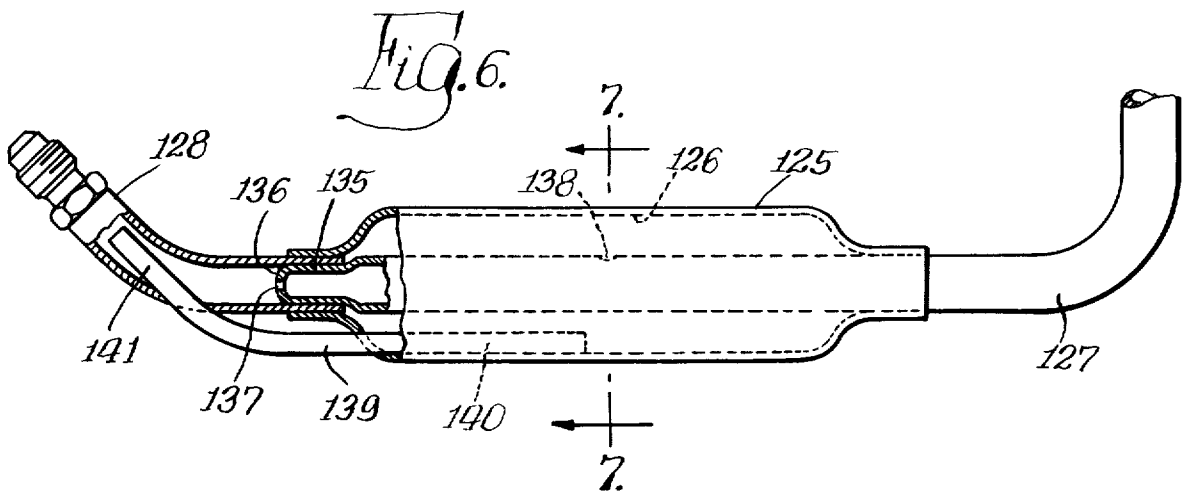
ABSTRACT

A refrigerant charging apparatus for charging an operating refrigeration system. The apparatus includes an expansion chamber connected between a thermal expansion valve and the suction line of the refrigeration system. The expansion chamber and a temperature sensing bulb associated with the thermal expansion valve are disposed in heat transfer relationship with the suction line and each other. The charging apparatus is utilized to provide small quantities of refrigerant from a pressurized supply seriatim into the refrigeration system with each charge being effectively assimilated into the system prior to the delivery of the next charge. The sequential charging and assimilation continues automatically until the system is properly charged and the apparatus has automatically ceased injection of refrigerant into the system. After a predetermined period of time has elapsed to assure a complete charge based on the system size, the charging apparatus is removed from the system. In an improved form, the charging apparatus defines an expansion chamber reservoir with a duct for bypassing a portion of the refrigerant around the expansion chamber to the refrigeration system suction line, thereby to provide internal metering for passing the refrigerant more directly from the supply to the refrigeration system. In a further improved form, the charging apparatus includes structure for indicating the temperature of the charging apparatus to provide a visual indication selectively of an undercharged and overcharged condition of the system.

43 Claims, 7 Drawing Figures







REFRIGERANT CHARGING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application comprises a continuation-in-part of application Ser. No. 430,182, filed Jan. 2, 1974, now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to refrigerant charging apparatuses and methods of adding refrigerant to an operating undercharged refrigeration system.

2. Description of the Prior Art

In one form of conventional refrigeration system fluid refrigerant is circulated from a compressor through a condenser to an evaporator wherein the refrigerant fluid expands to effect a desired cooling operation. The expanded fluid is then returned to the compressor for re-compression and re-circulation. At times it is necessary to replace refrigerant fluid which may have leaked from the system. One conventional method of recharging the system is to provide a pressurized can of liquid refrigerant and establish controlled communication between the can and the refrigeration system to permit the pressure of the liquid refrigerant in the can to cause delivery thereof into the system.

In one refrigeration system charging apparatus shown in U.S. Pat. No. 3,303,663, issued to W. V. Miller et al., refrigerant is delivered from a supply vessel successively through a blocking valve, a thermostatic control inlet valve, and a thermostatic controlled bleed valve. The blocking valve is provided to prevent an excess charge of refrigerant from being delivered to the system under certain ambient conditions. The bleed valve is arranged to sense both the temperature and pressure relations of the refrigerant in the suction line of the system and to bleed excess refrigerant to atmosphere when an excess of refrigerant charge is present in the suction line. The thermostatic inlet valve is biased to be normally closed and to open when the temperature pressure characteristics of the refrigerant in the suction line indicate a low charge.

In U.S. Pat. No. 3,400,552 of R. A. Johnson et al., electrically controlled inlet and bleed valves are detachably connected to the suction line of an operating refrigeration system to control the delivery of refrigerant thereto. The valves are controlled by both pressure and temperature responsive transducers. The control is made to be responsive to both the ambient temperature and suction line pressure for controlling delivery of the fluid.

In the reserve refrigerant supply and apparatus of J. R. Zwickl, shown in U.S. Pat. No. 2,055,780, refrigerant is delivered from a supply to a crankcase serving as a suction chamber in the refrigeration system. A thermostatic bulb is placed in the path of inlet air flowing over the evaporator of the system for use in controlling delivery of refrigerant from the supply to the crankcase in combination with the pressure conditions existing in the crankcase.

In U.S. Pat. No. 3,791,165 of Fred V. Honnold, Jr. et al., a method and apparatus for changing a refrigeration system is provided wherein a preselected superheat temperature of the refrigerant leaving the evaporator coil is determined by a difference in pressure of

refrigerant leaving the coil and the pressure of refrigerant in a sensing bulb disposed in heat transfer relation with the refrigerant line leaving the evaporator. In the Honnold, Jr. et al. charging method, the temperature of the heat exchange medium ambient to the condenser is measured in passing in heat exchange relationship with refrigerant in the condenser. In Honnold, Jr. et al., means are provided for indicating the differential between the actual temperature of refrigerant leaving the evaporator and the saturated refrigerant temperature corresponding to the pressure sensed by the pressure-responsive means which senses the pressure of the refrigerant leaving the evaporator.

In William Wagner U.S. Pat. No. 3,785,163, the liquid refrigerant is converted to saturated vapor and fed into the suction side of the refrigeration system so that a melting of frost on the suction line is utilized to indicate the charging of the system to optimum capacity. Upon defrosting of the suction line, the flow of saturated vapor refrigerant into the system is stopped manually.

In U.S. Pat. No. 3,813,893, of John F. Gemender et al., a thermostatically operated valve senses the suction line temperature for controlling the introduction of refrigerant into the refrigeration system. A restrictor is provided to limit the delivery to a rate permitting supply of the refrigerant to the thermostatic valve in a liquefied state. A pressure gauge is provided for determining the condition of the system being charged. The temperature sensing bulb of the thermostatic valve is mounted to the suction line and is insulated against sensing other temperature conditions such as that of the ambient air.

SUMMARY OF THE INVENTION

The present invention comprehends an improved simplified refrigerant charging apparatus for charging an operating refrigeration system which automatically effects a full charge of the system from a pressurized supply. The charging apparatus functions to provide quantity of refrigerant to the system, and after assimilation thereof by the system to deliver a subsequent quantity for subsequent assimilation thereof. The cycle is automatically repeated until the system is fully charged, whereupon the charging operation is terminated.

The apparatus includes an expansion chamber means which, together with the sensing means of the thermal expansion delivery valve, is disposed in heat transfer association with the suction line of the operating refrigeration system. In the illustrated embodiment, the sensing element comprises a sensing bulb which thusly responds to the temperature of both the expansion chamber and the suction line to provide an improved control of the refrigerant delivery.

More specifically, the sensing means determine the temperature of the suction line and the saturated vapor temperature of the refrigerant in the expansion chamber. When the integrated temperature sensed by the bulb reaches a predetermined temperature indicating assimilation of the refrigerant in the operating system, the expansion valve is opened to pass a subsequent incremental quantity of refrigerant to the expansion chamber and suction line.

The incremental charging of the operating system is continued until no further automatic delivery is effected to the system. Thus, the charging apparatus ef-

fects a fully automatic slow charging of the system to a full condition without the need for bleeding valves and other auxiliary control equipment, such as blocking valves, required heretofore in the prior art. As only a single thermal expansion valve is required to provide the automatic charging, the charging apparatus is extremely simple and economical of construction while yet providing the improved automatic refrigerant charging operation as discussed above.

In the further improved embodiment of the invention as disclosed herein, the expansion chamber means defines a reservoir having a tubular wall. The inlet conduit extends through the reservoir and is provided at its distal end with a constricted portion having a small outlet opening. The outlet duct leading to the suction line of the refrigeration system is in communication with the outlet opening whereby a portion of the refrigerant from the supply is bypassed past the reservoir expansion chamber directly to the outlet duct and suction line.

The inlet duct is further provided with a port opening to the expansion chamber which is of larger cross section than the port leading to the outlet duct whereby another substantial portion of the refrigerant is delivered from the inlet duct into the expansion chamber for providing the desired temperature information to the expansion valve sensing bulb.

To permit rapid transfer of the expanded refrigerant from the expansion chamber, a transfer duct is provided communicating between the expansion chamber and the outlet duct.

The present invention further comprehends improved means for facilitating the charging of the refrigeration system by an operator, which means provides a visual indication of undercharged and overcharged conditions of the system in a novel and a simple manner. In the illustrated embodiment, the visual indicating means comprise temperature responsive crystal elements carried on the clamp in mass heat transfer association with the expansion chamber reservoir, the suction line, and the expansion valve sensing bulb. The crystal elements are preselected to provide a color change at temperature conditions corresponding firstly to an undercharged condition of the system and secondly to an overcharged condition of the system.

In the improved charging apparatus, the time for fully charging the refrigeration system is reduced by permitting a portion of the refrigerant to pass directly from the supply to the suction line bypassing the expansion chamber. The temperature of the expansion chamber is made to follow accurately the temperature of the expanding refrigerant by rapid evacuation of the previously expanded refrigerant from the expansion chamber through the transfer duct. The improved visual indicating means further facilitates the rapid charging of the system by providing to the servicing technician accurate and substantially immediate indication of the charge condition of the system.

BRIEF DESCRIPTION OF THE DRAWING

Other features and advantages of the invention will be apparent from the following description taken in connection with the accompanying drawing wherein:

FIG. 1 is a schematic elevation of a refrigerant charging apparatus embodying the invention as used in charging an operating refrigeration system;

FIG. 2 is a fragmentary enlarged elevation of the temperature sensing portion of the charging apparatus;

FIG. 3 is a vertical section taken substantially along the line 3—3 of FIG. 2;

FIG. 4 is a fragmentary enlarged elevation of a modified form of temperature sensing portion of the charging apparatus;

FIG. 5 is a vertical section taken substantially along the line 5—5 of FIG. 4;

FIG. 6 is a fragmentary longitudinal section with portions broken away taken substantially along the line 6—6 of FIG. 5; and

FIG. 7 is an enlarged transverse section taken substantially along the line 7—7 of FIG. 6.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the exemplary embodiment of the invention as disclosed in FIGS. 1-3 of the drawing, a refrigerant charging apparatus generally designated 10 is shown as arranged for charging an operating refrigeration system generally designated 11 from a container generally designated 12 of pressurized refrigerant fluid. The apparatus is particularly adapted to remote condenser unit refrigeration systems such as house central air conditioners. These systems, due to long connecting lines between the evaporator and condenser, require a period of time to assimilate an added charge of refrigerant. The charging apparatus effects an automatic charging of the refrigeration system by delivering incremental quantities of refrigerant from container 12 to the system while allowing the individual quantities to be assimilated in the system prior to the delivery of the succeeding quantity to provide an improved recharging operation.

The invention is illustrated in connection with a conventional refrigeration system including an evaporator 13 in which the refrigerant is expanded to effect the desired refrigerating operation. The refrigerant is delivered to a condenser 15 from a compressor 14 which compresses previously expanded refrigerant fluid and delivers it through the condenser to a conventional evaporator 13 and a conventional expansion device 16 which may comprise a capillary element. Refrigerant is returned from the evaporator to the compressor through a suction line 17 which has a charging inlet 18 connected thereto for receiving replacement refrigerant fluid as from supply 12. Refrigerant line 17 conventionally comprises a metal tube 19 and a surrounding layer of insulation 20, as illustrated in FIG. 2.

Charging apparatus 10 includes a temperature sensing means 21 for controlling the operation of a calibrated adjustable thermal expansion valve 22 connected through a manually operated shutoff valve 23 to the pressurized supply 12. As shown in FIG. 2, a portion of the insulation 20 of suction line 17 is removed to expose the conduit 19. Temperature sensing means 21 includes a temperature sensing bulb 24 and means 25 defining an expansion chamber 26. A conduit 27 is connected between valve 22 and expansion chamber means 25 and a conduit 28 is connected between expansion chamber means 25 and charging inlet 18. As illustrated in FIG. 3, the expansion chamber means 25 and sensing bulb 24 are forcibly urged into thermal transfer relationship with suction line tube 19 and each other by means of a clamp generally designated 29 having clamping elements 30 and 31 adjustably embracing

the juxtaposed line portion 19, bulb 24 and chamber means 25 by means of a screw 32 and wingbolt 33. Temperature sensing bulb 24 is connected to valve 22 through a suitable connecting line 34.

The refrigerant in pressure supply 12 may comprise conventional liquefied Freon which, when delivered through valves 23 and 22 to expansion chamber 26, expands therein to vapor at zero superheat, thereby causing closing of valve 22 in response to delivery of the small incremental quantity thereof to the expansion chamber. The refrigerant gas is delivered from chamber 26 through inlet 18 into the suction line 17 of the operating refrigeration system and delivered to compressor 14 for cycling to the evaporator as discussed above. Assimilation of this refrigerant is sensed by the temperature responsive bulb 24 as a result of its connection to the suction line tube 19 and when the sensed temperature rises to a predetermined temperature, valve 22 is caused to reopen to deliver a subsequent incremental quantity of liquid from supply 12 to the expansion chamber 26. The cycle is then repeated with each incremental quantity of refrigerant being assimilated into the system prior to the delivery of the next quantity so that an automatic slow charging of the system to a fully charged condition is effected.

The refrigerant is added to suction line 17 in a saturated vapor state. The charging apparatus uses the mass heat transfer of the expansion means 25 and mass heat transfer of the suction line portion 19 to effect a proper superheat level for both metering and limiting the addition of fluid to the system to eliminate the need for bleeding devices and blocking devices as have been required heretofore in the art.

Thus, the charging apparatus provides an improved method of adding refrigerant to an operating under-charged refrigeration system including the steps of disposing an expansion chamber and a temperature sensing element in heat transfer association with each other and the suction line of the refrigeration system, causing addition of refrigerant from a supply to the system through the chamber in response to sensing a temperature above a first predetermined temperature, terminating addition of refrigerant in response to cooling the sensing element to below a second predetermined temperature as the added refrigerant expands in the chamber, causing additional refrigerant to be added to the system in response to the sensing element again sensing the predetermined temperature, and repeating such additions of refrigerant to the system until the system is fully charged.

By permitting stabilization of the system between each incremental charge delivery, an improved recharging of the system is effected.

The installation of the charging apparatus is extremely simple requiring merely the exposure of a portion of the suction line conduit and the clamping of the expansion chamber and sensing bulb elements in positive thermal transfer relationship therewith. The charging apparatus may more specifically be utilized with refrigeration or air conditioning systems using refrigerant compatible with the designated apparatus expansion valve 22. The valve 22 may be adjustable as by adjustment knob 22a to control the temperature at which the valve opens and closes. The recharging may be effected at normal ambient temperatures such as between 70° and 100°F.

Referring now to the embodiment of FIGS. 4-7, an improved temperature sensing means generally designated 121 may be utilized in a modified form of charging apparatus generally designated 110 for controlling the operation of the thermal expansion valve. The temperature sensing means 121 differs from temperature sensing means 21 of the first embodiment in providing for direct delivery of a portion of the refrigerant from the inlet supply conduit 127 to the outlet delivery conduit 128 bypassing the expansion chamber reservoir 125. The charging apparatus 110 is arranged to automatically meter the bypass refrigerant for effectively reducing the time required to fully charge the refrigeration system while yet avoiding the delivery of liquid refrigerant into the suction line.

More specifically, as best seen in FIG. 6, the inlet conduit 127 defines a duct extending into and through the chamber 126 and includes a constricted distal end 135 having a transverse end wall 136 provided with a small port 137. The mid-portion of duct 127 in chamber 126 is provided with a second port 138 providing communication between the interior of the duct and expansion chamber 126. In the illustrated embodiment, port 137 has a cross-sectional area of approximately one-third that of the port 138. Illustratively, port 137 may have a diameter of 0.062 inch and port 138 may have a diameter of 0.109 inch.

Thus, concurrently, a flow of liquid refrigerant may pass directly from inlet duct 127 expanding to the vapor state through port 137 into the outlet duct 128 and a portion of the refrigerant may expand outwardly through port 138 into the expansion chamber 126. As discussed above relative to the embodiment of FIG. 1-3, the expansion of the refrigerant into the expansion chamber cools the expansion chamber wall so as to provide a desired temperature indication to the sensing bulb 24. As shown in FIG. 5, reservoir 125 is similarly clamped in mass heat transfer association with bulb 24 and suction line 17 by the clamp 29. Thus, control of the expansion valve 22 as a function of the temperature sensed by bulb 24 is similar in each of the disclosed embodiments.

To maintain substantially instantaneous control of the temperature of the reservoir wall 125, the reservoir chamber is continuously exhausted by means of a transfer duct 139 having an inner portion 140 communicating with the expansion chamber 126, and an outer portion 141 communicating with the outlet duct 128. As shown in FIG. 6, the outlet portion 141 opens in the direction of refrigerant flow through outlet duct 128 so as to facilitate transfer of refrigerant fluid through the transfer duct from the expansion chamber so as to assure a constant flow of expanded refrigerant through the expansion chamber together with the direct delivery of refrigerant through port 137 to the outlet duct as discussed above.

As in the first described embodiment, the assimilation of the refrigerant by the refrigeration system is sensed by the temperature responsive bulb 24 so as to cause the expansion valve 22 to sequentially open in delivering incremental quantities of refrigerant liquid from the supply 12 to the refrigeration system. The further improved charging apparatus 110 provides for an increased rate of charging of the system while yet the charging is maintained fully under the automatic control effected by the mass heat transfer temperature control of the sensing bulb 24 in regulating the opening

and closing of valve 22 so as to effectively meter the refrigerant into the suction line for automatically bringing the refrigeration system to the desired fully charged condition.

As indicated briefly above, the present invention further comprehends the provision of visual indication means for facilitating the charging of the system by the operator. More specifically, the visual indication means comprises means generally designated 142 for visually indicating the temperature of the clamp 29 which, in effect, comprises an integration of the temperatures of the expansion chamber reservoir 125 and the suction line 17 as sensed by bulb 24.

More specifically, as shown in FIG. 4, the visual indication means 142 illustratively comprises a pair of temperature sensitive crystal elements 143 and 144 carried on clamp 29. The crystal elements are preselected to provide each a temperature indication at a low temperature and at a high temperature. In the illustrated embodiment, crystal 143 is preselected to provide a temperature change indication at approximately 37°F. and crystal element 144 is preselected to provide a temperature change indication at approximately 76°F. The crystal elements exhibit the same color when the temperature of the clamp 29 is between the preselected temperatures at which crystal elements 143 and 144 change color. When the temperature is above the temperature at which crystal element 144 changes color, or below the temperature at which crystal element 143 changes color, a visual indication of improper charge is apparent from the color difference in the crystals. Illustratively, crystal element 143 may be arranged to change from a dark brown to a light green/dark blue color below approximately 36°F. and crystal element 144 may be arranged to change color from a dark brown to a light green/dark blue color above approximately 76°F.

The crystal elements are preferably of relatively large size, such as 1 inch square and may have a thickness of approximately one sixty-fourth inch to one thirty-second inch. Such crystal elements are commercially available from Robert Parker, Research, 2066 Research, Livermore, Calif. 98550.

To facilitate reading of the temperature conditions suitable indicium 145, such as the letter O, may be associated with crystal element 143 to identify that crystal as the overcharge indication crystal and indicium 146, such as the letter U, may be associated with the crystal element 144 to identify that crystal as the undercharge indication crystal.

Except as otherwise noted, elements of charging apparatus 110 which are similar to elements of charging apparatus 10 are identified by similar reference numerals except 100 higher. The foregoing disclosure of specific embodiments is illustrative of the broad inventive concepts comprehended by the invention.

Having described the invention, the embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In a refrigerant charging apparatus having a thermal expansion valve provided with a temperature sensing bulb, and a source of liquid refrigerant for charging an operating refrigeration system including a compressor, a condenser, an evaporator, an expansion device connecting the evaporator with the condenser, and a suction line connecting the evaporator to the compres-

sor and including a charging port, the improvement comprising

means defining an expansion chamber connected between said thermal expansion valve and said suction line charging port, said expansion chamber and said temperature sensing bulb being disposed in mass heat transfer relation with said suction line to cause said temperature sensing bulb to respond to the temperature of both said expansion chamber and said suction line.

2. The refrigerant charging apparatus of claim 1 wherein said temperature sensing bulb is in direct heat transfer relation with said expansion chamber means.

3. The refrigerant charging apparatus of claim 1 wherein said temperature sensing bulb, said expansion chamber means, and said suction line comprise tubular wall elements disposed in axially parallel contacting association.

4. The refrigerant charging apparatus of claim 1 wherein said temperature sensing bulb, said expansion chamber means, and said suction line comprise tubular wall elements, and said improvement further includes a clamp embracing said wall elements to retain them forcibly in said contacting association.

5. The refrigerant charging apparatus of claim 1 wherein mounting means are provided mounting the expansion chamber means and sensing bulb to said suction line.

6. The refrigerant charging apparatus of claim 1 wherein said expansion valve is spaced substantially from said suction line.

7. A flow control device for delivering refrigerant fluid in increments from a pressurized liquid supply into the suction line of an operating refrigeration system, comprising:

a valve;

wall means defining an expansion chamber;

means for connecting said valve and chamber means in series between said liquid supply and said suction line; and

valve control means for controlling operation of the valve as a function of the temperature of both said expansion chamber means and the suction line whereby said valve is opened as a result of said expansion chamber means and said suction line being at a temperature above a first predetermined temperature to pass a small quantity of refrigerant liquid from the supply to said expansion chamber for vaporization therein, is closed by the resultant cooling of the expansion chamber means to a temperature below a second predetermined temperature, and is reopened to pass a subsequent small quantity of refrigerant liquid from the supply to said expansion chamber after the previous quantity is assimilated into the refrigeration system and said chamber and said suction line temperature has exceeded said first predetermined temperature, such opening and closing of said valve being automatically repeated until said refrigeration system is fully charged.

8. The flow control device of claim 7 wherein said valve control means comprises a temperature responsive sensing element in heat transfer association with each of said expansion chamber means and the suction line.

9. The flow control device of claim 7 wherein said valve is provided with manually adjustable means for

causing operation thereof at different selected temperatures.

10. The flow control device of claim 7 wherein said valve control means includes a temperature sensing element clamped to said suction line.

11. The flow control device of claim 7 wherein said valve control means includes a temperature sensing element clamped to said expansion chamber means.

12. The flow control device of claim 7 wherein said valve control means includes a temperature sensing element clamped to said suction line and said expansion chamber means.

13. The method of adding refrigerant to an operating undercharged refrigeration system comprising:

disposing an expansion chamber and a temperature sensing element in heat transfer association with each other and the suction line of said refrigeration system;

causing addition of refrigerant from a supply to said system through said chamber in response to sensing a temperature above a first predetermined temperature;

terminating addition of refrigerant in response to cooling said sensing element to below a second predetermined temperature as said added refrigerant expands in said chamber;

causing additional refrigerant to be added to the system in response to said sensing element again sensing a temperature above said first predetermined temperature; and

repeating said additions of refrigerant to said system.

14. The method of adding refrigerant to an operating undercharged refrigeration system of claim 13 wherein the additions of refrigerant to said system are repeated until a predetermined period of time elapses.

15. The method of adding refrigerant to an operating undercharged refrigeration system of claim 13 wherein the refrigerant is supplied to said expansion chamber as a liquid.

16. The method of adding refrigerant to an operating undercharged refrigeration system of claim 13 wherein the additions of refrigerant to said system are repeated until a predetermined period of time elapses without said sensing element sensing a temperature above said first predetermined temperature following a termination of an addition and then preventing further delivery of refrigerant from said supply.

17. The refrigerant charging apparatus of claim 1 further including means for bypassing a portion of the refrigerant from said valve past said expansion chamber to said suction line.

18. The refrigerant charging apparatus of claim 1 further including means for bypassing a portion of the refrigerant from said valve past said expansion chamber and supplying said refrigerant in the vapor state to said suction line charging port.

19. The refrigerant charging apparatus of claim 1 further provided with means for visually indicating information relative to said sensed temperature.

20. The refrigerant charging apparatus of claim 1 further provided with means for visually indicating information relative to said sensed temperature including means for indicating a drop in said temperature to below approximately 36°F.

21. The refrigerant charging apparatus of claim 1 further provided with means for visually indicating information relative to said sensed temperature including

means for indicating a rise in said temperature above approximately 76°F.

22. The refrigerant charging apparatus of claim 7 further including means for bypassing a portion of the refrigerant from said valve past said expansion chamber to said suction line.

23. The refrigerant charging apparatus of claim 7 further provided with means for visually indicating information relative to said temperature of said expansion chamber means and said suction line.

24. The refrigerant charging apparatus of claim 7 further provided with means for visually indicating information relative to said temperature of said expansion chamber means and said suction line including means for indicating a drop in said temperature to below approximately 36°F.

25. The refrigerant charging apparatus of claim 7 further provided with means for visibly indicating information relative to said temperature of said expansion chamber means and said suction line including means for indicating a rise in said temperature above approximately 76°F.

26. The method of adding refrigerant to an operating undercharged refrigeration system of claim 13 wherein a portion of the refrigerant being added to the system is bypassed from said supply past said chamber to said suction line.

27. The method of adding refrigerant to an operating undercharged refrigeration system of claim 13 wherein a portion of the refrigerant being added to the system is bypassed from said supply past said chamber to said suction line concurrently with the addition of said refrigerant through said chamber.

28. The method of adding refrigerant to an operating undercharged refrigeration system of claim 13 wherein said refrigerant is delivered from said supply as a liquid and a portion of the refrigerant is added to the system in the vapor state through conduit means bypassing the expansion chamber.

29. A mass heat transfer charging apparatus for providing refrigerant fluid from a liquid supply to a suction portion of a refrigeration apparatus, said apparatus comprising:

wall means formed of thermally conductive material defining an expansion chamber;

an inlet duct extending into said chamber and having first and second outlet ports, said first port opening to said expansion chamber;

an outlet duct having an inner end in fluid conductive association with said second port for conducting fluid delivered from said inlet duct through said second port to said suction portion; and

a transfer duct having an inner portion connecting with said expansion chamber, and an outer portion communicating with said outlet duct for transferring to said outlet duct fluid delivered from said inlet duct through said first port to said expansion chamber.

30. The mass heat transfer charging apparatus of claim 29 wherein said inlet duct extends fully across said expansion chamber.

31. The mass heat transfer charging apparatus of claim 29 wherein said inlet duct extends fully across said expansion chamber and said second port is disposed outwardly of said wall means.

32. The mass heat transfer charging apparatus of claim 29 wherein said inlet duct defines a constricted

end and said second port is provided in said constricted end.

33. The mass heat transfer charging apparatus of claim 29 wherein said transfer duct outer portion defines an end of the transfer duct in said outlet duct in the direction of fluid flow therethrough.

34. The mass heat transfer charging apparatus of claim 29 wherein said second port has a cross-section area approximately one-third that of the first port.

35. The mass heat transfer charging apparatus of claim 29 wherein said second port has a cross-section area approximately one-fourth that of said transfer duct.

36. The mass heat transfer charging apparatus of claim 29 wherein said wall means defines a tubular element, and said inlet duct extends coaxially therethrough.

37. Visual indication means for indicating the temperature of a refrigerant charging apparatus wall means, said indication means comprising

a plurality of temperature sensitive crystal elements in heat transfer association with said wall means, one of said crystal elements defining means for indicating a temperature change at a near-freezing temperature and another of said crystal elements defining means for indicating a temperature change at a temperature substantially above freezing temperature.

38. The refrigerant charging system temperature indication means of claim 37 wherein said near-freezing

temperature is approximately 37°F.

39. The refrigerant charging system temperature indication means of claim 37 wherein said substantially above-freezing temperature is approximately 76°F.

40. The refrigerant charging system temperature indication means of claim 37 wherein said crystal elements comprise elements having the same color when the temperature of said wall means is above said near-freezing temperature, and wherein one of said elements changes color at temperatures below said near-freezing temperature.

41. The refrigerant charging system temperature indication means of claim 37 wherein said crystal elements comprise elements having the same color when the temperature of said wall means is below said substantially above-freezing temperature; and wherein one of said elements changes color at temperatures above said substantially above-freezing temperature.

42. The refrigerant charging system temperature indication means of claim 37 wherein said crystal elements are provided with indicia means for indicating selectively an undercharged condition and an overcharged condition of the system being charged corresponding to the temperature of said wall means.

43. The refrigerant charging system temperature indication means of claim 37 wherein said wall comprises a clamp element and said crystal elements are carried by said clamp element.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,903,709
DATED : September 9, 1975
INVENTOR(S) : RICHARD M. ANDERSON ET AL

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Claim 7, line 33, after "pressurized" correct "liquiud" to
--liquid--

Claim 13, line 28, after "in" correct "repsonse" to
--response--

Claim 20, line 60, after "The" correct "refirgerant" to
--refrigerant--

Claim 29, line 55, after "said" correct "oulet" to --outlet--

Claim 34, line 9, after "a" correct "cross-section" to
--cross-sectional--

Claim 43, line 26, after "wall" insert --means--.

Signed and Sealed this
seventeenth Day of February 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks