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REFRIGERATION SYSTEM CHARGING APPARATUS

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FIG. 1

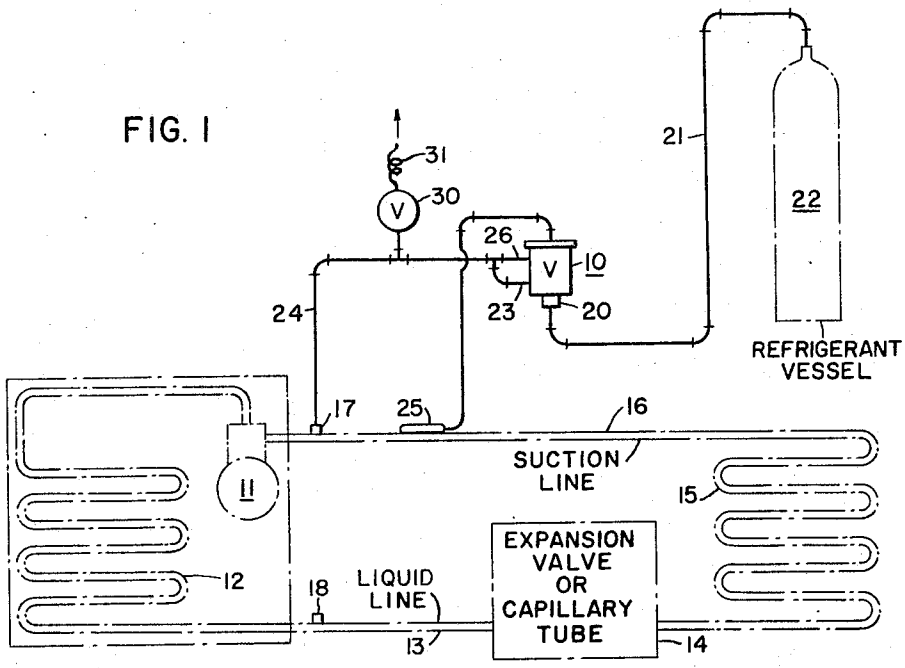
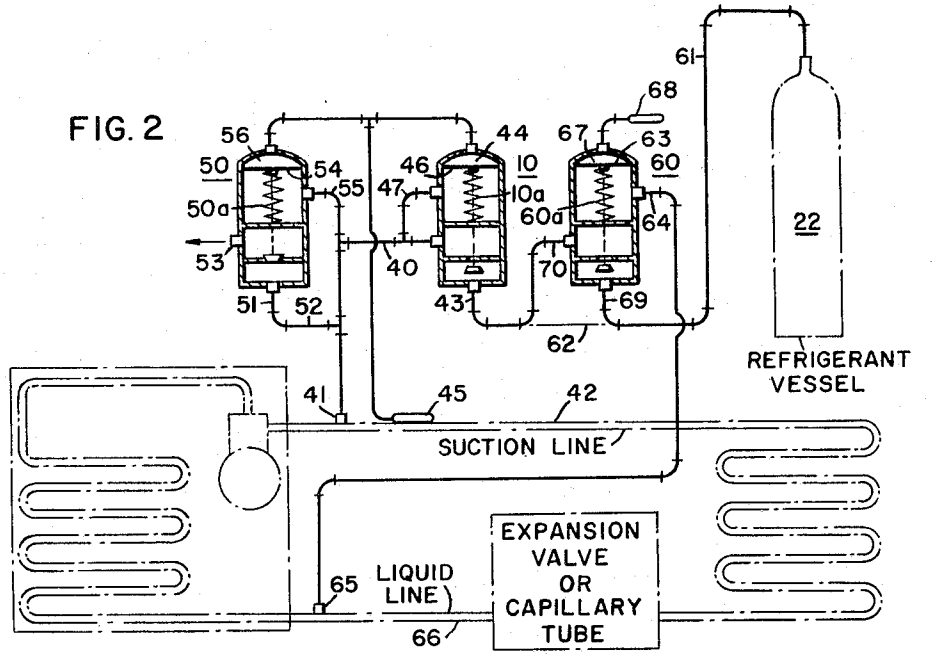


FIG. 2



WITNESSES

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REFRIGERATION SYSTEM CHARGING APPARATUS

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The present invention relates to refrigeration systems of the expansion type and more particularly to apparatus for predetermining the charge or amount of refrigerant in an operating refrigeration system.

Expansion refrigeration systems of the type having a compressor, a condensing coil, an expansion valve or capillary tube, and an evaporating coil containing a refrigerant cycling back and forth from liquid or semi-liquid to gaseous states in a sealed system are well known. Such systems may be normally charged with a predetermined amount of refrigerant at the factory and then sealed, although gage ports are usually provided through which refrigerant may be added or removed from the system. Such systems employing capillary tubes instead of expansion valves require rather precise control of the amount or charge of the refrigerant for best operation under given conditions of use. All of the refrigeration systems referred to may require changes in the refrigrant charge because of the ambient conditions of use encountered in the field or because of usage over a long period of time. Also, the amount of piping in a refrigeration system may not be finally determined until the system is installed so that the charge of refrigerant in the system must be adjusted after installation in accordance with the actual amount of piping used. The need for a change in the charge of refrigerant in such a cooling system may be indicated in various ways such as by the temperature pressure characteristics of the refrigerant in the suction line to the compressor, or by the temperature pressure characteristics of the refrigerant in the liquid line and these indications may be variable under different actual or ambient conditions of operation.

It is a principal object of the present invention to provide apparatus for automatically predetermining the charge of a normally sealed expansion refrigeration system during its operation to obtain a desired condition of operation as may be indicated by the temperature pressure characteristics of the refrigerant at various points in the system.

Another object of the present invention is to provide apparatus for automatically changing the charge of refrigerant in a normally sealed expansion refrigeration system during its operation to obtain a charge of refrigerant in the system that will produce a desired temperature pressure characteristic of refrigerant in either the suction line or the liquid line in the refrigeration system for the ambient conditions encountered during the then operation of the system.

In a simplified form of the invention, the charging apparatus is comprised of a thermostatic controlled, inlet valve having an intake port adapted to be connected to a source of refrigerant charge under relatively high pressure and an outlet port adapted to be connected to the gage port in the suction line of the operating cooling system whose refrigerant charge is to be predetermined during operation. The thermal control bulb or element for the inlet valve is adapted to be connected in temperature sensing relation to the cooling system suction line. Also, the pressure responsive control element of the thermostatic inlet valve is connected to its outlet and therefore the suction line of the cooling system to sense the refrigerant pressure in such line. Assuming the charge of refrigerant in the cooling system to be low, in accordance with the invention, the thermostatic inlet valve is calibrated and arranged to be open under such conditions to permit refrigerant from the source to enter the cooling system through the gage port during operation of the cooling system until the temperature pressure relation for the refrigerant charge in the cooling system suction line reaches a desired value indicative of the correct charge of refrigerant. This same form of the invention may be slightly modified to include a controlled leak to the atmosphere from the outlet of the thermostatic inlet valve that is connected to the suction line of the refrigeration system so that an excess amount of the refrigerant charge in the suction line may be bled off until the inlet valve opens to recharge the system to the desired amount of charge at which time the bleed and the charge may balance each other. Of course, some loss of refrigerant from the refrigerant source will occur during use of the aforementioned inlet valve and bleed arrangement but this may be tolerated if the bleed is not too heavy.

A modified form of the invention which may be used to adjust the refrigerant charge in an operating cooling system by either reducing or increasing the charge without loss of refrigerant from the source of refrigerant would include a second thermostatic valve which may be termed a bleed valve having its inlet connected to the outlet of the first inlet valve and the suction line of the cooling system and also having its outlet open to the atmosphere. The temperature responsive control element of the bleed valve is connected in sensing relation to the cooling system suction line similarly to the temperature responsive control element of the inlet valve. Also the pressure responsive control element of the bleed valve is connected to the inlet and hence the suction line of the cooling system to thus sense the pressure of refrigerant in the suction line. This second bleed valve is arranged and calibrated to operate reversely from the first inlet valve as described in the preceding paragraph so that when there is an excess of charge in the suction line of the cooling system, the bleed valve is opened to release the excess charge to the atmosphere while the inlet valve remains closed to prevent loss of refrigerant from the source of high pressure refrigerant. When the excess charge of refrigerant in the suction line is bled off so that the refrigerant charge is at the desired value as indicated by its temperature pressure relation in the suction line, the second valve will be closed and by suitably calibrating both the first inlet valve and the second bleed valve the arrangement may be such that both valves will be closed when the approximate desired charge of refrigerant is present in the operating cooling system.

Yet another modified form of the invention provides that a third or blocking valve of thermostatic controlled operation similar to the inlet and bleed valves previously described be adapted to be connected with its inlet to the source of high pressure refrigerant and its outlet to the inlet of the first or inlet valve. The temperature sensing control element of the blocking valve is arranged to sense ambient or atmospheric temperature while its pressure responsive control is adapted to be connected to the gage port in the liquid line of the operating cooling system. This blocking valve is calibrated and arranged to be closed when the relative pressure in the liquid line and the ambient temperature conditions for the operating cooling system are such as to indicate a maximum charge of the cooling system, so that the blocking valve is closed to prevent passage of refrigerant from the source to the inlet valve even though suction line pressure and temperature conditions sensed by the inlet valve could be such as to cause the inlet valve to be open. Thus, overcharge of the operating cooling system under certain ambient conditions of operation is prevented.

Further objects, features and the attendant advantages

of the invention will be apparent with reference to the following specification and drawing in which:

FIGURE 1 is a diagrammatic view of an operating cooling system with the refrigerant charging apparatus of the invention including only a thermostatic inlet valve connected thereto together with the source of high pressure refrigerant; and

FIG. 2 is a fragmentary diagrammatic view of the modified refrigerant charging apparatus of the invention showing the thermostatic expansion inlet valve, a thermostatic bleed valve and a thermostatic blocking valve as connected to both the suction line and the liquid line of a cooling system which itself is not shown in detail.

Referring first to FIG. 1 of the drawing, the simpler form of the invention employing only a single thermostatic controlled inlet valve **10** will be described. A more detailed showing of the mechanical arrangement of the thermostatic inlet valve **10** is shown by FIG. 2 of the drawing. All of the thermostatic controlled expansion valves as used in the various embodiments of the invention are of a type well known in the art and for example may be the thermostatic expansion valve manufactured by the Alco Valve Company of St. Louis, Missouri and identified as their "T-Series Thermo Expansion Valves." Each of the thermostatic expansion valves as arranged to be used for either the inlet valve, the bleed valve, or the blocking valve is suitably calibrated and arranged operate in a manner as will be more particularly described in the following specification.

Still referring to FIG. 1 of the drawing, an operating cooling system whose refrigerant charge is to be predetermined by the charging apparatus of the invention is shown to include a pump **11**, a condensing coil **12**, a liquid line **13**, an expansion valve or capillary tube **14**, an evaporating coil **15**, and a suction line **16**. The suction line **16** is provided with a gage port **17** and the liquid line **13** is provided with a gage port **18** as is conventional in the art. The gage ports **17**, **18** may be used to bleed off excess refrigerant charge or to insert additional refrigerant charge as required and also various testing apparatus may be connected to the gage ports as is well known to those skilled in the art.

The thermostatic inlet valve **10** of the charging apparatus of the invention is provided with an inlet passage **20** adapted to be connected through the line **21** to a source of refrigerant charge under high pressure **22**. The outlet of the thermostatic controlled valve **10** is connected at **23** to the line **24** that is adapted to be connected to the gage port **17** of the suction line **16** as shown. The temperature sensing control element or bulb **25** of the thermostatic inlet valve **10** is adapted to be connected in temperature sensing relation to the suction line **16** of the operating cooling system as shown. The pressure responsive control element of the thermostatic inlet valve **10** is connected at **26** to the line **24** also adapted to be connected to the gage port **17** of the suction line **16** as shown in a manner to sense the pressure of the refrigerant in the suction line **16** of the operating cooling system.

The thermostatic valve **10** as used for an inlet valve in the refrigerant charging apparatus of the invention is calibrated and arranged and biased to be normally closed and movable to be opened to permit refrigerant from the refrigerant source **22** to pass through its outlet **23** and into the gage port **17** of the suction line **16** of the cooling system when the temperature pressure characteristics of the refrigerant in the suction line **16** indicate a low charge as sensed by the temperature responsive valve control element **25** and the pressure responsive valve control element connected to the conduit **26** and opposing the bias means in the valve. It is not believed necessary to outline any specific ranges of calibration of the operation for the inlet valve **10** in accordance with refrigerant pressure in the suction line **16** and temperature of the suction line **16** since these parameters are variable and would be determined by the type of refrigeration system being charged and the type of expansion valve or capillary used together with the ambient conditions expected during normal operation. Also it is believed that such calibration parameters would be well known to those skilled in the art.

Thus far, a simplified system for automatically adding refrigerant to an undercharged refrigeration system during its operation has been described. In the event that there is an excessive charge in the operating cooling system as indicated by the sensed temperature and pressure relations in the suction line, the thermostatic controlled inlet valve **10** is operative to remain closed. However, it might be desirable to bleed off the excess charge of refrigerant and for this purpose a valve **30** and controlled leak or bleed **31** to the atmosphere may be provided. It would be only necessary to open the valve **30**, allowing excess charge of refrigerant in the suction line **16** to bleed off into the atmosphere until the thermostatic controlled inlet valve **10** opens to permit charging from the source of refrigerant **22** during continued operation of the charging apparatus of the invention for a short period of time thereafter, and assuming the bleed of excess refrigerant through the bleed element **31** to be relatively small, a balance of the desired charge of refrigerant in the operating refrigeration system may be obtained following which the valves **30** and **10** are closed and the charging apparatus of the invention is disconnected from the suction line gage port **17**.

Referring now to FIG. 2 of the drawing, a modified and somewhat more elaborate form of the invention will be described in which the charge of refrigerant in the operating cooling system may be predetermined to be a desired value whether or not excess refrigerant must be bled off from the operating cooling system or additional refrigerant from the source of refrigerant must be added and the arrangement is such that no loss of refrigerant from the source of refrigerant occurs. In this arrangement the thermostatic controlled inlet valve **10** similar to that shown in FIG. 1 is also provided with its outlet adapted to be connected by the tubing **40** to the gage port **41** of the suction line **42** of the operating cooling system, not shown in detail. In the arrangement shown by FIG. 2, the inlet **43** of the thermostatic controlled inlet valve **10** is connected in series with a blocking valve **60** to the source of refrigerant under high pressure **61** but it should be understood that the blocking valve may be omitted and the inlet **43** of the inlet valve **10** may be connected directly to the source of refrigerant under high pressure at **61** by the optional duct shown at **62** in dotted lines. Considering now the optional arrangement without the blocking valve **60** which is to be later described, the temperature sensing control element **44** of the inlet valve **10** is connected to the temperature sensing bulb **45** adapted to be connected in temperature sensing relation to the suction line **42** of the operating cooling system and the pressure sensitive control element or diaphragm **46** of the inlet valve is adapted to be connected by the duct **47** to the duct **40** and the gage port **41** of the suction line in a manner to sense the pressure of the refrigerant in the suction line **42**. It will be noted that the arrangement of the inlet valve **10** is such that it is normally biased by the spring **10***a* to be closed and may be opened to pass refrigerant from the source **22** and its inlet **43** to its outlet **40** and the gage port **41** of the suction line **42** of the operating cooling system when there is insufficient charge of refrigerant in the cooling system.

In addition a thermostatic controlled bleed valve **50** is provided with its inlet **51** connected by the duct **52** to the duct **40** and the gage port **41** of the suction line **42** of the operating cooling system. The outlet **53** of the thermostatic control bleed valve **50** is open to the atmosphere while the pressure responsive control element **54** of the bleed valve **51** is adapted to be connected by the duct **55** to the duct **40** and also the gage port **41** of the

cooling system suction line **42** to be responsive to the pressure of refrigerant therein. Also the thermostatic responsive control element **56** of the bleed valve **50** is connected to the same temperature sensing bulb **45** as is the thermostatic control element **44** for the inlet valve **10**. Therefore the thermostatic controlled bleed valve **50** is arranged to sense both the temperature and pressure relations of the refrigerant in the suction line **42**. The bleed valve **50**, however, is arranged to operate reversely from the inlet valve **10** and is normally biased to be closed but is calibrated to respond such that the spring **50***a* will be opposed and the valve will be opened to bleed excess refrigerant from the gage port **41** through its inlet **51** to its outlet **53** and to the atmosphere only when the temperature pressure relations sensed by the bleed valve **50** are such as to indicate an excess of refrigerant charge in the suction line **42**. By suitably calibrating both the inlet valve **10** and the bleed valve **50** and their operation, it is possible to provide that both the inlet valve **10** and the bleed valve **50** will be closed when the approximate desired amount of refrigerant charge in the suction line **42** is obtained as indicated by the relative pressure relations of the refrigerant in the suction line **42** sensed by temperature and pressure responsive control elements of the valves **10** and **50**.

Under certain conditions of ambient operation the temperature pressure relationship of the refrigerant in the suction line **42** of the operating cooling system might be such as to cause the inlet valve **10** to be opened to permit further charging of refrigerant from the source of refrigerant **61** when actually there is an adequate charge of refrigerant in the operating cooling system under the ambient conditions being encountered. In order to prevent an excessive charge of refrigerant under such ambient conditions, a third thermostatic controlled valve which may be termed a blocking valve **60** may be provided to prevent passage of refrigerant from the source of refrigerant **61** to the inlet valve **10**. The thermostatic controlled blocking valve **60** is similar to the previously described valves **10** and **50** except for its calibration and manner of operation. In the case of the blocking valve **60** its pressure responsive control diaphragm **63** is adapted to be connected by the line **64** to gage port **65** of the liquid line **66** of the operating cooling system or to any high pressure line of the cooling system such as the discharge line from the compressor **11**. Also in the case of the thermostatic controlled blocking valve **60** its temperature responsive control element **67** is connected to the temperature sensing bulb **68** which is arranged to sense the ambient or atmospheric temperature conditions in the vicinity of the operating cooling system such as the condenser cooling air. The inlet of the blocking valve **60** is adapted to be connected at **69** to the source of refrigerant under high pressure **22** by the line **61** and its outlet **70** is adapted to be connected to the inlet **43** of the inlet valve **10** previously described. The blocking valve is normally biased to be open by the spring **60***a* but is calibrated and arranged to operate such that when the pressure of the refrigerant in the liquid line **66** as sensed at its gage port **65** in relation to the ambient atmospheric temperature sensed by the temperature sensing bulb **68** is such as to indicate an adequate charge of refrigerant in the operating cooling system, the blocking valve spring **60***a* will be opposed to cause the valve to be closed to prevent passage of refrigerant from the source **22** to the inlet valve **10** even though the inlet valve **10** may be open because of the temperature pressure relation of the refrigerant sensed by it in the suction line **42** of the operating cooling system.

Various modifications will occur to those skilled in the art and it should be understood that the invention is not limited to any particular mechanical arrangement of thermostatic expansion valve nor to any particular calibrated ranges of operation for the valves **10**, **50** and **60** since such ranges of calibrations will vary for the

different types of cooling systems with which the charging apparatus of the invention may be used. For example, as defined by some of the appended claims, various combinations of the inlet valve **10** with bleed valve **50** and the blocking valve **60** may be used such as the blocking valve **60** with only the inlet valve **10**, or the inlet valve **10** with only the bleed valve **50**.

We claim as our invention:

1. Refrigerant charging apparatus adapted to be detachably connected to a source of refrigerant for predetermining the charge of refrigerant in an operating expansion cooling system of the type containing a refrigerant and having a suction line gage port and a liquid line gage port comprising: valve means including an inlet valve, and a blocking valve; each of said inlet and blocking valves being thermostatically controlled and having inlet and outlet ports together with a thermal control means and bias means including pressure responsive means for opening and closing the respective valve in accordance with relative conditions of temperature and pressure sensed by the respective valve; means adapted to detachably connect the inlet port of said blocking valve to a source of refrigerant; means adapted to detachably connect the pressure responsive means of said blocking valve to the gage port of the liquid line of an operating cooling system; the thermal control means of said blocking valve being responsive to ambient atmospheric temperature whereby said valve is closed to prevent passage of refrigerant from the source of refrigerant when the pressure in said liquid line is a predetermined value for a related ambient atmospheric temperature; means connecting the inlet port of said inlet valve to the outlet port of said blocking valve; means adapted to detachably connect the outlet port of said inlet valve to the suction line gage port of an operating cooling system; means connecting the pressure responsive means of said inlet valve to the outlet port of said inlet valve; and means adapted to detachably connect the thermal control means of said inlet valve to the suction line of the cooling system in temperature sensing relation whereby said valve is open when the temperature of said suction line is a predetermined value for a related pressure in the suction line as sensed by the pressure responsive means of said inlet valve to thereby pass refrigerant from said source and blocking valve into the suction line of the operating cooling system until the temperature of the suction line is a predetermined value for a related pressure in the suction line.

2. The invention of claim **1** in which a bleed passage is connected to the outlet port of said inlet valve whereby excess refrigerant in the cooling system may be bled into the atmosphere.

3. Refrigerant charging apparatus adapted to be detachably connected to a source of refrigerant for predetermining the charge of refrigerant in an operating expansion cooling system of the type containing a refrigerant and having a suction line gage port and a liquid line gage port comprising: valve means including an inlet valve, a bleed valve, and a blocking valve; each of said inlet, bleed, and blocking valves being thermostatically controlled and having inlet and outlet ports together with a thermal control means opposed by bias means including pressure responsive means for opening and closing the respective valve in accordance with relative conditions of temperature and pressure sensed by the respective valve; means adapted to detachably connect the inlet port of said blocking valve to a source of refrigerant; means adapted to detachably connect the pressure responsive means of said blocking valve to the gage port of the liquid line of the operating cooling system; the thermal control means of said blocking valve being responsive to ambient atmospheric temperature whereby said valve is closed to prevent passage of refrigerant from the source of refrigerant when the pressure in said liquid line of the operating cooling system is a predetermined value for a related ambient atmospheric temperature; means connecting the

inlet port of said inlet valve to the outlet port of said blocking valve; means adapted to detachably connect the outlet port of said inlet valve to the suction line gage port of the operating cooling system; means connecting the pressure responsive means of said inlet valve to the outlet port of said inlet valve; means adapted to detachably connect the thermal control means of said inlet valve to the suction line of the operating cooling system in temperature sensing relation whereby said valve is open when the temperature of said suction line is a predetermined value for a related pressure in the suction line as sensed by the pressure responsive means of said inlet valve; means adapted to detachably connect the inlet port of said bleed valve to the suction line gage port of the operating cooling system; means adapted to detachably connect the pressure responsive means of said bleed valve to the inlet port of said bleed valve; the outlet port of said bleed valve being open to atmosphere; and means adapted to detachably connect the thermal control means for said bleed valve in temperature sensing relation to the suction line of the operating cooling system whereby said bleed valve is open to bleed excess refrigerant from the system into the atmosphere when the temperature of the suction line in the operating cooling system is a predetermined value for a related pressure in the suction line as sensed by the pressure responsive control means of said bleed valve.

References Cited by the Examiner

UNITED STATES PATENTS

2,359,595	10/1944	Urban	62—149
2,689,463	9/1954	Arf	62—149 X
2,951,349	9/1960	Etherington	62—77 X
2,951,350	9/1960	Etherington et al.	62—292 X

LLOYD L. KING, *Primary Examiner.*