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H. EHRENS

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METHOD OF AND APPARATUS FOR TESTING REFRIGERANT SYSTEMS

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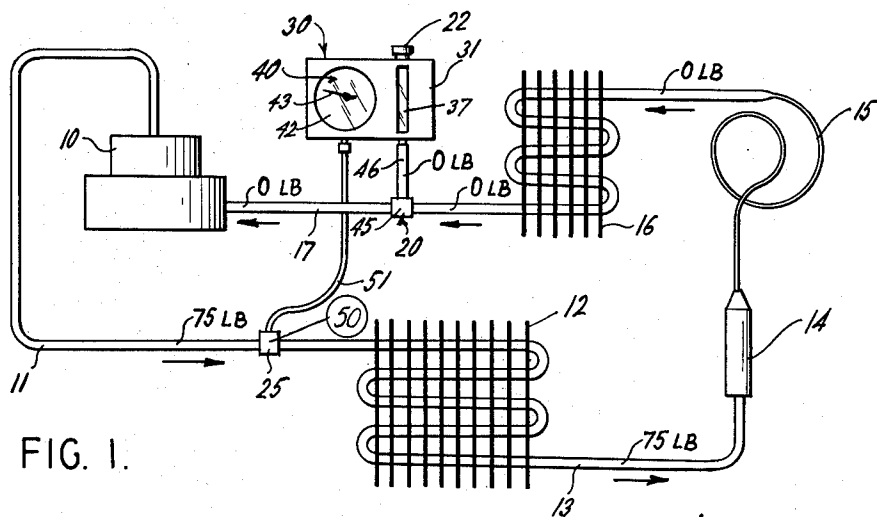


FIG. 1.

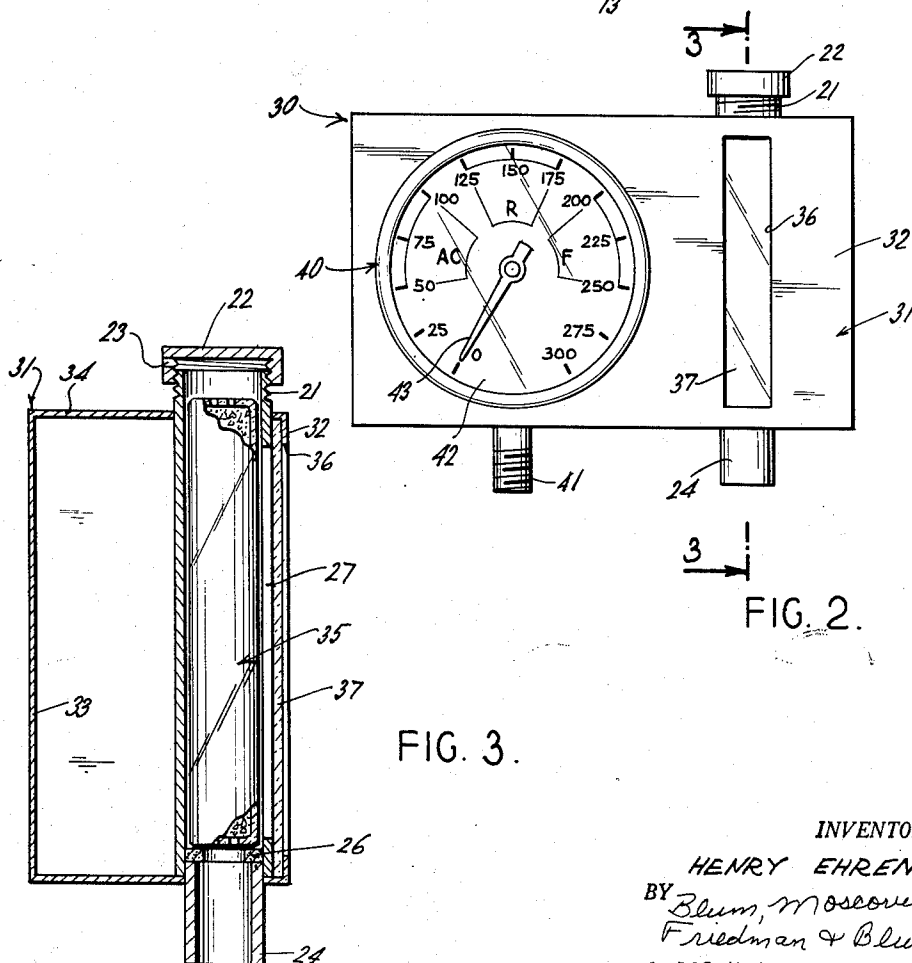


FIG. 2.

FIG. 3.

INVENTOR.
HENRY EHRENS
BY *Blum, Moscowitz,
Friedman & Blum*
ATTORNEYS

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METHOD OF AND APPARATUS FOR TESTING REFRIGERANT SYSTEMS

Henry Ehrens, Cresskill, N.J., assignor to Sealed Unit Parts Co., Inc., New York, N.Y., a corporation of New York

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This invention relates to heat exchange refrigerant circulating systems such as refrigerators, air conditioners, freezers and the like and, more particularly, to a novel method of and apparatus for testing efficiency of such a system.

In the normal cycle used in mechanical refrigeration, such as employed in refrigerators, air conditioners, freezers, and other applications, a refrigerant is compressed in a compressor and delivered from the outlet of the compressor to a condenser. From the condenser, the refrigerant, under relatively high pressure, is expanded through a small diameter opening into an evaporator where it is used to absorb heat from the atmosphere or other substance to be cooled. From the evaporator, the expanded and relatively warm refrigerant is returned to the compressor. A suitable strainer is usually included in the system between the condenser and the expansion point.

Formerly, expansion of a refrigerant into the evaporator was effected by an expansion valve or the like which was adjustable or variable to control the degree of expansion. Such valves were a frequent cause of malfunctioning of the system, and were a hindrance to trouble-free operation of hermetically sealed refrigerant circulating systems.

A solution to this problem was found in the use of a capillary or restriction tube as a replacement for such valves. The fixed and nonadjustable characteristics of such a tube present many advantages over the previously used expansion valve and other types of adjustable and variable controls, the main advantage being trouble-free operation. As a consequence, practically all manufacturers of refrigerant circulating systems of the hermetically sealed type now use such a capillary or restrictor tube between the strainer and the evaporator, and are thereby enabled to eliminate all service valves from the closed system.

However, the substitution of such capillary tubes in hermetically sealed refrigerant circulating systems has introduced a service problem. One reason for this problem is that the designers of such a system have never standardized the bore and length of capillary or restrictor tubes for each type of application. This condition makes difficult exact replacement of the capillary or restrictor tube when there is a malfunctioning of the latter, as due, for example, to clogging, flattening, or other deterioration of the capillary tube. This makes it difficult for a serviceman to replace a removed capillary tube, installed as original equipment, with an exactly corresponding capillary tube. Consequently, replacement of the capillary tube, when the latter is the cause of malfunctioning of the system, has largely been on a hit-or-miss basis. As a result, there has been a long felt need for some arrangement whereby a serviceman, when servicing such a system and replacing parts therein, can readily and easily check whether or not a substituted capillary tube, for example, is of the right bore and length, gives too much restriction, or gives too little restriction. Also, such an arrangement would be particularly useful during manufacture for the purpose of spot checking production lines to see whether or

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not the units have been assembled correctly and if the compressor is functioning properly.

The present invention provides a simple and inexpensive solution to this problem both from the standpoint of servicing a refrigerant circulating system and also from the standpoint of checking the units as they are being manufactured on a production line to see whether or not they will operate according to design. More particularly, in accordance with the present invention it has been found that, if the system is opened to atmosphere at a point between the evaporator and the inlet of the compressor, and if the refrigerant is completely removed from the system and replaced by dry atmospheric air, then, with this dry atmospheric air being circulated through this system, and with the latter open to atmosphere at such point, measurement of the pressure in the system at a point between the compressor outlet and the condenser inlet will give an indication of whether or not the system is operating at its designed evaporator temperature. Specifically, there is a definite relation between the pressure at the compressor outlet and in advance of the condenser, when the system is operated with dry air and open to the atmosphere at the compressor inlet, and the temperature of the refrigerant at the evaporator when the system is re-filled with refrigerant.

For example, in the case of an air conditioner wherein the system is open to the atmosphere between the evaporator and the compressor inlet, and provided with means for drying atmospheric air, if the pressure measured between the compressor outlet and the condenser inlet is 80 p.s.i. when the system has attained a balance (when the volume of air forced through the restricting device is equal to the suction volume of the compressor), then the evaporator temperature, when the system is refilled with refrigerant, will be at the design value of 36° F., for example. On the other hand, or if there is a restriction in the capillary tube resulting in more restriction than required for the designed operating values, the pressure at the compressor outlet and in advance of the condenser will increase substantially beyond such "balance" value of 80 p.s.i. before the inflow and outflow of dry atmospheric air is in equilibrium.

The invention also includes novel apparatus for effecting the method. This novel apparatus comprises a unit having an atmospheric air inlet pipe arranged to contain a desiccant cartridge to dry air entering the pipe. The unit also includes a pressure gauge which may be calibrated in temperature readings corresponding to the pressures, and whose dial may be subdivided into temperature or pressure ranges corresponding respectively to air conditioning system temperatures, refrigerator temperatures, and freezer temperatures. This unit is provided with suitable conduit means by means of which the air inlet pipe or tube may be tapped into the refrigerant circulating system at a point between the evaporator and the compressor inlet and wherein the gauge may be connected to the system at a point between the compressor outlet and the condenser. If no valves are provided at these two points, line taps may be installed in the system conduit at the two points for connection of the conduits of the apparatus unit to the system.

For an understanding of the principles of the invention, reference is made to the following description of a typical embodiment thereof as illustrated in the accompanying drawing.

In the drawing:

FIG. 1 is a schematic layout of a refrigerant circulating system with the invention testing apparatus connected thereto;

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FIG. 2 is a front elevational view of a testing unit embodying the invention; and

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

Referring to FIG. 1 of the drawing, a more or less conventional mechanical type refrigerant circulating system is illustrated as including a mechanical compressor 10 whose outlet delivers refrigerant at relatively high pressure to a discharge line 11 connected to a condenser 12. A discharge line 13 from condenser 12 is connected to a strainer 14 whose outlet is connected to a capillary or restrictor tube 15. The refrigerant from capillary tube 15 is expanded into an evaporator 16 whose discharge line is coextensive with inlet line 17 of compressor 10.

The described system operates normally in the following manner. The refrigerant is compressed by compressor 10 and is directed through discharge line 11 to condenser 12. From condenser 12, the condensed refrigerant, still at a pressure of 75 p.s.i.g. flows through strainer 14 to the refrigerant or capillary tube 15 where, at the outlet of tube 15, it is expanded into the evaporator 16. In the course of such expansion, the refrigerant absorbs heat from the air or other substance surrounding the evaporator 16 to cool such air or other substance, and then flows through inlet line 17 to compressor 10. Under normal operation, if the system is used in an air conditioner, the evaporator design temperature will be about 36° F., if the system is used in a refrigerator, the evaporator design temperature will be of the order of 10° F., and if the system is used in a freezer, the evaporator design temperature will be of the order of -20° F.

Any malfunctioning of the system would be indicated by an excessive variation of the temperature of the evaporator from its design value, usually an increase in temperature. One defect of the system which could cause such a change in the evaporator temperature would be malfunctioning of the capillary tube 15, due to an undue restriction therein, or inefficient operation of the compressor 10. If there is malfunctioning of the capillary tube 15, the indicated procedure for the serviceman is to replace this capillary tube. However, as stated, manufacturers have not established set standards for the length and orifice size of capillary tubes for different applications, and therefore replacement of the capillary tube, on the part of the servicemen, is a hit-or-miss affair. Consequently, unless the serviceman has some way of testing to whether or not the system is operating efficiently, he cannot tell whether a replacement capillary tube has the right length and orifice size or not. The present invention is designed to readily permit such testing.

In accordance with the present invention, the refrigerant is completely drained from the system, with the use of a vacuum pump if necessary to assure thorough removal of refrigerant from the system. Next, the system is opened to atmosphere at the point 20 in the inlet line 17 of compressor 10; that is, at a point between the evaporator and the compressor inlet. The compressor 10 is then re-started and allowed to build up pressure in the system using dry air entering at the point 20. At the same time, the pressure at point 25 in the discharge line of compressor 10 is measured, this measurement thus taking place at a point between the compressor outlet and the condenser inlet. The pressure will gradually build up at the point 25 and eventually will reach a substantially stable value with dry air in the system and with the system open to atmosphere at the point 20. By noting the stable value of the pressure at point 25, and comparing this value with known values from a chart or the like, the serviceman can determine what the temperature of evaporator 16 will be when the system is re-filled with refrigerant.

For example, if the system is an air conditioning system, and if the pressure at point 25 stabilizes at about 80 p.s.i.g., the serviceman will know that the system, when re-

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filled with refrigerant, will produce an evaporator temperature of the order of 36° F. which is the design operating temperature for an air conditioning system. Other values will be appropriate for the system when used for a freezer or for a refrigerator. Should, however, the pressure at point 25 continue to build up beyond 80 p.s.i.g. (in the case of an air conditioner), the serviceman will know that the capillary tube is providing an undue restriction either due to its length or the small size of its orifice, and it will be necessary for him to substitute another capillary tube providing less restriction in the line. This testing continues until the balance pressure attained at point 25 is the proper value to produce the design operating temperature at evaporator 16. When the pressure at point 25 is at the proper value, the system is re-filled with refrigerant and again hermetically sealed, and it will then operate at its normal design value.

On the other hand, should the pressure not build up to the design value within a reasonable time, at the point 25, the serviceman will know that the compressor is not functioning properly in that it cannot produce the proper pressure at the point 25 and this will indicate that the compressor needs servicing or replacing. To facilitate such testing, the apparatus shown more in detail in FIGS. 2 and 3 is provided.

Referring to FIG. 3, the testing unit, generally indicated at 30, includes a casing or housing 31 having a front wall 32 and a rear wall 33 and in the connecting walls 34, 34. For a purpose to be described, front wall 32 has an upwardly extending relatively elongated rectangular aperture 36 therein. A transparent window 37 is disposed on the inner surface of wall 32 across the aperture 36. In alignment with the aperture 36, a nipple 21 extends through the casing 31, being welded or brazed to the lower wall 34 and having an end extending through an opening in the other wall 34 and threaded to receive a cap 22 provided with a radial aperture 23. A shorter nipple 24 extends through an opening in the lower wall 34 and has a telescoping fit within the nipple 21 and is welded or brazed in fluid tight relation thereto. The inner end of nipple 24 forms a shoulder on which is seated a suitable sealing gasket 26, and a desiccant cartridge 35 apertured at each end is removably disposed within the nipple 21 and seated on the gasket 26. Nipple 21 has an elongated rectangular slot 27 in its front surface which is sealingly closed by the window 37 so that the condition of the cartridge 35 may be observed through the window 37 and the slots 36 and 27. Such desiccant cartridges change color with use.

Mounted through the front wall 32 of casing 31 is a pressure gauge 40 having an inlet nipple 41 extending through the lower wall 34. Pressure gauge 40 has a dial 42 which may be calibrated in temperatures, either in degrees Fahrenheit or degrees centigrade, respectively corresponding to definite pressure values, the gauge having a needle 43 movable over its scale. In the particular example illustrated, the scale is divided into three sectors marked respectively "AC," "R," and "F." The sector "AC" represents the temperature or pressure range corresponding to the values for air conditioners. The sector "R" represents the temperature or pressure ranges corresponding to refrigerators. The sector "F" represents the range of temperatures or pressures corresponding to freezers. As illustrated, the gauge is calibrated in pressure values but, in practice, the calibrations would be replaced by the corresponding temperature calibrations. Also, the three sectors can be differently colored for ready observation.

To use the unit 30, the nipple 24 is connected to a connection at the point 20 and the gauge inlet nipple 41 is connected to a connection at the point 25. If appropriate connectors are provided at these two points, the connections may be made directly thereto. However, and in the more usual case, the system is hermetically sealed without any valves or the like being provided at points 20 and 25. In such case, a line tap 45 is used at the point 20

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and connected by a pipe or conduit 46 to the nipple 24. Similarly, a line tap 50 is applied at the point 25 and connected by a flexible conduit 51 to the inlet nipple 41. The line tap 25 may be used to drain the refrigerant from the system by operating the compressor 10 and also by using a vacuum, if necessary.

When the conduit 46 is connected between line tap 45 and nipple 24, and the conduit 51 is connected between line tap 50 and nipple 41, with the compressor 10 operating, and with cap 22 in the position shown in FIG. 3, atmospheric air will enter through the aperture 23 and will be dried by passing through the desiccant cartridge 35. The compressor 10 will gradually build up pressure, drawing atmospheric air into the system and through the desiccant cartridge 35, until a balance is achieved with there being zero p.s.i.g. at the point indicated and a definite pressure at the point 25, such as 75 p.s.i.g. The relatively stabilized pressure reading of the gauge 40 is then noted and, if it is within the proper range for the apparatus with which the system is being used, it will indicate to the serviceman that, when the system is re-filled with refrigerant, the design temperature will be available at the evaporator 16. After such stabilized value is attained, and if the stabilized value of pressure at the point 25 is of the proper value, the apparatus 30 can be disconnected, and the system re-filled with refrigerant.

By the term "balance" or "balance point" as used herein is meant that point at which the compressor outlet pressure reaches a stable value, with the volume of dry air forced through the capillary tube being equal to the suction or intake volume of the compressor so that no air enters the system at point 20.

While a specific embodiment of the invention has been shown and described in detail in order to illustrate the application of the principles of the invention, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. A method of testing a normally hermetically sealed refrigerant system of the type including, in a closed series circuit, a compressor, a condenser, a capillary tube, and an evaporator: said method comprising, while maintaining all the system components operatively connected to each other, removing all the refrigerant from the system; opening the fully connected system to atmosphere at a first point between the evaporator outlet and the compressor inlet; then operating the system to balance the pressures at such first point; and, while so operating the system, measuring the pressure at a second point between the compressor outlet and the condenser inlet to obtain a measure of the evaporator temperature when the system is re-filled with refrigerant.

2. A method of testing a normally hermetically sealed refrigerant system of the type including, in a closed series circuit, a compressor, a condenser, a capillary tube, and an evaporator: said method comprising, while maintaining all the system components operatively connected to each other, removing all the refrigerant from the system; supplying dry air at atmospheric pressure to the fully con-

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nected system at a first point between the evaporator outlet and the compressor inlet; then operating the system to balance the pressures at said first point; and, while so operating the system, measuring the pressure at a second point between the compressor outlet and the condenser inlet to obtain a measure of the evaporator temperature when the system is re-filled with refrigerant.

3. A method of testing a sealed refrigerant system as claimed in claim 2 including the further steps of, if the measured pressure exceeds a predetermined value corresponding to the design operating temperature of the evaporator, replacing the capillary tube with a capillary tube offering less restriction to flow; and repeating the testing and replacing steps until the measured pressure corresponds to the design operating temperature of the evaporator.

4. A method of testing a sealed refrigerant system as claimed in claim 2 including the further steps of, if the measured pressure is substantially less than a predetermined value corresponding to the design operating temperature of the evaporator, correcting the compressor to produce a higher output pressure; and repeating the testing and correcting steps until the measured pressure corresponds to the design operating temperature of the evaporator.

5. Apparatus for testing a refrigerant system which is hermetically sealed during normal use and which includes, in a closed series circuit, a compressor, a condenser, a capillary tube, and an evaporator, while maintaining all the system components operatively connected to each other but operating with the refrigerant removed from the system: said apparatus comprising, in combination, a casing; an inlet tube extending through said casing; a pressure gauge mounted in said casing; means for admitting atmospheric air to one end of said inlet tube; means operable to connect the other end of said inlet tube to a first point in the system located between the evaporator outlet and the compressor inlet; and means operable to connect the inlet of said pressure gauge to a second point in the system located between the compressor outlet and the condenser inlet.

6. Apparatus as claimed in claim 5 including a desiccant cartridge removably disposed in said air inlet tube.

7. Apparatus as claimed in claim 5 in which said one end of said inlet tube is threaded to receive a cap having an air inlet aperture in a circumferential wall and constituting said air admitting means.

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