Aug. 12, 1952 H. B. POWNALL 2,606,430

AUTOMATIC LUBRICATION MEANS FOR PLURAL STAGE COMPRESSORS

Filed Aug. 24, 1951 4 Sheets-Sheet 1

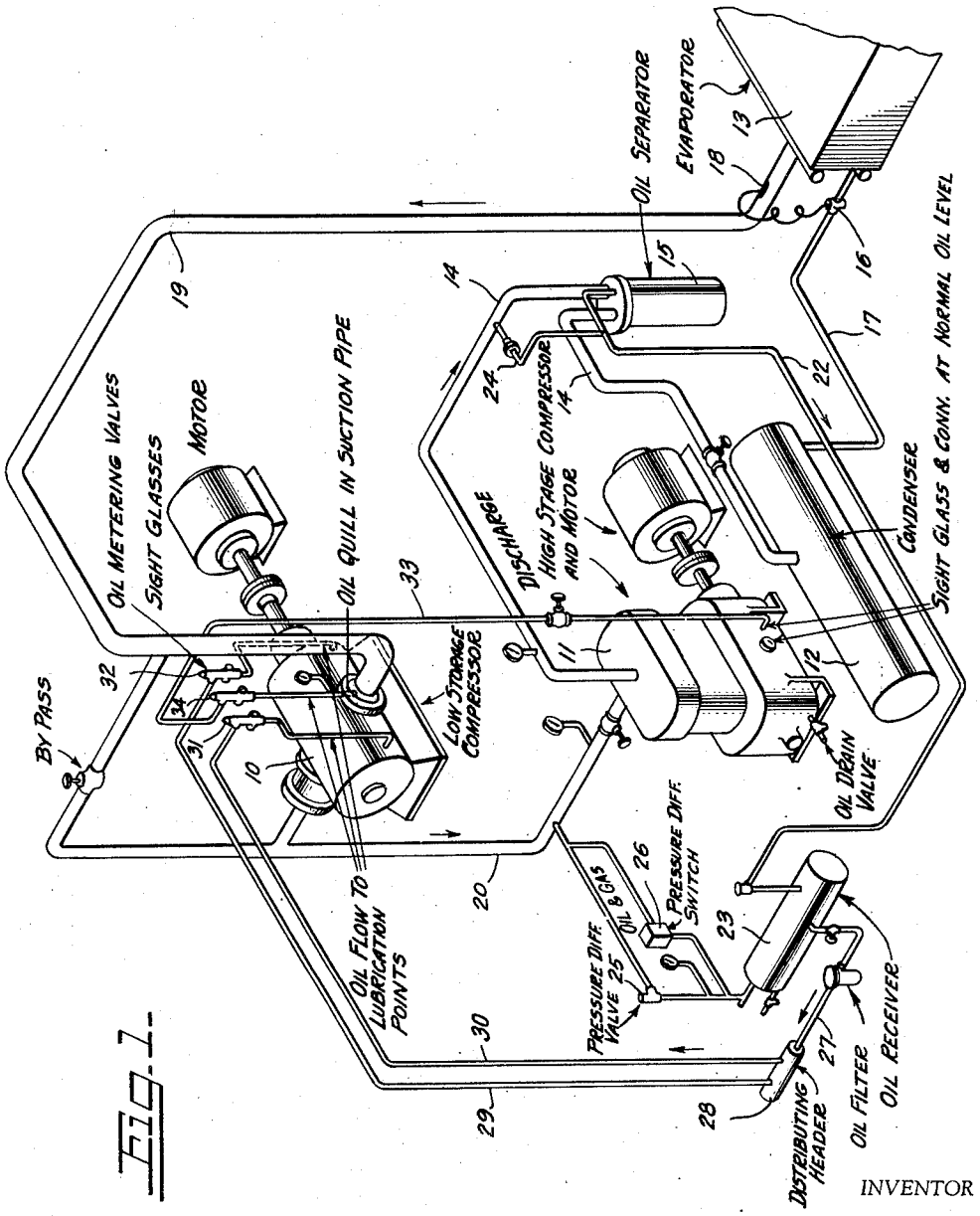

FIG. 1.

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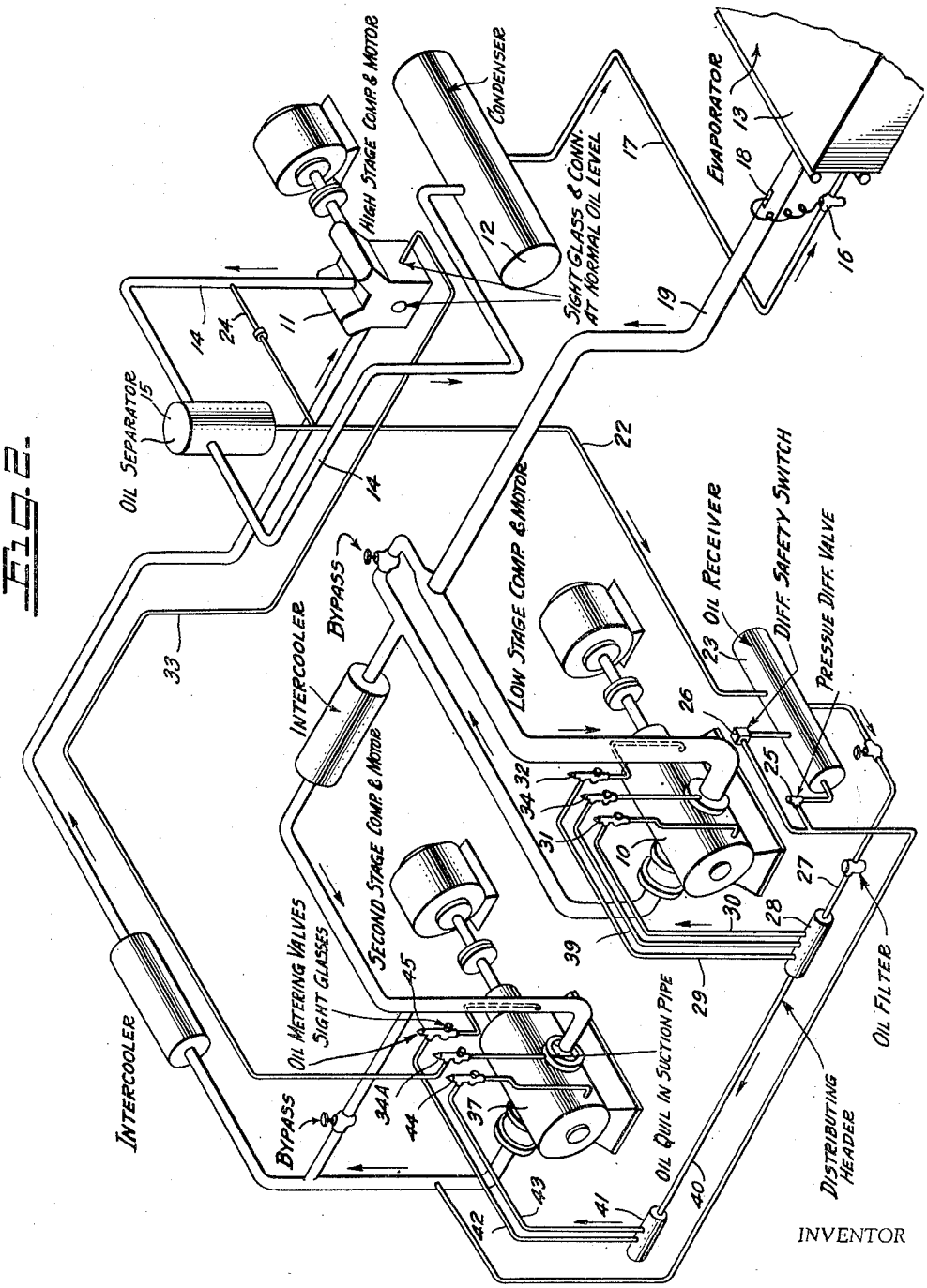
Fig. 2.



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AUTOMATIC LUBRICATION MEANS FOR PLURAL STAGE COMPRESSORS

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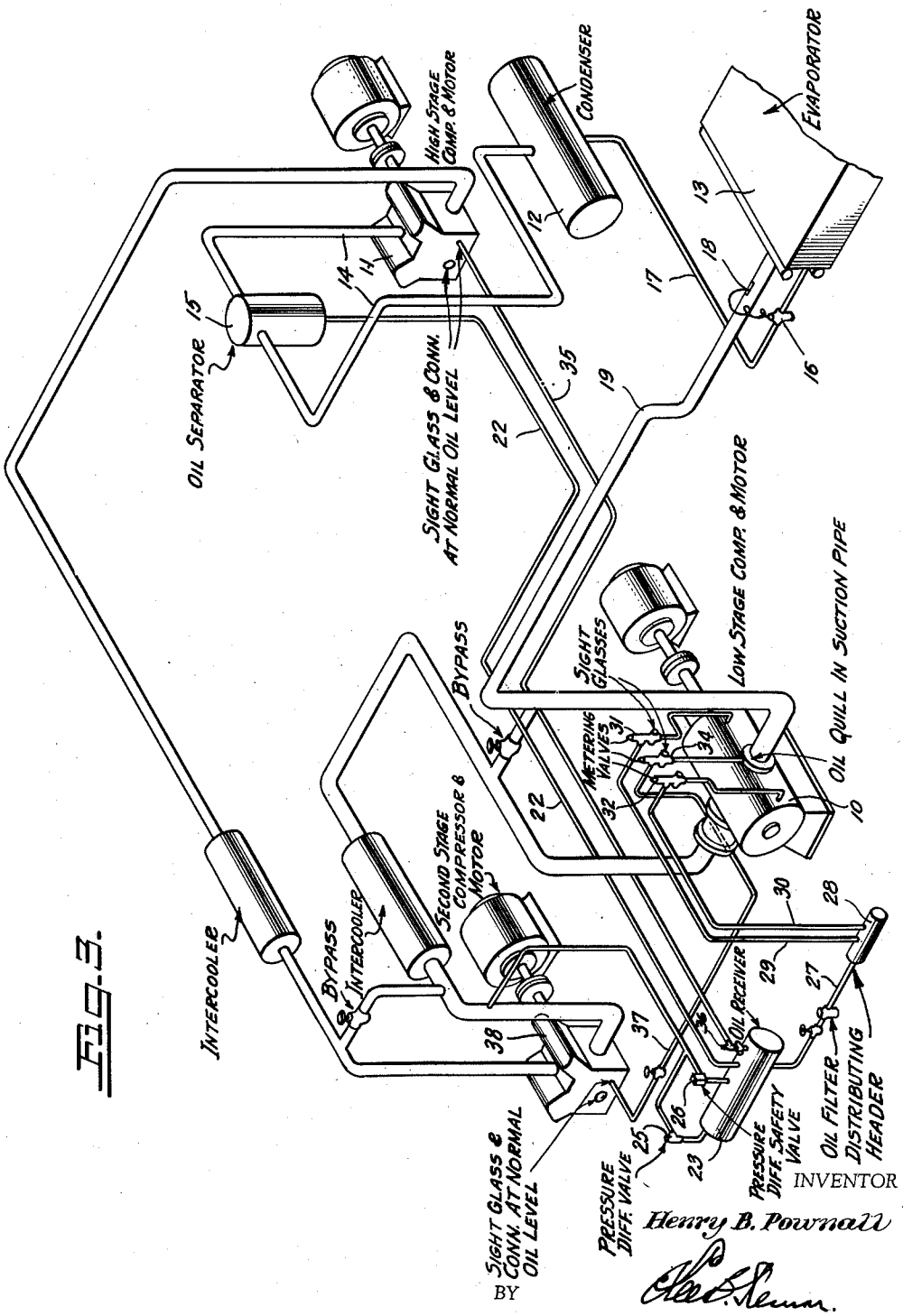

FIG. 3.

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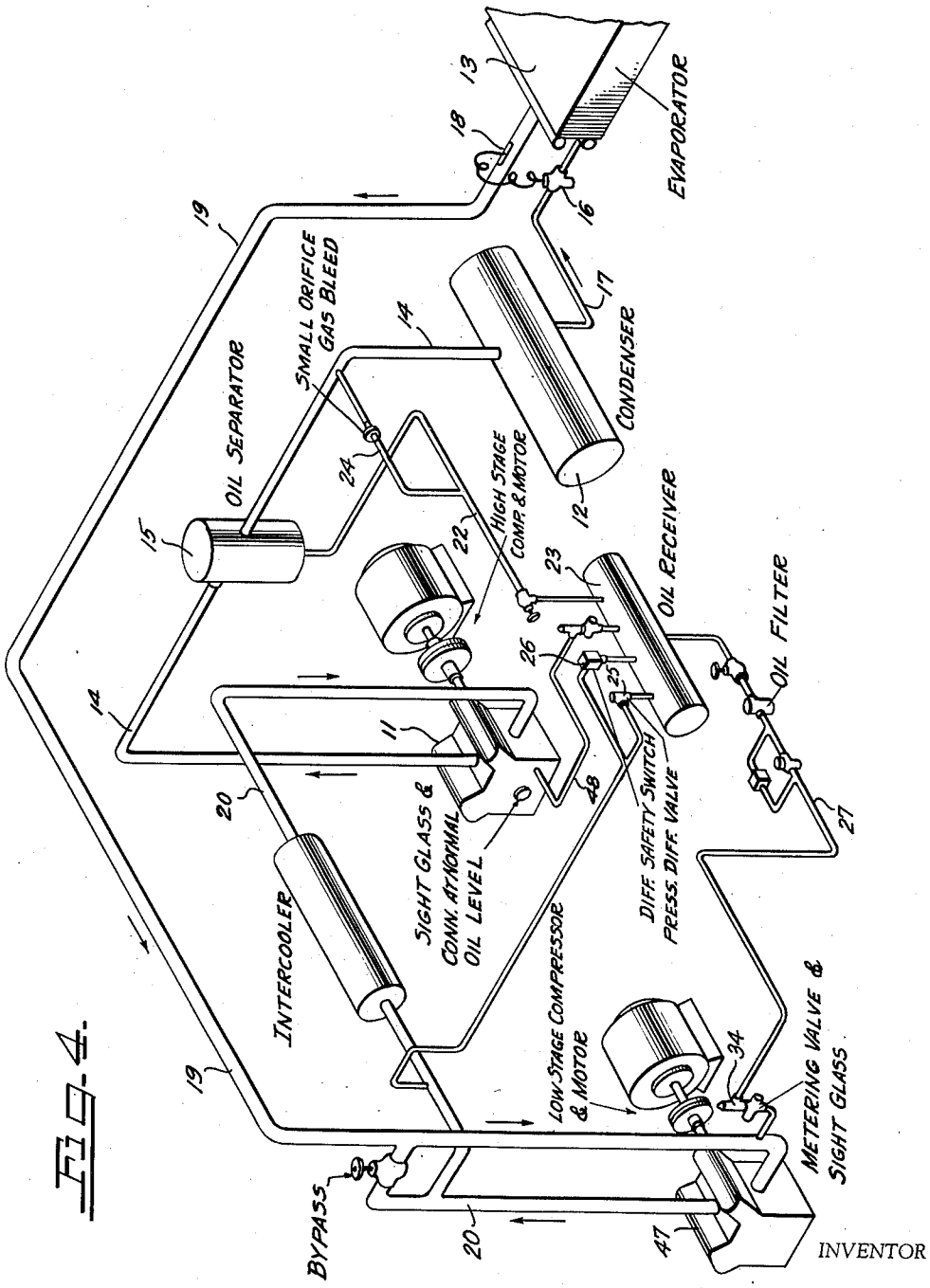

Fig. 4.

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AUTOMATIC LUBRICATION MEANS FOR PLURAL STAGE COMPRESSORS

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13 Claims. (Cl. 62—117.6)

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This invention relates to lubricating systems and more particularly to lubricating systems for compressors of the plural stage type. Perhaps the principal use of this invention will be in connection with plural stage refrigeration systems and the invention will be described herein with particular reference to refrigeration systems, although it is believed that the same principles will be equally applicable in many cases to plural stage compression systems in general.

In the refrigeration art there has been a marked increase in the demand for extremely low temperature rooms and warehouses. This has been occasioned, in part at least, by the demand for increased storage facilities for frozen food products as well as for refrigerated space for testing machinery of all kinds.

It has been found that rotary type compressors can be used to good advantage in plural stage refrigeration systems, and particularly in the low or intermediate stages of such systems. However, the problem of satisfactory and reliable lubrication for the low and intermediate stage machines has proven troublesome. These troubles are inherent in the use of such devices as Mansell lubricators. The chief difficulty in using lubricators of this type is that they require constant attendance in order to insure that there is, at all times, an adequate supply of lubricant furnished to the rotary machine; and, further to insure that the oil level in the crankcase of the piston machine or machines, does not rise above the operating level.

It is an object of this invention to provide a fully automatic lubricating means for plural stage refrigeration systems which will substantially eliminate the need for manual attendance.

Other objects of this invention will be apparent from the following description read in conjunction with the attached drawings, in which:

Figure 1 shows a two stage system in which the high stage compressor is of the piston type and the low stage machine is of the rotary type.

Figure 2 shows a three stage system in which the high stage machine is of the piston type and the intermediate and low stage machines are of the rotary type.

Figure 3 shows a three stage system in which the intermediate and high stage machines are of the piston type and the low stage machine is of the rotary type.

Figure 4 shows a two stage system in which piston type machines are used for both stages.

In each of the figures, corresponding parts have been given the same reference numerals.

In order that the lubricating means of this invention may be workable in refrigeration systems it must be used with a refrigerant in which the oil is miscible. All refrigerants of the Freon group satisfy this requirement while ammonia, for example, does not.

The oil which is pumped by a piston type compressor in a single stage refrigeration system, eventually reaches equilibrium with the oil which is returned from the evaporator to the intake of the compressor. In a plural stage refrigeration system such as shown in Figure 1, however, regardless of how oil is fed to the bearings of the rotary machine, so long as an ample supply is fed, there will be an overflow into the compressor proper which will go out the discharge side of the low stage machine, and be fed from there directly to the suction side of the high stage machine. Under these conditions, the amount of oil returned to the suction side of the high stage machine will always be in excess of the normal pumping rate of the piston machine and this will inevitably result in a raising level of oil in the crankcase of the latter machine.

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In general the disclosure of Figure 1, solves the lubrication problem as follows:

An oil separator is connected to the discharge line of the high stage machine and the oil output from this separator is fed to an oil receiver. The oil in the latter is placed under a pressure which is positive with respect to the pressure on the discharge side of the low stage machine. An outlet line connects the oil receiver with the end bearings of the rotary machine through a pair of oil metering valves. In addition, there is provided a connection between the crankcase of the high stage machine and the suction or inlet side of the low stage machine.

Referring still to Figure 1 of the attached drawings for a more complete understanding of the instant invention, there is shown a two stage system which illustrates the invention in a simple form. The basic refrigerant circuit shown includes a low stage rotary machine 10, a high stage piston machine 11, a condenser 12 and an evaporator 13. Interposed in line 14, which connects the discharge side of the high stage machine to the condenser, is an oil separator 15, and the usual thermal expansion valve 16 is interposed in line 17 between the condenser and the evaporator. Valve 16 may conveniently be of the superheat type controlled by the bulb 18. As will be apparent to those skilled in the art, refrigerant which has boiled off as gas in the evaporator is withdrawn through line 19 to the suction inlet of the low stage rotary compressor 10. The rotary machine compresses the refrigerant and feeds it through line 20 to the suction inlet of the high stage machine, and the latter delivers refrigerant, largely in liquid form, through line 14 to the condenser 12 by way of the oil separator 15. Liquid refrigerant from the condenser 12 under control of the thermal valve 16 is then readmitted to the evaporator 13 and this completes the basic refrigerant circuit.

The oil separator 15, of conventional construction, is effective to separate about ninety percent of the oil contained in the discharge from the high stage machine. This oil is fed through a

line 22 to an oil receiver 23. The oil in the receiver must be maintained at a pressure which is positive with respect to the discharge pressure of the low stage machine. This is accomplished, as shown in Figure 1, by means of a small orificed bleed line 24 connected between the discharge from the high stage machine in line 14 to line 22. Unless this pressure is maintained at the proper level, the system will not work. Accordingly a pressure differential valve 25 is connected between the oil receiver and the discharge side of the rotary compressor. This valve as shown is paralleled by a pressure differential switch 26, which conveniently may be arranged to shut down the entire system, in the event that the proper pressure is not maintained in the oil receiver. From the oil receiver, oil is fed through line 27 to a manifold 28 and from there a pair of lines 29 and 30 carry the oil, under pressure, to the end bearings of the rotary machine through oil metering valves 31 and 32.

With the system as thus far described, oil under pressure will be fed continuously to the end bearings of the rotary machine, and in such quantity that it will overflow into the compressor chamber where, being miscible with the refrigerant it will be carried out the discharge of the rotary machine and returned to the suction inlet of the piston machine. As stated above, under these conditions oil is returned to the piston machine at a somewhat higher rate than the normal pumping rate of the piston machine. Consequently the oil level in the crankcase has a tendency to rise to a higher level than is desired. In order to stabilize the crankcase oil level and render the system fully automatic, a line 33 is connected between the crankcase of the piston machine and the suction inlet of the rotary machine, through an oil metering valve 34 of the same type as valves 31 and 32. The point of connection of line 33 to the crankcase of the piston machine is at the normal crankcase oil level, and any time, therefore, that the oil level rises above this point, the pressure differential existing between the crankcase of the piston machine and the suction inlet of the rotary machine will cause oil to be forced through line 33 to the suction inlet of the rotary machine. Here it will be mixed with refrigerant and returned to the inlet of the piston machine. In this way, equilibrium conditions are established insofar as oil level in the crankcase of the high stage machine is concerned, and adequate lubrication of the rotary compressor bearings is maintained.

It will be apparent to those skilled in the art that the oil metering valves 31, 32 and 34 serve to restrict the flow of oil and to maintain a pressure differential in the conduits in which they are connected.

The above described automatic lubrication system is equally applicable to refrigeration systems employing more than two stages. Further examples illustrating the application of the broad principle of the present invention to three stage systems are shown in Figures 2 and 3.

In Figure 2, a second rotary machine 37 has been added to provide a third or intermediate stage, while in Figure 3, a piston machine 38 has been added to provide a third or intermediate stage. In each case, the same general lubrication scheme is used. In Figure 2 the suction inlet of the low stage machine 10 as well as the end bearing members are lubricated directly from the oil receiver through lines 27, 29, 30 and 39, manifold 28 and oil metering valves 31, 32 and 34. The

intermediate stage rotary machine has its end bearings lubricated directly from the oil receiver through an extension 40 of line 27, a second manifold 41, lines 42 and 43 and metering valves 44 and 45. The crankcase oil level of the high stage machine is stabilized, as in Figure 1, by a conduit 33 connecting the crankcase of the piston machine 11 to the suction inlet of the intermediate stage rotary machine 37, through an oil metering valve 34A. Otherwise the system is the same.

In Figure 3 the crankcase level in the intermediate stage piston type machine is stabilized, as in Figures 1 and 2, by a connection 37 to the suction inlet of the low stage rotary machine. The crankcase oil level in the high stage machine is stabilized by a line 35 connected between the crankcase at the normal oil level to the oil receiver, through a throttling valve 36. This same line 35 in the system shown in Figure 3, takes the place of orificed bleed line 24 of Figure 1 and serves as a source of pressure for the oil receiver which is above the discharge pressure of the low stage machine.

Referring now to Figure 4 of the attached drawings, a two stage refrigeration system is shown. This system makes use of piston type compressors for both the low and high stages. The low stage piston machine 47 is connected similarly to the low stage rotary machine 10, shown in Figure 1, and since the refrigerant circuit is identical, no further discussion is believed necessary. The oil separator 15 is connected, as before, between the discharge from the high stage machine and the input to the condenser with the oil line 22 connecting the oil separator to the oil receiver 23. The output line 27 from the oil receiver in this case, however, leads to the suction inlet of the low stage machine rather than to a manifold or distributing header as shown in the other figures of the drawings. A line 48 is connected intermediate the crankcase of the high stage compressor at a point substantially corresponding to the normal oil level therein and the top of the oil receiver 23, in order to stabilize the oil level in the high stage compressor. A pressure differential valve 25 is connected in the same way as in the apparatus shown in Figure 1, i. e., between the top of the oil receiver and the discharge side of the low stage machine. This valve serves, as before, to maintain a substantially fixed pressure differential between the oil receiver and the discharge side of the low stage compressor.

It will be apparent to those skilled in the art that this invention is not limited in its application to the specific two and three stage systems shown in the accompanying drawings but in fact has wide application in plural stage refrigeration and compression systems. It will also be apparent that by means of this invention a fully automatic lubricating system for plural stage refrigeration apparatus has been provided.

I claim:

1. A two stage refrigeration system in which a piston type compressor is used for the high stage and a rotary type compressor is used for the low stage, and in which the rotary compressor discharges refrigerant into the suction inlet of the piston compressor: means for furnishing an ample supply of oil to the end bearings of the rotary compressor; a closed lubricant conduit connected between the crankcase of the high stage compressor at a point corresponding substantially to a normal oil level therein, and the suction inlet

of the low stage compressor; and means operatively connected in said conduit for restricting the flow therein and for maintaining a pressure differential in said conduit between said compressors; whereby the oil level in the crankcase of the high stage machine is stabilized and lubricant is supplied to the low stage rotary machine during operation of the system.

2. A three stage refrigeration system in which a piston type compressor is used for the high stage and rotary type compressors for the low and intermediate stages, and in which the low stage compressor discharges refrigerant into the suction inlet of the interemiate stage compressor and the latter discharges refrigerant into the suction inlet of the high stage compressor: means for furnishing an ample supply of oil to the end bearings of the rotary compressors and to the suction inlet of the low stage rotary compressor; a closed lubricant conduit connected between the crankcase of the piston compressor at a point corresponding substantially to a normal oil level therein and the suction inlet of the intermediate stage rotary compressor; and means operatively connected in said conduit for restricting the flow therein and for maintaining a pressure differential in said conduit between said compressors; whereby the oil level in the crankcase of the high stage machine is stabilized and lubricant is supplied to the rotary compressors during operation of the system.

3. A three stage refrigeration system in which a rotary compressor is used for the low stage and piston type compressors are used for the high and intermediate stages, and in which the low stage compressor discharges refrigerant into the suction inlet of the intermediate stage compressor and the latter discharges refrigerant into the suction inlet of the high stage compressor: means including an oil separator connected in the discharge line of the high stage machine and an oil receiver for furnishing an ample amount of oil to the end bearings of the rotary compressor; a closed lubricant conduit connected between the crankcase of the intermediate stage compressor at a point corresponding to a normal oil level therein and the suction inlet of the low stage rotary compressor in order to stabilize the oil level in the crankcase of the intermediate stage compressor; means operatively connected in said conduit for restricting the flow therein and for maintaining a pressure differential in said conduit between said compressors; a second closed lubricant conduit connected between the crankcase of the high stage compressor at a point corresponding to a normal level of the oil therein and said oil receiver; and means operatively connected to said conduit for restricting the flow therein and for maintaining a pressure differential in said conduit between said compressors; whereby the oil level in the high stage compressor is stabilized and oil is supplied to the lower stage compressors during operation of the system.

4. In a plural stage refrigeration system in which at least one compressor is of the rotary and one of the piston type, the latter being the high stage machine, an automatic lubricating means comprising: an oil separator connected to the high pressure side of the piston type compressor to effect separation of oil from refrigerant; an oil receiver connected to the oil discharge side of said oil separator; means for maintaining the oil in said receiver under a pressure which is positive with respect to the rotary compressor discharge pressure; closed lubricant conduits connecting said oil receiver and rotary compressor for lubricating said rotary compressor; means operatively connected in each of said conduits for restricting the flow therein and for maintaining a pressure differential in said conduits; a lubricant bleed line connected between the crankcase of the piston compressor and the suction inlet of the rotary compressor, said line having a flow restricting valve operatively connected therein for preventing oil in the crankcase of the piston compressor from rising above a predetermined level.

5. A plural stage refrigeration system comprising: at least two compressors, the discharge of one being connected to the suction inlet of the other, and at least one of which is of the piston and one of the rotary type, the piston compressor being the high stage machine; an evaporator; a condenser; closed-refrigerant carrying conduits connecting said compressors, condenser, and evaporator in a normal refrigeration circuit; means for furnishing lubricant to the end bearings of said rotary compressor; closed lubricant conduit means connected between the crankcase of said piston compressor and the suction side of a rotary compressor operating in the system as a lower stage compressor; and means operatively connected in said conduit for restricting the flow and maintaining a pressure differential therein.

6. A plural stage refrigeration system comprising: a piston type high stage compressor; a rotary type low stage compressor; a condenser; an evaporator; closed fluid conduits connecting said compressors, condenser, and evaporator, in a closed normal refrigerant circuit; an oil separator interposed between the discharge of the high stage machine and the inlet of the condenser; an oil receiver connected to the oil outlet of said oil separator; an orificed lubricant bleed line connected between the discharge side of said piston type compressor and said oil receiver; closed lubricant conduits connecting said oil receiver to the end bearings of said rotary compressor; means operatively connected in said conduits for restricting the flow and maintaining a pressure differential therein; a pressure differential valve connected between said oil receiver and the discharge side of said rotary compressor; and a closed lubricant conduit having a flow restricting valve operatively connected therein connecting the crankcase of said high stage compressor to the suction inlet of said low stage compressor to maintain the oil in the crankcase of the high stage compressor at a predetermined level.

7. A plural stage refrigeration system comprising: a piston type high stage compressor; a rotary type low stage compressor; a rotary type intermediate stage compressor; a condenser; an evaporator; closed fluid conduits connecting said compressors, condenser, and evaporator, in a closed normal refrigeration circuit; an oil separator connected between the discharge of said high stage compressor and the inlet of said condenser; an oil receiver; a closed lubricant conduit connecting the oil discharge side of said oil separator and said oil receiver; an orificed lubricant bleed line connected between the discharge side of said high stage compressor and said oil receiver; a pressure differential valve connected between said oil receiver and the discharge side of said intermediate stage compressor; means including closed lubricant conduits connecting said oil receiver to the end bearings of each of said rotary compressors and to the suction inlet of said low stage rotary compressor; means operatively connected in each of said conduits for restricting the flow

and maintaining a pressure differential therein; and a closed lubricant conduit connecting the crankcase of said high stage compressor to the suction inlet of said intermediate stage compressor, said conduit having means operatively connected therein for restricting the flow and maintaining a pressure differential to maintain a predetermined oil level in the crankcase of said high stage compressor.

8. A plural stage refrigeration system comprising: a low stage rotary compressor; an intermediate stage piston type compressor; a high stage piston type compressor; a condenser; an evaporator; means including closed fluid conduits connecting said compressors, condenser and evaporator in a closed normal refrigeration circuit; an oil separator connected to the discharge side of said high stage compressor; an oil receiver; closed lubricant conduit means connecting the oil discharge side of said oil separator to said oil receiver; a pressure differential valve connected between said oil receiver and the suction inlet side of said intermediate stage piston compressor; closed lubricant conduits connecting said oil receiver to the end bearings of said low stage rotary compressor; means operatively connected in each of said closed conduits for restricting flow and maintaining a pressure differential therein; a closed lubricant conduit connecting the crankcase of said intermediate stage compressor to the suction inlet of said low stage rotary compressor; means operatively connected in said conduit for restricting the flow and maintaining a pressure differential therein; and means including a closed lubricant conduit connecting the crankcase of said high stage compressor to said oil receiver, said conduit having a flow restricting valve therein; whereby a predetermined oil level is maintained in the crankcase of said piston type compressors.

9. A plural stage refrigeration system comprising: a low stage piston type compressor; a high stage piston type compressor; a condenser; an evaporator; means including closed fluid conduits connecting said compressors, condenser and evaporator in a closed normal refrigeration circuit; an oil separator connected to the discharge side of said high stage compressor; an oil receiver; closed lubricant conduit means connecting the oil discharge side of said oil separator to said oil receiver; a pressure differential valve connected between said oil receiver and the discharge side of said low stage compressor; means including a closed lubricant conduit having a flow restricting valve therein connecting said oil receiver to the suction inlet of said low stage compressor; and means including a closed lubricant conduit having a flow restricting valve therein connecting the crankcase of said high stage compressor to said oil receiver, whereby a predetermined oil level is maintained in the crankcase of said high stage compressor.

10. Lubricating means for a plural stage refrigeration system of the type in which a low stage compressor discharges refrigerant into the suction inlet of a high stage compressor and in which a piston type compressor is used for the high stage, the said means comprising: a closed lubricant conduit connected intermediate the crankcase of the high stage compressor at a point corresponding substantially to a predetermined oil level therein and the suction inlet of a lower stage compressor; and means operatively connected in said conduit for restricting the flow therein to maintain a pressure differential in said conduit between said compressors; whereby the oil level in the crankcase of the high stage compressor is stabilized and lubricant is supplied to the lower stage compressor during operation of the system.

11. Lubricating means for a plural stage refrigeration system in which at least one compressor is of the rotary and one of the piston type, the latter being the high stage machine, and in which the rotary compressor discharges refrigerant into the suction inlet of the high stage machine, the said means comprising: means for furnishing an ample supply of oil to the end bearings of the rotary machine; a closed lubricant conduit connected intermediate the crankcase of the high stage machine at a point corresponding substantially to a normal oil level therein and the suction inlet of the rotary machine; and means operatively connected in said conduit for restricting the flow therein to maintain a pressure differential in said conduit between said machines; whereby the oil level in the crankcase of the high stage machine is stabilized and lubricant is supplied to the low stage rotary machine during operation of the system.

12. Lubricating means for a plural stage compression system of the type in which a low stage compressor discharges refrigerant into the suction inlet of a high stage compressor and in which a piston type compressor is used for the high stage, said means comprising: a closed lubricant conduit connected intermediate the crankcase of the high stage compressor at a point corresponding substantially to a predetermined oil level therein and the suction inlet of a lower stage compressor; and means operatively connected in said conduit for restricting the flow therein to maintain a pressure differential in said conduit between said compressors; whereby the oil level in the crankcase of the high stage compressor is stabilized and lubricant is supplied to said lower stage compressor during operation of the system.

13. A plural stage refrigeration system comprising in combination: two or more compressors, at least one of which is of the piston type and operates at a substantially higher pressure than another compressor, and in which a lower stage compressor discharges refrigerant into the suction inlet of the high stage compressor; condensing means; evaporating means; means connecting said compressors, condenser and evaporator means in a closed normal multi-stage refrigeration system; a closed lubricant conduit connected between the crankcase of the piston compressor at a point corresponding substantially to a predetermined oil level therein and the refrigerant suction inlet of a lower stage compressor; means operatively connected in said conduit for restricting the flow therein and for maintaining a pressure differential in said conduit between said compressors; whereby the oil level in the crankcase of the high stage piston compressor is stabilized and lubricant is supplied to the lower stage compressor during operation of the system.

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