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MULTIPLE COMPRESSOR SYSTEMS FOR REFRIGERATION INSTALLATION

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2 Sheets-Sheet 1

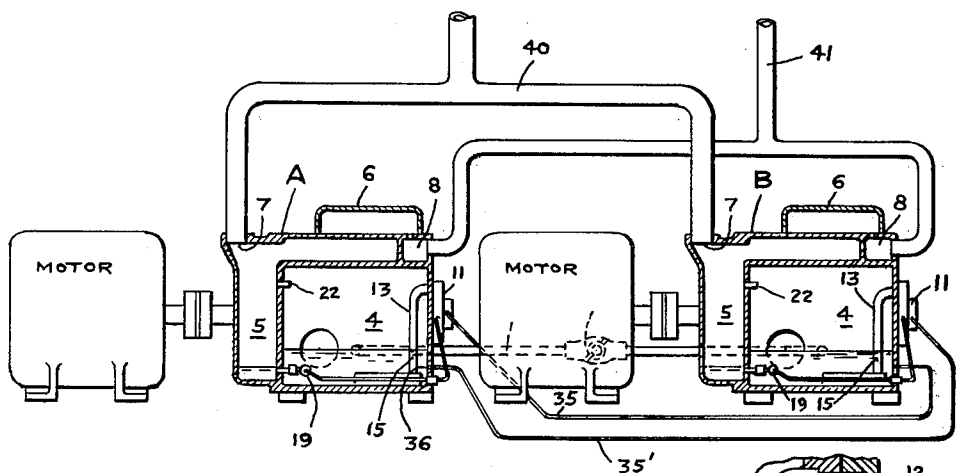


FIG. 2

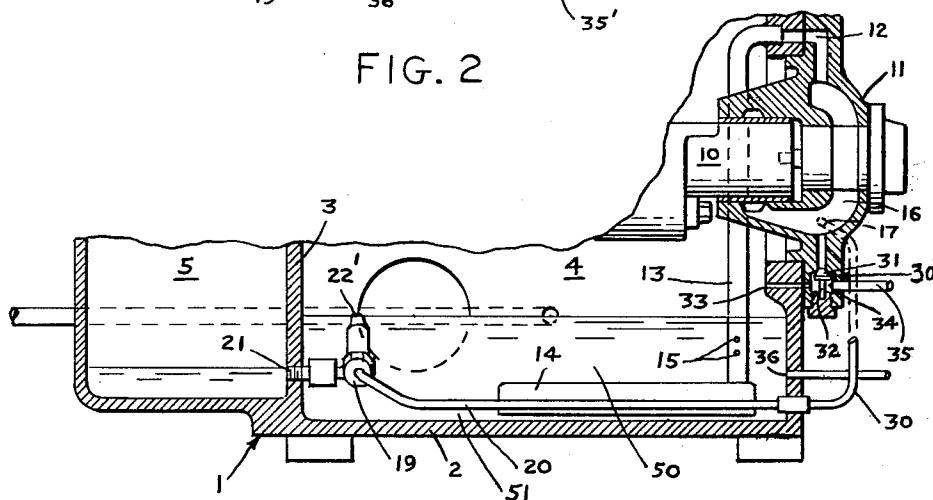


FIG. 1

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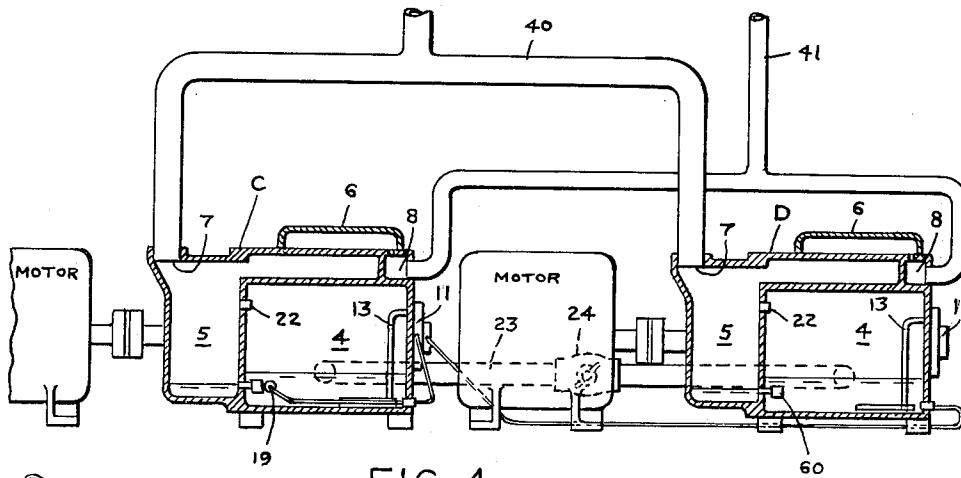


FIG. 4

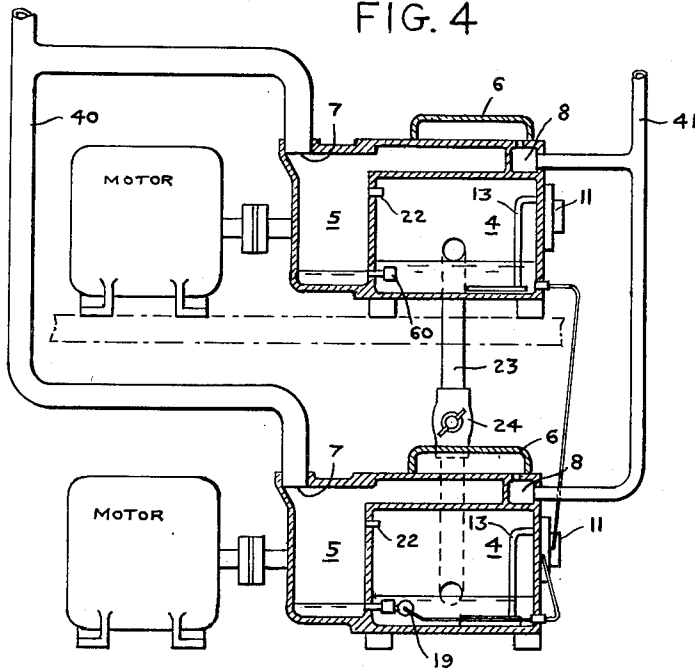


FIG. 3

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1

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MULTIPLE COMPRESSOR SYSTEMS FOR REFRIGERATION INSTALLATION

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15 Claims. (Cl. 230—206)

This invention relates to refrigeration installations and more particularly to multiple compressor systems used to circulate the refrigerant in such installations.

The application of multiple compressors as the circulating means in a refrigeration system as is shown in U.S. Patent 2,076,332 has certain advantages, both from the standpoint of manufacture and operational effectiveness, over single units having the capabilities of the multiple units.

For example shutting down a unit in the multiple system is a more efficient way of regulating the capacity of the system than can be accomplished with unloaders on a single unit.

Furthermore, individual units can be added to the refrigeration installation along with normal plant growth or expansion.

But inherent defects in the construction of the components of the system and their adaptation to multiple compressor operation have created serious operational difficulties which have limited the application of these systems in refrigeration installations.

One such difficulty is presented in prior art duplex systems. For example, during operation with one unit the pressure in the crankcase of the operating compressor is usually greater than that in the suction compartment. As a consequence oil that collects in the suction compartment due to reasons well known in the art, will not return to the crankcase where it is needed in proper quantity as lubricant.

Another operational limitation is presented in systems using more than two compressors, wherein one or more may be idle, as follows: the system pressure drop during foregoing operation may prevent the equalization of oil levels in the crankcases of the individual units. As a consequence one or more of the running units may become oil starved.

Various methods have been developed for multiple compressor systems to relieve the arresting influence that the higher gas pressure in the crankcase compartment has on lubricant collected in the suction compartment.

One such system is disclosed in U.S. Patent 2,869,775 and provides a compressor including check valves which prevent the buildup of abnormal pressures in the crankcase compartment, as described above, which arrests lubricant return thereto.

An analysis of the foregoing patent indicates that the problem relative lubricant return from suction to crankcase compartment is solved but that in providing means for destroying the system pressure to maintain substantially equal levels of lubricant in all of the crankcase compartments other difficulties are presented and particularly in installations including more than two compressors. In order to provide a system of three or more units wherein the system pressure does not interfere with the equalization of oil levels in the crankcases, it is necessary, according to the teachings of the foregoing patent, to maintain definite relationship between the conduits interconnecting the suction, discharge and crankcase compartments and between check valves mounted in the partitions of the individual compressors. Said another way the system contemplated by Patent 2,869,775 solves the problem relative oil return from the suction to crank-

2

case compartment in an individual unit but in attempting to provide for equalization of oil levels in all units of the system, presents complex technical requirements which increase the overall cost thereof.

In addition to insure proper operation the system contemplated in the above patent must be operated in accordance with predetermined operational instructions which at times may be difficult to meet.

The system contemplated in application Serial No. 1,300 of Richard K. Berger et al. filed January 8, 1960 and assigned to Worthington Corporation solves both the problem of oil return from suction compartment to crankcase compartment and equalization of oil level in all crankcases in such manner so as not to require complex technical considerations in the design or operation of the overall system.

However, in solving these prior art deficiencies another disadvantage is presented, namely maintaining the dimension of the leveling conduit in a definite relation relative the equalizing orifice, adds to the cost of the system. Said another way the conduit and valves associated therewith due to the above requirement are overly large and thusly add appreciably to the manufacturing costs of the system.

In addition high oil temperatures at low pressure operating conditions are presented in the above systems including simply an equalizing conduit to provide for equal lubricant levels in the crankcase.

The present invention solves the problems mentioned above and in addition provides means for eliminating the high oil temperatures and costs associated with the above systems.

More particularly this is accomplished with the provision of means which bypass lubricant from one unit to another unit of the system which may in turn bypass still another unit as will be described in detail hereinafter.

Accordingly, it is an object of this invention to provide a multiple compressor system for a refrigeration installation which overcomes the problems mentioned hereinabove.

It is another object of this invention to provide a multiple compressor system for a refrigeration system with means for insuring cooler lubricant temperatures during adverse operating conditions.

It is a further object of this invention to provide a multiple compressor system for a refrigeration system with means that assure positive oil return and equalizes lubricant levels in the crankcase.

It is another object of this invention to provide a less costly multiple compressor system by providing standardized components which are manufactured according to assembly line techniques.

It is a further object of this invention to provide a multiple compressor system which can be adapted to any refrigeration installation with minimum design consideration and at lowest possible cost.

With the foregoing objectives in view, and others as may appear from the accompanying specification, the invention consists of various features of construction and combination of parts, which will be first described in connection with the accompanying drawings, in which like parts have the same reference characters, showing the multiple compressor system contemplated herein, and the features of the invention will be specifically pointed out in the claims.

In the drawings:

FIGURE 1 is a fragmentary longitudinal view in part section showing an open type compressor.

FIGURE 2 is a schematic view showing a further form of multiple compressor system.

FIGURE 3 is a schematic view showing another form of multiple compressor system.

FIGURE 4 is a schematic view showing one form of multiple compressor system.

Referring to the drawings FIGURE 1 shows an open type compressor designated 1 and generally adapted for use in the multiple compressor systems shown herein and embodying the novel components which provide for the return of lubricant from the suction to crankcase compartment and in addition maintain substantially equal lubricant levels in all crankcase compartments when applied in a multiple type system as hereinafter described.

While FIGURE 1 shows an open type compressor, it will be understood by those familiar with this art that the concepts outlined herein may be applied to compressors of the hermetic type and that reference to open units hereinafter is solely for purposes of illustration.

The concepts shown in the unit described in application Serial No. 742,111 filed July 16, 1958, now Patent No. 2,956,730, dated Oct. 18, 1960, by Clark B. Hamilton and Linwood A. Pickle form the basic element of the multiple compressor system contemplated herein. The compressor 1 basically comprises a casing 2 including a partition 3 which divides same into a crankcase compartment 4 and a suction compartment 5.

As will be understood in the art all of the elements, such as cylinders, pistons and the like, of a conventional compressor are associated with the units contemplated herein and the compressor may be of one cylinder or multi-cylinder type without departing from the scope of the present invention.

The compressor is provided with the usual head 6 including the usual valves (not shown) to control fluid flow through the cylinder. As is customary fluid from the low side of the refrigeration installation is passed to suction compartment 5 through opening 7 and to the high side of the installation from the discharge chamber 8.

The bearings 9 and shaft 10 serving to drive the moving parts of the compressor are lubricated by any suitable lubrication system.

Thus, in the present form of the invention the crankcase compartment 4 is shown as having lubricant 50 collected in a reservoir generally designated 51 and formed in the lower portion of the crankcase compartment. This lubricant is supplied at a predetermined pressure to the moving parts by any suitable type pump generally designated 11, connected to shaft 10, which takes its suction through inlet 12 and suction pipe 13, which is connected to strainer 14 shown as disposed in the lower portion of reservoir 51. Holes 15, which may be drilled, are formed in pipe 13. The function of these holes or openings will be described in detail hereinafter.

Lubricant flowing to pump 11 is discharged into outlet 16. A predetermined quantity of the lubricant passed to outlet 16 is passed through opening 17 which is connected to ejector 19 by means taking the form of a by-pass line 20. As will be evident flow from pump 11 to ejector 19 can be regulated by proper sizing of opening 17 and line 20.

As was mentioned hereinabove, and as is more fully treated in above application Serial No. 742,111: disposition of ejector 19 in partition 3 so that suction portion 21 communicates with suction compartment 5, and discharge portion 22' opens into crankcase compartment 4 provides positive means for returning lubricant collected in the suction compartment to the crankcase compartment.

A positive type lubricant return is essential because crankcase pressure is higher than suction compartment pressure as a result of blowby of refrigerant into crankcase compartment during compressor operation. This condition is further amplified in a multiple system due to the variations in pressure caused when one or more units are unloaded or shut down as will be understood by one skilled in the art.

In addition to providing the ejector 19 for returning lubricant to the crankcase an opening taking the form of

a port 22 is formed in the partition 3 so that there results a substantial equilization of pressure between the suction and crankcase compartments.

And in similar fashion to the concepts disclosed in above application Serial No. 1,300, means taking the form of a balancing conduit 23 interconnect the crankcases of the compressor forming the multiple system and coact with ports 22 to destroy the effects of the system pressure drop which tends to arrest equalization of lubricant levels in the crankcase compartments. A valve 24 is included in conduit 23 permitting more versatile operation of the system.

While the above described components resemble the apparatus shown and described in application Serial No. 1,300 also assigned to Worthington Corporation, it is pointed out that balancing conduit 23 and valve 24 are of smaller size and thusly reduce appreciably the cost of the system.

In order to provide the advantages contemplated herein applicants provide means taking the form of a bypass arrangement generally designated 30' associated at one end with the pump of first compressor A and at the other end with the crankcase of a second compressor B to coact with the components outlined above to teach a system which provides for equalization of lubricant levels in all crankcases and one that tends to operate at cooler oil temperatures.

More particularly bypass arrangement 30' comprises a passage means 31 formed in the discharge portion of pump 11 and communicating with outlet 16. Valve means 32 is disposed in passage means 31 to insure proper supply of lubricant to the moving surfaces of the compressor. Accordingly, when a predetermined pressure is reached in outlet 16 valve means 32 opens and permits flow of lubricant to the crankcase of the first compressor A through by-pass 33 and to the crankcase of the second compressor B through bypass 34 and line 35. This arrangement of by-pass oil flow shows a split flow from the chamber 34. The hole 33 returns a greater portion of the oil into crankcase A and a smaller portion is bypassed through tube 35 which flows into crankcase B. Thus the tube 35 is sized to feed approximately $\frac{1}{4}$ of the by-passed oil from chamber 34 to compressor B and $\frac{3}{4}$ through hole 33 into crankcase A. Oil pumps, in general used in this type of compressor, are oversized and hence approximately $\frac{2}{3}$ of the pump's capacity is by-passed into chamber 34 or 4 gals. per min. A pressure of approximately 1.1 p.s.i.g. exists in chamber 34 which causes a flow of 3 gals. per minute through hole 33 and 1 gal. per minute through tube 35. The sizing of tube 35 is thus fashioned for the distribution of split by-passed flow from chamber 34 into crankcases A and B.

The apparatus described above thusly permits the adaptation of compressor 1, which in itself is an advance as it solves the oil return problem present in individual installations, into a multiple system without the necessity of incorporating complex design changes and at appreciably lower costs.

A multiple system including the above compressor is shown in FIGURE 2 and can be readily assembled by interconnecting the suction compartment 5 through conduit means 40 with the low side of the refrigeration installation. In similar fashion the discharge compartments 8 are interconnected by conduit means 41 to the high side of the installation. Conduit 23 interconnects the crankcases to provide means which permit the passage of lubricant between the crankcases. Line 35 connected to compressor A at by-pass 34 is connected to the crankcase of compressor B at the base thereof. Similarly line 35' which runs from lubrication system associated with compressor B is connected to the crankcase of compressor A at 36.

In operation and with both compressors A and B running under ideal conditions the flow bypassed from A to B through line 35 and from B to A through line 35'

5

will be substantially the same to thusly maintain proper crankcase levels. Of course lubricant collected in either of the suction compartments 5 will continually be returned to the crankcase compartments 4 through ejectors 19.

Under unloaded conditions wherein compressor B is fully unloaded and compressor A is fully loaded, the pressure in crankcase 4 of compressor B rises appreciably. Due to different outputs in the pumps associated with the units as may occur in practice and should the pump in B bypass more oil into A than the pump of A into B the effect is to lower the lubricant level in compressor B until it reaches a level equivalent to the level of uppermost hole 15. With more lubricant pumped into A the level therein tends to increase the crankcase pressure which supplements the loss of lubricant in B bypassing lubricant thereto through balancing line 24. Coacting with this flow to B through line 23 is the flickering in oil pressure in pump 11 of compressor B which tends to reduce the flow passed from compressor B to compressor A.

Thusly in the above described fashion applicant provides means for maintaining equalization of lubricant level during the most adverse operating conditions.

FIGURES 3 and 4 show a modified form of multiple compressor installation having a compressor C which resembles the compressors described as forming the basic elements of the system shown in FIGURES 1 and 2.

Except for incorporating means taking the form of a check valve 60 in compressor D to permit flow of lubricant from the suction compartment to the crankcase compartment and the elimination of the bypass means associated with the pump of compressor A, compressor D in essence resembles the above described units.

Parts having generally the same construction and purpose as the corresponding parts in FIGURES 1 and 2 have been given the same reference characters, and instead of permitting flow in either direction in conduit 23 as was the case in the embodiment of FIGURE 2 flow in this instant is unidirectional from compressor D to C.

Arrangement such as is described above permits the disposition of C in superposed relation with D as is shown in FIGURE 3 to thusly permit assembly of the system in an area wherein space is limited.

This system operates as follows: compressor D is sequenced to unload first and during unloaded conditions crankcase pressure in D is higher than the pressure in crankcase C. It is evident that lubricant will tend to flow into compressor C thusly tending to oil starve compressor D. However, due to the provision of bypass means comprising the pump, line 35 and interconnection with the crankcase of compressor D the lubricant level or supply of this compressor is replenished and maintained at proper level.

With the above provisions applicant describes a multiple compressor system which eliminates the objections of prior type systems and it will be evident to those skilled in the art that many changes may be made without departing from the scope of the appended claims.

What is claimed is:

1. A multiple compressor system for use in a refrigeration installation including a first and second compressor, each of said compressors comprising a casing having a partition therein for dividing the compressor into a suction and crankcase compartment, a discharge compartment in each of said casings, a suction conduit interconnecting each of the suction compartments and said suction conduit connected to the low side of the refrigeration installation, a discharge conduit interconnecting each of the discharge compartments and said discharge conduit connected to the high side of said refrigeration installation, port means in the partition of each said compressor providing communication between the suction and crankcase compartments whereby substantially equal pressures are maintained in said compartments, ejector means

6

in the partition of one of said compressors for passing lubricant from the suction compartment to the crankcase compartment, means in the partition of the other compressor permitting flow of lubricant from the suction compartment to the crankcase compartment, bypass means interconnecting the crankcase compartments of both compressors and adapted to flow lubricant from the compressor having said ejector to the other compressor, and a conduit interconnecting the crankcase compartments of both of said compressors.

2. A multiple compressor system for use in a refrigeration installation including a first and second compressor, each compressor comprising a casing having a partition therein for dividing the casing into suction and crankcase compartments, a discharge compartment in each of said casings, a lubrication system for said compressors and disposed in the casings, a suction conduit interconnecting each of the suction compartments and said suction conduit connected to the low side of the refrigeration installation, a discharge conduit interconnecting each of the discharge compartments and said discharge conduit connected to the high side of said refrigeration installation, port means in the partitions of each of said compressors providing communication between the suction and crankcase compartments whereby substantially equal pressures are maintained in said compartments, ejector means including a suction inlet and discharge outlet disposed in the partition of one of said compressors, the suction inlet of the ejector means communicating with said suction compartment, the discharge outlet of the ejector being disposed in said crankcase compartment, means interconnecting the ejector with the lubrication system whereby during operation said ejector passes fluid from the suction compartment to the crankcase compartment, means in the partition of the other compressor permitting flow of lubricant from the suction compartment to the crankcase compartment, bypass means connected to the lubrication system of the compressor including the ejector means and the crankcase of the other compressor, and a balancing conduit interconnecting the crankcase compartments of both said compressors.

3. A multiple compressor system for use in a refrigeration installation including a first and second compressor, each compressor comprising a casing having a partition therein for dividing the casing into suction and crankcase compartments, a discharge compartment in each of said casings, a lubrication system having a pump including an inlet and outlet for said compressors and connected to the casings, a suction conduit interconnecting each of the suction compartments and said suction conduit connected to the low side of the refrigeration installation, a discharge conduit interconnecting each of the discharge compartments and said discharge conduit connected to the high side of said refrigeration installation, port means in the partitions of each of said casings providing communication between the suction and crankcase compartments whereby substantially equal pressures are maintained in said compartments, ejector means including a suction inlet and discharge outlet disposed in the partition of one of said compressors, the suction inlet of the ejector means communicating with said suction compartment, the discharge outlet of the ejector being disposed in said crankcase compartment, conduit means interconnecting the ejector with the outlet of said pump whereby during operation thereof said ejector passes fluid from the suction compartment to the crankcase compartment, check valve means in the partition of the other compressor permitting flow of lubricant from the suction compartment to the crankcase compartment, bypass means connected to the outlet of the pump and the crankcase of the compressor including the check valve, and a balancing conduit including valve means interconnecting the crankcase compartments of both of said compressors.

4. The multiple compressor installation claimed in claim 3 wherein flow through said balancing conduit is

from the compressor having the check valve to the compressor having the ejector.

5 The multiple compressor installation claimed in claim 3 wherein the pump includes a first and second passage means connected to the outlet thereof, one of said passage means communicating with the crankcase compartment, the other passage being connected to the bypass means, and check valve disposed in said passage means to cut off communication between the pump outlet and the bypass means at predetermined times.

10 6. The multiple compressor installation claimed in claim 5 wherein the passage means communicating with said crankcase is of greater dimension than the passage means connected to the bypass means.

15 7. The multiple compressor installation claimed in claim 6 wherein flow through said balancing conduit is from the compressor having the check valve to the compressor having the ejector.

20 8. The multiple compressor installation claimed in claim 7 wherein the compressor having the check valve is superposed over the compressor having the ejector.

9. A multiple compressor system for use in a refrigeration installation including a first and second compressor, each compressor comprising a casing having a partition therein for dividing the casing into a suction and crankcase compartments, a discharge compartment in each of said casings, a lubrication system for each of said compressors and disposed in the casings, a suction conduit interconnecting each of the suction compartments and said suction conduit connected to the low side of the refrigeration installation, a discharge conduit interconnecting each of the discharge compartments and said discharge conduit connected to the high side of said refrigeration installation, port means in the partition of each of said compressors providing communication between the suction and crankcase compartments whereby substantially equal pressures are maintained in said compartments, ejector means including a suction inlet and discharge outlet disposed in the partitions of both said compressors, the suction inlets of the respective ejector means communicating with the respective suction compartments, the discharge outlets of the respective ejector means disposed in the respective crankcase compartment, means interconnecting the ejectors with the respective lubrication systems whereby during operation thereof the ejectors pass fluid from their respective suction compartments to the respective crankcase compartments, first bypass means interconnecting the lubrication system of the first compressor with the crankcase of the second compressor, second bypass means interconnecting the lubrication system of the second compressor to the crankcase of the first compressor, and a balancing conduit interconnecting the crankcase compartments of both said compressors.

10. A multiple compressor system for use in a refrigeration installation including a first and second compressor, each compressor comprising a casing having a partition therein for dividing the casing into suction and crankcase compartments, a discharge compartment in each of said casings, a lubrication system having a pump including an inlet and outlet for said compressors and connected to the casing, a suction conduit interconnecting each of the suction compartments and said suction conduits connected to the low side of the refrigeration installation, a discharge conduit interconnecting each of the discharge compartments and said discharge conduit connected to the high side of said refrigeration installation, port means in the partitions of each of said casings providing communication between the suction and crankcase compartments whereby substantially equal pressures are maintained in said compartments, ejector means including a suction inlet and discharge outlet disposed in the partitions of both said compressors, the suction inlets of the respective ejection

tor means communicating with the respective suction compartments, the discharge outlets of the respective ejector means disposed in the respective crankcase compartments, conduit means interconnecting the ejector with the outlets of the pumps whereby during operation thereof the ejectors pass fluid from their respective suction compartments to the respective crankcase compartments, first bypass means interconnecting the outlet of the pump in the first compressor with the crankcase of the second compressor, second bypass means interconnecting the outlet of the pump of the second compressor with the crankcase of the first compressor, and a balancing conduit interconnecting the crankcase compartments of both said compressors.

11. The multiple compressor installation claimed in claim 10 wherein both of the pumps include first and second passage means connected to the pump outlets, one of said passage means communicating with the crankcase compartment, the other passage means being connected to the bypass associated with the compressor, and check valves disposed in the passage means of both pumps to cut off communication between the pump outlets and their respective bypass means.

12. The combination claimed in claim 10 wherein both pumps include suction tubes connected to the inlet thereof at one end and disposed in the crankcase at their other ends, and means at predetermined positions in said suction tubes to reduce the pressure output of the respective pumps when the level of lubricant in the crankcases fall below a predetermined level.

13. The multiple compressor installation claimed in claim 11 wherein both passage means communicating with their respective crankcases are of lesser dimension than the passage means connected to the individual bypass means.

14. The multiple compressor installation claimed in claim 12 wherein the balancing circuit includes a valve means disposed therein.

15. A multiple compressor system for use in a refrigeration installation including a first and second compressor, each compressor comprising a casing having a partition therein for dividing the casing into a suction and crankcase compartment, a discharge compartment in each of said casings, a lubrication system for each of said compressors having a pump including an inlet and outlet and said pumps connected to the respective casings, a suction conduit interconnecting each of the suction compartments and said suction conduit connected to the low side of the refrigeration installation, a discharge conduit interconnecting each of the discharge compartments and said discharge conduit connected to the high side of said refrigeration installation, port means in the partitions of each of said casings providing communication between the suction and crankcase compartments whereby substantially equal pressures are maintained in said compartments vent means in the partition of each compressor and beneath the port means to permit lubricant to flow from said suction compartment to said crankcase compartment, conduit means interconnecting said pump means of the first compressor to the crankcase of the second compressor, conduit means interconnecting the pump means of the second compressor to the crankcase of the first compressor whereby said pump means operate to maintain an equal level of lubricant in both said compressors.

References Cited in the file of this patent

UNITED STATES PATENTS

2,076,332	Zercher	Apr. 6, 1937
2,253,623	Jordon	Aug. 26, 1941
2,869,775	Neubauer	Jan. 20, 1959
2,918,210	Touborg	Dec. 22, 1959
2,956,730	Hamilton et al.	Oct. 18, 1960