

Aug. 17, 1965

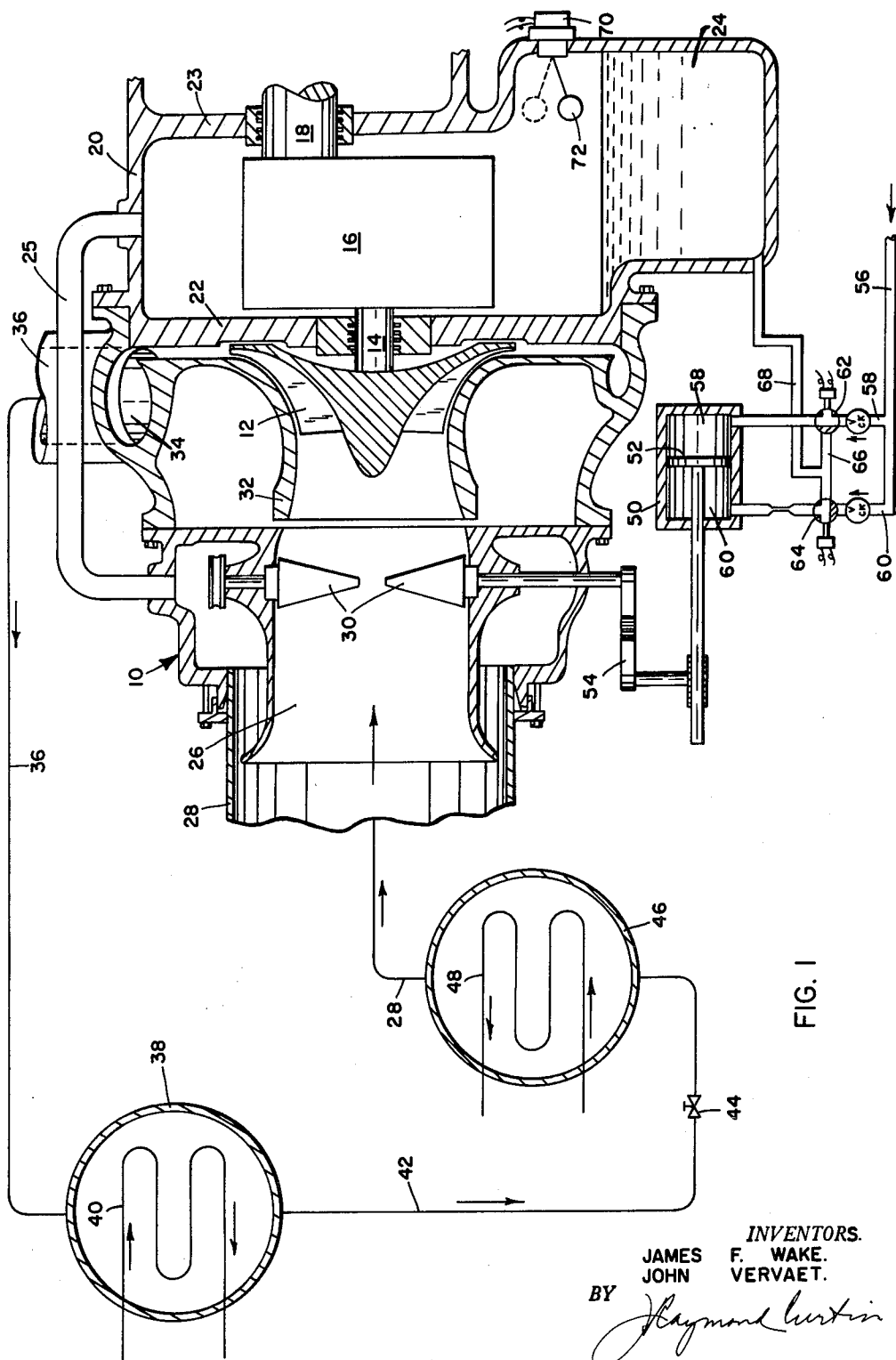
J. F. WAKE ETAL

3,200,603

LUBRICANT CONTROL MEANS FOR REFRIGERATION APPARATUS

Filed Nov. 15, 1963

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 3

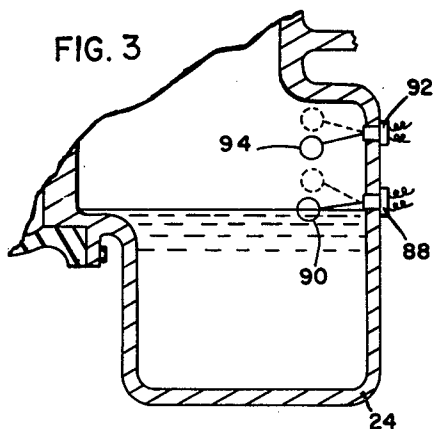


FIG. 2

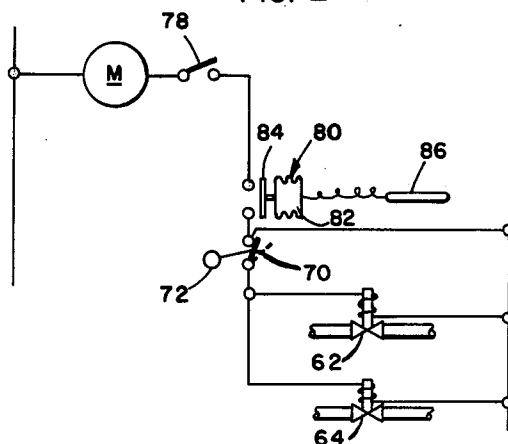


FIG. 5

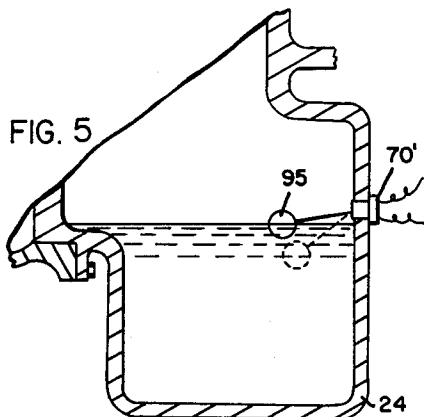
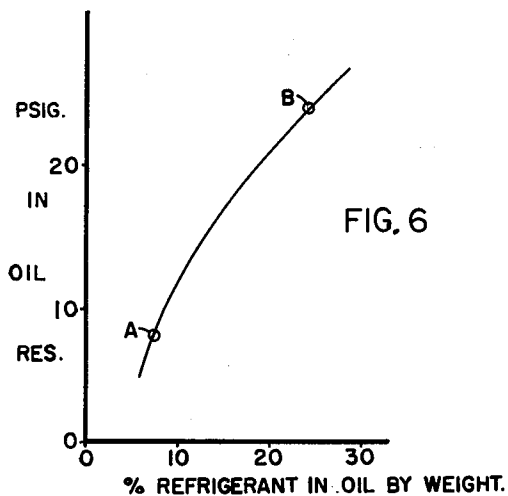
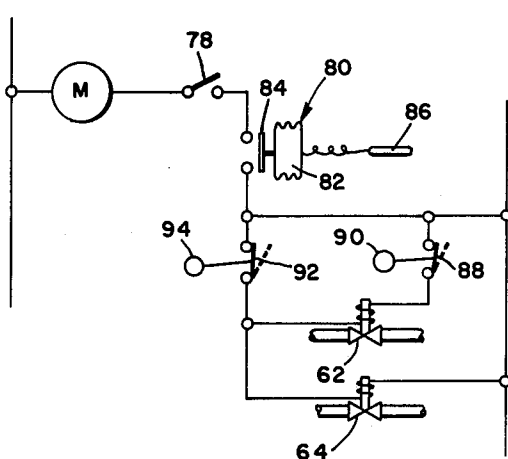


FIG. 4



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LUBRICANT CONTROL MEANS FOR REFRIGERATION APPARATUS

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Filed Nov. 15, 1963, Ser. No. 324,029

10 Claims. (Cl. 62-84)

This invention relates broadly to refrigeration apparatus. More particularly, this invention relates to refrigeration apparatus incorporating a compressor for the purpose of extracting gaseous refrigerant from the evaporator, compressing it and forwarding it to a condenser for liquefaction. Still more particularly, this invention relates to refrigeration apparatus employing a mechanical compressor having a lubrication requirement satisfied by a lubricant flow circuit wherein there is provided a control for preventing undesirable withdrawal of lubricant from the lubricant flow circuit occasioned by the rapid vaporization or boiling of refrigerant, mixed or adsorbed with the lubricant, under certain operating conditions.

In a refrigeration machine incorporating a mechanical compressor of the kind under consideration, it is necessary, for proper operation of the compressor, that a lubrication system be provided. The function of the lubrication system is to supply lubricant to those parts of the machinery requiring lubrication. To this end there is provided in the compression unit a source of lubricant in communication with the low pressure side of the machine. Lubricant is supplied to the various parts of the machine requiring lubrication through a circuit by an appropriate pump. After the lubricant has been supplied to the components of the compressor, such as the bearing and seals, it drains to the sump to complete the lubrication circuit.

In a refrigeration apparatus of the type described, refrigerant flows through the machine from the compressor to the condenser at elevated pressure. In the condenser it is liquefied and flows to the evaporator through an expansion member. In the evaporator the refrigerant is vaporized and flows through a suction line to the compressor to complete the refrigerant flow circuit. There are many instances in the operation and in the non-operation of the machine described wherein portions of the refrigerant flowing in the refrigerant circuit mix with the lubricant. This occurs, for example, under operating conditions when lubricant leaks from the lubricant flow circuit into the refrigerant flow circuit. It also occurs during shutdown when portions of the refrigerant escape from the refrigerant circuit and find their way into the sump or reservoir accommodating the lubricant. In this latter instance, the refrigerant is adsorbed by the lubricant and becomes a liquid mixture in the oil sump. The proportions of oil and refrigerant are in direct relation to the temperature and pressure in the oil sump. When the machine is subsequently started, pressure in the sump is reduced as the compressor reduces the pressure in the low pressure side of the refrigeration system. The reduction in pressure in the sump, occasioned by the operation of the compressor, causes the liquid refrigerant admixed or adsorbed into the lubricant in the sump to vaporize or flash off, as a result in a change in equilibrium of the mixture. A vent line is provided in equipment of the kind under consideration connecting the sump with the low pressure side so that the vaporous refrigerant formed in the sump may rejoin the refrigerant flow circuit. Unfortunately, under circumstances where the liquid refrigerant is present in rather large concentrations in the sump, there is a tendency for the vaporizing refrigerant to entrain or carry over portions of lubricant into the refrigerant flow circuit through the vent line.

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If this situation is permitted to continue for a reasonable length of time, the lubricant charge in the sump will be seriously depleted, and insufficient lubricant will be available in the lubrication circuit to satisfy the lubrication requirement of the machine.

This invention has for its chief object the provision of a control for regulating the vaporization of refrigerant admixed with lubricant in the sump of the motor compressor unit employed in the machine.

An additional object of this invention is the provision of an improved method of controlling the vaporization of refrigerant admixed with lubricant in the sump or reservoir provided in the motor compression unit for the purpose of supplying lubricant to the lubrication circuit of the machine.

A further object of this invention is the provision of a control of the kind described wherein the control is responsive to a condition of the fluid mixture present in the sump indicative of excessive vaporization of the refrigerant such as would cause a loss of lubricant from the lubrication system of the machine.

These and other objects of the invention will be apparent upon a consideration of the ensuing specification and drawings in which:

FIGURE 1 is a schematic representation of a refrigeration machine equipped with a control forming the subject of this invention;

FIGURE 2 is a schematic view of a portion of the electrical control circuit employed with a machine utilizing the invention forming the subject of this application;

FIGURE 3 is a fragmentary view of a refrigeration machine of the kind shown in FIGURE 1, incorporating a modification of the invention;

FIGURE 4 is a schematic view of a portion of an electrical circuit used with a refrigeration machine employing the form of the invention illustrated in FIGURE 3;

FIGURE 5 is a view similar to FIGURE 3 illustrating an additional embodiment of the invention; and

FIGURE 6 is a graphical representation of the relationship between the pressure in the oil sump and the concentration of refrigerant to oil at a given temperature.

Referring more particularly to the drawing for an illustration of the invention, there is shown a centrifugal refrigeration machine utilizing a motor-compressor unit 10 having an impeller 12 affixed to a driven shaft 14, connected in turn to a driver shaft 18 through gearing 16. The driver shaft is operably connected to a motor, not shown, and is mounted in bearings located in casing 20 serving as an enclosure for the motor-compressor unit. Disposed within a lower portion of the casing 20 is a sump 24 for the accommodation of lubricant for supply to the various components of the motor compressor unit requiring lubrication through a lubricant flow circuit.

It will be appreciated that the lubricant flow circuit, as the term is used hereinafter, includes the sump 24 together with a supply pump, not shown, for transmitting via conduits lubricant to the various components of the motor compressor unit requiring lubrication. The components, such as bearings and seals, are provided with passages permitting flow of lubricant therethrough, and eventual return by gravity to the sump.

In the refrigeration machine illustrated, there is provided conduit 26 serving as an inlet to the suction side of the impeller 12. Conduit 26 communicates with suction line 28 so that suction gas flowing in the low pressure side of the machine may be induced by the action of impeller 12 to flow into the compressor and be discharged through volute 34 to discharge line 36. A series of circumferentially spaced, radially extending guide vanes 30 are arranged at the inlet to the compressor and serve to regulate, by angular manipulation thereof, the pumping

capacity of the impeller, controlling the capacity of the refrigeration machine. From the discharge line, the gaseous refrigerant flows at elevated temperature and pressure to condenser 38 where it is liquified by the action of cooling coil 40. Liquefied refrigerant formed in the condenser 33 flows through line 42 to the evaporator 46 via expansion valve 44. It will be appreciated that expansion valve 44 effects a reduction in pressure so that the liquid refrigerant, when passed in heat transfer relation with a medium flowing in coil 48 will be vaporized for flow through suction line 28 to the motor-compressor unit completing the refrigerant flow cycle.

As indicated above, the capacity of the machine is controlled by manipulation of the guide vanes 30. The particular arrangement chosen to effect automatic operation of the guide vane means does not form a part of this invention, and that chosen for description is intended for the purpose of description only, it being appreciated that other arrangements for effecting operation of the guide vanes 30 may be utilized with the invention herein described.

The guide vane actuating mechanism illustrated in FIGURE 2 includes a power cylinder 50 within which piston 52 reciprocates. Connected to piston 52 is a rack and pinion unit which in turn is affixed to the guide vanes through a mechanical linkage 54. The function of linkage 54 is to transmit to the guide vanes movement of the piston 52 within the cylinder 50. As a part of the lubrication circuit there is provided a conduit 56 which is in communication with the lubricant pump, not shown, and which supplies lubricant under pressure to the cylinder 50. To this end, there are shown two branch conduits 58 and 60 connected to opposite ends of the cylinder 50. Three-way valves 62 and 64 control flow of lubricant in branch conduits 58 and 60. There is likewise shown a drain line 66 communicating with valves 62 and 64 and connected with conduit 68 for returning lubricant to sump 24. With the construction shown, there is included an electrical control circuit controlling three-way valves 62 and 64 so that lubricant is supplied to one end of the cylinder and drained from the other in accordance with the particular demand on the machine. In order that the refrigeration demand be communicated to the actuating mechanism, there is shown in FIGURE 2 a thermal responsive unit 80 including a bellows 82 connected to armature 84. Also connected to the bellows 82 is a bulb 86 arranged to sense the temperature of a fluid medium in coil 48. It will be appreciated that fluid medium flowing in coil 48 may be part of a circuit for the flow of cooled fluid in an air conditioning installation.

As pointed out above, conduit 25 is employed to equalize pressure between the sump 24 and suction line 28 in the motor compressor unit. At the time the machine is placed in operation for the purpose of cooling the medium flowing in coil 48, the guide vanes may be positioned so that there is a maximum resistance to flow of gaseous refrigerant to impeller 12, it being common practice to provide that the guide vanes be closed upon termination of machine operation. The action of the impeller as the motor-compressor unit is energized reduces the pressure in conduit 28, as well as evaporator 46. Likewise, the pressure in sump 24 will be reduced through its communication with conduit 28 via line 25. During previous operation of the machine, small quantities of refrigerant in the gaseous state had leaked into the sump via the bearings and seals supporting shaft 14. Likewise, portions of the refrigerant in the gaseous state flowing in line 25 enter the sump 24, condense and become adsorbed by the lubricant therein so that a mixture of lubricant and refrigerant is present in the sump. At the time the machine is started the thermal control associated with the coil 48 signals the control mechanism to indicate a need for refrigeration. This causes the guide vanes to move to an open position so that additional capacity may be had. During this period the pressure

in the low pressure side of the machine is falling as the compressor attempts to increase refrigerant flow to satisfy the demand. As the pressure is reduced, those portions of liquid refrigerant that have been absorbed by the lubricant vaporize, causing a boiling of the mixture disposed in sump 24. If the action described is permitted to continue, the flashing refrigerant which flows through line 25 and rejoins the refrigerant flow circuit may entrain with it a sufficient proportion of the lubricant so that insufficient lubricant would be available to satisfy the lubrication requirement of the machine.

This invention contemplates a control which regulates the departure of refrigerant from the sump. The control includes a circuit which incorporates a switch 70 under the influence of a float 72. Switch 70, as illustrated in FIGURE 2, is in series with an off-on switch 78, regulating operation of the motor and driving the compressor impeller 12.

Considering the operation of the machine, once the machine is placed in operation the vanes start to open and the pressure is reduced in sump 24 as described above, resulting in vaporization of the absorbed refrigerant. The ebullition or boiling causes the fluid level in the sump 24 to rise. The term "fluid level" is used because there is both liquid and gas constituting a fluid in the sump at this stage. Once the fluid level rises to the extent that float 72 is moved to the dotted position illustrated in FIGURE 1, switch 70 is opened interrupting the circuit through the coil of the solenoid controlling valves 62 and 64. Under these circumstances, lubricant is admitted to cylinder 50 in such a manner as to cause the guide vanes to reverse their direction of movement as indicated by the thermal control and begin to close. This in turn interrupts the reduction in pressure in the sump and may, in fact, under some operating conditions, cause the pressure in line 28 upstream of the guide vanes to rise slightly. Termination of the reduction of pressure in sump 24 terminates in turn the rate of vaporization of refrigerant, causing the liquid in the sump to become more quiescent and permit float 72 to return to its position closing switch 70.

This action may continue until the refrigerant oil mixture is again at equilibrium as established by the operating condition from the temperature bulb 86 or other means. FIGURE 6 graphically illustrates this relationship between the concentration of refrigerant in the lubricant and the equilibrium condition. Point A, for example, shows a high concentration of refrigerant in the lubricant at shutdown when the compressor is subject to relatively high temperatures in a machine room and/or a crankcase heater. As the pressure and saturated temperature drop under the action of the compressor, operation at point B (design condition) ensues. The control described above functions to permit the reduction in equilibrium to occur without violent boiling of refrigerant accompanied by undesirable entrainment of the lubricant.

Considering FIGURES 3 and 4, there is shown an embodiment of the invention in which there is included two switches 88 and 92, under control of two floats 90 and 94, respectively. In this embodiment of the invention, the boiling of the refrigerant as the pressure is reduced in sump 24 first actuates float 90 to the position indicated in dotted lines. This action opens switch 88 causing valve 62 to cycle to a position which traps lubricant on the side of the piston communicating with valve 62. This in turn causes the piston to assume a substantially fixed position in cylinder 50. In other words, the action of the guide vanes is halted. If boiling in sump 24 continues, float 94 assumes the position illustrated in dotted lines in FIGURES 3, and switch 92 is opened. This now causes the piston to move in the opposite direction, causing the vanes to close. This action in turn terminates the reduction in pressure and may even elevate the pressure to a slight degree. At least the boiling of refrigerant in the sump is reduced,

and the level of liquid therein is reduced in the manner described in conjunction with the embodiment of the invention illustrated in FIGURES 1 and 2.

FIGURE 5 illustrates an embodiment of the invention wherein the change in specific density of the mixture of refrigerant and lubricant brought about by the vaporization of refrigerant is employed to regulate the pressure in the sump and consequently vary the rate of refrigerant boiling in the sump. Float 95 assumes a position such that switch regulating valve 70' is maintained closed. As the specific density of the fluid is reduced the float drops and opens switch 70'. It will be appreciated that the float is formed of material enabling the desired action to occur.

A particular advantage inherent in the use of the invention is the substantial prevention of damage to the lubricant pump caused by "flashing" of refrigerant in the pump inlet. With the arrangement described a controlled release of adsorbed refrigerant is achieved. It is achieved in a manner that assures release of the refrigerant at a rate low enough to minimize or prevent flashing of the refrigerant at the pump inlet sometimes associated with cavitation.

It will be appreciated that with the lubricant pump located adjacent the bottom of the sump, there will exist a first pressure at the surface which is system pressure determined by the position of the suction vanes. At the bottom of the sump a higher pressure as determined by the head of liquid in the sump exists. A third pressure intermediate the two described exists at the inlet to the lubricant pump, this pressure being related to the inlet velocity. It will be appreciated that as long as the pressure at the surface is maintained at a predetermined value the pressure at the pump inlet is likewise maintained at a value sufficient to discourage "flashing" of the adsorbed refrigerant.

While we have described a preferred embodiment of the invention, it will be understood the invention is not limited thereto since it may be otherwise embodied within the scope of the following claims.

We claim:

1. In the operation of a refrigeration machine including an evaporator, a refrigerant gas compressor having a lubrication sump for accommodating lubricant for supply to the compressor, wherein the lubricant in the sump includes a portion of the refrigerant charge adsorbed therein, the method of preventing loss of lubricant through entrainment by vaporization of the adsorbed refrigerant which comprises the steps of withdrawing gaseous refrigerant from the evaporator in accordance with the refrigeration demand on the machine and varying the withdrawal to regulate the pressure in the compressor pump independently of the refrigeration demand.

2. The method described in claim 1 wherein the step of varying the withdrawal of gaseous refrigerant is responsive to a variation in the concentration of refrigerant in the fluid mixture in the sump.

3. The method described in claim 1 wherein said step of varying the withdrawal of gaseous refrigerant is responsive to the level of the fluid mixture in the sump.

4. The method described in claim 1 wherein said step of varying the withdrawal of gaseous refrigerant is ac-

complished by first stabilizing the rate of withdrawal and then reducing the rate of withdrawal.

5. A refrigeration machine comprising a compressor having a casing forming an enclosure therefor; an evaporator; a suction line connecting the evaporator and the inlet of the compressor; capacity control means interposed between the compressor and the evaporator; lubrication means associated with said compressor for supplying lubricant to the parts of the compressor requiring lubrication, said lubrication means including a sump for the accommodation of lubricant together with a portion of the refrigerant circulating in the machine that may mix or absorb with the lubricant, said sump being in communication with the evaporator through the suction line, means for regulating pressure within the sump to control vaporization of the refrigerant in the mixture disposed therein, said means including mechanism responsive to the level of liquid or mixture in the sump for regulating the capacity control means to vary the pressure in the evaporator.

6. In a refrigeration machine including a motor driven compressor having lubrication means for supplying lubricant to those parts of the compressor requiring lubrication wherein lubricant with portions of the refrigerant charge adsorbed therein collects in an area subject to the low pressure side of the machine, means for controlling vaporization of the adsorbed refrigerant to prevent loss of lubricant by entrainment in the vaporized refrigerant, said means including mechanism regulating the pressure in the low pressure side of the machine, said mechanism including a control responsive to a condition of the lubricant refrigerant mixture in the lubricant collection area.

7. The invention described in claim 6 wherein said mechanism includes capacity control regulation means operable in response to said control responsive to the condition of the mixture of refrigerant and lubricant.

8. The invention described in claim 6 wherein said condition responsive control includes a single switch operable in response to the level of fluid in said lubricant collection area.

9. The invention described in claim 6 wherein said condition responsive control includes first and second switches operable in response to the level of fluid in said lubricant collection area.

10. The invention described in claim 6 wherein said condition responsive control includes switch means operable in response to the specific density of the mixture in said lubricant collection area.

References Cited by the Examiner

UNITED STATES PATENTS

1,981,606	11/34	Stock	62-468 X
2,048,026	7/36	Philipp	62-83
2,145,354	1/39	Hull	62-193
2,346,886	4/44	Williams	62-193
2,390,650	12/45	Hollatz et al.	62-192
2,418,853	4/47	Shoemaker	62-193 X
2,480,813	8/49	Prince	62-468 X
2,762,204	9/56	Hanson	62-193
3,081,604	3/63	Namisiak et al.	62-192 X

ROBERT A. O'LEARY, *Primary Examiner.*

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,200,603

August 17, 1965

James F. Wake et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 5, line 53, for "pump" read -- sump --.

Signed and sealed this 21st day of January 1969.

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

EDWARD J. BRENNER

Commissioner of Patents