May 11, 1954

A. W. RUFF

2,677,944

PLURAL STAGE REFRIGERATION APPARATUS

Filed Dec. 1, 1950

3 Sheets-Sheet 1

Fig. 1.

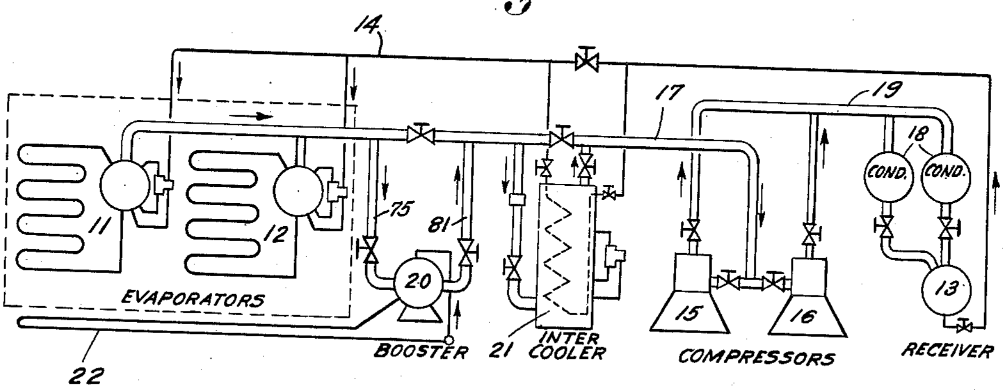
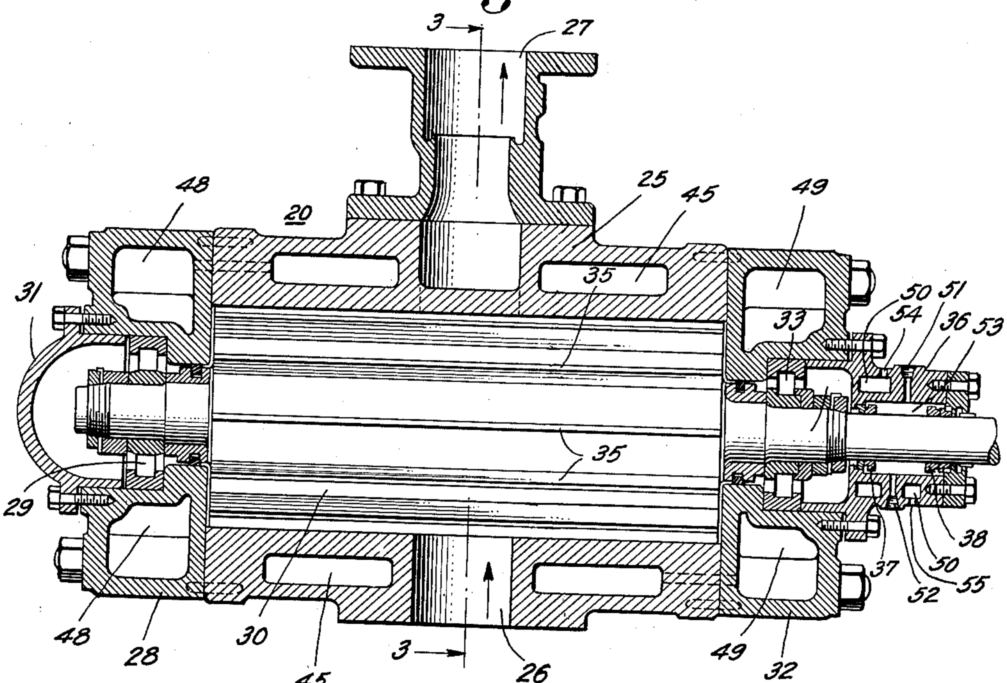


Fig. 2.



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3 Sheets-Sheet 2

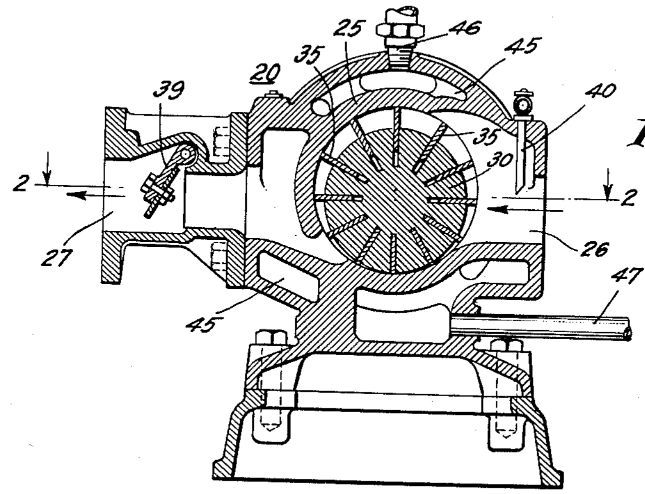
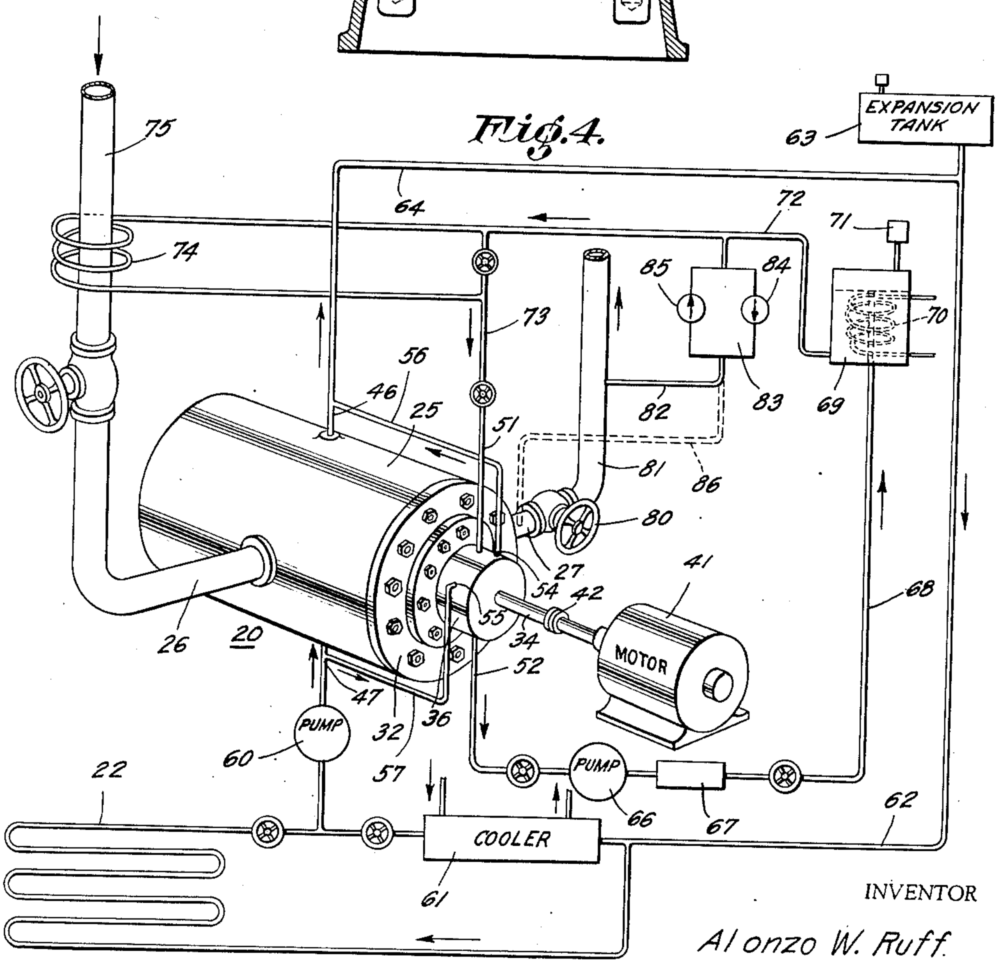


Fig. 3.

Fig. 4.



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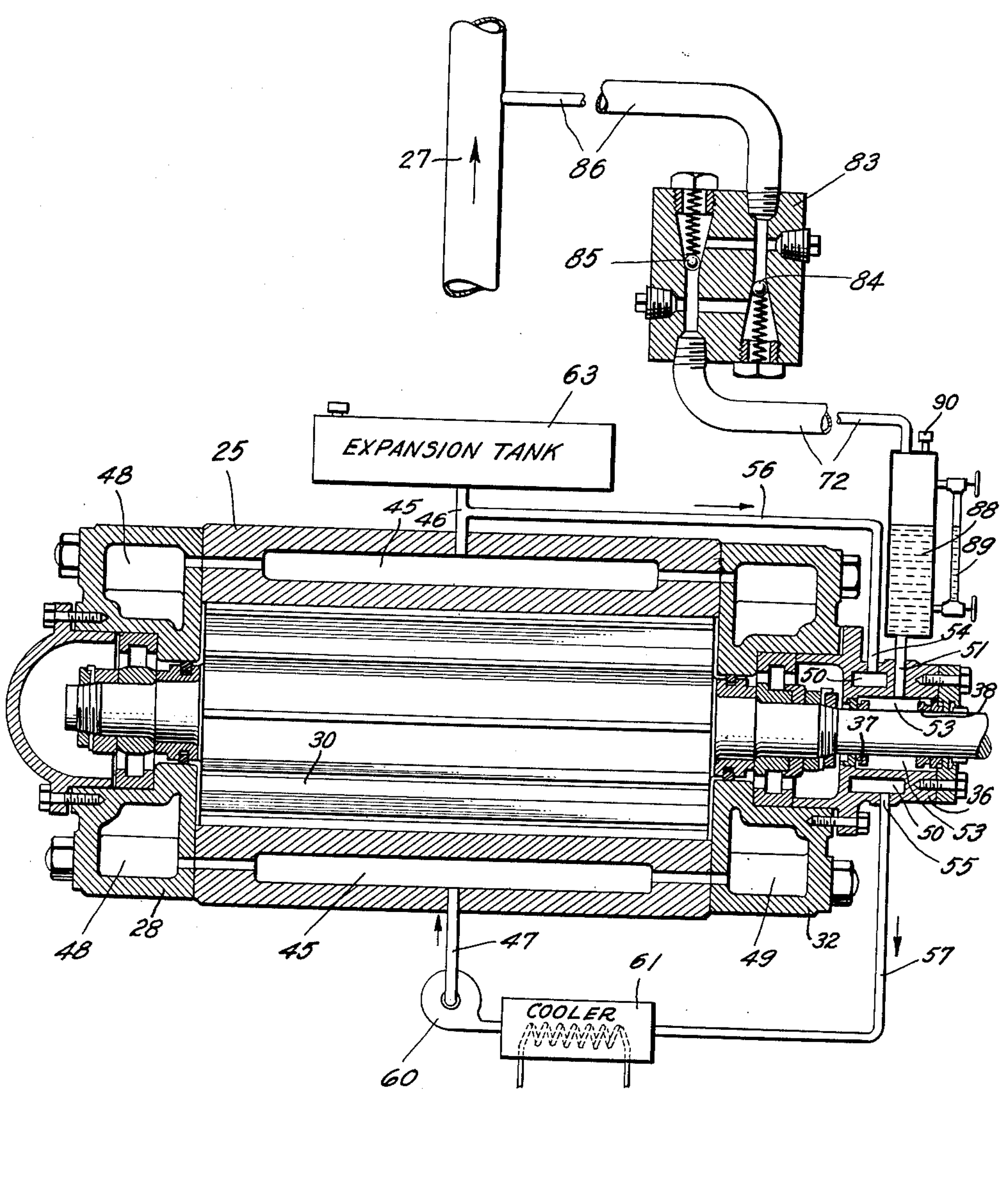
3 Sheets-Sheet 3

Fig. 5.



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Patented May 11, 1954

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UNITED STATES PATENT OFFICE

2,677,944

PLURAL STAGE REFRIGERATION APPARATUS

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Application December 1, 1950, Serial No. 198,602

10 Claims. (Cl. 62—117.6)

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This invention relates to refrigeration systems and more particularly to a booster compressor stage, and improvements in the cooling and sealing of booster compressors.

In mechanical refrigeration systems of the compressor-condenser-expander circuit type, it is often desirable to increase the refrigeration capacity of the system. Increased capacity may be necessary in order to permit the handling of deep frozen food products now in wide use, or to permit research laboratory tests at relatively low temperatures. The improved compressor disclosed herein has been found well suited for addition to existing refrigeration systems to greatly increase refrigeration capacity by making it possible to lower the effective evaporator temperature.

It is an object of this invention to provide an efficient booster compressor for initially compressing a gaseous refrigerant medium.

It is another object of this invention to provide a refrigerant compressor having improved cooling and sealing means.

It is another object of this invention to provide a refrigerant compressor which is relatively small in size and easily installed in existing refrigeration systems.

It is a still further object of this invention to provide a booster compressor, together with cooling and sealing circuits, which is efficient in operation and relatively low in cost.

Other objects, advantages and features of the present invention will become readily apparent from the following description of the embodiment illustrated in the accompanying drawings wherein:

Figure 1 is a diagrammatic illustration of a refrigeration system including a booster compressor stage.

Figure 2 is a horizontal sectional view of a preferred form of compressor and taken on line 2—2 of Figure 3.

Figure 3 is a vertical sectional view taken on line 3—3 of Figure 2.

Figure 4 is a diagrammatic illustration of a preferred arrangement of cooling and sealing circuits for the compressor shown in Figures 1, 2 and 3.

Figure 5 is a diagrammatic illustration of a modified arrangement of cooling and sealing circuits.

Referring to the drawings, the exemplary embodiment of the invention is shown applied to a closed refrigeration system including evaporators 11 and 12 supplied with liquified gaseous refrigerant from a receiver 13 by line 14. The gaseous refrigerant from the evaporators 11 and 12 is conducted to compressors 15 and 16 by line 17 and passes to the condensers 18 through line 19, and liquified refrigerant from the condensers is collected in the receiver 13. Conventional details such as evaporator, compressor and receiver controls, and condenser cooling means are not shown in the diagrammatic illustration. The compressor booster stage includes a compressor 20 connected in the line 17 between the evaporators and the conventional compressors 15 and 16. A duplicate compressor may be connected in parallel with the compressor 20 where required. An intercooler 21 may also be connected in the gas line 17 between the booster 20 and the compressors 15 and 16. Suitable valves are provided in connection with line 17 for connecting-in or by-passing the booster 20 and the intercooler 21. The booster compressor 20 is provided with a cooling jacket described hereinafter, and the liquid cooling medium utilized in said jacket may be passed through a heat dissipating coil 22 located, for example, in the floor of a room or chamber containing the evaporators 11 and 12 to prevent freezing and buckling of such floors.

Referring to Figures 2 and 3, the booster compressor 20 is preferably of the rotary vane type having a casing 25 with a cylindrical bore. The casing 25 is provided with an inlet 26 and with an outlet 27 for gaseous refrigerant. The casing 25 is provided with a head 28 at one end having an off-center bearing 29 for the cylindrical rotor 30. The head 28 is closed by a plate 31. The other end of the casing 25 is provided with a head 32 also containing an off-center bearing 33 for the drive shaft 34 extending outward from the rotor 30. Sliding vanes 35, radially disposed, are arranged in slots in the rotor 30 and are urged outward into contact with the inner surface of the casing 25 when the rotor is driven by the shaft 34. A shaft seal casing 36 is secured to the head 32 and includes spaced packing members 37 and 38 engaging the drive shaft 34. A flap-type check valve 39 may be provided in the compressor outlet 27, and a lubricant inlet 40 may be provided in the inlet 26. The compressor shaft 34 may be driven by any suitable means such as the direct drive motor 41 illustrated in Figure 4. The motor 41 may be in line with the compressor shaft 34 and be coupled thereto by a suitable coupling 42, or the motor may be mounted above the compressor 20 to conserve space, in which event a belt and pulley, chain, or gear drive may be used.

The compressor casing 25, as shown best in Figure 5, is provided with passages **45** forming a cooling jacket surrounding the rotor **30**. An inlet 47 and an outlet 46 are connected to the cooling jacket passages 45. The head 28 is also provided with passages 48 communicating with the passages 45 to permit cooling of the shaft bearing 29. The head 32 has similar passages 49 communicating with the passages **45** for cooling the bearing 33. The shaft seal casing **36** is provided with passages 50 connected with the coolant outlet 46 by the line 56 and with the coolant inlet by line 57 for cooling the shaft seals **37** and 38. Casing **36** also has an inlet **51** and an outlet 52, Figure 2, for the chamber **53** between the seals 37 and 38 so that liquid under sufficient pressure may be provided in said chamber to prevent any leakage of air into the compressor and to prevent any leakage of refrigerant gas outward through the seal **37**.

The cooling and sealing circuits illustrated in Figure 4 will now be described. The compressor 20 is cooled by an anti-freeze liquid, such as oil, circulated through the jacket passages **45**, **48**, 49, and 50, by means of pump 60. Hot liquid from the compressor jackets may, for example, be circulated through the lines 64 and 62 to a coil 22 embedded in the floor of a low temperature refrigerated space to prevent floor buckling, or it may be circulated through the cooler **61**, the latter being a conventional heat exchanger including coils through which cold water may be circulated. The cooled liquid is then pumped into the jacket inlet 47 and into line **57** to the seal jacket 50. Cooling liquid may be added to this circuit at an expansion tank 63. The circulated cooling liquid cools the compressor bearings 29 and 33 as well as the shaft seals **37** and **38**.

Liquid, such as oil, is supplied to the shaft seal chamber 53 through inlet 51 and may be circulated by pump 66 connected to the outlet **52**, as shown in Figure 4. The sealing oil is pumped by pump 66 through a strainer 67 and thence through line 68 to a seal oil pot **69**. The closed oil pot 69 may be provided with a cooling coil **70** through which water is circulated and may have a filler cap 71 to permit the addition of oil to the sealing oil circuit. Sealing oil flows from the pot 69 through lines 72 and 73 back to the seal housing inlet 51. The sealing oil may be passed through a coil 74 wrapped around the compressor gas inlet pipe 75, if desired, for cooling the seal oil. The compressed gas outlet **27** is provided with a cut off valve 80 in the line **81**. A pipe 82 conducts compressor outlet pressure through a two-way check valve unit **83** to the seal oil line 72. The check valve unit **83** comprises two check valves 84 and 85. The check valves may be spring loaded ball type check valves, as shown in Figure 5, and valve **84** is effective to communicate the compressor outlet pressure in line 81 or in compressor outlet **27** to the sealing liquid in line 72. Valve 85 is effective to vent excessive pressures in the sealing liquid line 72 to the compressor outlet line. The check valve unit 83 may be connected directly to the compressor outlet line 27 as shown by the line 86 in Figure 5. This alternative connection 86 is also shown in dotted lines in Figure 4. Other forms of pressure equalizing devices, such as diaphragms, bellows, pistons, or the like, may be used in place of the double check valve unit **83**.

The modified seal oil system shown in Figure 5 is similar to that shown in Figure 4 except that the seal oil is not circulated by a pump and is not cooled other than by the cooling jacket passages **50** in the seal casing **36**. In the Figure 5 system the passage **50** is provided with an inlet **51** but has not outlet connection. The inlet **51** is connected to an oil pot **88** which may have a visual sight gauge **89** to indicate the level of seal oil in the oil pot **88**. The top of the oil pot 88 is provided with a filler cap **90** and is connected by line **72** to the double check valve unit **83** described hereinbefore. The unit **83** may be connected to the compressor outlet **27** by line 86 for the purpose of maintaining compressor outlet pressure on the seal oil in chamber **53**.

The operation of the systems disclosed will now be described. Low pressure gaseous refrigerant from the evaporators **11** and **12** is compressed in compressors **15** or **16**, cooled in condenser 18, and the liquid refrigerant collected in receiver **13** from which it is circulated back to the evaporators **11** or **12**. In order to boost the refrigeration capacity of this closed system, the rotary vane type compressor **20** is connected in the gaseous refrigerant line between the evaporator **12** and the compressor **15**. The booster compressor **20**, in a typical installation, may compress the gaseous refrigerant, such as ammonia gas, to pressures of the order of thirty-five pounds per square inch and the high stage compressors **15** and **16** increase this intermediate pressure to a pressure of the order of one hundred and eighty-five pounds per square inch. The compressed gaseous refrigerant from the booster compressor **20** may be cooled by the intercooler **21** before it reaches the high stage compressors **15** and **16**. The rotary vane compressor **20** is cooled by the circulation of a suitable anti-freeze liquid, such as oil, through the jacket passages **45**, **48**, **49**, and **50**, by means of pump **60**. The heat in the cooling liquid flowing from the compressor jackets may be dissipated in the coil **22** located in the floor of the evaporator chamber or refrigerated space; or, it may be dissipated in the cooler **61**. The cooling liquid from outlet **46** then passes back to the jacket inlet **47** by lines **62** and **64**, an expansion tank **63** being connected in the line. In the Figure 5 modification, the cooling liquid from outlet **46** passes through line **56** to the sealing cooling jacket **50** and then through line **57** to the cooler **61**, pump **60**, and inlet **47**. The double seal **37—38** on the drive shaft **34** of the booster compressor **20** is cooled by the cooling liquid in the passage 50. A sealing liquid such as oil is supplied to the space **53** between the seals **37** and 38 and is maintained at a pressure about equal to the compressor outlet pressure to prevent air from leaking into the compressor during operation and to prevent refrigerant gas from leaking out through the seal **37** during stand-by. The sealing liquid pressure is maintained by the equalizing check valve unit **83**, and where the sealing liquid is externally cooled it is circulated by pump 66 for cooling in the oil pot **69** or by the coil **74** on the compressor inlet line **75**. Both the cooling liquid circuit and the sealing liquid circuit are closed circuits, and these circuits are independent of each other. The pressure in the sealing liquid circuit is automatically controlled by the pressure existing in the compressor outlet, and may be held at a limited positive pressure during compressor operation as well as during standby. The maintenance of positive pressure on the sealing liquid during standby is particularly important when two or more rotary compressors **20** are operated in parallel and one is shut down, because a vacuum condition could exist through-out a compressor and air might leak through the seal into the refrigerant in the compressor except as the oil pressure seal is maintained. The circulation of cooling jacket liquid through coils in the floor of a low temperature storage room, thus protecting the earth under the floor from freezing and buckling the floor, is an advantageous economy since the need for cooling water is avoided and the need for a separate source of heat to warm floor piping is also avoided.

The present invention contemplates the use of various forms of rotary compressors, pumps, heat exchangers, valves, automatic controls, etc., as it will be readily apparent to the skilled refrigeration engineer that many such variations are possible within the scope of the following claims.

I claim:

1. A system for cooling and sealing a rotary type refrigerant gas compressor in which a liquid coolant is circulated in a closed circuit which includes a jacket surrounding the compressor and a jacket which surrounds the sealing means for the driven end of the compressor shaft, comprising: pump means for circulating the liquid coolant in both of said jackets; housing means for containing a liquid sealing medium in confined contact with the driven end of the compressor shaft; and pressure communicating means connected with the compressor outlet for maintaining pressure equal to compressor outlet pressure on the said sealing medium.

2. A system for cooling and sealing a rotary type refrigerant gas compressor in which a liquid coolant is circulated in a closed circuit which includes a jacket surrounding the compressor and a jacket which surrounds the sealing means for the driven end of the compressor shaft, comprising: means for circulating the coolant in both of said jackets, said means including a circulating pump and a heat exchanger for dissipating heat from said coolant; housing means for containing a liquid sealing medium in confined contact with the driven end of the compressor shaft; and pressure communicating means connected with the compressor outlet for maintaining compressor outlet pressure on the said sealing medium.

3. A system for cooling and sealing a rotary type refrigerant gas compressor in which a coolant is circulated in a closed circuit which includes a jacket surrounding the compressor and a jacket which surrounds the sealing means for the driven end of the compressor shaft, comprising: means for circulating the coolant in both of said jackets, said means including a circulating pump and a heat dissipating coil associated with the floor of a refrigerated chamber; housing means for containing a liquid sealing medium in confined contact with the driven end of the compressor shaft; and means connected with the compressor outlet for maintaining compressor outlet pressure on the said sealing medium.

4. A system for cooling and sealing a rotary type refrigerant gas compressor in which a liquid coolant is circulated in a closed circuit which includes a jacket surrounding the compressor and a jacket which surrounds the sealing means for the driven end of the compressor shaft, comprising: means for circulating the coolant through both of said jackets; a closed sealing medium circuit for circulating a liquid sealing medium into contact with the driven end of the compressor shaft, said circuit including a circulating pump, a heat exchanger, and a pressure communicating connection with the compressor outlet for maintaining a pressure on the sealing

medium in contact with said compressor shaft as high as the normal outlet pressure of said compressor.

5. A system for cooling and sealing a rotary type refrigerant gas compressor in which a liquid coolant is circulated in a closed circuit which includes a jacket surrounding the compressor and a jacket which surrounds the sealing means for the driven end of the compressor shaft, comprising: a closed coolant circuit including a circulating pump and a heat exchanger connected for circulating the coolant in both of said jackets; a closed sealing medium circuit including a circulating pump and a heat exchanger connected for circulating a sealing liquid in confined contact with the driven end of said compressor shaft; and a pressure communicating connection between said sealing medium circuit and the outlet of said compressor for maintaining a pressure on the sealing medium in contact with said shaft at least as high as the compressor outlet pressure.

6. A cooling and sealing system as recited in claim 5 in which said pressure communicating connection includes a check valve.

7. A cooling and sealing system as recited in claim 5 in which said pressure communicating connection includes two check valves, one of said valves maintaining compressor outlet pressure on said sealing medium, the other of said valves relieving excess pressure on said sealing valve into said compressor outlet.

8. A booster compressor stage for a closed refrigeration system, said stage comprising a refrigerant gas compressor in which a liquid coolant is circulated in a closed circuit which includes a jacket surrounding the compressor and a jacket which surrounds sealing means for the driven end of the compressor shaft, means for circulating the coolant in both of said jackets, housing means for containing a liquid sealing medium in confined contact with the driven end of the compressor shaft, and means connected with the compressor outlet for maintaining pressure on said sealing medium.

9. A booster compressor stage for a closed refrigeration system, said stage comprising a rotary refrigerant gas compressor in which a liquid coolant is circulated in a closed circuit which includes a jacket surrounding the compressor and a jacket which surrounds sealing means for the driven end of the compressor shaft, said circuit including a circulating pump and a heat exchanger for dissipating heat from said coolant, housing means for containing a liquid sealing medium in confined contact with the driven end of said compressor shaft, and pressure communicating means including a check valve connected with the compressor outlet for maintaining a pressure on said sealing medium.

10. A booster compressor stage for refrigeration systems, said stage comprising: a rotary vane-type compressor for gaseous refrigerant, said compressor having a suction line and a discharge line connected thereto and adapted to be connected in a refrigeration system, said compressor having a surrounding jacket for coolant circulation; a rotary drive shaft projecting from said compressor; a pair of packing members spaced apart on said shaft; a casing secured to said compressor surrounding said packing members and said drive shaft and having a surrounding jacket; a closed coolant circuit including a circulating pump and a heat exchanger connected to circulate a coolant through both of said jack-

ets; a closed sealing medium circuit including a circulating pump and a heat exchanger connected to circulate a sealing medium through said casing between said packing members; and a pressure communicating connection between said compressor discharge line and said sealing medium circuit for maintaining a pressure on said sealing medium substantially equal to said compressor outlet pressure.

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