Dec. 11, 1962 C. P. WOOD, JR 3,067,590

PUMPING APPARATUS FOR REFRIGERATOR SYSTEMS

Filed July 6, 1960 3 Sheets-Sheet 1

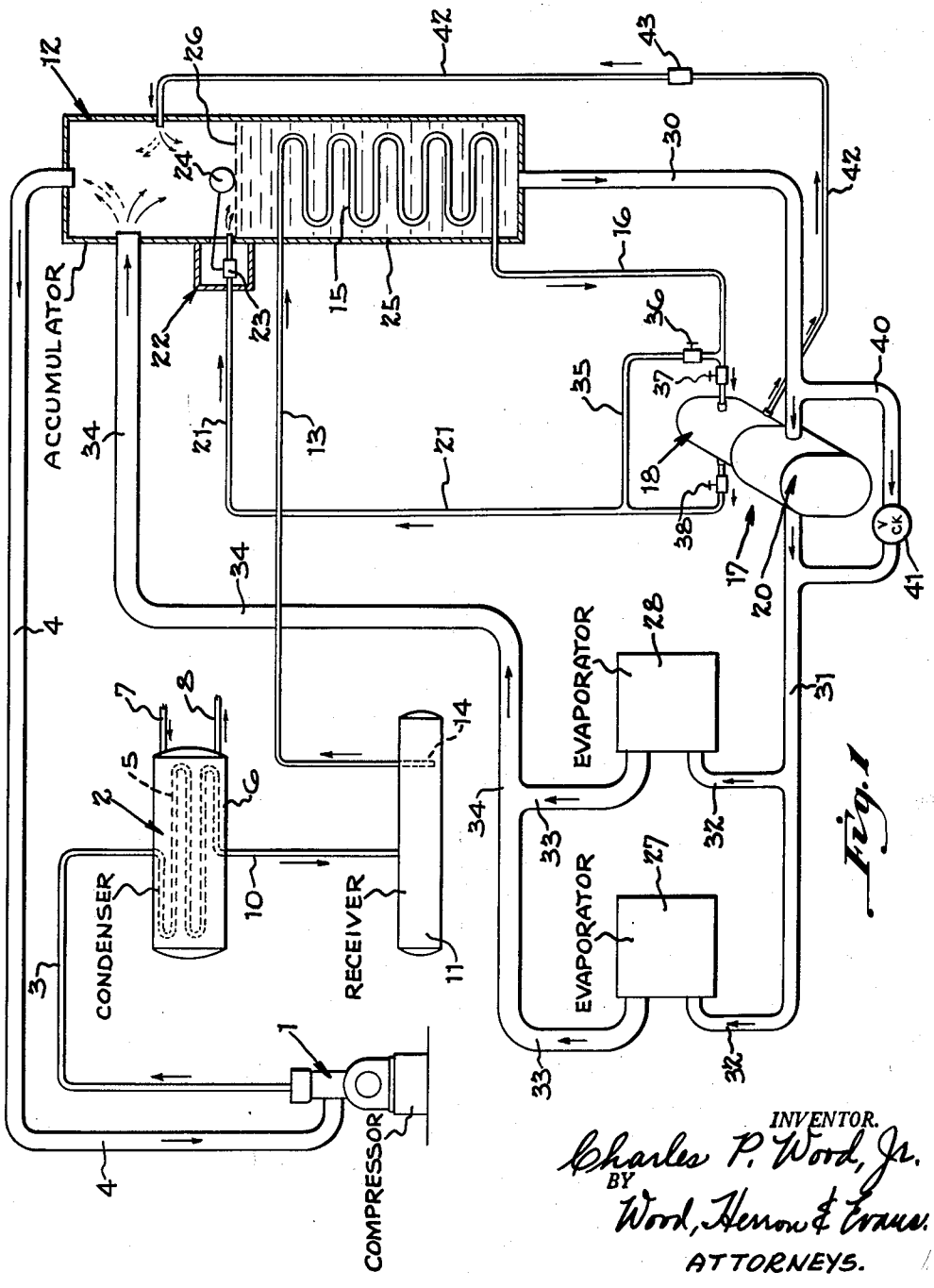


Fig. 1

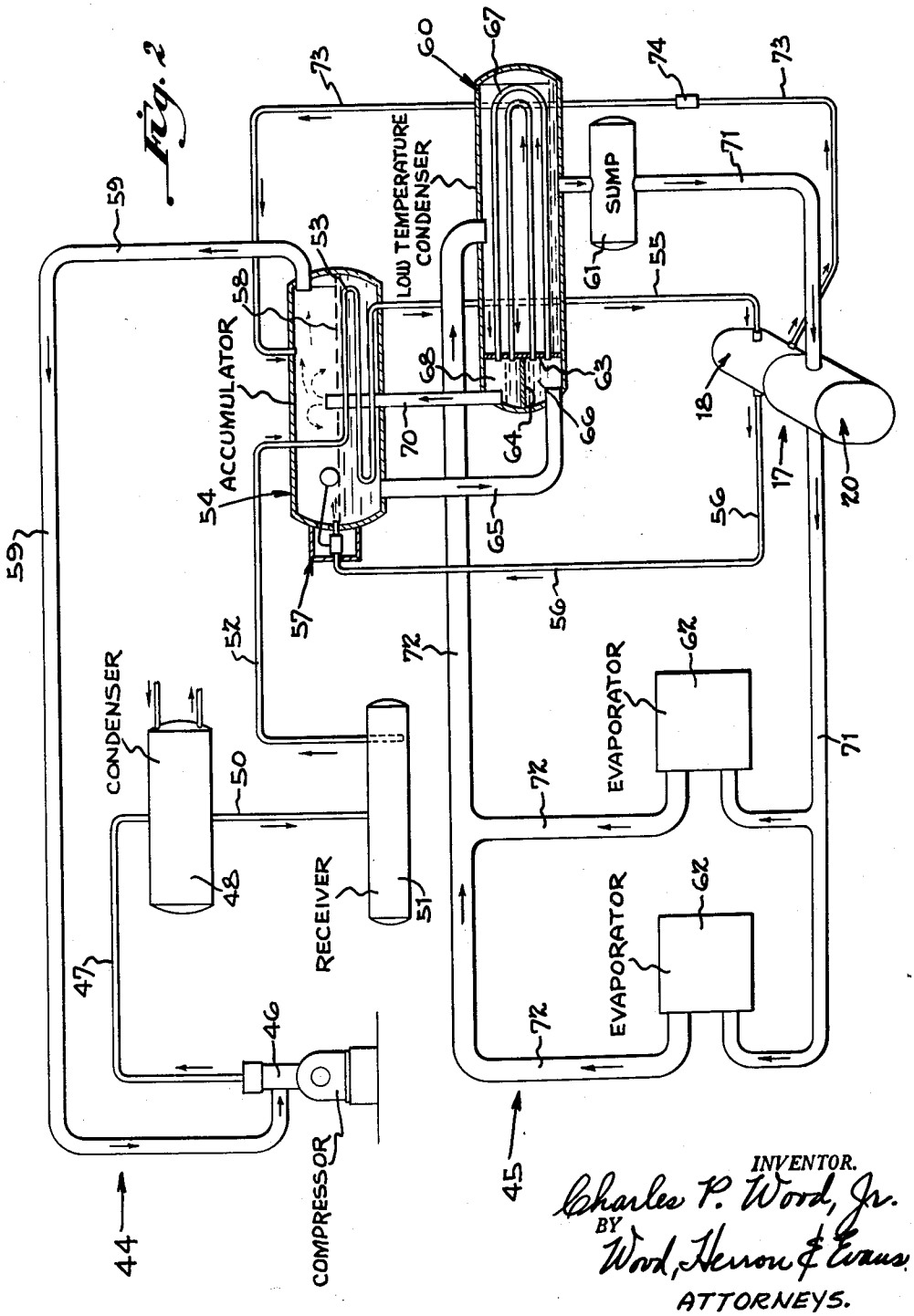
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PUMPING APPARATUS FOR REFRIGERATOR SYSTEMS

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Fig. 2



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PUMPING APPARATUS FOR REFRIGERATOR SYSTEMS

Filed July 6, 1960 3 Sheets-Sheet 3

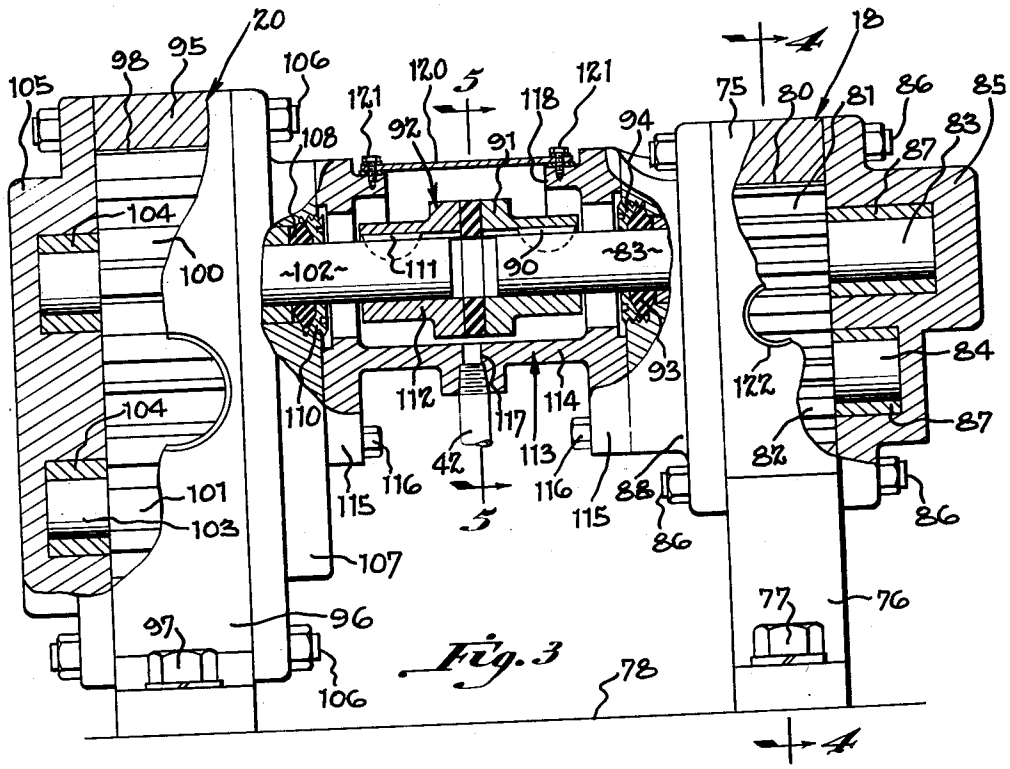


Fig. 3

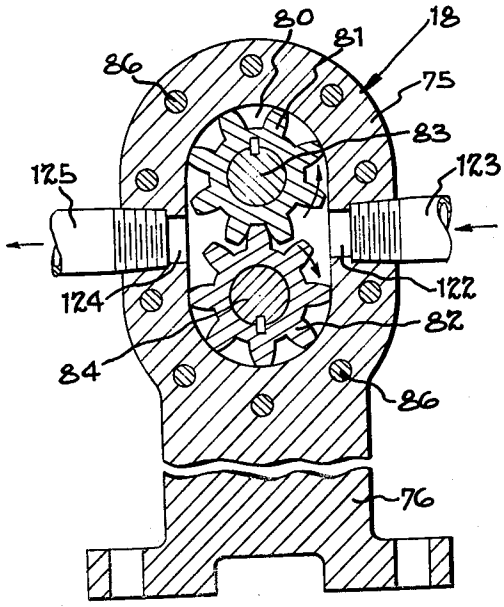


Fig. 4

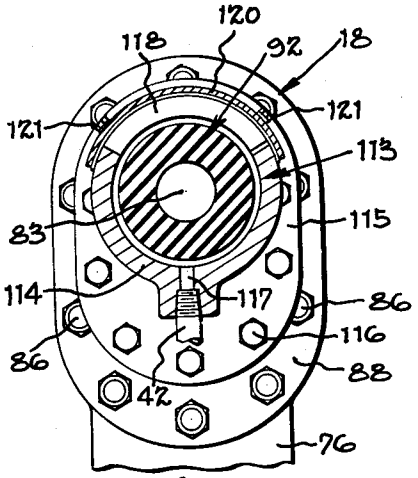


Fig. 5

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3,067,590

PUMPING APPARATUS FOR REFRIGERATOR SYSTEMS

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Filed July 6, 1960, Ser. No. 41,086
7 Claims. (Cl. 62—335)

This invention relates to refrigeration systems of the industrial type and is directed particularly to an improvement involving the use of a refrigerant-powered pump for increasing the cooling capacity and efficiency of the system.

One of the primary objectives of the present invention has been to provide a simple liquid-powered pumping apparatus which takes advantage of the kinetic energy of the high pressure liquid refrigerant flowing in a high pressure portion of the refrigerating system to advance liquid refrigerant at a lower pressure toward the evaporator in an automatic manner, thereby to improve the cooling capacity of the system.

Briefly, a refrigerating system for which the present invention is intended includes essentially a compressor, a condenser wherein the compressed refrigerant gas is liquified by heat exchange, a high pressure receiver connected to the condenser, an accumulator which acts as a reservoir for storing a supply of the liquid refrigerant advanced from the receiver, and one or more evaporators connected with the accumulator. The accumulator includes a liquid level control valve which maintains a given volume of liquid refrigerant under low pressure for advancement to the evaporator or evaporators, wherein the liquid refrigerant expands and thereby absorbs heat.

That portion of the system between the compressor and liquid level control valve of the accumulator is under high pressure through the metering action of the liquid level control valve. On the other hand, the space in the accumulator above the liquid level is connected with the intake side of the compressor to carry the heat-laden refrigerant gas from the evaporators back to the compressor for recirculation; hence, the accumulator is maintained under a lower pressure. As a consequence, in a conventional system, the liquid refrigerant from the accumulator flows toward the evaporators under low pressure which is developed usually by gravity, the accumulator being mounted at an elevation above the evaporator.

According to the present invention, the liquid-powered pump takes mechanical advantage of the high pressure liquid refrigerant which is being forced by the condensing pressure into the accumulator and utilizes the energy thereof to force the low pressure liquid refrigerant from the accumulator to the evaporators. Otherwise expressed, the apparatus essentially comprises a positive displacement liquid-powered motor, which is interposed in the high pressure line leading from the compressor to the accumulator, combined with a directly coupled pump of the positive displacement type interposed in the low pressure line leading from the accumulator to the evaporators.

In practicing the invention, the liquid-powered pump may be any one of several types, such as a reciprocating, pulsating or rotary pump, and in the present disclosure, which has been selected to bring out the principles of the invention, a motor-pump unit is utilized comprising a rotary, positive displacement motor coupled directly to a rotary, positive displacement pump. The motor is interposed in the high pressure line which advances the liquid refrigerant from the high pressure liquid receiver to the accumulator under control of the liquid level control valve of the accumulator, while the pump is interposed in the low pressure supply line leading from the lower portion of the accumulator to the evaporators. Accordingly, when the liquid level control valve of the accumulator

opens to admit high pressure liquid refrigerant to the accumulator, the advancing liquid refrigerant energizes the motor, which in turn drives the pump which is interposed in the supply line to the evaporators so as to force the low pressure liquid refrigerant under positive displacement to the evaporators, thereby taking advantage of the kinetic energy which is imparted to the liquid high pressure refrigerant by the compressor.

Another objective of the invention has been to provide a self-contained motor and pump unit of the rotary, positive displacement type, wherein the pump provides a substantially greater cubic displacement per revolution than the motor which is directly coupled to it, thereby to relate the quantity of liquid flowing under high pressure toward the accumulator, to the quantity of liquid being forced under low pressure toward the evaporators.

In the embodiment which has been selected to illustrate the principles of the invention, the pump and motor each comprise a gear type unit, wherein a pair of intermeshing gears is enclosed within a casing which includes a cavity enclosing the gears and providing a running fit. In the case of the motor, the high pressure liquid refrigerant is introduced into one side of the cavity causing rotation of the gears, the fluid being exhausted from the opposite side of the cavity. One of the motor gears is mounted upon a drive shaft which is directly connected to one of the pump gears so as to drive the pump at a one-to-one ratio. The pump gears are similar to the motor gears but are substantially larger to provide greater cubic pumping displacement per revolution than the volume of high pressure liquid driving the motor.

According to another aspect of the invention, the motor and pump comprises a self-contained unit, the motor and pump being joined in sealed relationship by a shaft housing, the arrangement being such that any leakage of gas or liquid refrigerant about the shaft of the pump or motor is trapped within the unit so as to prevent contamination of the atmosphere through leakage. In the preferred embodiment, the sealed shaft housing is provided with an exhaust conduit which communicates with the upper portion of the evaporator, which is maintained under low pressure. As a consequence, any leakage, whether gas or liquid, is drawn by suction into the accumulator for recirculation throughout the refrigerating system.

A further objective of this invention has been to improve the efficiency and cooling capacity of a condensing cycle refrigeration system having primary and secondary stages, as distinguished from the more conventional recirculating system. The condensing cycle system is of particular advantage where lower temperatures are required and where space is limited, and has the further advantage of eliminating oil from the secondary stage which, when present in the system, forms a film on the internal surfaces of the evaporators and acts as an insulator which retards the chilling action. When applied to the condensing cycle system, the motor is interposed in the high pressure liquid refrigerant line of the primary stage, which line supplies the high pressure liquid refrigerant to the accumulator. On the other hand, the pump which is coupled to the motor, is interposed in the line of the second stage which supplies liquid refrigerant under low pressure to the evaporators. The motor is thus driven by the kinetic energy which is conferred to the refrigerant by the compressor of the primary stage.

The secondary stage has no compressor and is mechanically isolated from the primary stage, the heat from the evaporators being transferred to the primary stage through a heat exchanger which communicates with the primary stage. Therefore, any lubricating oil which may escape from the compressor is completely isolated from the secondary stage evaporators. As high pressure liquid refrigerant is advanced to the accumulator of the primary

stage, liquid powered motor is energized so as to drive the pump which is interposed in the low pressure supply conduit at the secondary stage, thus forcing the low pressure liquid refrigerant toward the evaporators to increase the efficiency of the system.

The various features and advantages of the invention will be more fully apparent to those skilled in the art from the following detailed description taken in conjunction with the drawings.

In the drawings:

FIGURE 1 is a diagrammatic view showing a refrigeration system of the recirculation type embodying the refrigerant-powered motor and pump apparatus of the present invention.

FIGURE 2 is a diagrammatic view of a condensing cycle type of refrigeration system embodying the motor and pump apparatus of this invention.

FIGURE 3 is an enlarged side view, partially in cross section, detailing a gear type motor and pump unit suitable for use in practicing the invention.

FIGURE 4 is a sectional view taken along 4—4 of FIGURE 3, further detailing the motor-pump structure.

FIGURE 5 is a sectional view taken along line 5—5 of FIGURE 3, detailing the flexible coupling which interconnects the motor and pump.

Recirculating System

The refrigerating apparatus shown in FIGURE 1, which has been selected to illustrate the principles of the invention, represents a typical industrial installation which is known in the industry as a recirculation system. An industrial system of this character is adapted to a wide variety of uses and may cool or chill a number of compartments or rooms, each having its own evaporator to maintain a desired temperature. Liquid ammonia is most widely used as a refrigerant in industrial systems of this type and the invention is disclosed in relation to an ammonia system; however, it will be understood that the principles of the invention may be utilized in systems using refrigerants other than ammonia and operating under pressures and temperatures other than those which are specified by way of example herein.

Referring to FIGURE 1, the recirculation type system is powered by a motor-driven compressor **1**, which is connected to a condenser indicated generally at **2** by way of a conduit **3**. It is to be noted at this point, that the compressor and other components of the system, as hereinafter disclosed, and the circuit itself, generally follow conventional practice. The heat-laden refrigerant is supplied in the form of a gas to the compressor **1** by way of a suction line **4** which extends from the accumulator, as explained later, and upon being compressed, the refrigerant is advanced under high pressure to the condenser **2** still in gaseous form but under a higher pressure. In a typical system of this character, the compressed gas may be under a pressure in the neighborhood of 185 p.s.i. and at a temperature in the neighborhood of 250° F. as it is advanced from the compressor **1** toward the condenser **2**.

The condenser **2**, as illustrated, is of the water-cooled type comprising a coil **5** enclosed in a tank **6**, cold water being circulated through the tank by way of the lines **7** and **8** so as to carry off heat from the ammonia gas passing through the coil **5**. As the ammonia gas passes through the condenser **5**, it is cooled and converted to liquid ammonia, which flows by way of the conduit **10** to a high pressure receiver **11**, the liquid being maintained in the receiver under high pressure but at a lower temperature. In the present example, the pressure within the receiver also is in the neighborhood of 185 p.s.i., the temperature having been reduced by the condenser **2** to approximately 85° F. The high pressure receiver is partially filled with liquid refrigerant and its upper portion acts as a gas cushion to maintain the liquid ammonia under high pressure and at a given liquid level to be advanced to an accumulator **12** by a conduit **13**, which draws off the high pressure liquid from the bottom of the receiver **11** as at **14**. The line **13** passes through the wall of the accumulator **12** and communicates with the upper end of a sub-cooling coil **15** mounted within the accumulator, such that the warm liquid ammonia under pressure flows downwardly, as indicated by the arrows. After passing through the sub-cooling coil **15**, the liquid ammonia flows from the accumulator **12** by way of line **16** to the motor-pump unit **17**, consisting of a motor indicated generally at **18** which is directly coupled to a pump, indicated generally at **20**.

The high pressure liquid refrigerant line **16** communicates directly with the motor **18** for driving the pump, as explained later in detail; after passing through the motor, the liquid refrigerant advances by way of line **21** to a liquid level control device, such as a float valve, as indicated generally at **22**, which communicates with the accumulator **12**. As indicated diagrammatically, float valve **22** comprises a flow control valve **23** having a float **24** residing within the shell **25** of the accumulator **12** and arranged to maintain the ammonia within the accumulator at the liquid level indicated at **26**. From the foregoing, it will be observed that the high pressure liquid ammonia from the receiver **11** first passes through the sub-cooling coil **15** within the accumulator, wherein heat exchange lowers the temperature of the incoming liquid to prevent the liquid from flashing into gas as it passes through the motor, after which the cooled liquid refrigerant passes by way of line **16** to drive the motor-pump unit **17** before being delivered to the accumulator shell **25** under control of the float valve **22**. It will also be noted that the float valve **22** meters the flow of liquid refrigerant and, in so doing, develops the high back pressure in the lines **13** and **21**.

The purpose of the accumulator is to maintain a supply of liquid refrigerant to be advanced to the evaporators **27** and **28**, wherein the liquid ammonia is allowed to expand and thus absorb heat; the accumulator also acts as a collector for the expanded and excess unevaporated refrigerant returning from the evaporators. The liquid refrigerant is advanced under low pressure from the bottom of the accumulator to the evaporators by way of the conduit **30** which communicates with the motor-driven pump **20**. After passing through the pump, which acts as a booster, as explained later, the refrigerant is conducted by way of conduit **31** and branch conduits **32—32** to the evaporators **27** and **28**. After the refrigerant passes into the evaporators and expanded to carry off heat, it is returned by way of branch conduits **33—33** and conduit **34** to the upper portion of the accumulator, which is maintained under a lower pressure. In its expanded state, the refrigerant is essentially in the form of a mixture of liquid and gas. The liquid ammonia drops by gravity downwardly into the accumulator shell, while the gas is drawn off by the suction line **4**, which is maintained under suction pressure by operation of the compressor **1** as indicated by the arrows in FIGURE 1.

From the foregoing, it will be seen that the amount of heat absorbed by the evaporators determines the rate of flow of liquid refrigerant through the conduits **30–32** to the evaporators. The liquid level control valve **22** in turn responds to the delivery of liquid to the evaporators to advance corresponding amounts of high pressure liquid refrigerant from the receiver **11** to the accumulator **12** for recirculation through the sub-cooling coil, and through the motor to the accumulator shell.

Motor-Pump Operation

The motor **18**, as noted earlier, preferably is of the rotary positive displacement type, as distinguished from a turbine motor, for example, which depends upon a velocity flow stream for energization. The pump **20**, similarly is of the positive displacement type and is coupled in direct driving connection with the motor. In the present example, the motor and pump are both gear type

structures, as described later with reference to FIGURES 3–5; however, it will be understood that various other combinations may be utilized for the same purpose, such as rotary vane pumps and motors. In the present example, the cubic displacement per revolution of the pump is substantially two times greater than the displacement of the motor which is directly coupled to the pump.

As the float valve 22 opens to admit refrigerant to the accumulator under back pressure maintained in the receiver 11, the liquid refrigerant flows by way of lines 13, 16 and 21, and through the motor 18, thus driving the pump 20 which is interposed in the conduits 30 and 31 leading to the evaporators 27 and 28. It will be understood that at this point the pressure of the refrigerant is reduced somewhat by the resistance of the motor; hence, the liquid refrigerant flowing from the receiver 11 through the lines 13 and 16 is subcooled in coil 15 to prevent excessive flash gas in the motor and beyond. On the other hand, the refrigerant flowing by way of conduit 30 from the accumulator toward the evaporators is under lower pressure since the pressure depends upon the gravity flow produced by the liquid level in the accumulator. Accordingly, as the low pressure refrigerant enters the pump by way of line 30, it is forced under slightly higher pressure by operation of the pump into the conduit 31 and thus is advanced in a positive manner and at increased volume to the evaporators 27 and 28. The liquid-powered pump therefore substantially increases the efficiency of the system, taking advantage of the energy of the pressurized liquid refrigerant which circulates from the sub-cooling coil 15 to the accumulator shell 25.

In order to permit the motor to be serviced, if this should become necessary after prolonged service, there is provided a branch conduit 35 which by-passes the motor 18 from line 16 to line 21. This branch line includes a normally closed hand-operated valve 36. In addition, lines 16 and 21 are each provided with similar normally open valves 37 and 38 on opposite sides of the motor. The valves 37 and 38 thus can be closed and valve 36 opened so as to by-pass the refrigerant, permitting normal operation of the system when the motor 18 is decommissioned for servicing.

The pump 20 is also provided with a by-pass line 40, which permits operation of the system in a normal way when the pump is decommissioned. The by-pass line 40 includes a check valve 41 which permits passage of the refrigerant in the direction indicated by the arrow and which blocks the flow in the opposite direction. The check valve 41 thus prevents the refrigerant from by-passing back to the accumulator shell during pump operation but permits operation of the system by gravity when the motor-pump unit is shut down for servicing. Moreover, in the event that low pressure refrigerant is flowing to the evaporators while an excess of liquid is stored in the accumulator, the float valve will not call for more liquid from the receiver. In this event, the motor-pump unit will remain inactive, while the low pressure refrigerant simply by-passes the pump and advances to the evaporators by gravity in the conventional manner.

As described later with reference to FIGURES 3–5, the pump-motor unit 17 includes packing glands or seals arranged to prevent leakage of refrigerant about the rotating shaft of the motor and pump. However, in the event that the packing glands should eventually become worn, permitting leakage of refrigerant either from the pump or from the motor, there is provided a shaft housing joining the motor and pump and completely enclosing the shaft and seals. This housing converts the motor and pump into a completely enclosed, self-contained unit, which is sealed against external leakage.

In order to carry off any refrigerant which may seep past the packing glands, there is provided an exhaust line 42 having an end communicating with the shaft housing of the motor-pump unit and having an opposite end in communication with the upper portion of the accumulator, which is under partial vacuum, as noted earlier. The gas which may leak into the shaft housing, as well as droplets of liquid ammonia entrained therein, are thus drawn by vacuum from the shaft housing to the accumulator, as indicated by the arrows. This arrangement prevents loss of refrigerant through leakage and prevents the escape of gas into the atmosphere in the case of a leaking gland. In order to provide ready detection of such leakage, a sight glass, as indicated diagrammatically at 43, is inserted in the line 42.

Condensing Cycle System

The refrigerating system shown in FIGURE 2 illustrates the principles of the invention as applied to an industrial system of the condensing cycle type. This system also has a wide variety of uses, and is of particular advantage where lower temperatures are required and where space is limited, one example being commercial ice cream machines, or as in lard or butter apparatus, where relatively small-sized evaporators must be used. The condensing cycle system has the further advantage of eliminating oil from the low temperature secondary stage which communicates with the evaporators. The presence of oil detracts from the efficiency of any refrigerating system, because the oil eventually forms a coating upon the internal surfaces of the evaporators; this coating acts as an insulating medium which inhibits the passage of heat through the evaporators.

Described with reference to FIGURE 2, the system in general comprises a primary stage or circuit indicated generally at 44 and a secondary stage indicated at 45, the arrangement being such that the two circuits do not communicate with one another. Instead, heat is absorbed by the evaporators of the secondary stage and transmitted through a heat exchange arrangement to the primary stage. The primary circuit or stage includes a motor-driven compressor 46 which is connected by a high pressure line 47 to a condenser 48. Since the compressor, which involves the use of lubricant, is interposed in the primary stage, lubricant which may escape into the primary stage cannot find its way into the evaporators of the secondary stage. As noted previously with respect to FIGURE 1, the condenser 48 is water-cooled and is adapted to cool and liquify the compressed, high pressure refrigerant gas flowing from the compressor. From the condenser 48, the liquified ammonia flows by way of line 50 to a high pressure receiver 51 which provides head pressure for forcing the liquid refrigerant to the accumulator. The liquid ammonia flows from the receiver 51 by way of line 52 and through a sub-cooling coil 53 within the shell of an accumulator, indicated generally at 54.

After passing through the sub-cooling coil 53, the liquid refrigerant passes by way of line 55 to the motor 18 of the motor-pump unit 17, then by way of line 56 to a float valve, indicated generally at 57, which is similar to valve 22 previously described with reference to FIGURE 1, which regulates the liquid level 58 within the accumulator shell. The circuit includes a suction line 59 extending from the upper portion of the accumulator to the compressor and arranged to maintain a partial vacuum within the accumulator and return the heat-laden refrigerant gas back to the compressor 46. This completes the primary circuit; however, it should be understood at this point that the high pressure liquid ammonia drives the motor 18 as it advances to the accumulator under back pressure by operation of the float valve. In the present disclosure, the pump 20 acts upon the low pressure refrigerant of the secondary stage, as explained below.

The secondary stage or system 45 essentially comprises a low temperature condenser or heat exchanger 60, a sump 61, either contained within the heat exchanger or separated as shown, and one or more evaporators 62. This system also may utilize liquid ammonia as a refrigerant or may utilize other refrigerants for this purpose.

In the present example, the low temperature condenser 60 comprises a tank having a header 63 at one end, the header being divided into two compartments by a separator 64. Liquid refrigerant under high pressure is fed by way of a conduit 65 from the bottom of accumulator 54 into the lower compartment 66 of the accumulator. This liquid then flows from the lower compartment 66, through the elongated heat exchange coils 67 to the upper compartment 68 as indicated by the arrows. During passage through the heat exchange coils 67, the liquid refrigerant absorbs heat from the gas within the condenser 60, thus condensing the gas to liquid, and expands then discharges into the upper compartment 68, primarily in the form of gas, with liquid entrained therein. This gas is returned to the accumulator 54 by way of conduit 70 then is carried back to the compressor by way of the suction line 59.

Operation of Modified System

As the float valve 57 opens to supply refrigerant to the accumulator 54 of the primary stage 44, the liquid refrigerant under high pressure flows through the line 55 and energizes the motor 18, which is interposed in this line, so as to drive the pump 20, as described earlier with respect to the apparatus of FIGURE 1. However, in this case, the chilled refrigerant flows by way of the conduit 71 of the secondary stage 45 from the low temperature condenser 60 through the sump 61 interposed in conduit 71, and through the pump 20, which is also interposed in the conduit 71. As noted with respect to the system of FIGURE 1, the cubic displacement per revolution of the pump, in the present example, is substantially two times greater than the displacement of the motor.

It will be understood at this point that the sub-cooled refrigerant flowing from the coil 53 of the accumulator of the primary stage 44 is under high pressure and provides sufficient kinetic energy (which is derived from the compressor) to drive the pump. On the other hand, the cooled refrigerant from the low temperature condenser 60 of the secondary stage 45 is forced toward the evaporators 62 by the pump 20 under less pressure but at increased volume, thus increasing the efficiency of the system. Upon entering the evaporators 62, the liquid refrigerant expands and carries off heat, then is returned by way of the conduit 72 to the low temperature condenser or heat exchanger 60 essentially in the form of gas and liquid.

As noted with respect to the recirculation system of FIGURE 1, the pressure system also may be provided with a high pressure line (not shown) by-passing the motor 18, together with hand-operated valves permitting operation of the system by gravity when the motor must be shut down for servicing. In this case, the pump 20 similarly is provided with a by-pass line interposed in the low pressure conduit 71 and including a check valve to permit the low pressure fluid to flow by gravity to the evaporators when the motor is shut down.

As noted earlier with respect to FIGURE 1, the present system is also provided with an exhaust line or tube 73 having one end communicating with the shaft housing of the motor-pump unit, the tube having an opposite end connected to the top of the primary stage accumulator 54, which is maintained under low pressure by operation of the compressor 46. The tube 73 may also be provided with a sight glass 74 for visual inspection. The exhaust line 73 thus maintains the shaft housing under low pressure so as to carry off any refrigerant gas or liquid which may leak into the housing through the shaft seal of the motor or pump. In view of the fact that the pump is in communication with the secondary stage, while the exhaust line 73 communicates with the primary stage, the same kind of refrigerant must be used in both stages to prevent contamination through intermingling of the refrigerant.

Motor and Pump Construction

As noted earlier, the motor-pump unit disclosed in FIGURES 3–5 has been selected to illustrate a typical example of a rotary type motor and pump suitable for use in the present invention. It should be specifically noted that the gear type motor and pump is used for purposes of illustration only, and that any one of the several well known types of positive displacement pumps and liquid motors may be substituted. As best shown in FIGURE 4, the motor 18 comprises two intermeshing gears, one of the gears being coupled directly to the pump. The pump 20 also comprises a pair of intermeshing gears, the pump and motor both operating under positive displacement, the cubic displacement of the pump preferably being in two-to-one ratio with the motor, as pointed out earlier.

The motor 18 comprises a housing 75 having a mounting bracket 76 bolted as at 77 to a base 78, which also mounts the pump 20. The motor housing 75 includes an oval-shaped cavity 80 (FIGURE 4) which encloses the gears 81 and 82 and provides a running fit with the teeth thereof. The upper gear 81 is keyed to a drive shaft 83, while the lower gear 80 is keyed to an idler shaft 84. As viewed in FIGURE 3, the right hand ends of the shafts 83 and 84 are journalled in a bearing cap 85 which is bolted as at 86 to the gear housing 75. The bearing cap has a pair of blind bores which include bushings 87 for the shafts. The lefthand side of the gear housing 75 is provided with a second bearing cap 88 also bolted as at 86 to the gear housing. The idler shaft 84 of the lower gear is journalled in a blind bore (not shown) while the drive shaft 83 is journalled in and projects through the bearing cap, being keyed as at 90 to the drive element 91 of a flexible coupling indicated generally at 92. A packing gland 93 within the bearing cap 88 embraces the drive shaft 83 and is held under pressure by a retainer ring 94 which is threaded into the bearing cap 88.

The pump 20 is similar to the motor, comprising in general a pumphousing 95 having a mounting bracket 96 bolted as at 97 to the base 78 in spaced relation to the motor. The housing 95 includes a cavity 98 enclosing the upper and lower pump gears 100 and 101. The upper gear 100 is mounted upon a drive shaft 102 coaxial with the motor drive shaft 83, while the lower gear is mounted upon an idler shaft 103. The left hand end of the pump shafts are journalled in bushings 104—104 which are mounted in blind bores formed in the bearing cap 105; the cap is bolted as at 106 to the pump casing 95. The opposite end of the drive shaft 102 passes through a bearing cap 107, which is also bolted as at 106 to the pump housing 95. A packing gland 108, having an adjustable retainer ring 110 surrounding the drive shaft 102, provides a seal about the shaft. The opposite end of the idler shaft 103 is journalled in a blind bore formed in the bearing cap 107. The outer end of the drive shaft 102 is keyed as at 111 to the driven elements 112 of the flexible coupling previously indicated at 92. This coupling provides a direct connection between driven and drive shafts and compensates for the minor deviations in alignment of the shafts. Since the coupler is conventional, certain details of construction have been omitted.

The shaft housing 113 comprises a generally cylindrical sleeve 114, having flanges 115—115 at opposite ends, which are bolted as at 116 to the bearing caps 88 and 107 of the motor and pump. The exhaust line, previously indicated at 42 or 73, communicates with a bore 117 formed in the lower portion of the sleeve 114, such that liquid refrigerant drains by gravity to the exhaust line. The upper portion of the sleeve 114 may include an opening 118 which is sealed off by a cover plate 120 (FIGURE 3) secured in place by screws 121. This plate may be removed for servicing the packing glands

93 and 108 should this become necessary after prolonged service.

As shown in FIGURE 4, the high pressure liquid refrigerant is advanced to the motor by way of the bore 122 of the motor housing 75, which includes a fitting or adaptor 123 for the high pressure lines 16 or 55, previously described with reference to FIGURES 1 and 2. The high pressure refrigerant rotates the motor gears in the direction indicated by the arrows in FIGURE 4, and is exhausted by way of an exhaust port 124. This port includes similar fittings or adaptor 125 to which is connected the conduit 21 or 56 (FIGURE 1 or 2) leading to the float valve of the accumulator. It will be noted that the pump components are substantially greater in size than the motor components to provide the desired ratio of pump displacement over motor displacement as pointed out earlier.

Having described my invention, I claim:

1. In a refrigerating system, an accumulator, a first conduit adapted to supply liquid refrigerant under high pressure to the accumulator, liquid level control means associated with the accumulator and adapted to control the flow of liquid refrigerant through said first conduit into the accumulator and to maintain the refrigerant at a given liquid level in the accumulator, an evaporator, a second conduit connected to the evaporator and adapted to supply liquid refrigerant under relatively low pressure to the evaporator, means adapted to maintain a suction pressure in the accumulator above said liquid level, a positive displacement rotary liquid-powered motor interposed in said first conduit and adapted to be driven by the liquid refrigerant which is advanced under high pressure to the accumulator under control of said liquid level control means, and a positive displacement rotary liquid pump in direct driving connection with said motor and interposed in said second conduit, said pump providing positive displacement of liquid per revolution of the pump at a rate which is substantially greater than the positive displacement per revolution of the motor, said pump adapted to advance refrigerant liquid under low pressure toward the evaporator in response to energization of said liquid-powered motor, the liquid refrigerant being advanced by said pump to the evaporator at a rate substantially greater than the flow of refrigerant under high pressure through said first conduit and motor to the accumulator.

2. In a refrigerating system, an accumulator, a first conduit adapted to supply liquid refrigerant under high pressure to the accumulator, a liquid level control valve associated with the accumulator and adapted to control the flow of liquid refrigerant through said first conduit, into the accumulator and to maintain the refrigerant at a given liquid level in the accumulator, an evaporator, a second conduit connected to the evaporator and adapted to supply liquid refrigerant under relatively low pressure to the evaporator, means connected to the accumulator above the liquid level thereof and adapted to maintain a suction pressure above said liquid level, a positive displacement liquid-powered rotary motor interposed in said first conduit and adapted to be energized by the liquid refrigerant which is advanced under high pressure to the accumulator under control of said liquid level control means, a positive displacement rotary liquid pump interposed in said second conduit, driving means connecting the motor and pump, and a closure element surrounding said driving means and joining the motor and pump in sealed relationship, said pump providing positive displacement of liquid per revolution of the pump at a rate which is substantially greater than the positive displacement per revolution of the motor, said pump adapted to advance refrigerant liquid under low pressure through the second conduit toward the evaporator in response to energization of said liquid-powered motor, the liquid refrigerant being advanced by said pump to the evaporator at a rate substantially greater than the flow of refrigerant under high pressure through said first conduit and motor to the accumulator, and a third conduit extending from said closure element to the accumulator and communicating with the space above the level of the refrigerant therein, said conduit adapted to exhaust leaking refrigerant from said closure element and to deliver the same to the accumulator.

3. In a refrigerating system, an accumulator, a first conduit adapted to supply liquid refrigerant under high pressure to the accumulator, liquid level control means associated with the accumulator and adapted to control the flow of liquid refrigerant through said first conduit into the accumulator and to maintain the refrigerant at a given liquid level in the accumulator, an evaporator, a second conduit connected to the evaporator and adapted to supply liquid refrigerant under relatively low pressure to the evaporator, means connected to the accumulator above the liquid level thereof and adapted to maintain a suction pressure above said liquid level, a positive displacement rotary liquid-powered motor interposed in said first conduit and adapted to be energized by the liquid refrigerant which is advanced under high pressure to the accumulator under control of said liquid level control means, a positive displacement rotary liquid pump interposed in said second conduit, said pump adapted to advance refrigerant liquid under low pressure through the second conduit toward the evaporator in response to energization of said motor, said pump providing positive placement of liquid per revolution of the pump at a rate substantially greater than the positive displacement per revolution of the motor, a drive shaft connecting said motor to said pump, a shaft housing surrounding the said drive shaft and having opposite ends secured in sealing engagement with the motor and pump, and a third conduit communicating with and extending from said shaft housing to the accumulator and communicating with the space under suction pressure above the level of the refrigerant therein, said conduit adapted to exhaust leaking refrigerant from said shaft housing and to deliver the same to the accumulator.

4. In a condensing cycle refrigeration system, a primary stage having an accumulator, a first conduit adapted to supply primary stage liquid refrigerant under pressure to the accumulator, a secondary stage including an evaporator, a second conduit adapted to advance secondary stage liquid refrigerant to the evaporator, a liquid-powered motor interposed in said first conduit and adapted to be energized by the primary stage liquid refrigerant which is advanced through said first conduit to the accumulator, a pump interposed in said second conduit which advances secondary stage liquid refrigerant to the evaporator, said pump in driving connection with the motor and adapted to advance secondary stage liquid refrigerant under low pressure toward the evaporator in response to energization of said liquid-powered motor by the primary stage liquid refrigerant.

5. In a condensing cycle refrigeration system, a primary stage having an accumulator, a first conduit adapted to supply primary stage cooled liquid refrigerant under pressure to the accumulator, a secondary stage including a condenser adapted to confine secondary stage liquid refrigerant, means for circulating primary stage liquid refrigerant from the accumulator through the condenser, said condenser adapted to provide heat exchange between the primary and secondary stage refrigerant, an evaporator in said secondary stage, a second conduit communicating with the said condenser adapted to advance secondary stage cooled refrigerant from the said condenser to the evaporator, a liquid-powered motor interposed in said first conduit adapted to be energized by the primary stage liquid refrigerant which is advanced to the accumulator, a pump interposed in said second conduit which advances secondary stage liquid refrigerant to the evaporator, a driving connection between the motor and pump, said

pump adapted to advance secondary stage liquid refrigerant under pressure toward the evaporator in response to energization of said liquid-powered motor by the primary stage liquid refrigerant.

6. In a condensing cycle refrigeration system, a primary stage having an accumulator, a first conduit adapted to supply primary stage liquid refrigerant under pressure to the accumulator, liquid level control means associated with the accumulator and adapted to control the flow of refrigerant through said first conduit, a secondary stage including a low temperature condenser, heat exchange means in said low temperature condenser, said condenser adapted to confine secondary stage liquid refrigerant in contact with said heat exchange means, means for circulating primary stage liquid refrigerant from the accumulator and through the heat exchange means of the low temperature condenser, an evaporator in said secondary stage, a second conduit communicating with the said low temperature condenser adapted to advance said secondary stage liquid refrigerant from the said condenser to the evaporator, a liquid-powered motor interposed in said first conduit and adapted to be energized by the primary stage liquid refrigerant which is advanced to the accumulator, a pump interposed in said second conduit which advances liquid secondary stage refrigerant from the low temperature condenser to the evaporator, a driving connection between the motor and pump, said pump adapted to advance secondary stage liquid refrigerant under low pressure toward the evaporator in response to energization of said liquid-powered motor by the primary stage liquid refrigerant.

7. In a condensing cycle refrigeration system, a primary stage having an accumulator, a first conduit adapted to supply primary stage liquid refrigerant under pressure to the accumulator, liquid level control means associated with the accumulator and adapted to control the flow of refrigerant through said first conduit and to maintain the refrigerant at a given liquid level therein, means for maintaining the upper portion of the accumulator under suction pressure, a secondary stage including an evaporator, a second conduit adapted to advance secondary stage refrigerant to the evaporator, a liquid-powered motor interposed in said first conduit and adapted to be energized by said primary stage liquid refrigerant which is advanced through said first conduit to the accumulator, a pump interposed in said second conduit which advances secondary stage liquid refrigerant to the evaporator, a drive element connecting said motor and pump, a housing surrounding said drive element and secured in sealed engagement with the motor and pump, and an exhaust conduit extending from said shaft housing to the accumulator above the level of the liquid refrigerant in the accumulator and adapted to evacuate leaking refrigerant from said housing, said pump adapted to advance secondary stage liquid refrigerant through said second conduit to the evaporator upon energization of the motor in response to advancement of primary stage liquid refrigerant high pressure through the first conduit to the accumulator.

References Cited in the file of this patent

UNITED STATES PATENTS

1,433,733	Lindsay	Oct. 31, 1922
1,944,472	Sloan	Jan. 23, 1934
2,156,096	Robinson	Apr. 25, 1939
2,519,010	Zearfoss	Aug. 15, 1950
2,754,665	Brandt	July 17, 1956
2,775,204	Batten	Dec. 25, 1956
2,844,945	Muffly	July 29, 1958