Feb. 7, 1933. A. J. KERCHER 1,896,448

REFRIGERATING APPARATUS

Filed Jan. 5, 1927 2 Sheets-Sheet 1

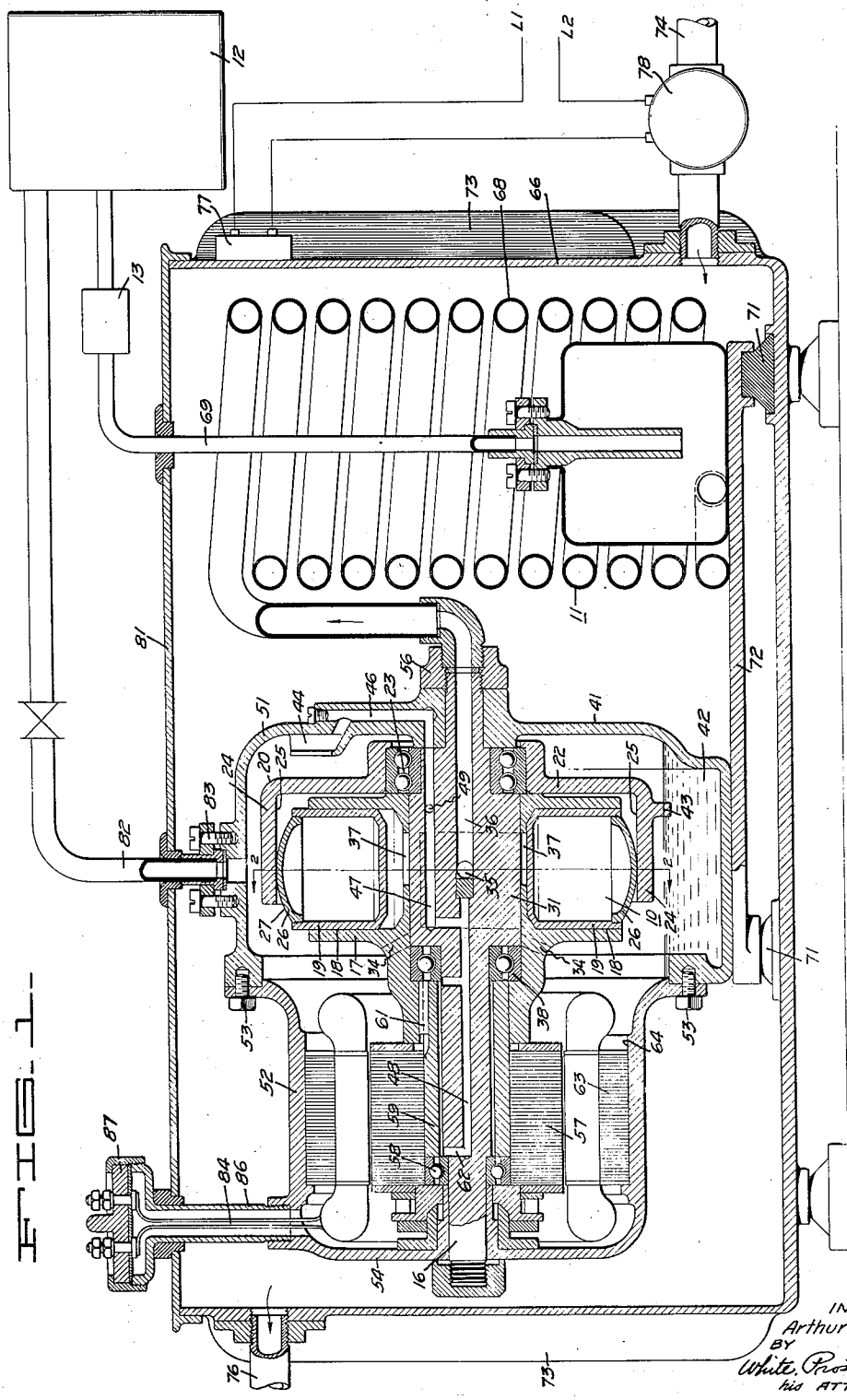


FIG. 1.

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FIG. 2.

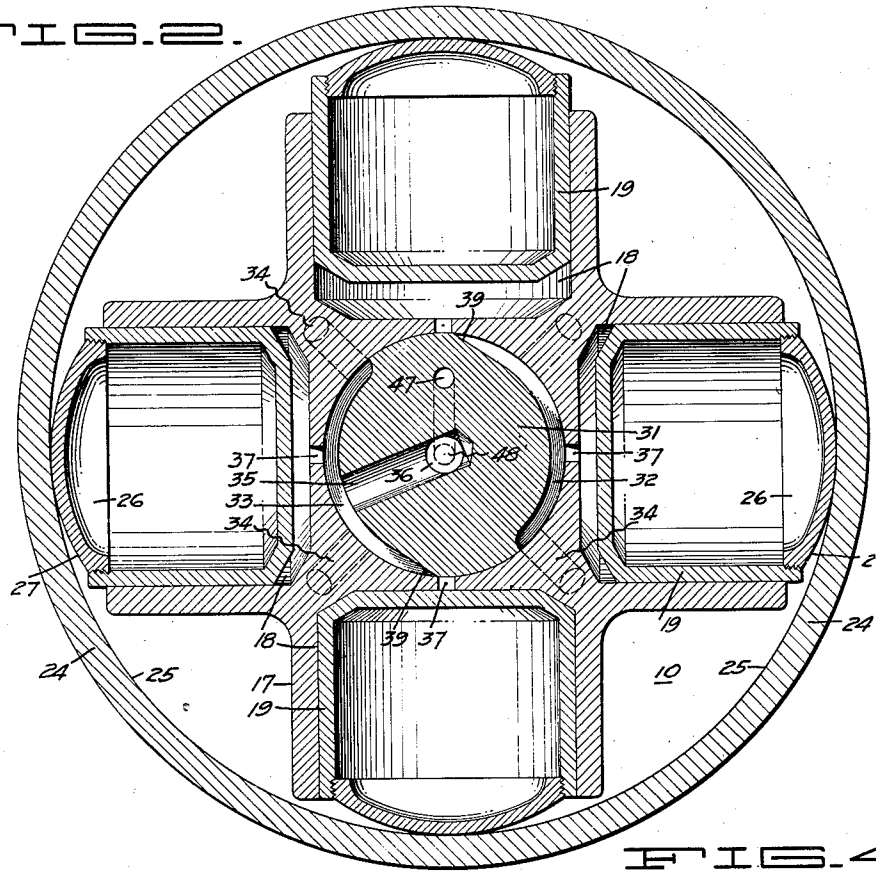


FIG. 4.

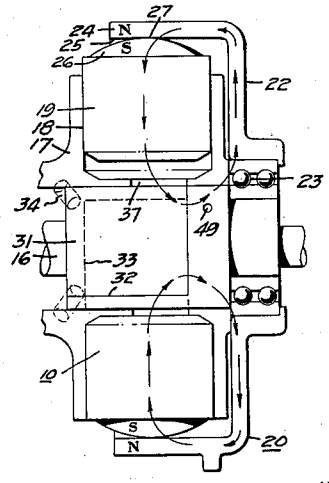
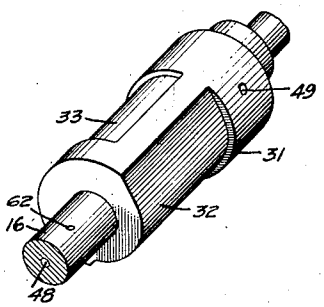


FIG. 3.



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REFRIGERATING APPARATUS

Application filed January 5, 1927. Serial No. 159,035.

This invention relates generally to refrigerating apparatus of the type adapted for household use.

As is well known in the art, refrigerating systems usually employ an expansible fluid which is continuously passed through a thermodynamic cycle in order to absorb heat from the medium to be refrigerated. In this thermodynamic cycle the fluid is compressed, heat removed from it in a condenser or other suitable exchange device, and is then expanded to absorb heat. In large installations it is a comparatively simple problem to provide satisfactory machinery for carrying out this cycle, but with small apparatus for household use, many difficulties are encountered. For example, the compressor and its driving motor must be practically noiseless in operation. The apparatus should be simple in construction so as to facilitate manufacture, should be efficient in operation, and should require a minimum of servicing when in operation.

Because of the construction of the reciprocating compressors employed and the manner in which the motors and compressors are mounted, noise and vibration has made their operation annoying even when cushioning means has been adopted. Furthermore they must be frequently serviced because of mechanical imperfections and as lubricating oil frequently gets into the circulating system and interferes with its efficient operation. Another disadvantage has been that the several parts of the apparatus have been segregated, thus limiting its adaptability. The high cost of manufacture however has probably been the most serious factor tending to limit their use.

It is an object of this invention to devise a reliable refrigerating apparatus which can be manufactured at relatively low cost and which will require a minimum of servicing.

It is the further object of this invention to devise a self-contained refrigerating apparatus which will have a wide range of adaptability.

It is the further object of this invention to construct a refrigerating apparatus in which all vibration and noise will be reduced to a minimum.

It is the further object of this invention to devise a novel form of compressor for refrigerating apparatus which will combine the functions of a compressor and an oil separator.

It is another object of this invention to devise a pump or fluid compressor which will have a minimum of parts, will not require expensive and accurate maintaining and which will therefore be cheap to manufacture.

Another object of this invention is to provide a novel form of electric motor for driving a refrigerating compressor which will be simple in construction and may be readily assembled.

The further objects of this invention will appear from the following description in which I have set forth the preferred embodiment of my invention. It is to be understood that the appended claims are to be accorded a range of equivalents consistent with the state of the prior art.

Referring to the drawings:

Fig. 1 is a side elevational view in cross section showing a refrigerating apparatus embodying the principals of this invention.

Fig. 2 is a cross sectional view taken along the line 2—2 of Fig. 1 and showing the construction of the fluid compressor.

Fig. 3 is a prospective view of the compressor shaft showing the arrangement of the compressor ports.

Fig. 4 is a diagrammatic view illustrating the manner in which the actuator ring is magnetized to retain the compressor pistons.

This invention is chiefly concerned with the manner in which a fluid compressor and condenser of a refrigerating system are coordinated and with the structural details of the compressors whereby several new and important results are obtained. The apparatus necessary for the usual thermodynamic cycle consists generally of a fluid compressor 10 which delivers refrigerant fluid under pressure to the heat exchange device or condenser 11. After heat has been removed or dissipated from the fluid by passage through the condenser 11, the fluid is delivered to a heat absorber 12 of standard construction where the fluid is permitted to expand and absorb

heat from the medium to be refrigerated. A suitable expansion or control valve 13 may be inserted between the condenser and heat absorber in order to maintain the proper pressure within the condenser. From the heat absorber 12 the expanded fluid is returned to the intake of the compressor 10.

The compressor is preferably of the type described in my copending application referred to above, that is it employs a stationary central shaft about which rotates a piston and cylinder assembly. However many improvements have been embodied which render the compressor far cheaper to manufacture and more effective in use. Referring to the detailed construction illustrated, there is provided a stationary inner shaft 16 about which the cylinder member 17 is adapted to rotate. The cylinder member 17 is machined to provide a number of cylinder bores 18 which are arranged substantially radial with respect to the center of shaft 16. In Fig. 2 of the drawings I have shown the use of four cylinder bores, although of course it is evident that any number of bores may be employed depending upon the capacity desired for the compressor. Fitted within the bores 18 are the pistons 19, these pistons being adapted to be reciprocated by means of an actuator 20.

The actuator 20 is of novel construction in that no positive mechanical connection is provided between it and the pistons 19. It is constructed with an end plate 22 which is journaled to the shaft 16, as by means of the ball bearing assembly 23, this bearing being arranged so that the actuator may revolve freely about an axis eccentric with the axis of rotation of the cylinder member 17. Upon the rim of the end plate 22, there is a peripheral ring 24 having an inner periphery 25 which is preferably cylindrical in shape. Each of the pistons 19 is preferably constructed hollow so as to be relatively light, and is provided with an outwardly bulged or curved end portion 26. The outer spherical surface 27 of end portion 26 forms an abutting engagement with the inner peripheral surface 25 of the ring 24. Ordinarily the centrifugal force of the rotating mass of the pistons is sufficient to retain the pistons in abutting engagement with the ring 24. The eccentricity of the actuator introduces a slight amount of relative sliding movement between the pistons and ring 24, but because there is a single point in contact between the pistons and the ring, the friction of this engagement will be slight. The abutting contact between the actuator and the pistons is important not only in that it simplifies the mechanical construction of the compressor, but also in that it facilitates assembly and makes possible actual disalinement of the pistons without impairing in any way the operation of the compressor. In other words if in machining the cylinder bores 18, one or more of the bores are not machined exactly at right angles to the shaft 16, or are disaligned with the bore of the diametrically opposite cylinder, the point of contact between the spherical surface 27 and the ring 24 will simply be shifted slightly from the axis of the piston and the piston will still be permitted to reciprocate freely within its bore. In other forms of compressors where the pistons are connected by means of pins to an eccentric actuator, small inaccuracies in the alinement of the cylinder bores will make it difficult to assemble the compressor and will result in undue wear and noise when the compressor is in operation.

In certain instances it is preferable to always retain the pistons against the actuator ring 24 even when the compressor is at rest or moving relatively slow. This result may be accomplished by magnetizing the actuator as indicated diagrammatically in Fig. 4. Thus in magnetizing the actuator the rim of ring 24 is made either the north or south magnetic pole, and as the piston, cylinder member 17, and shaft 16 are all constructed of metal having relatively high permeability, the magnetic lines of force will occur as indicated. Thus the pistons will be magnetically retained against the inner peripheral surface 25 when the compressor is operated slowly or at rest. As it is proposed to make the actuator 20 of relatively hard steel, it will retain its magnetism for an indefinite period.

The valves for regulating the intake and discharge of the compressor are preferably arranged in conjunction with the stationary shaft 16. Thus this shaft is provided with an enlarged valve portion 31 which is adapted to fit snugly within the cylinder member 17. Recessed within the periphery of this valve portion 31 there is an arcuate admission port 32, and another arcuate discharge port 33. The intake or admission port 32 communicates successively with a plurality of admission passages 34 provided in the cylinder member 17, these passages communicating with the fluid medium surrounding the compressors. For a purpose later to be described these passages 34 extend outwardly or in a radial direction with respect to the axis of rotation of member 17. The discharge port 33 has permanent communication with the passages 35 and 36 in the shaft 16, passageway 36 leading to an external system of piping. Both the intake and discharge ports 32 and 33 are adapted to be alternately placed in communication with ports or passages 37 which communicate with the interior of the compressor cylinders. Additional means may be provided for journaling the cylinder member 17 upon the shaft 16 in the form of a ball bearing assembly 38. This bearing assembly is preferably placed contiguous to one end of the valve portion 31 so that it will serve as a closure for one end of the intake

port 32. For convenience in manufacture it is preferable to extend this port to one end of valve member 31, instead of machining the same so that it will lie intermediate the ends of the valve member, as is necessary in case of the discharge port 33. To aid in maintaining a film of lubricant between the valve member 31 and the cylinder member 17, the edges of ports 32 and 33 which lie in the direction of rotation of the cylinder member 17, preferably gradually merged into the peripheral surface of valve member 31 as indicated at 39.

The operation of the compressor involved may be better understood by reference to Fig. 2. Assuming that the piston and cylinder assembly is rotated in counterclockwise direction, then actuator 20 also rotates about an axis eccentric to the axis of rotation of the piston and cylinder assembly so that the pistons will be reciprocated a distance equal to twice the eccentricity. Taking first the cycle of one piston, say the piston shown at the bottom of the figure, as this piston rotates counterclockwise about the shaft, it is moved outwardly by centrifugal force or by the magnetism of the actuator and reaches the limit of its outward movement when in a position diametrically opposite to its original position. During this outward movement of the piston fluid is sucked into the cylinder through port 32 and one of passageways 34. However as the piston continues for the last half of its movement, its passage 32 is placed in communication with discharge port 33 and passages 35 and 36 so that as the piston is again moved inwardly to the limit of its movement, fluid compressed below the piston is discharged through passage 36.

For reasons which will be presently apparent the compressor is preferably entirely enclosed within a housing 41, this housing also serving as a convenient means for mounting the stationary shaft 16. In so far as the lubrication of the compressor is concerned, this housing 41 makes it possible to subject the external parts of the compressor to a spray of oil and to provide means for introducing oil into the compressor. In the bottom of housing 41 there is a quantity of lubricating oil 42 and the periphery of actuator 20 is provided with one or more lugs 43 which dip into this oil and thus splash and spray the same upon the external parts of the compressor. A certain amount of oil is also continuously introduced into the compressor through passages provided in the stationary shaft 16. A convenient means for accomplishing this result comprises a small reservoir 44 arranged near the upper portion of the housing in such a position as to catch a certain amount of the oil sprayed by the lug 43. Oil from this reservoir is conducted by gravity through passage 46 and passages 47 and 48 in the shaft 16. From passage 48 oil may be conducted to the bearing assembly 38 and by means of passage 49 communicating with passage 47, is conducted to the periphery of valve member 31. A certain amount of the oil introduced through passage 49 finds its way through passages 37 into the cylinders and aids in sealing the pistons. Because of the separating action caused by the rapid rotary movement of the piston and cylinder assembly this oil will not find its way into the passages 35 and 36 and thus will not become mixed with the fluid discharged from the compressor. Furthermore because of the radial position of intake passages 34 any oil which has become mixed with the fluid being drawn into the compressor, or any oil finding its way into passages 34 will be thrown outwardly by centrifugal force and thus prevented from being discharged into the condenser. The thorough manner in which the compressor is lubricated makes accurate and fine machinery unnecessary and permits the use of large tolerances without causing undue leakage, thus further cheapening the cost of manufacture.

The electric motor for driving the compressor described above is preferably also inclosed within housing 41 and incorporated with the compressor as a motor compressor unit. Thus the housing 41 is constructed of two portions 51 and 52 removably secured together as by means of cap screws 53, the part 51 serving to inclose the compressor and the part 52 inclosing the electric motor. The compressor shaft 16 preferably has one end extended through and suitably mounted upon the end 54 of housing portion 52, and has its other end extending through the housing portion 51 whereby it may engage with an external fitting 56 for connecting the condenser with the discharge passage 36. The motor rotor 57 is preferably journaled upon the shaft 16 as by means of a bearing assembly 58, and is preferably directly coupled to rotate the cylinder member 17, as by means of a coupling sleeve 59, one end of which has a force fit within the rotor 57 and the other end being nonrotatably secured to the cylinder member 17 as by means of a key 61. Bearing assembly 57 may be lubricated from the passage 48 by means of another passage 62. For simplicity the motor stator 63 has a forced or drive fit with the inner peripheral surface 64 of the housing portion 52. The windings of the motor are preferably impregnated with a suitable solid insulating compound which will not only minimize all alternating current hum but will also prevent any injury thereto by contact with the lubricating oil or the refrigerant fluid.

While a compressor as described above will operate with a very small amount of noise and vibration, where such compressors are employed with domestic refrigerating systems, noise must be reduced to the point

where it cannot be detected even a few feet away from the compressor. As a special feature of this invention it is proposed to minimize transmission of noise by means of a liquid mass to which the motor and compressor are subjected. In practice this is accomplished by making the housing 41 fluid tight and then entirely submerging this housing in liquid such as water. Another feature of this invention is that the liquid which serves to minimize transmission of noise from the motor and compressor, also serves to transfer heat from the heat exchange device or condenser 11. Thus both the motor compressor and the condenser 11 have been shown as mounted within a metallic receptacle 66 which contains a suitable liquid mass such as water. It is to be understood however that any mass of large inertia may be employed to minimize transmission of sound vibrations to the surrounding air. The condenser 11 may be of any conventional construction, as for example a coiled tube 68 having its one end communicating with passage 36 by pipe connection 56, and its other end connecting to a liquid discharge pipe 69 which leads from the receptacle 66. Both the compressor and the condenser are spaced from the walls of the receptacle 66 and are provided with suitable cushioning mountings to prevent direct transmission of vibrations to the walls of the receptacle. One suitable form of cushioning mounting utilizes rubber blocks 71 which rest upon the bottom of the receptacle and which support the base plate 72 upon which the motor compressor unit and the condenser are supported. It is obvious however that in place of the rubber blocks I may employ resilient compression springs, or the motor compressor unit may be suspended by means of tensioning springs. The heat which is dissipated from the condenser and from the housing of the compressor, is absorbed by the liquid 67 and transferred to the walls of the receptacle 66 both by convection and conduction. For dissipating this heat from the system the walls of the receptacle may be provided with cooling ribs or fins 73 to aid in transmitting the heat to the surrounding air. As a supplemental or alternative method of keeping the liquid within the receptacle below a certain temperature, a cool liquid may be introduced into the receptacle and the heated liquid continuously removed. For example there is shown a liquid intake pipe 74 and liquid removal pipe 76 adjacent the upper portion of the receptacle. The liquid within the receptacle may always be maintained cool during operation of the compressor by continuously introducing cool water through pipe 74 and removing heated liquid through pipe 76, or cool liquid may only be introduced through pipe 74 when the heat transmitting surface of the receptacle is inadequate to dissipate the heat at a sufficient rate to keep the liquid cool. If desired the introduction of cold liquid into the receptacle may be controlled thermostatically so that cold liquid is only circulated when the temperature of the surrounding air is too high to adequately carry away the heat of the liquid. For example I have indicated diagrammatically a thermostatically controlled switch 77 mounted in thermal contact with one wall of receptacle 66, and which controls an electrically operated valve 78. The terminals of switch 77 and valve 78 are connected to a common source of current such as lines L_1 and L_2. When the temperature in the receptacle rises to a value above which efficient operation of the refrigerating plant is impaired, thermostatically controlled switch 77 is operated to open valve 78 and thus permit introduction of cool liquid into the receptacle.

The top of the receptacle 60 has been shown as provided with a suitable cover 81 through which may extend the pipe connections to the compressor and condenser. The compressor intake pipe 82 which connects the absorber to the compressor, communicates through one side of housing 42, a suitable connection 83 being provided to prevent entrance of the liquid within the receptacle 66. The wires 84 for making electrical connections to the motor are preferably extended through a conduit 86 which extends up through cover 81 and is provided with a suitable terminal box 87.

In operation the liquid mass surrounding the compressor housing effectively deadens all noise and vibration and prevents all sound waves from being transmitted to the surrounding air. The heat generated from operation of the motor and by compressing the fluid in the compressor, is transferred to the lubricating oil 42 and to the compressor motor housing 41 and thus transferred to liquid within the receptacle. This liquid also serves to remove heat from the fluid in the condenser 11, all the heat removed from both the compressor and condenser is transferred to the walls of the receptacle, where it is dissipated by radiation and by convection currents of air coming into contact with the outer surfaces of the receptacle. The liquid within the receptacle may also be kept cool by introducing cold liquid through pipe 74, or introduction of liquid through this pipe may be automatically controlled by the thermostat arrangement described above. As the intake passages 34 of the compressor communicate directly with the interior of the compressor housing 41, the interior of the housing will always be maintained at the intake pressure and all fluid leakage from compressor pistons and valve mechanism, will find its way back into the compressor intake. As previously explained the compressor acts as a centrifugal oil separator so that when the compressed fluid reaches discharge passage

36, substantially all oil has been removed so that no oil is carried over into the condenser parts and the control valve 13. At the same time however an excess of lubricant will be present for the relatively moving parts of the compressor, since oil is continuously introduced into the compressor through the reservoir 44. The compressor operates with such a small amount of friction, that when the current is disconnected from the motor as in stopping the refrigerator, back pressure on the discharge side of the compressor will rotate the compressor backwards as a pneumatic motor until the pressure in the intake and discharge has become substantially equalized. When the motor is again energized, it starts at practically no load since several revolutions of the compressor are necessary to first build up a discharge pressure. This no load start is important since many of the alternating current motors available for refrigerators have a relatively low starting torque. After the compressor has been at rest for some time all of the oil will drain from reservoir 44. When the compressor is again started in operation, oil from lug 43 will not reach reservoir 44 until the compressor has attained a relatively high speed. In other words I have provided a pumping device for introducing oil into the compressor which is rendered practically inoperative unless the compressor speed is above a certain minimum value. Without this feature the centrifugal action of the moving parts of the compressor would be ineffective to remove all of the oil from the fluid refrigerant during starting of the compressor when the compressor runs at a relatively low speed, with the result that oil would be carried over in the discharge passageway 36.

It is apparent that a variety of refrigerant fluids may be used with the refrigerating system described above. For example I may employ ammonia, sulphur dioxide, carbon dioxide, methyl-chloride, ethyl-chloride, or other such fluids, although because of its low pressure required for condensation, ethyl-chloride is the preferred fluid. It is obvious that the character of the refrigerant fluid employed will determine the capacity and discharge pressure of the fluid compressor. When using ethyl-chloride it has been found essential that all oil be removed from the fluid before it is discharged into the condenser. With the apparatus as described above it has been found that ethyl-chloride may be successfully employed without the addition of a separate oil separator in the discharge of the compressor, the centrifugal action of the separator being sufficient to effect complete oil separation.

I claim:

1. In a refrigerating system in which a refrigerant fluid is continuously circulated through a heat exchange device and a heat absorber, a compressor for circulating fluid through the heat exchange device and absorber, a receptacle within which is mounted the compressor and heat exchange device, upstanding cooling fins formed upon the outer surface of the receptacle, and a liquid within the receptacle to minimize transmission of sound from the compressor and to transfer heat from the compressor and heat exchange device to the receptacle.

2. In a refrigerating system comprising a heat exchange device for removing heat from a refrigerant fluid, a heat absorber for permitting the expanded fluid to absorb heat from a medium to be cooled, a compressor for receiving expanded fluid from the heat absorber and delivering the compressed fluid to the heat exchange device, and a motor for driving the compressor, the combination of a sealed housing enclosing the motor and compressor, a receptacle for enclosing said housing, resilient means for supporting the housing within the receptacle and in spaced relationship with all of the walls of the receptacle, and a liquid mass within the space between the housing and each wall of the receptacle for minimizing transmission of sound from the housing.

3. In a refrigerating system in which a refrigerant fluid is continuously circulated through a heat exchange device and a heat absorber, by means of a motor driven fluid compressor; a unit consisting of a receptacle within which the heat exchange device is disposed, a sealed housing for the motor and compressor also disposed within the receptacle, resilient means for supporting the housing within the receptacle and in spaced relationship with all of the walls of the receptacle, and a liquid mass within the receptacle for transferring heat to the receptacle and for minimizing transmission of sound from the housing.

4. A fluid compressing unit comprising a fluid compressor, a motor for driving the compressor, a liquid-tight housing enclosing both said motor and said compressor, a receptacle, resilient means supporting said housing in spaced relationship with all of the walls of said receptacle, whereby transmission of vibration of the housing to the receptacle is precluded, and a mass of liquid disposed within the space between the housing and each wall of the receptacle, to minimize transmission of noise from the housing.

In testimony whereof, I have hereunto set my hand.

ARTHUR J. KERCHER.