

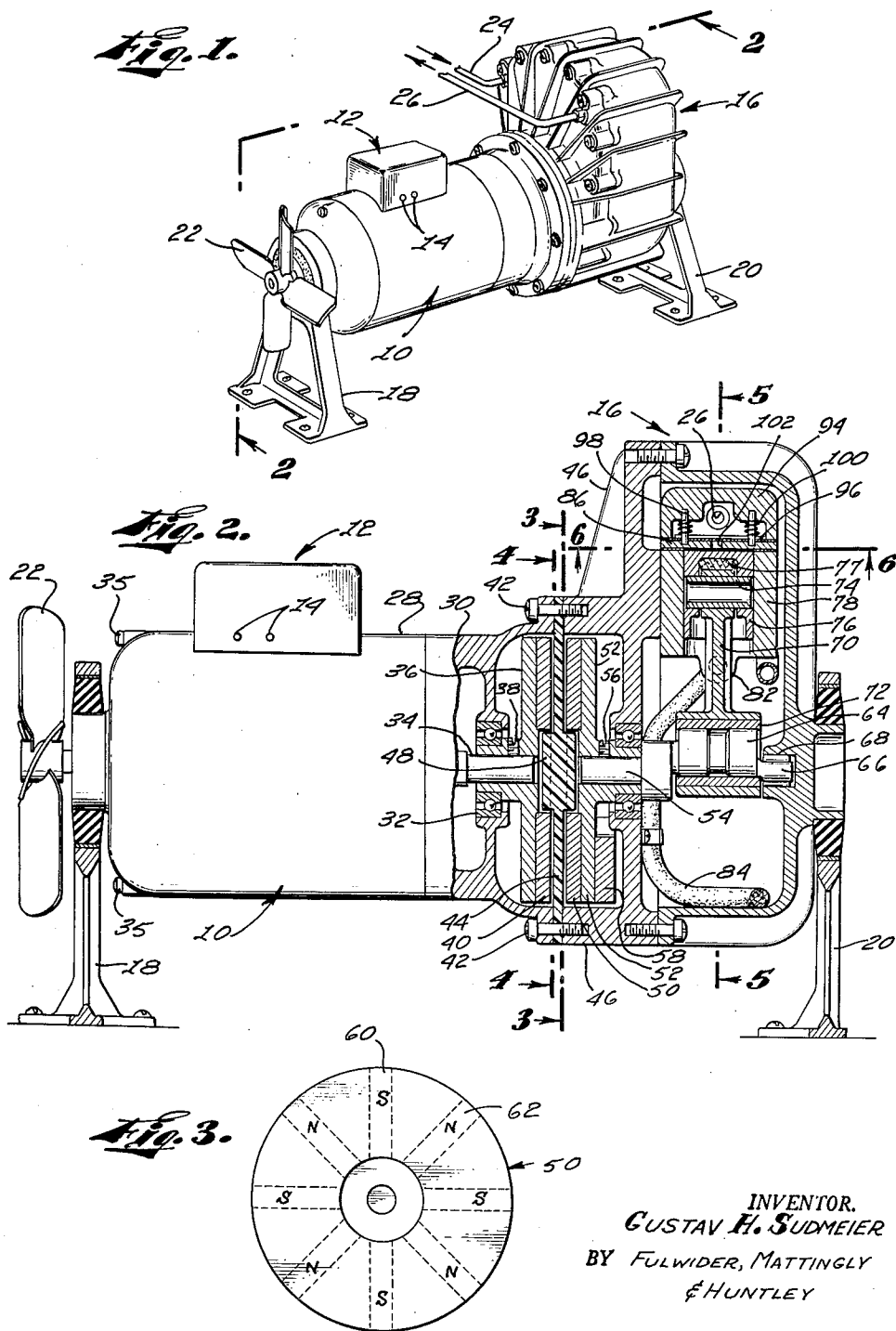
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G. H. SUDMEIER
COMPRESSOR APPARATUS

3,080,495

Filed May 13, 1958

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 4.

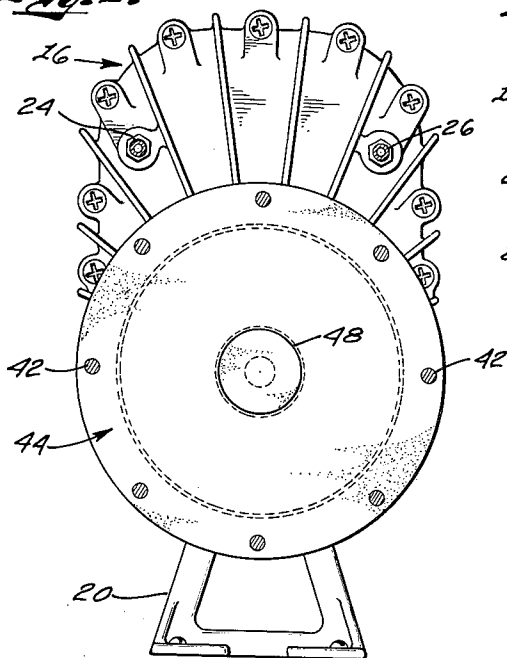


Fig. 5.

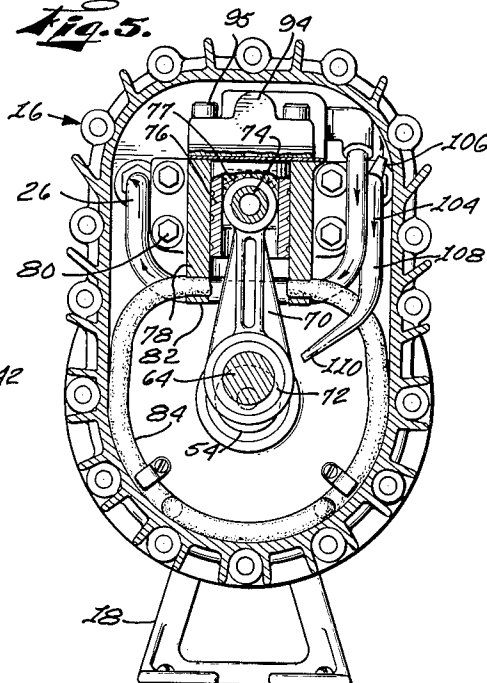


Fig. 7.

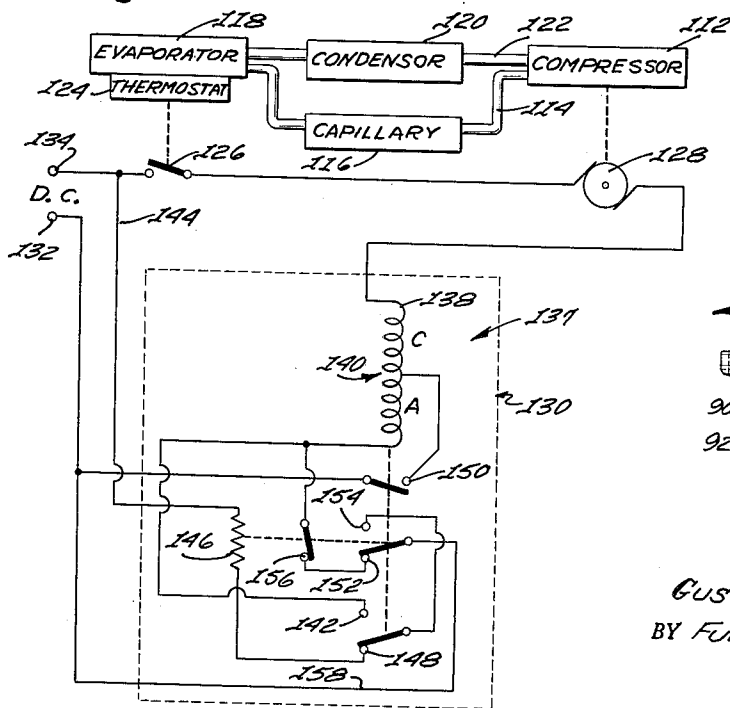
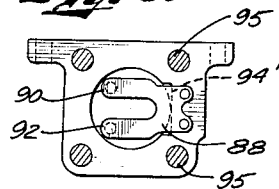


Fig. 6.



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COMPRESSOR APPARATUS

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2 Claims. (Cl. 310-104)

This invention relates generally to fluid compressor apparatus, and more particularly to a fluid compressor apparatus adaptable for use in refrigeration systems.

An ever-present problem in refrigeration systems of the type employing a compressor and circulating refrigerant, lies in the loss of refrigerant from the system and particularly from the compressor. It has previously been proposed to avoid the loss of refrigerant in systems of this type by enclosing the compressor in a hermetically-sealed chamber. Of course, due to the fact that the compressor is normally driven by an electrical motor, to avoid the existence of a drive shaft passing through the sealed chamber, it has been customary to enclose the motor as well as the compressor. Although arrangements of this type render the motor inaccessible for maintenance, requiring degasification of the system to gain access to the motor, such systems provide a considerably-improved arrangement wherein alternating-current motors are employed. However, in the event that direct-current motors are used this arrangement does not provide a solution. Electrical arcing is invariably present in a direct-current motor, for example at the commutator, and if a direct-current motor is enclosed in an atmosphere of refrigerant, the arcing is likely to effect a chemical change in the refrigerant to form various acids which are corrosive to the refrigeration system. Therefore, compressors which employ direct-current electrical motors have not generally been housed in hermetically sealed chambers, and as a result losses of refrigerant have been tolerated.

When compressors, or other apparatus employing moving parts, are hermetically sealed, the inaccessibility of the apparatus demands that the maintenance requirements of the apparatus be reduced as much as possible. Of course, the moving parts of the apparatus must be lubricated in order to function properly; therefore, it has previously been proposed to employ the compressed fluid, e.g. circulating fluid refrigerant, in a compressor to carry lubricant in suspension to the friction surfaces in the compressor. However, if the refrigerant is well saturated with lubricant, the efficiency of the refrigeration system is considerably reduced. Therefore, there is a need for a method and apparatus for providing lubricant to the moving parts of an apparatus in a sealed chamber by means of a circulating fluid, in which the efficiency of the system employing the apparatus is not substantially reduced.

Many different types of small compressors for refrigeration use have been proposed in the past; however, there remains a need for a small, efficient compressor that is economical to manufacture and which possesses light weight and is flexible in its application so as to be capable of being mounted in various positions.

The present invention, in its more general form comprises a refrigeration system utilizing a small compressor which is hermetically-sealed separately from the driving motor. In the apparatus, the driving motor is coupled to the compressor through a sealed non-ferrous plate, by employing magnetic coupling. The coupling includes magnetic toroids positioned upon each side of the non-ferrous plate, that are mechanically affixed to the shafts which are to be interconnected.

The magnetic coupling of the present invention effects a synchronous drive between the motor and the compressor, i.e. coupling without slip, therefore if for any reason the compressor falls out of synchronism with the motor, the coupling is broken. The present invention

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therefore includes a control system which functions to sense the occurrence of a break in the magnetic coupling, to de-energize the motor for a brief interval whereby the motor may come to a stop and allow the magnetic coupling to become re-established.

Furthermore, the present invention provides an improved compressor structure, which is lubricated by a lubricant carried by the refrigerant. Means are incorporated in the system for controlling the extent to which the refrigerant is saturated with lubricant, thereby maintaining the efficiency of the refrigeration system relatively high.

It is therefore a major object of the present invention to provide an improved refrigeration system.

It is another object of the present invention to provide an improved fluid compressor.

Still another object of the present invention is to provide a compressor unit employing a direct-current motor, wherein the compressor unit is hermetically sealed.

A further object of the present invention is to provide an improved coupling apparatus whereby motion may be transmitted through a closed chamber.

Still a further object of the present invention is to provide an improved system for lubricating the friction surfaces in an enclosed compressor.

A still further object of the present invention is to provide an improved control system for use in conjunction with a magnetic coupling, which functions to control a driving means in a manner so that the driving means is stopped temporarily in the event of a break in the magnetic coupling, to thereby allow automatic restoration of the magnetic coupling.

These and other objects and advantages of the present invention will become apparent from the following specification and accompanying drawings in which:

FIGURE 1 is a perspective view of a compressor unit incorporating the principles of the present invention;

FIGURE 2 is an enlarged vertical sectional view taken along the line 2-2 of FIGURE 1;

FIGURE 3 is a partial vertical sectional view taken along the line 3-3 of FIGURE 2;

FIGURE 4 is a vertical sectional view taken along the line 4-4 of FIGURE 2;

FIGURE 5 is a vertical sectional view taken along the line 5-5 of FIGURE 2;

FIGURE 6 is a partial horizontal sectional view taken along the line 6-6 of FIGURE 2; and

FIGURE 7 is a diagrammatic representation of a refrigeration system and electrical control system incorporating the principles of the present invention.

Referring now to the drawings and particularly to FIGURE 1 thereof, there is shown a direct-current motor 10 having a housing 12 mounted thereon. The housing 12 contains a control circuit (hereinafter described) and provides a pair of terminals 14 which are adapted to be connected to a source of direct-current power to energize the motor 10. The motor 10 is rigidly affixed and coupled to a compressor 16, which will be more fully described hereinafter. The integrated unit formed by the compressor 16 and the motor 10 is supported by mounting brackets 18 and 20 which may be employed to mount the unit in either a horizontal or a vertical position.

A fan 22 is connected to the shaft of the motor 10, at the end remote from the compressor 16. The fan 22 functions to circulate air about the motor 10 and the compressor 16 to maintain these units at a satisfactory operating temperature.

In the operation of the compressor fluid, e.g. gaseous refrigerant, is drawn into the compressor 16 through a tube 24 at a relatively low pressure and exhausted from the compressor through a tube 26 at a relatively high pressure. Of course, the gaseous fluid from the

tube 26 may be employed in refrigeration apparatus as hereinafter described.

Reference will now be made to FIGURE 2 for a consideration of the manner in which the motor 10 is coupled to drive the compressor 16. The motor 10 has a divided housing formed of a major housing 28, constructed in accordance with conventional motor techniques, and an end housing cap 30 which carries a bearing 32 that in turn supports the drive shaft 34 of the motor. A pair of bolts 35 serve to hold the cap 30 to the housing 28. Thus the operating components of the motor are readily accessible simply by removing the bolts 35.

A backing plate 36 is affixed to the drive shaft 34 of the motor 10 by a set screw 38. The plate 36 is formed of ferrous material and is circular in form. A toroid 40, formed of ferrite material, is rigidly affixed upon the backing plate 36. Of course, other ferrous materials, having considerable magnetic retentivity may also be used in forming the toroid 40. In the event that the toroid 40 is formed of a ferrite material, it may be affixed to the plate 36 by a synthetic resin adhesive.

The motor 10 is held in rigid engagement with the compressor 16 by a plurality of studs 42 which pass through an external rim of the cap 30 and a circular non-ferrous plate 44 to threadably engage an end section 46 of the compressor housing. The non-ferrous plate 44 may for example, be formed of fiber glass impregnated with synthetic resin. The separator or plate 44 has a center section 48 of increased thickness (FIGURE 4) which is concentric to the plate. The motor 10 is affixed to the compressor 16 so that the toroid 40 is positioned contiguous to the plate 44, and the center section 48 lies within the toroid 40. The center section 48 of the plate 44 reinforces the plate against flexing under pressure and rubbing against the revolving members as the toroid 40.

At the compressor side of the plate 44 a toroid 50 is positioned, which also receives the center section 48 of the plate 44. The toroid 50 is similar to the toroid 40 and is affixed upon a backing plate 52 which is in turn mounted upon a shaft 54 of the compressor and there held by a set screw 56.

A counterbalance 58, in the form of a circular segment, is adhered to the compressor side of the plate 52 to offset the weight of the reciprocating portion of the compressor. This member may consist of resin impregnated fiberglass, and be adhered to the plate 52 by resin.

The toroids 40 and 50 contain a magnetic pattern as shown in FIGURE 3, which includes a number of alternate north and south pole radially-extending magnetized areas 60. In providing the magnetic pattern as shown in FIGURE 3, considerable potential energy is contained by the state of the toroids. Therefore these members are formed as toroids to avoid a center section wherein a large number of magnetic interfaces would be closely positioned which would tend to be difficult to maintain. That is because the magnetized members are toroidal in shape, the proximity of the radial magnetic interfaces may be spaced apart and therefore the remanence of magnetic pattern is higher or more lasting.

Referring now to FIGURE 2, it may be seen that the magnetic coupling between the toroids 40 and 50 positioned in faced-opposing relationship includes a number of magnetic circuits, e.g. eight circuits which pass through the backing plates 36 and 52, the toroids 40 and 50, and the non-magnetic gap including the plate 44. In the operation of the coupling, the toroids 40 and 50 are locked together by the magnetic lines of force in these magnetic circuits, therefore the energy of motion which appears at the shaft 48 is transferred through the magnetic coupling to the shaft 54.

Referring now to FIGURES 2 and 5, a consideration will be made of the components of the compressor ap-

paratus. The compressor shaft 54 is formed integral with a crank shaft 64 that terminates in a shaft 66 which is journaled into a bearing 68. The crank shaft 64 carries a connecting rod 70 by means of a rod bearing 72. The connecting rod 70 is in turn connected to a wrist pin 74 mounted in a piston 76. A small wick 77 (FIGURE 2) is positioned between the piston 76 and the top of the connecting rod 70. The wick 77 receives lubricant from the circulating fluid which carries suspended lubricant. The wick provides lubricant for the wrist pin 74.

The piston 76 is positioned within a cylinder 78 supported upon the end section 46 of the compressor housing by studs 80. By loosening the studs 80, the cylinder may be adjusted vertically over a small distance to compensate for variations in the compressor components. The cylinder 78 is formed to include extensions 82 (FIGURE 5) which contain bores that receive the ends of a lubricating wick 84.

A valve plate 86 (FIGURE 2) is positioned over the top of the cylinder 78 and contains intake and exhaust ports. Contacting the lower, or internal surface, of the valve plate 86 is a reed 88 (FIGURE 6) which includes extensions 90 and 92 that cover ports in the valve plate 86 which are mated with similar ports in a cylinder head 94. It is to be noted, that the ports are opened as the reed 88 is flexed over a curved fulcrum surface 94' of the cylinder 78. As a result, the flexing reed 88 does not encounter a sharp surface and is capable of extended periods of operation.

The cylinder head 94 is affixed to the cylinder 78 by studs 95 (FIGURE 5) and contain a passage (FIGURE 2) which is connected to the exhaust tube 26. An exhaust valve plate 96 is held within the cylinder head on pins 98 which also carry springs 100 that urge the plate 96 downwardly to cover a port 102 in the valve plate 86. Of course, when the pressure within the cylinder 78 exceeds the pressure in the cylinder head 74 by a predetermined amount, the springs 100 yield thereby opening the port 102 and enabling fluid to pass from the cylinder into the exhaust tube 26.

In the operation of the compressor as considered above, the motor 10 revolves the shaft 34 which is coupled to the shaft 54 through the plate 44 by the toroids 40 and 50 and by magnetic flux. Revolution of the compressor shaft 54 reciprocates the piston 76 by means of the connecting rod 70 to perform the compressing operation.

In considering the intake or down stroke of the piston 76, it is to be noted that the low pressure intake 24 is connected to the interior of the compressor housing through a tube 104 (FIGURE 5), therefore, the initial flow is into the housing. Inside the compressor housing, the tube 104 divides into a short open section 106 and an extended restricted section 108. In passing through the tube 104, the circulation fluid is impinged against the surface of the inner wall of the tube and oil or other lubricants which may be carried in suspension by the gaseous fluid is deposited upon the surface. The gaseous fluid then passes through the upper section 106 of the tube 104 to discharge into the compressor housing. The lubricant deposited upon the tube surface drains out of the tube section 108. Of course, some gaseous fluid also passes through the section 108 forcing lubricant from a nozzle-like section 110 of the tube 104, to be sprayed upon an exposed portion of the rod bearing 72. Of course, the rod bearing is channeled to receive the lubricant. It is to be noted, that by reason of this arrangement the amount of lubricant carried by the refrigerant is somewhat controlled as lubricant is continually removed by impingement of the gaseous fluid against a surface in the tube 104. Furthermore, it is to be noted that free lubricant in the compressor is taken up by the wick 84 which provides lubricant to the piston 76. Of course, by avoiding the use of unconfined lubricant which would normally be splashed about within the compressor and by removing lubricant from the refrigerant, the amount of lubricant

carried by the refrigerant is somewhat controlled and maintained relatively low thereby maintaining the efficiency of the system at a higher level.

The fluid refrigerant contained in the compressor housing at a relatively low pressure is drawn through ports in the cylinder head 94 and the valve plate 86 during a downstroke of the piston 76. The fluid is permitted to pass through the cylinder head 94 and the valve plate 86 when the pressure outside the cylinder 76 exceeds the pressure inside the cylinder by an amount adequate to flex the extensions 90 and 92 of the reed 88 (FIGURE 6), thereby opening the ports through the valve plate and the cylinder head.

At the end of the downstroke of the piston 76 an upstroke is initiated to compress the fluid in the cylinder 78. During an upstroke of the piston 76, the fluid, e.g. gaseous refrigerant, is compressed to exert a pressure upon the exhaust valve plate 96 (FIGURE 2) which moves upwardly, by compressing the springs 100, to allow the fluid to pass through a port 102 into the exhaust tube 26.

In view of the above description, it may be seen that the fluid compressed by the compressor 16 is maintained within the compressor by a positively sealed structure. Thus, the compressor of the present invention is hermetically sealed yet does not enclose the drive motor and can therefore employ a direct current motor. It is also to be noted that none of the compressor's output serves to maintain seals or other closure mechanisms in the compressor.

It is also to be noted, that the compressor incorporates a novel lubricating system which employs the fluid of the compressor to carry lubricant; however, the lubricant content of the fluid is somewhat controlled and does not reach saturation and decrease the efficiency of operation in a refrigeration system.

As previously indicated, the magnetic coupling between the toroids 40 and 50 is locked therefore, the compressor 16 is driven in synchronism with the motor 10. In the event of a break in the magnetic coupling between the compressor and the motor it is necessary to stop the motor to enable the magnetic coupling to become re-established. Also, the magnetic coupling may not possess sufficient strength to allow the compressor to be started under load conditions. Of course, unless the compressor is given a period to balance the various pressures therein after shut-down, the torque required for starting the compressor may be considerable.

Upon the occurrence of a break in the magnetic coupling, the motor 10 would continue to revolve under no load conditions with the compressor 16 idle. To prevent the occurrence of operation failures of this type, an automatic electrical control system is provided for use in conjunction with the motor 10 and the compressor 16, which functions to sense the occurrence of a failure in the magnetic coupling and to de-energize the motor 10 upon such an occurrence, and allow the motor to halt and re-establish magnetic coupling. A delay interval may also be provided by the control system during which the motor remains stopped while the various pressures within the compressor 16 balance out to allow the motor to start under no-load conditions.

Referring now to FIGURE 7, the control system of the present invention will be considered. A compressor 112, which may comprise the compressor described above, is connected to a condenser 120. The condenser is in turn connected to an evaporator 118 which is connected to the compressor block 112 to form a conventional refrigeration system. A thermostat 124, associated with the evaporator 112 functions to control a switch 126 in accordance with the temperature of the evaporator 118. The capillary 116, along with the evaporator 118 and the condenser 120 may be standard refrigeration system components and, as previously indicated, the compressor 112 may comprise a compressor as previously described herein. The compressor 112 is mechanically coupled to a motor 128 which may be the motor 10 and which op-

erates the compressor in accordance with the temperature of the evaporator 118, under control of the switch 126 and a control circuit 130.

In the control circuit 130, a pair of lines 132 and 134 are adapted to be connected to a source of direct current power as through terminals 14 (FIGURE 1). The line 134 is connected through the thermostat-controlled switch 126 to one terminal of the motor 128. The other terminal of the motor 128 is connected to a relay having a hold coil 138 and an actuating coil 140. The actuating coil of the relay is in turn connected to contacts 142 of the relay. The line 134 is also connected through a line 144 and a resistance heating element 146 to the stationary contact of contacts 148. The other direct current-receiving line 132 is connected to the movable contact of contacts 150 and to the movable contact of contacts 152. The movable contact of contacts 152 also engages a second stationary contact to form contacts 154.

In the operation of the system, the resistance element 146 functions to heat a bimetallic blade of the type well-known in the art, which may comprise the movable contact of the contacts 156. Heating of the blade opens the contacts 156. Additionally, the bimetallic blade is mechanically coupled to the contacts 152 and prevents the closure of contacts 152 until such time as the bimetallic blade is heated to a predetermined temperature.

An understanding of the control circuit may now best be effected by considering a cycle of operation thereof. Assume that the lines 132 and 134 are connected to a source of direct current and that the temperature of the evaporator 118 has reached a level so that the thermostat 124 functions to close the switch 126. Electrical current then flows through the line 134, the switch 126, the motor 128, and hold coil 138, the activate coil 140, the contacts 156 and 152 then through the line 158 back to the line 132. During the initial surge of this current, the contacts of the relay 137 are raised by the activate coil 140 thereby closing the contacts 150, 154, and 142 and opening the contacts 152 and 148. Upon the completion of this switching operation, it is to be noted that the activate coil 140 is shorted out through the contacts 142 and 154, line 158, and contacts 150.

The motor 128 now continues to run with the control circuit 130 consuming essentially no energy, the only energy being that required to maintain the relay 137 in an energized position by the energization of the hold coil 138.

Assume now that for some reason the coupling between the motor 128 and the compressor 112 fails and the motor 128 begins to run under no load conditions. Upon this occurrence the current through the motor 128 will decrease substantially as will the current in the serially connected hold coil 138. As a result, the movable contacts of the relay 137 drop to the lower position opening the contacts 150 and 142 and closing the contacts 148. Of course, as previously indicated, the contacts 152 are prevented from closing until such time as the bimetallic blade associated with the thermal heating element 146 reaches a predetermined temperature.

With the contacts in the above-described state, the thermal element 146 is energized by current passing from the line 134, through the line 144, the element 146, contacts 148, contacts 154 and the line 158. After a predetermined interval, during which the motor 128 stops and the pressures in the compressor 112 balance out, the heating element 146 heats the bimetallic element to an adequate temperature to open the contacts 156, and allow the contacts 152 to close. Upon this occurrence the current passing through the contacts 152 is interrupted and the resistance element 146 is de-energized. However, the contacts 156 remain open for a brief interval until such time as the bimetallic blade associated with the element 146 cools sufficiently to enable the contacts 146 to close. Upon closure of the contacts 156 the motor 128 is again energized in the manner first described.

Of course, it is to be understood that the time delay may be varied to allow various periods for the magnetic coupling to become re-established. Such variations may be effected in accordance with well-known practices either by varying the resistance heating element 146 or the bimetallic blade associated therewith.

It may therefore be seen, that in the event that the motor 128 becomes decoupled from the compressor 112 for any reason, or if coupling is never effected due to the system attempting to operate prior to the balancing of pressures in the compressor, the control system 130 senses such an occurrence and temporarily delays the operation of the motor 128, enabling the system to prepare for a subsequent start-up operation.

An important feature of the control system of the present invention resides in the mode of operation which does not require substantial energy demands during non-operating intervals.

It should be noted that although the particular embodiment of the invention herein shown and described is fully capable of providing the advantages and achieving the objects previously set forth, such embodiment is merely illustrative of this invention and therefore modifications and changes may be made thereto without departing from the spirit of the invention or the scope of the following claims.

I claim:

1. A drive system for inter-coupling first and second concentric aligned mechanical shafts, comprising: a first homogeneous toroid of magnetic material having a flat annular surface containing an even plurality of alternate-polarity elongate magnetic pole faces extending radially fully across said annular surface; first mounting means for affixing said first toroid to said first shaft whereas said first toroid is concentric with said first shaft and said annular surface of said first toroid is face-opposing said second shaft; a second homogeneous toroid of magnetic material having a flat annular surface containing a like even plurality of alternate-polarity elongate magnetic pole faces extending radially fully across said annular surface; second mounting means for affixing said second toroid to said second shaft whereas said second toroid is concentric with said second shaft and said annular surface of said second toroid is face-opposing said first shaft; and a housing substantially enclosing one of said toroids, and including a flat separator of non-ferrous material supported and contacted solely by said housing and positioned between said flat annular surfaces of said first and second toroids whereby said toroids are magnetically interconnected and physically separated.

2. A drive system for inter-coupling first and second concentric aligned mechanical shafts, comprising: a first homogeneous toroid of magnetic material having a flat annular surface containing an even plurality of uniformly-spaced alternate-polarity elongate magnetic pole faces extending radially fully across said annular surface and having a length greater than the internal diameter of said first toroid; first mounting means for affixing said first toroid to said first shaft whereas said first toroid is concentric with said first shaft and said annular surface of said first toroid is face-opposing said second shaft; a second homogeneous toroid of magnetic material having a flat annular surface containing a like even plurality of uniformly-spaced alternate-polarity elongate magnetic pole faces extending radially fully across said annular surface and having a length greater than the internal diameter of said second toroid; second mounting means for affixing said second toroid to said second shaft whereas said second toroid is concentric with said second shaft and said annular surface of said second toroid is face-opposing said first shaft; and a housing substantially enclosing one of said toroids, and including a flat homogeneous separator of non-ferrous material supported and contacted solely by said housing and positioned between said flat annular surfaces of said first and second toroids whereby said toroids are physically separated and magnetically coupled, said separator having an integrally-formed center section of increased thickness extending axially into each of said toroids whereby to provide additional support for said toroids.

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