March 7, 1944. A. A. McCORMACK 2,343,514

REFRIGERATING APPARATUS

Filed March 14, 1941 3 Sheets-Sheet 1

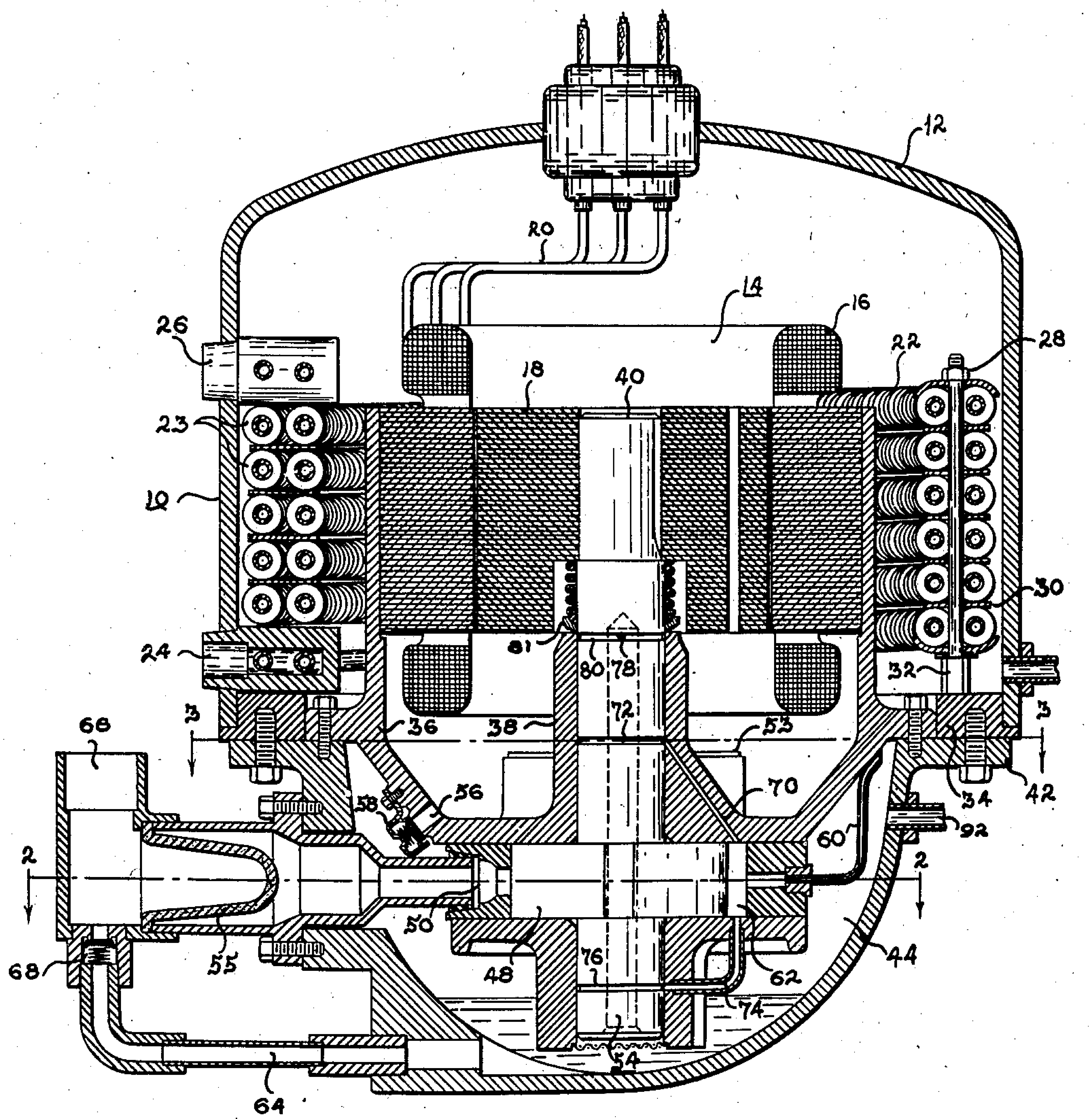

Fig. 1

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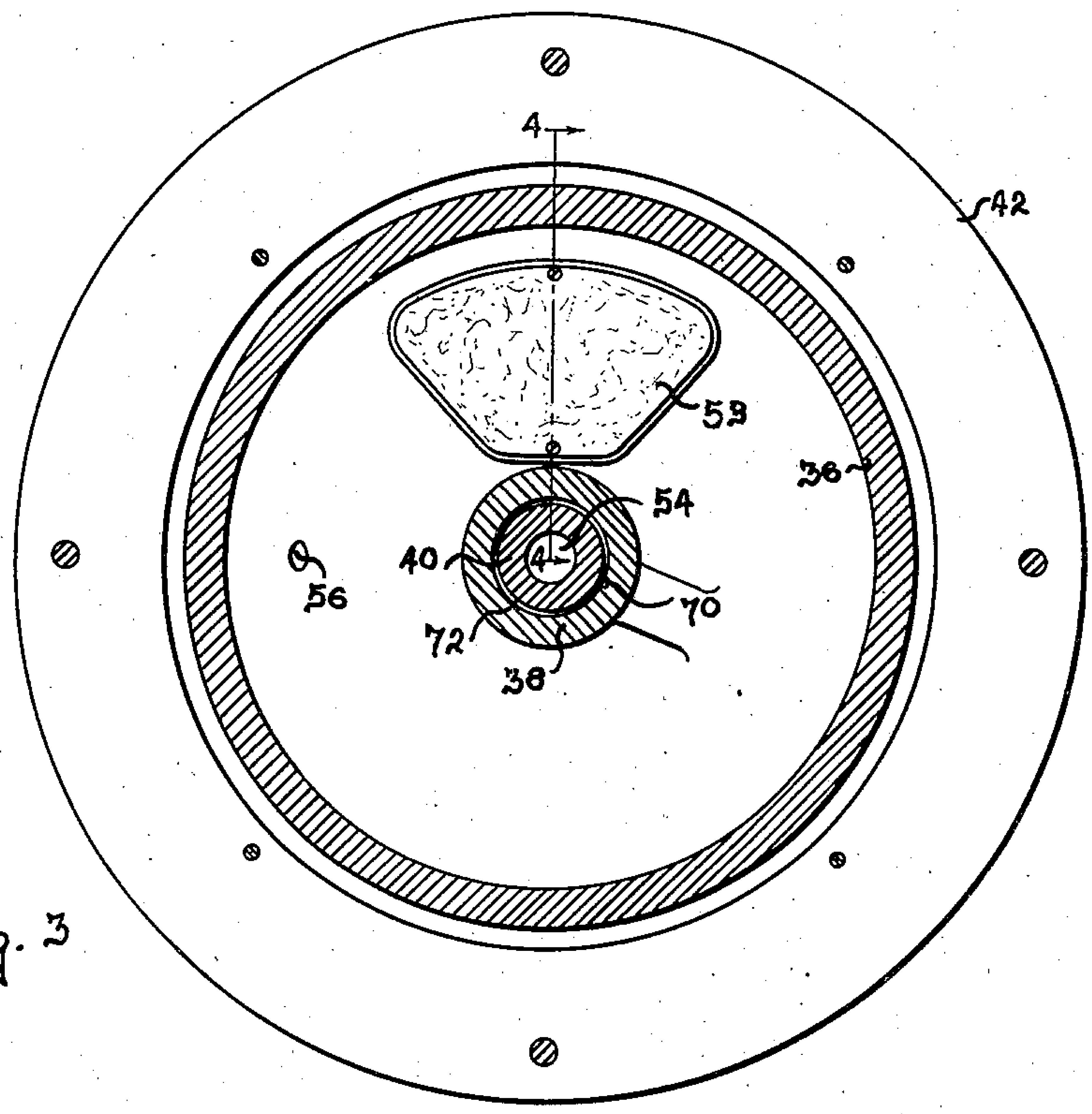

Fig. 3

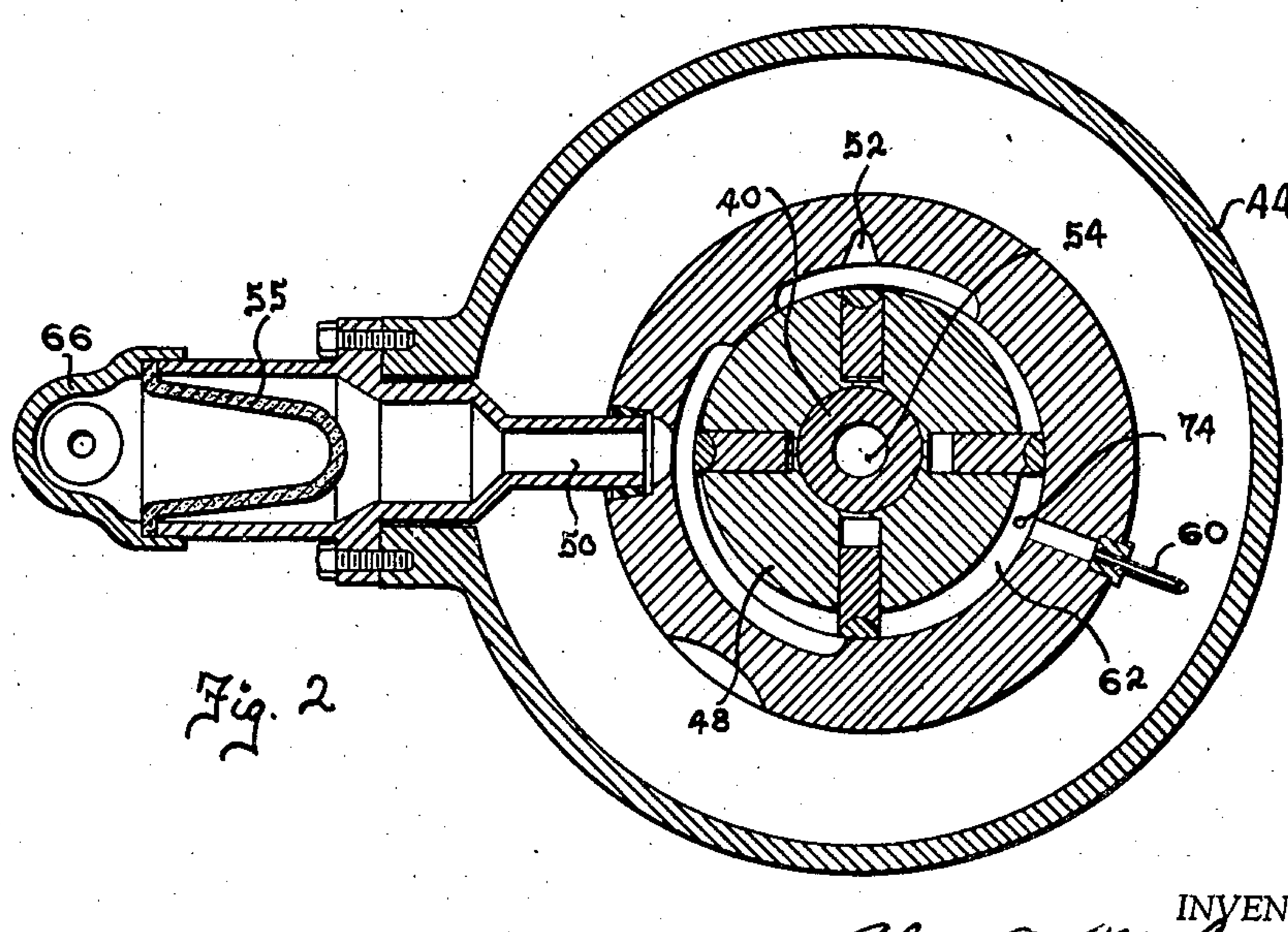

Fig. 2

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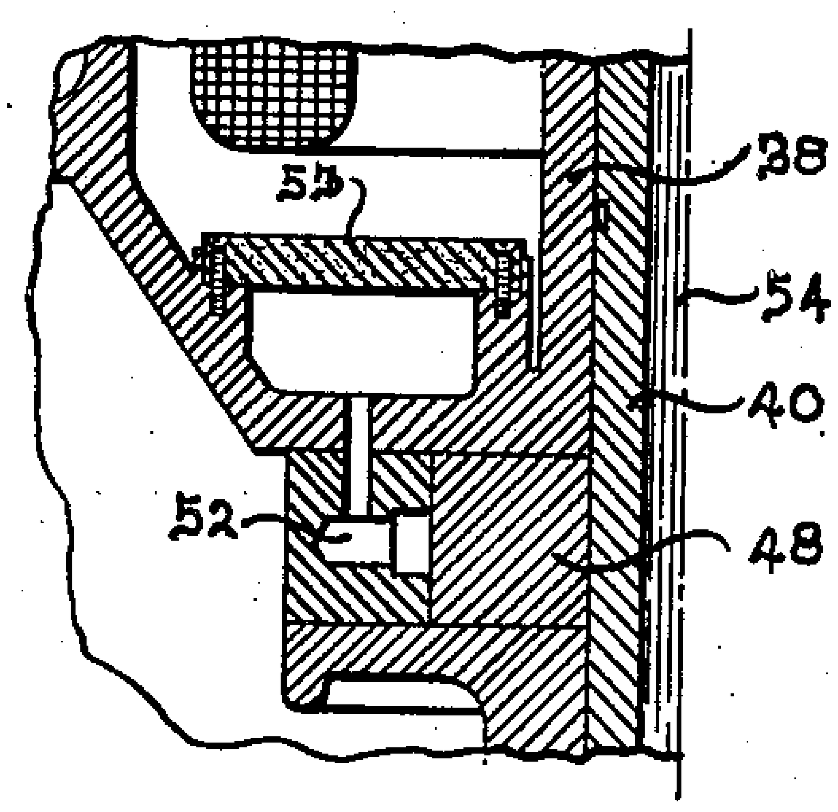

Fig. 4

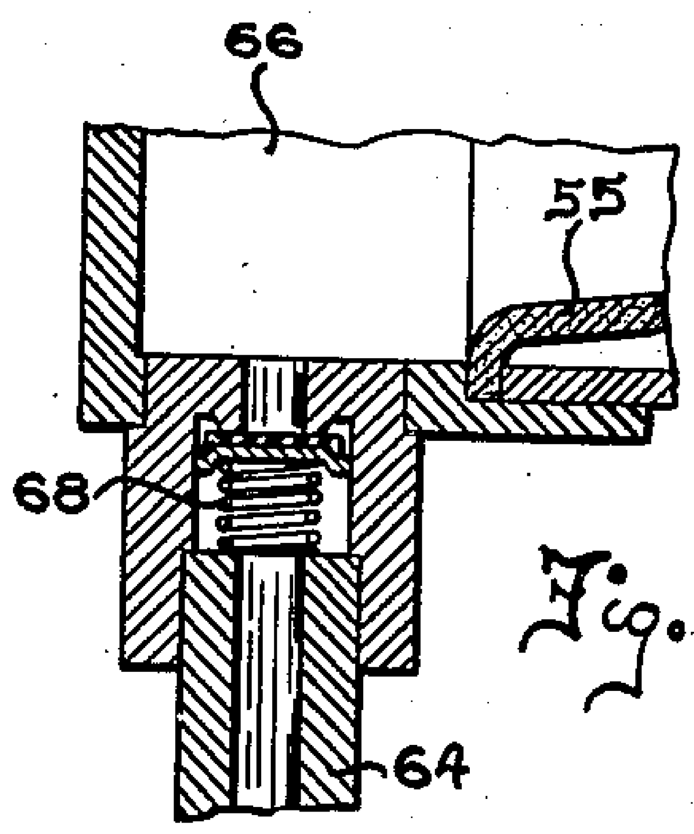

Fig. 6

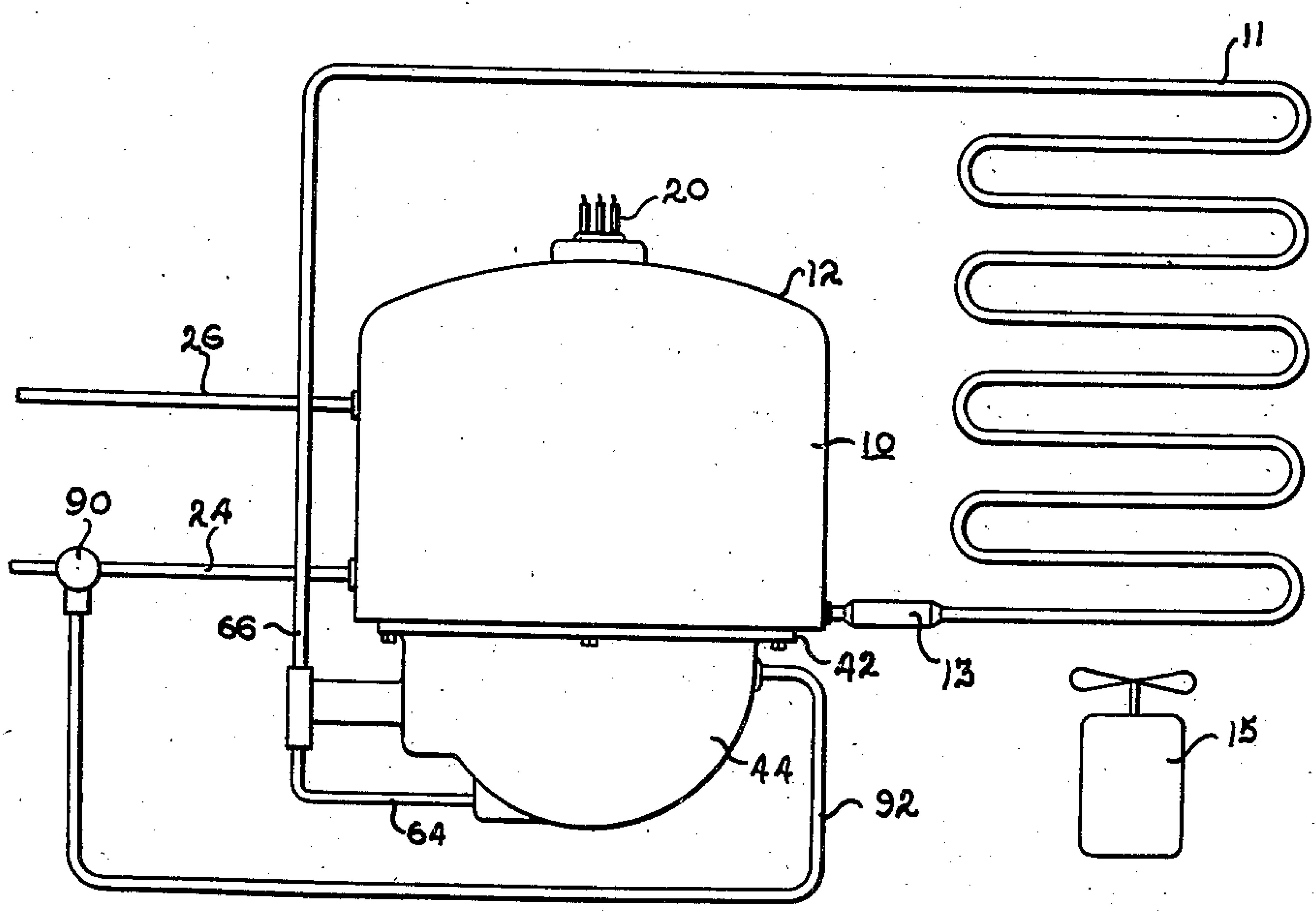

Fig. 5

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UNITED STATES PATENT OFFICE

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REFRIGERATING APPARATUS

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Application March 14, 1941, Serial No. 383,381

14 Claims. (Cl. 62—115)

This invention relates to refrigerating apparatus and more particularly to an improved refrigerating system of the reverse cycle type for use in air conditioning.

It has long been known that a refrigerating system may be used for either heating or cooling the air for an enclosure by reversing the cycle of operation in some manner or the other. A large number of arrangements have been proposed for reversing the cycle of operation of refrigerating systems but none have gone into extensive use either because of the complicated controls which have been required or because of other difficulties.

One object of this invention is to provide a simplified reverse cycle system in which all of the refrigerant controls are mounted wholly within the sealed refrigerant circuit.

Another object is to provide a system in which the cycle of operation may be reversed merely by reversing the direction of rotation of the compressor.

Another object of this invention is to provide an improved and simplified means for controlling the flow of condenser cooling water which may also be used for controlling the flow of water over the evaporator during the heating cycle.

A further object of this invention is to provide an improved oil sump arrangement in which the main supply of lubricant is subjected to the high side pressure at all times irrespective of the direction of rotation of the compressor.

A further object of this invention is to provide an improved means for separating the lubricant from the compressed refrigerant.

A further object of this invention is to provide an improved rotary compressor especially adapted for use in a reverse cycle system.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings, wherein a preferred form of the present invention is clearly shown.

In the drawings:

Fig. 1 is a vertical sectional view showing the motor-compressor construction;

Fig. 2 is a sectional view taken on the line 2—2 of Fig. 1;

Fig. 3 is a sectional view taken on the line 3—3 of Fig. 1;

Fig. 4 is a fragmentary sectional view taken on the line 4—4 of Fig. 3;

Fig. 5 is a diagrammatic view of a reverse cycle system embodying my invention; and

Fig. 6 is an enlarged sectional view showing one of the refrigerant valves.

Referring now to the drawings, reference character 10 designates a sealed unit which functions as a motor-compressor-condenser unit during the cooling cycle and functions as a motor-compressor-evaporator unit during the heating cycle. The fan unit 15 circulates air to be conditioned in thermal exchange relationship with a heat exchange unit 11 arranged in refrigerant flow relationship with the unit 10. The flow of refrigerant between the units 10 and 11 is controlled by a fixed restrictor diagrammatically shown at 13. The fixed restrictor may be of any conventional construction such as a small bore capillary tube. The unit 10 comprises an upper shell 12 within which is mounted a motor 14, having a field winding 16 and an armature 18. The motor 14 shown herein is merely intended to represent a conventional motor of the type which may be caused to operate in either direction desired. Electrical energy is supplied to the motor through the leads 20.

A finned water coil 22 is mounted within the casing 12 between the motor stator and the lower portion of the casing 12 as shown in the drawings. Water enters the coil 22 through the inlet 24 and leaves the coil through the outlet 26. During the cooling cycle the water flowing through the coil 22 serves to condense the compressed refrigerant discharged from the compressor and during the heating cycle the water gives up heat to the low pressure liquid refrigerant supplied to the unit 10 from the heat exchange unit 11. The coil 22 is held in place by means of one or more bolts such as the bolt 28. Spacer washers 30 are provided on each of the bolts 28 so as to hold the various convolutions of the coil 22 in proper spaced relationship. As shown in the drawings, the bolt 28 is provided with an elongated head 32 which serves to space the lowermost convolutions of the coil 22 from the ring 34. As shown in Fig. 1, the coil 22 is provided with fins such as 23 so as to increase the heat transfer surface of the coil. The motor stator 16 is supported by the main frame 36 which also includes a bearing extension 38 within which is journalled the main motor-compressor shaft 40. The frame 36 is bolted or otherwise secured to the casing 44 which encloses the main compressor mechanism and which serves as a lubricant reservoir. The casing 44 is provided with a flange 42 to which the ring 34 and the main frame 36 are secured as shown.

The compressor comprises a conventional four vane rotor 48 operated by the shaft 40 in the usual and well-known manner. During the cooling cycle, refrigerant vaporized in the heat exchange coil 11 leaves the coil 11 through the line 66 and enters the compressor through the port 50. The compressed refrigerant discharges from the compressor through the port 52 as best shown in Figs. 2 and 4. Lubricant is supplied to the motor-compressor bearing through the central bore 54 provided in the main shaft 40. In order to avoid the necessity for a mechanical lubricant pump, I make use of the difference in pressure between the suction side and the discharge side of the compressor for forcibly feeding lubricant to the bearing surfaces in the manner explained more fully hereinafter. Since the direction of rotation of the compressor is reversed when the cycle of operation of the refrigerating system is reversed, it is necessary to provide some means for maintaining the pressure within the lubricant supply chamber substantially equal to the high side pressure irrespective of the direction of rotation of the compressor. It is also desirable to provide some means for returning to the lubricant sump that lubricant which is discharged from the compressor along with the compressed gas. In order to maintain the pressure within the lubricant chamber 44 substantially equal to the high side pressure at all times, I have provided a pair of pressure operated valves 58 and 68 which tend to equalize the pressure between the lubricant chamber 44 and the high side of the refrigerant system. Valve 58 is arranged in the passage 56 provided in the main frame 36 and valve 68 is arranged in the passage 64 which connects the lubricant chamber with the refrigerant line 66. The passages 56 and 64 also serve as return passages for the lubricant discharged by the compressor.

Since a certain amount of lubricant is at all times discharged from the compressor along with the compressed gas, it is desirable to provide some means for separating the lubricant from the compressed gas. As shown in Fig. 4, the gas and lubricant discharged by the compressor through the port 52 is required to flow through a porous sintered bronze plate 53. In passing through the porous bronze plate 53, the lubricant separates from the refrigerant and drains into the lowermost portion of the motor housing with the result that upon opening of valve 58 the lubricant returns to the lubricant sump 44. Upon reversal of the direction of rotation of the compressor, the port 50 serves as the discharge port. In order to separate the lubricant from the refrigerant discharged through the port 50, I have provided a second porous sintered bronze element 55 which serves to collect the lubricant adjacent the inlet to the valve 68 whereby upon opening of the valve 68 the lubricant returns to the main lubricant sump 44. In order to insure the continuous return of lubricant to the main lubricant sump, I have provided a small capillary tube 60 which has its one end opening into the lubricant chamber above the lubricant level therein and its other end communicating with the interior of the compression chamber 62. Since the one end of the tube is open to the high side pressure and the other end is open to the compression chamber 62, at a point where the pressure therein is very nearly equal to the low side pressure, enough refrigerant vapor will flow from the lubricant chamber into the compression chamber to make room for the lubricant returning to the lubricant sump. The size of the capillary tube 60 is such that only enough vapor will leak therethrough to cause the desired amount of flow through the valves 58 and 68.

During operation of the compressor, lubricant from the high pressure lubricant reservoir 44 flows upwardly through the passage 54 in the shaft 40 and is fed to the bearing surface through one or more passages such as 78 shown in Fig. 1. The passage 78 feeds the lubricant to the groove 80 provided in the shaft 40 at the upper end of the bearing 38. The high pressure lubricant is prevented from escaping from the upper end of the bearing by means of a shaft seal 81 which may be of any conventional construction. The seal 81 also prevents high pressure gas from the motor compartment from interfering with proper lubrication of the upper end of the bearing. A lubricant return passage 70 is provided which has its lower end communicating with the compressor chamber 62 at a point midway between the inlet and outlet parts whereby the pressure at the outlet of the passage is very nearly equal to the low side pressure regardless of direction of rotation. By virtue of this arrangement, the lubricant which is under high pressure at 80 is caused to flow along the shaft bearing and into the groove 72 which communicates with the passage 70. A certain amount of lubricant will also find its way to the groove 72 from the main compression chamber whereby the entire upper bearing is lubricated. The lower bearing is also lubricated in much the same manner. Thus a lubricant return passage 74 is provided which corresponds to the passage 70 whereby lubricant under high pressure in the main compression chamber and in the lubricant sump 44 finds its way along the lower bearing into the groove 76 which communicates with the passage 74.

The flow of water through the coil 22 is controlled by the pressure operated valve 90 which varies the flow of water in accordance with the variations in the pressure within the lubricant sump 44. Line 92 connects the sump 44 with the valve 90. The valve 90 is of the type now used extensively for controlling the flow of cooling water in response to variations in head pressure and needs no further description.

By virtue of the above described arrangement, the valves 58 and 68 serve a triple purpose. They not only serve to return the lubricant discharged from the compressor to the lubricant sump, but also serve to maintain the lubricant sump under high pressure irrespective of direction of rotation of the compressor. Two distinct advantages result from maintaining the lubricant sump under pressure. In the first place, it provides forced lubrication and in the second place, the pressure within the lubricant chamber may be used in controlling the flow of water through the coil 22 during both cycles of operation.

It will also be noted that each of the porous sintered bronze elements 53 and 55 serves a dual purpose. Thus each element serves as a filter for the suction gas a portion of the time and as an oil separator for the discharge gas another portion of the time depending upon the direction of rotation of the compressor.

While the form of embodiment of the invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. In a reverse cycle refrigeration system in

which refrigerant may flow in either of two directions, a first heat exchange unit, a second heat exchange unit, refrigerant compressing mechanism, refrigerant flow connections between said heat exchange units and said compressing mechanism, means forming a lubricant sump from which lubricant is supplied to said compressing mechanism, means for so driving the compressing mechanism as to cause flow of refrigerant in either direction through said system, means for maintaining lubricant in said sump at a pressure substantially equal to the pressure at the discharge side of said compressor, means for restricting the flow of refrigerant from one of said heat exchange units to the other of said heat exchange units, means for flowing air to be conditioned over one of said heat exchange units, means for flowing an extraneous medium in thermal exchange with refrigerant in the other of said heat exchange units and means responsive to the pressure within said lubricant sump controlling the flow of said extraneous medium.

2. Refrigerating apparatus comprising in combination, a first heat exchanger, a second heat exchanger, a rotary compressor, refrigerant flow connections between said heat exchangers and said compressor, means for operating said compressor to cause flow of refrigerant in either of two directions, said refrigerant flow connections including a lubricant sump, means for supplying lubricant from said sump to said compressor, and means for maintaining the lubricant in said sump at a pressure higher than the compressor suction pressure irrespective of the direction of rotation of said compressor.

3. In combination, a first heat exchange unit, a second heat exchange unit, means for flowing air to be conditioned in thermal exchange with one of said units, means for circulating an extraneous medium in thermal exchange with the other of said units, compressor mechanism, refrigerant flow connections between said heat exchange units and said compressor mechanism, means for so driving the compressor mechanism as to cause flow of refrigerant in either of two directions through said compressor and said heat exchange units, means for maintaining one portion of said refrigerant flow connections under high side pressure irrespective of the direction of flow of refrigerant through said heat exchange units, and means responsive to the pressure in said one portion controlling the flow of said extraneous medium.

4. In combination, a casing, means forming a plurality of chambers within said casing, a rotary compressor within said casing, inlet and outlet ports for said compressor, means for driving said compressor including means for reversing the direction of rotation of said compressor whereby the inlet and outlet ports are interchanged in function, one of said ports communicating with one of said chambers and the other of said ports communicating with another of said chambers, means for supplying lubricant to said compressor, porous sintered bronze filter elements provided for each of said ports adapted to separate lubricant from the refrigerant discharged by said compressor, and means for returning the lubricant thus separated to the means for supplying lubricant to said compressor.

5. In combination, a casing, refrigerant condensing means within said casing, a motor within said casing, a rotary compressor within said casing, a refrigerant evaporator in refrigerant flow relationship with said compressor and said condensing means, a lubricant sump within said casing, means for maintaining said lubricant sump at a pressure substantially equal to the pressure at the outlet of said compressor, and a bleeder port between said lubricant sump and the compression chamber of said compressor, said bleeder port terminating above the liquid level in said sump, said motor including means for reversing the direction of rotation of said compressor.

6. In combination, a casing, partition means within said casing, a compressor within said casing, said compressor having an outlet on one side of said partition means and a lubricant supply sump on the other side of said partition means, means for supplying lubricant from said sump to said compressor, an opening in said partition means for returning lubricant from said compressor outlet to said sump, a valve for said opening, means for withdrawing refrigerant vapor from said lubricant sump into said compressor, and a porous metal plate adjacent the outlet of said compressor for separating the lubricant from the refrigerant.

7. In combination, a reversible compressor having a pair of ports adapted to serve as inlet and outlet ports, a lubricant sump for said compressor, means for supplying lubricant from said sump to said compressor, a first passage leading from one of said ports to said lubricant sump, a second passage leading from another of said ports to said sump, and means cooperating with said passages for maintaining said lubricant in said sump at a pressure substantially equal to the discharge pressure of said compressor.

8. In combination, a reversible compressor having a pair of ports adapted to serve as inlet and outlet ports, a lubricant sump for said compressor, means for supplying lubricant from said sump to said compressor, a first passage leading from one of said ports to said lubricant sump, a second passage leading from another of said ports to said sump, means cooperating with said passages for maintaining said lubricant in said sump at a pressure substantially equal to the discharge pressure of said compressor, and oil separating means adjacent each of said ports.

9. In a refrigerating system, a casing, a wall member dividing said casing into a motor compartment and a compressor compartment, a bearing in said wall member, a shaft journalled in said bearing, a motor in said motor compartment for rotating said shaft, a compressor within said compressor compartment driven by said shaft, said compressor comprising an inlet port communicating with said motor compartment and an outlet port communicating with said compressor compartment, a body of lubricant within said compressor compartment, means utilizing the difference in pressure between said compressor compartment and said motor compartment for supplying lubricant to said bearing, and means for preventing the escape of lubricant from said bearing into said motor compartment.

10. In a refrigerating system, a first heat exchange unit, a second heat exchange unit, means for flowing a fluid to be treated in thermal exchange with one of said units, means for circulating an extraneous medium in thermal exchange with the other of said units, compressor mechanism, refrigerant flow connections between said heat exchange units and said compressor mechanism, means for so driving the compressor mechanism as to cause flow of refrig-

erant in either of two directions to reverse the functions of said heat exchange units, means for maintaining one portion of said refrigerant flow connections under high side pressure at all times when said compressor mechanism is in operation, and means responsive to the pressure in said one portion controlling the flow of said extraneous medium.

11. In combination, a casing, means forming a plurality of chambers within said casing, a rotary compressor within said casing, inlet and outlet ports for said compressor, means for so driving the compressor as to cause flow of refrigerant in either of two directions whereby the inlet and outlet ports are interchanged in function, one of said ports communicating with one of said chambers and the other of said ports communicating with another of said chambers, means for supplying lubricant to said compressor, porous sintered filter elements provided for one of said ports adapted to separate lubricant from the refrigerant discharged by said compressor, and means for returning the lubricant thus separated to the means for supplying lubricant to said compressor.

12. In combination, a reversible compressor having a pair of ports adapted to serve as inlet and outlet ports, a lubricant sump for said compressor, means for supplying lubricant from said sump to said compressor, first passage means from one of said ports to said lubricant sump, second passage means from another of said ports to said sump, and means cooperating with said passage means for maintaining said lubricant in said sump at a pressure substantially equal to the discharge pressure of said compressor irrespective of direction of rotation of said compressor.

13. In combination, a casing, partition means within said casing, a compressor within said casing, said compressor having an outlet on one side of said partition means and a lubricant supply sump on the other side of said partition means, means for supplying lubricant from said sump to said compressor, a by-pass opening in said partition means for returning lubricant directly from said compressor outlet to said sump, a valve for said opening, and means for withdrawing refrigerant vapor from said lubricant sump into said compressor.

14. In combination, a casing, a rotary compressor within said casing, inlet and outlet ports for said compressor, means for so driving the compressor as to cause flow of refrigerant in either of two directions whereby the inlet and outlet ports are interchanged in function, means for supplying lubricant to said compressor, porous sintered filter elements provided for one of said ports adapted to separate lubricant from the refrigerant discharged by said compressor, and means for returning the lubricant thus separated to the means for supplying lubricant to said compressor.

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