March 11, 1941. H. F. SMITH 2,234,742

REFRIGERATING APPARATUS

Filed April 28, 1937 5 Sheets-Sheet 1

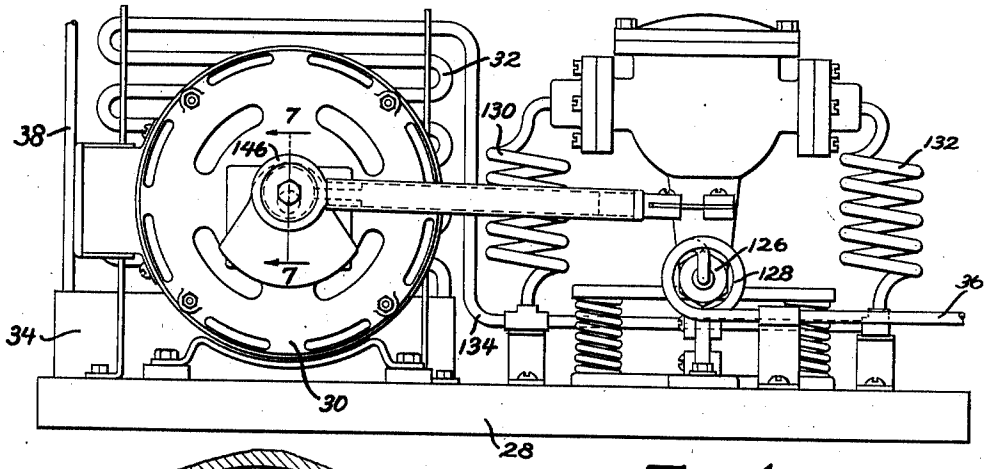

Fig. 1

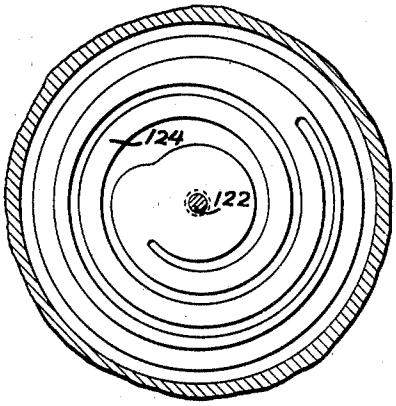

Fig. 3

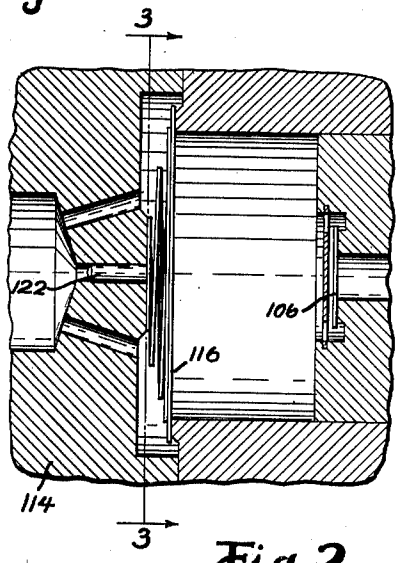

Fig. 2

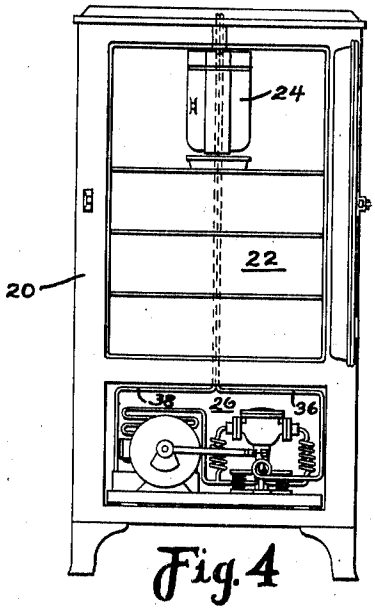

Fig. 4

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REFRIGERATING APPARATUS

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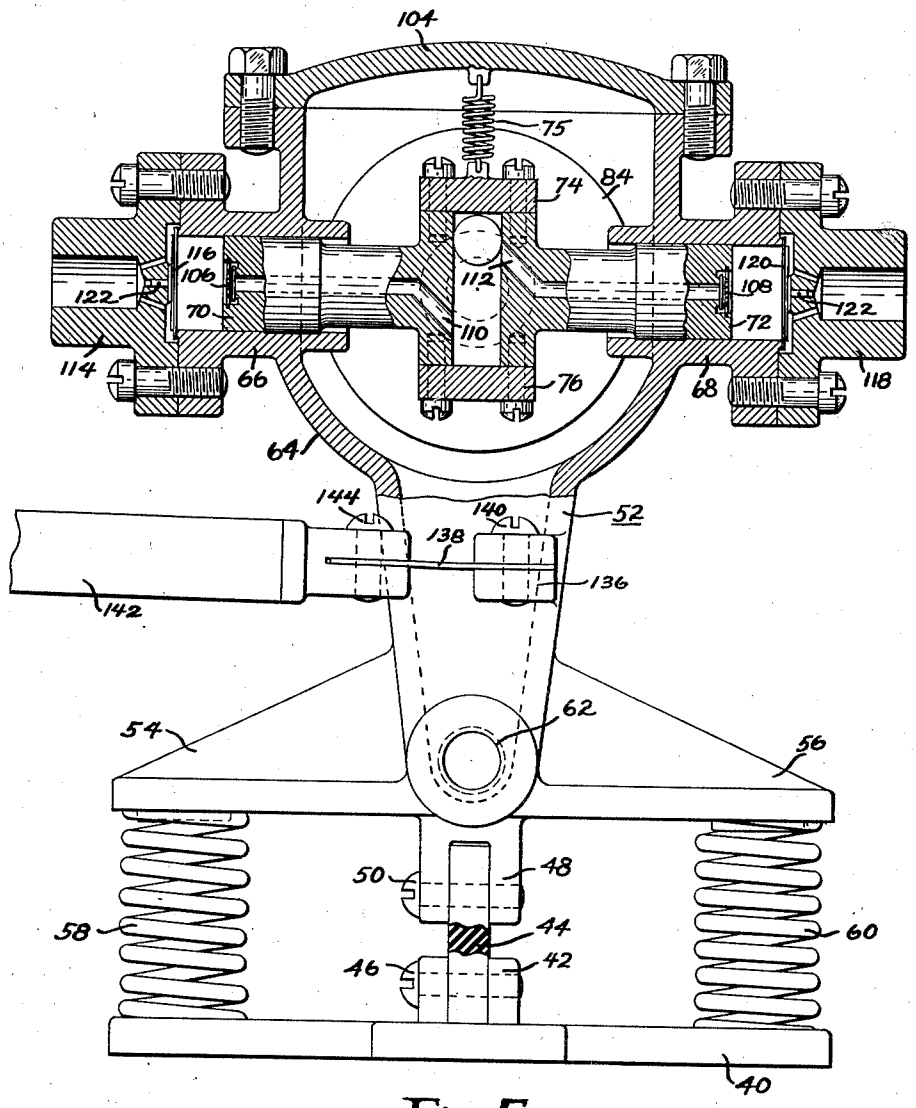

Fig. 5

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REFRIGERATING APPARATUS

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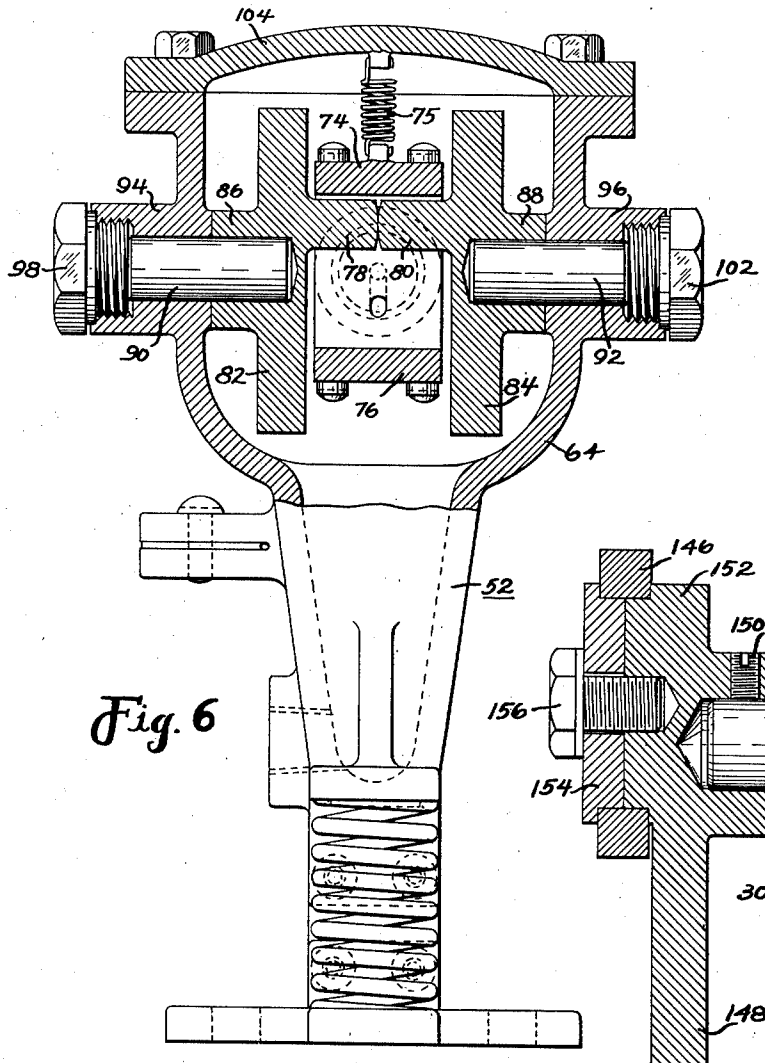

Fig. 6

Fig. 7

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REFRIGERATING APPARATUS

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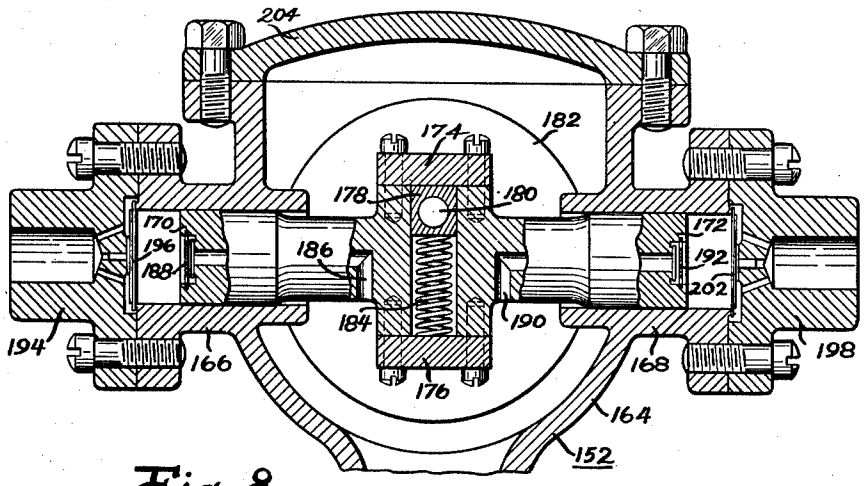

Fig. 8

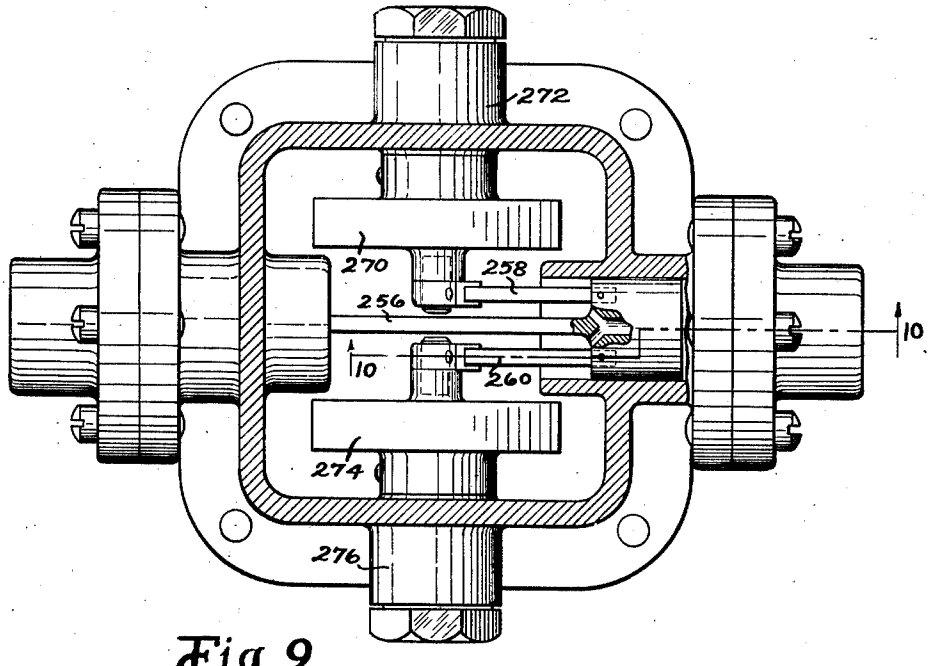

Fig. 9

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REFRIGERATING APPARATUS

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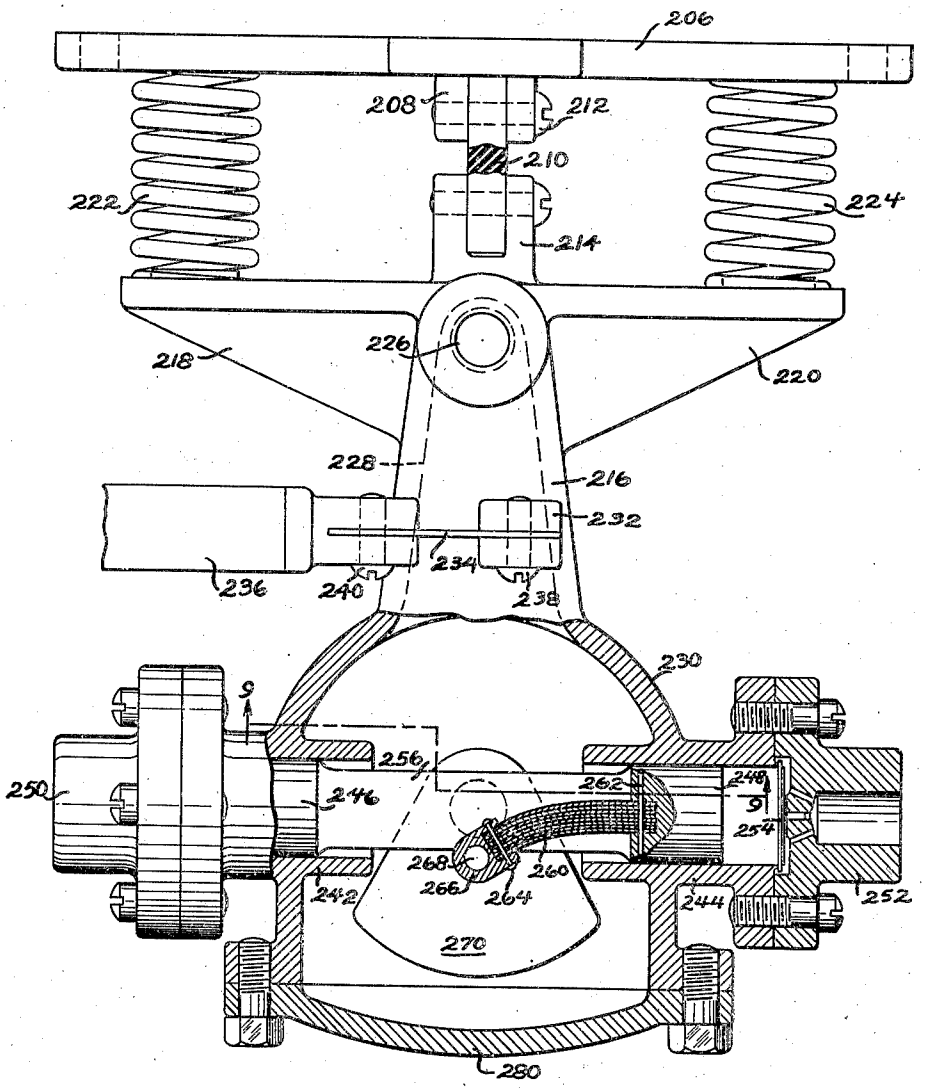

Fig. 10

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UNITED STATES PATENT OFFICE

2,234,742

REFRIGERATING APPARATUS

Harry F. Smith, Dayton, Ohio, assignor to General Motors Corporation, Dayton, Ohio, a corporation of Delaware

Application April 28, 1937, Serial No. 139,557

8 Claims. (Cl. 230—34)

This invention relates to refrigerating apparatus and more particularly to an improved construction of refrigerating systems and motor-compressor units.

In early refrigerating systems compressors were driven by an external driving means usually through a shaft seal upon the drive shaft of the compressor. Such compressors are still being used; but the shaft seals, while they have been considerably improved, have always been, and are still, a source of considerable trouble. In the smaller sizes of household units, sealed units containing the motor and compressor have been employed to eliminate the shaft seal. However, in such sealed units, it is necessary to use alternating current motors because direct current motors cannot be used in the presence of the common refrigerants.

It is an object of my invention to provide an improved form of refrigerating system wherein no shaft seal is required.

In systems employing conventional motor-compressor units, the compressor motor is subject to stalling upon heavy refrigeration loads. It is another object of my invention to provide a refrigerating system wherein a condenser, evaporator, and compressor are used and in which a compressor, movable independently of the remainder of the system, is provided with an inertia-operated piston which is operated by an external motor which moves the compressor housing in such a way that the piston or the impeller of the piston is driven by inertia without any direct connection with the motor.

It is another object of my invention to provide a free and improved form of inertia-operated compressor wherein means are provided to gradually stop the movement of the piston at each end of the stroke.

It is a further object of my invention to provide an improved, more efficient form of inertia-operated compressor wherein the inertia of the body of the compressor is absorbed by springs and returned as useful energy.

It is still another object of my invention to provide improved connecting means between the inertia-operated compressor and the remaining elements of the refrigerating system.

It is another object of my invention to improve the efficiency and mechanical advantage of an inertia-operated free piston compressor.

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 view in elevation of a motor-compressor-condenser unit embodying my invention;

Fig. 2 is an enlarged section of a cylinder head similar to that shown in Fig. 5;

Fig. 3 is a sectional view taken along the lines 3—3 of Fig. 2;

Fig. 4 is a view of a domestic refrigerator cabinet embodying the motor-compressor-condenser unit shown in Fig. 1;

Fig. 5 is an enlarged view of the compressor, partly in section, shown in a position like that of Fig. 1;

Fig. 6 is a view in elevation of the compressor taken from the right side of Fig. 5 showing the upper portion of the compressor in section;

Fig. 7 is a sectional view of the motor and counterweight taken along the line 7—7 of Fig. 1;

Fig. 8 is a sectional view similar to the upper portion of Fig. 5 of a modified form of compressor;

Fig. 9 is a sectional view taken along the line 9—9 of Fig. 10 showing another modified form of the invention; and

Fig. 10 is a sectional view taken along the line 10—10 of Fig. 9.

Briefly, I have shown a domestic electric refrigerator cabinet provided with a refrigeration system having a stationary motor, condenser, and evaporator but having a compressor, rockably mounted, connected to the remaining portions of the refrigerating system by flexible connections. This rockably mounted connection has opposed pistons therein which are sufficiently heavy to be operated by their own inertia created by the oscillations of the compressor. The compressor is oscillated through a connecting rod which is connected to an external portion of the housing of the compressor at one end, but at the other end, to a counter-balanced crank pin upon the motor shaft.

Referring now to the drawings and more particularly to Figs. 4 and 1, there is shown a domestic electric refrigerator cabinet 20 having a food compartment 22 containing a refrigerant evaporator 24 which cools the food compartment 22 and also is provided with shelves for receiving ice trays to freeze ice. Below the food compartment 22 is a machine compartment 26 which contains the motor-compressor unit shown in Fig. 1. This motor-compressor unit shown in Fig. 1 is provided with a base 28 which supports either a direct current or alternating current electric

motor 30 as well as the condenser 32 and a receiver 34. The compressor withdraws evaporated refrigerant from the evaporator 24 through a return conduit 36 and compresses this gas and forwards the compressed gas to the condenser 32 where it is liquefied and collected in the receiver 34. From the receiver 34 this liquid refrigerant is forwarded to the evaporator through the supply conduit 38.

Referring now, also, to Figs. 5 and 6 for a further description of the compressor, there is shown a compressor base 40 which is mounted upon the motor-compressor base 28. This compressor base 40 is provided with a slotted boss 42 which receives the lower end of a rubber web member 44 retained in the slot by a screw 46. The upper end of this rubber member 44 is received within the slotted boss 48 and retained by a screw 50. This slotted boss 48 is at the bottom of a rather large casting 52 which, at its lower portion, has the wings 54 and 56 which rest upon coil springs 58 and 60. These coil springs 58 and 60 preferably have a natural frequency of vibration when the inertia of the large casting is considered which is the same as the frequency at which the compressor is to be oscillated.

Above the boss 48 is the compressor inlet 62, and above this inlet is a crank case 64 which forms a sort of a lubricant reservoir. Upon opposite sides of the upper portion of this lubricant reservoir are the cylinders 66 and 68. Opposed pistons 70 and 72 extend into the cylinders and are connected together within the crank case by top and bottom plates 74 and 76 which leaves a space between the inner ends of the pistons to form a Scotch yoke. Pins 78 and 80 extend into this Scotch yoke and are cast integral with the flywheels 82 and 84 which are provided with bosses 86 and 88 which receive the pins 90 and 92 which protrude from the walls of the crank case 64. These pins are held in place and the crank case sealed by the plugs 98 and 102 which hold the pins in proper position. The top of the crank case is closed by a lid 104.

The pistons are provided with identical inlet valves 106 and 108 in their heads. The inlet valve 106 is connected with the crank case through a passage 110, while the inlet valve 108 is connected with the crank case by a passage 112. The cylinder 66 is provided with a removable cylinder head 114 provided with a discharge valve 116, while the cylinder 68 is provided with a removable cylinder head 118. The removable cylinder head 118 is provided with a discharge valve 120. The discharge valve 116 is kept in position by a pin 122 which is surrounded by a valve spring 124 extending between the cylinder head 114 and the valve 116.

The inlet opening 62 of the compressor is connected by a flare nut 126 with a coil portion 128 of the return conduit 36 which is coiled about the axis of the flare nut to provide sufficient flexibility to accommodate the rocking movement of the compressor. The cylinder heads 114 and 118 are connected to discharge coils 130 and 132 which provide a flexible connection with the conduit 134 which conduits the compressed refrigerant to the condenser 32. The surface of these coil tubes 130 and 132 also serves as a condensing surface.

The compressor is provided with a slotted boss 136 which receives laminated strip 138 retained at the boss 136 by a screw 140. The other end of the laminated strip 136 is retained within the slot in the end of the connecting rod 142 by a screw 144. The other end of the connecting rod 142 is provided with a bearing 146 which is mounted upon a split crank pin upon the motor shaft. Upon the end of the motor shaft a counterweight 148 is fastened by a set screw 150. The upper portion of this counterweight is provided with an extension 152 which forms one half of the crank pin bearing surface. The other half of the crank pin bearing surface is formed by a plug 154 with a shoulder which is fastened to the counterweight member by a cap screw 156. The counterweight 148 substantially balances the weight of the crank pin and the adjacent portions of the connecting rod 142. The laminated connection 138 provides a connection which requires no lubrication or maintenance.

When the motor operates it reciprocates the end of the connecting rod adjacent the compressor causing the compressor to oscillate about an axis which is near the boss 48. The casting 52 is made as light as possible and may be made of magnalium or aluminum. If desired, the cylinders may be provided with sleeves or inner liners of a harder material.

The springs 58 and 60, when the inertia of the compressor is taken into account, have a natural frequency of vibration which is identical to the frequency of the oscillations imparted to the compressor by the electric motor and connecting rod 142. The upper portion of the compressor rocks back and forth upon the springs 58 and 60, and the springs 58 and 60 take up the inertia of the compressor body. The rocking action of the compressor causes a movement between the pistons and their cylinders to provide suction and compression strokes of the pistons within the cylinders. This is due to the fact that the piston tends to stay stationary while the cylinder body moves.

The inertia of the compressor body at the two ends of its stroke is taken up by the springs which start it back in the opposite direction. The energy in the form of the inertia of the compressor body is transmitted to the springs which return it to the compressor body so that the energy incorporated in the inertia of the compressor body is not dissipated.

The Scotch yoke and crank connection between the pistons and the flywheels limits the movement of the pistons at each end of the stroke so that the discharge valves will not be damaged by excess movement of the piston. The flywheel and the crank pin limit and control the movement of the pistons and thus make the action of the pistons and the compression of the refrigerant more uniform. In order to prevent the pistons from stopping upon the dead center of the crank pin when the motor-compressor unit stops, I provide a tension spring 75 extending between the connecting plate 74 and the lid 104 to apply a slight pull, which would tend to keep the pistons in center position when the compressor is idle.

In Fig. 8, an improved modification of the compressor is shown. In this improved modification, the remainder of the compressor, the motor and the refrigerating system is the same as that shown in Figs. 1 to 7 inclusive. However, the crank construction is improved over that shown in Figs. 1 to 7. In this figure, the compressor is designated by the reference character 152, and has a casting 164 which forms the crank case wall and the cylinders 166 and 168. Within the cylinders are the pistons 170 and 172 connected by the plates 174 and 176 to form a Scotch yoke. Within the Scotch yoke is a slidable block 178 which

receives the crank pin 180 connected to the flywheel 182. Within the Scotch yoke, a compression type coil spring 184 urges the block 178 towards the upper end of the yoke, so as to tend to keep the pistons in the dead center position when the compressor is idle.

A passage 186 is provided, which connects to the inlet valve 188 formed in the piston 178, while the passage 190 is provided in the piston 172 which connects to the inlet valve 192 provided in the head of the piston 172. The cylinder 166 is provided with a cylinder head 194 provided with a discharge valve 196, while the cylinder 168 is provided with a cylinder head 198, provided with a discharge valve 202. The top of the crank case is covered by a plate 204.

In operation, when the motor begins to rock the compressor, the pistons remain substantially stationary. However, when the motor approaches its full speed, the pistons begin to move back and forth under the control of the crank pin 180 and the block 178 within the Scotch yoke along with the spring 184, which gradually permits the pistons to assume a full compression stroke at each end. The crank pin and Scotch yoke, however, prevent the pistons from traveling far enough to damage the discharge valves. The flywheel 182 may oscillate or may make complete revolutions when the compressor is operating at full speed. In either type of operation, the compressor operates at maximum efficiency as it comes up to approximately full speed.

The weight of the pistons plus the weight of the Scotch yoke is sufficient to draw in the gas from the crank case through the passages 186 and 190 through the piston valve into the compression chamber and to compress the gas within the compression chamber and force it out of the compression chamber through one of the discharge valves 196 or 202. Since the compressor does little compression except when the motor gets up to speed, the compressor is virtually unloaded at its start. If the compression load is too heavy, the motor will not be overloaded because of the character of the compressor load and the pistons will not reach top dead center.

In Figs. 9 and 10, another improved modification is shown. In this modification, the compressor is suspended from a base 206 which is fastened to form an overhead support provided upon a motor-compressor platform similar to the platform 28 shown in Fig. 1. This base 206 is provided with a boss 208 having a slot which receives a rubber member 210 held in place by the screw 212. This rubber member serves as a sort of a pivot for the compressor. The lower end of the rubber member 210 is received within a slot in the boss 214 of the compressor casting 216. The compressor casting 216 has wings 218 and 220, which support the compression coil springs 222 and 224 which extend between the wings 218 and 220 and the base 206.

The compressor casting 216 is provided with an inlet opening 226 which provides communication through the hollow neck 228 with the crank case portion 230 of the casting 216. This hollow neck 228 is provided with a split boss 232, which receives one end of the laminated metal flexible connecting member 234, which has its other end received within a slot in one end of the connecting rod 236. One end of this flexible member 234 is held by the screw 238, while the other end is held by the screw 240.

The crank case 230 is provided with cylinder walls 242 and 244 on opposite sides. These cylinders are provided with pistons 246 and 248, each of which is provided with inlet passages and inlet piston valves similarly to that shown in Figs. 2 and 8. The cylinder 242 is provided with a cylinder head 250 having a discharge valve (not shown), while the cylinder 244 is provided with a cylinder head 252 having a discharge valve 254, which controls the discharge of gas from the compression chamber of the cylinder 244.

The piston 248 is provided with recesses on either side of the connecting bar 256, which connects the pistons 246 and 248. Received within these recesses are flexible laminated connecting rods 258 and 260 which are formed of a number of thin leaves of spring steel or spring brass. The ends of these flexible connecting rods 258 and 260 are held by pins 262 and 264 which pass through holes or longitudinal slots in the leaves. The end of the flexible connecting rod opposite the piston is connected to a bearing member 266 fitted to the crank pin 268, while the connecting rod 258 is similarly connected to a bearing and crank shaft upon the opposite side of the bar 256. In this manner, the connecting rod 258 is connected to an eccentric weight 270 rotatably mounted within the bearing 272, while the connecting rod 260 is connected to the eccentric weight 274 which is pivotally mounted in the bearing 276. These connecting rods naturally tend to assume a straight position, but the weights, when the compressor is idle, are sufficiently heavy to force them to a bent position as shown in Fig. 10. With the aid of the gas being compressed, the connecting rods are sufficiently powerful under ordinary circumstances to stop the pistons and the weights at the dead center position. The bottom of the crank case is closed by the plate 280. The connecting rod 236 is connected to an eccentric upon the electric motor shaft in a similar way as that shown in Figs. 1 and 7.

When the motor begins to operate, it slowly oscillates the compressor head 230. However, when the motor and compressor approach full speed, the weights 270 begin to oscillate with the pistons, thus drawing gas from the crank case and into the compression chamber and then expelling the gas from the compression chamber through the discharge valve to the condenser. It should be noted that the weights 270 and 274 are so designed that they may make a complete revolution if so desired. However, normally these plates will oscillate substantially 90° from the position shown in Fig. 10, and it should be noted that toward the end of each stroke when the greatest amount of power is required, these weights have their greatest amount of mechanical advantage in forcing the piston to the end of its stroke. These weights naturally tend to cause the pistons to assume an intermediate position when the compressor is idle. The rocking parts of the compressor, particularly the cylinder heads and the crank case, may be made of light-weight material such as aluminum or magnalium.

Preferably, the weight of the compressor is so adjusted to the tension of the springs that the system has a natural vibration frequency, which is equal to that of the rocking of the compressor by the electric motor when operated at full speed. Likewise, the weights 270 and 274, together with the spring of the connecting rods 258 and 260, when the weight of the pistons is taken into account, have a natural vibration frequency which is equal to the frequency of oscil-

lations of the compressor provided by the motor at full speed. In this connection also, the compressor is virtually unloaded when the motor starts and does not begin to pump the refrigerant until the motor approaches full speed. Furthermore, an unusually heavy load upon the compressor will not overload the motor because the piston will only be moved as far as can be done by the inertia provided by the motor and in this way, the compressor load is prevented from becoming abnormally high. Also, if the compressor should stick or not operate properly, the motor will not be damaged. This construction makes it possible to use an external electric motor without employing a shaft seal upon the compressor. The compressor is connected to the refrigerating system in a manner similar to that shown in Fig. 1 with the difference that the connections of the liquid and return conduits are reversed from that shown in Fig. 1.

Thus, by my invention, I have provided a sealed refrigerating system which may be operated by an external electric motor which is particularly useful where a direct current only is available. The evaporator, condenser, and the remaining portions of the refrigerator may be conventional. Thus, I have provided an improved form of refrigerating system which is particularly useful when only direct current is available.

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. Refrigerating apparatus including a closed circuit incorporating a compressor, a condenser and an evaporator, said compressor incorporating an inertia-operated impeller, said evaporator being normally mounted in a fixed position, said compressor being yieldingly mounted and movable with respect to the remainder of the refrigerating system, and means for reciprocating the compressor independently of the evaporator for operating the impeller by inertia.

2. Refrigerating apparatus including a closed circuit incorporating a compressor, a condenser and an evaporator, said compressor incorporating an inertia-operated impeller, said evaporator being normally mounted in a fixed position, said compressor being yieldingly mounted and movable with respect to the remainder of the refrigerating system, and means for moving the compressor independently of the evaporator to operate the impeller by inertia.

3. Refrigerating apparatus including a closed circuit incorporating a compressor, a condenser and an evaporator, said compressor incorporating an inertia-operated impeller, said evaporator being normally mounted in a fixed position, said compressor being yieldingly mounted and movable with respect to the remainder of the refrigerating system, and means for moving the compressor independently of the evaporator to operate the impeller by inertia, said compressor being provided with yielding connections with the remainder of the refrigerant circuit.

4. A compressor including a housing containing a free piston operable by inertia, a crank and weight for controlling the movement of the piston, yielding means for yieldingly holding said piston in the mid-portion of its stroke, and means for moving the housing to operate the piston by inertia.

5. A pump including a housing containing a piston, a crank connected to the piston, said crank being provided with an eccentrically mounted weight, and means for oscillating said housing to oscillate said weight by inertia to operate the piston, said pump having spring means to absorb the inertia of the housing and to return this energy as useful energy in aiding the oscillation of the housing.

6. A pump including a housing containing a free piston operated by inertia, said housing being rockably mounted, spring means for opposing the rocking of the housing, said spring means together with said housing having a natural frequency of oscillation, and means for oscillating said housing at said natural frequency of oscillation in order to operate said piston.

7. A pump including a housing containing a piston, an oscillatable weighted member pivoted to said housing above its center of mass, means for connecting said piston and said weighted member, and means for reciprocating said housing for oscillating said weighted member and for reciprocating said piston.

8. A pump including a housing containing a piston, an oscillatable weighted member pivoted to said housing above its center of mass, spring means for connecting said piston and said weighted member, and means for reciprocating said housing for oscillating said weighted member and for reciprocating said piston.

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