

Aug. 10, 1937.

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2,089,626

REFRIGERATING APPARATUS

Filed Aug. 31, 1934

2 Sheets-Sheet 1

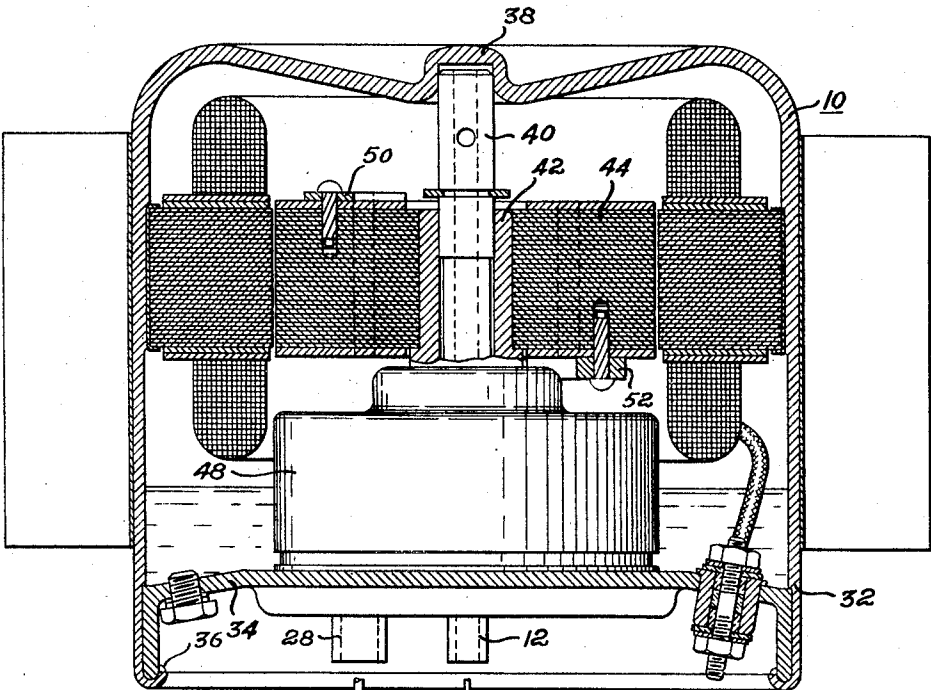


Fig. 1

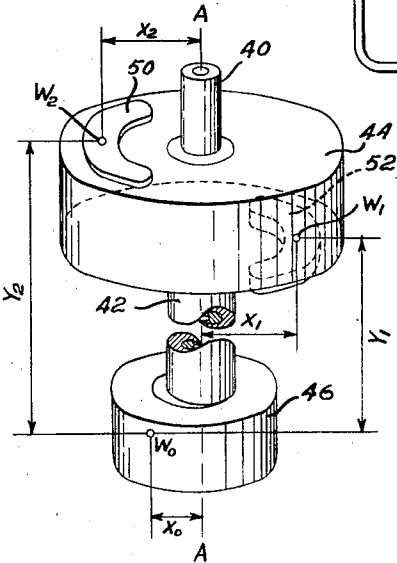


Fig. 2

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2 Sheets-Sheet 2

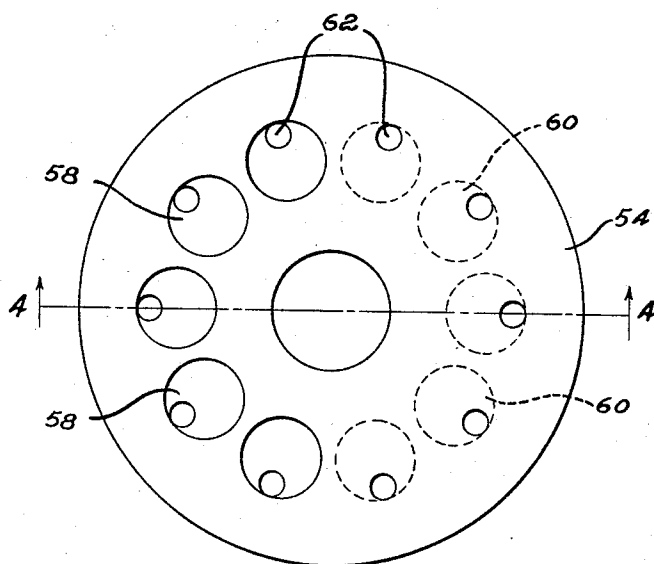


Fig. 3

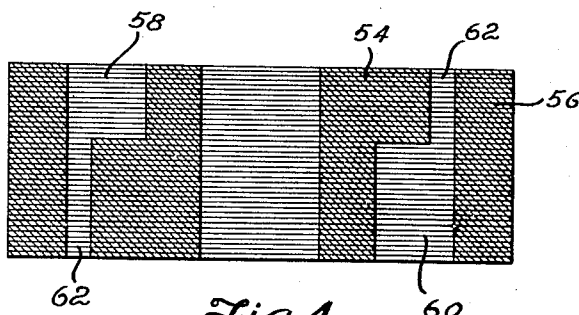


Fig. 4

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REFRIGERATING APPARATUS

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4 Claims. (Cl. 230-139)

This invention relates to refrigerating apparatus and more particularly to motor-compressor units for use with refrigerating apparatus.

Hitherto, in the design of motor-compressor units of the character described, particularly for such units which employ a rotary-compressor, it has been customary in order to reduce the vibration produced in operation to provide counter-balancing means for the unbalanced moving portion of the rotary compressor. Commonly, units of this type and especially those which are mounted within a hermetically sealed housing, are constructed with the rotor of the electric motor directly connected to the compressor by means of a shaft which mounts both the rotor and the moving portion of the compressor. Since the rotor is generally a symmetrical body, it is inherently self-balanced and in order to balance the moving portions of the compressor, counter-weights have been applied to the shaft in one position or another generally within the compressor itself or at a point closely adjacent thereto.

By the present invention, there is provided a motor-compressor unit in which the rotating system comprising the rotor, the shaft, and the moving portion of the compressor, are balanced both statically and dynamically by giving a predetermined unbalance to the rotor itself which is of such relation to the unbalance of the moving portion of the compressor, that the complete rotating system becomes fully balanced.

It is an object of the invention, therefore, to provide a statically and dynamically balanced motor-compressor unit wherein the rotor of the motor is given an unbalance which is so correlated with the unbalance of the moving portion of the compressor as to completely counter-balance the same both statically and dynamically.

A further object is to provide a rotor for use in a motor-compressor unit having a degree and character of unbalance such that when assembled with a compressor having a moving portion of predetermined unbalance, a completely balanced unit will result.

Another object is to provide a method of balancing a motor-compressor unit and particularly a method of assembling a rotor for use in such a unit in a manner which provides both static and dynamic balance of the complete unit.

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 cross section of a motor-compressor unit embodying the present invention and showing diagrammatically the refrigerating system in conjunction therewith;

Fig. 2 is a perspective view of the rotating system of the motor-compressor unit shown in Fig. 1;

Fig. 3 is a top view of a rotor illustrating a second embodiment of the present invention; while

Fig. 4 is a cross section on line 4-4 of Fig. 3.

Referring to Fig. 1, there is shown a motor-compressor unit generally designated as 10 having a refrigerant outlet 12 from which compressed gaseous refrigerant is delivered by means of a conduit 14 to a condenser 16 of suitable form, the drawings illustrating one of the flat hollow plate type. A conduit 18 delivers refrigerant liquefied in the condenser 16 to a heat interchanger 20 formed in a header of the evaporator 22. From the heat interchanger 20, cooled liquid refrigerant is delivered to a refrigerant control restrictor 24, whence it is permitted to expand into the evaporator 22 through the conduit 26. Evaporation of refrigerant in the evaporator 22 withdraws heat from a cabinet or other object to be cooled (not shown) and the evaporated refrigerant is withdrawn from the evaporator and delivered to the inlet 28 of the compressor 10 by means of a conduit 30. A suitable automatic switch (not shown) may be provided to maintain substantially constant temperatures at the evaporator 22.

The motor-compressor unit preferably comprises a hermetically sealed casing 32 which is closed by a base plate 34 secured thereto as by crimping and welding at 36. Rigidly mounted between the end plate 34 and a recess 38 formed in the top of the housing 32 is a hollow stationary shaft 40. A hollow rotary shaft 42 is journaled on the shaft 40 and carries at its upper end a rotor 44 and its lower end the moving portion 46 of a rotary-compressor 48. The compressor 48 may be of any well known type in which the moving portion is not symmetrical with the axis of the shaft 42 and is, therefore, unbalanced. Merely by way of example, the compressor illustrated is of the type having a cylindrical impeller journaled on an eccentric on the drive shaft and which is given a revolving or gyrating movement within a cylindrical compression chamber concentric to the axis of the shaft 42, a vane or divider block being provided in the cylinder block to divide the cylinder chamber into a suction

space and a compression space. Such compressors are well known in the art, and further description thereof is unnecessary.

In order to put the rotating system which comprises the rotor 44, the shaft 42 and the moving portion 46 into both static and dynamic balance, the rotor 44 is provided with means forming two counter-weights, one at either end of the rotor. In the form of the invention illustrated in Fig. 1, these may comprise an upper counter-weight 50 situated on the same side of the shaft as the center of gravity of the moving portion 46 and a lower balance weight 52 situated diametrically opposite to the weight 50 and the center of gravity of the moving portion 46. The weight and the position of the counter-balances 50 and 52 are determined in accordance with the unbalance of the moving portion 46 in the following manner. Referring to Fig. 2, if the point W_0 be considered the theoretical center of inertia which is located at a distance X_0 from the shaft axis A—A equal of the radius of gyration of the moving portion 46 with reference to the axis A—A; W_1 the center of inertia of the counter-weight 52 located at the distance X_1 from the axis A—A equal to the radius of gyration of the counter-weight 52; and W_2 the center of inertia of the counter-weight 50 which is located at a distance X_2 from the axis A—A equal to the radius of gyration of the counter-weight 50, and if the vertical distance between the points W_0 and W_1 be taken as Y_1 and the vertical distance between the points W_0 and W_2 be taken as Y_2 , the requirements for static balance are:

$$W_0X_0 + W_2X_2 - W_1X_1 = 0$$

This means that the sum of the moments of inertia of the three unbalanced portions of the rotating system with respect to the axis A—A must be equal to 0 giving proper regard to the sign of each.

In order to put the system in dynamic balance as well, it is necessary that the sum of the products of inertia of the three unbalanced portions of the system taken about a point on the axis A—A be equal to 0. For convenience, a reference point may be taken as the center of gyration of the mass W_0 . Then

$$W_2X_2Y_2 - W_1X_1Y_1 = 0$$

Conveniently, the distance X_1 may be made equal to the distance X_2 and may be assigned any arbitrary value less than the radius of the rotor 44. With the value of the quantities W_0 , X_0 , Y_1 , and Y_2 together with the value for X_1 and X_2 thus known they may be substituted in the above formulas to determine the quantities W_1 and W_2 . From these values suitable counter-weights may be designed and attached to the rotor 44 in the manner illustrated.

Referring now to Figs. 3 and 4, there is illustrated a modification of the present invention wherein the necessary unbalance of the rotor is provided by lightening holes formed in the rotor opposite to the points where additional weight is necessary for counter-balancing. This rotor 54 may conveniently comprise a plurality of laminations 56 of sheet metal. At one side of the rotor and in the top section thereof, there is formed one or more lightening holes 58, while at the opposite side near the bottom, there is formed a similar number of corresponding lightening holes 60. Conveniently in order to provide a passage for gaseous refrigerant through the rotor, smaller holes 62 are formed therein communicating with

the lightening holes 58 and 60, although it will be understood that this feature is not essential to the present invention. It will be noted that the holes 58 are of lesser depth than the holes 60, and that there is thus provided a preponderance of weight at the top of the rotor opposite the holes 58 and a preponderance of weight at the bottom of the rotor opposite the holes 60, and that the preponderance at the bottom is greater than the preponderance at the top corresponding to the greater weight of the counter-balance 52 relative to the counter-balance 50. The holes 58 and 60 may be formed by drilling the rotor after it is assembled. It is preferred, however, to form the rotor of laminations with holes punched therein to correspond to the holes 58 and the holes 60. It will be noted that each of the laminations may be formed from the same die and that the proper unbalance can be provided by assembling the laminations in such a manner that the upper portion of the rotor has the large holes 58 located at one side of the axis while the lower portion has the large holes 60 located at the opposite side of the axis. It will be understood that while the rotor illustrated is formed of laminations, all of which are identical, it is possible to form a rotor from a stack of more than one kind of laminations and that the depth of the hole 58 plus the depth of the hole 60 need not be equal to the thickness of the rotor as is illustrated in Fig. 4.

By this construction, there is provided a rotor which when assembled with a shaft and the moving portion of a compressor having a predetermined degree of unbalance, provides a rotating system which is completely balanced both statically and dynamically without additional counterweights.

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 motor-compressor unit, the combination of a sealed casing, a drive shaft within said casing, a dynamically unbalanced compressor rotor on the lower portion of said shaft, a compressor stator cooperating with said rotor, a motor stator in the upper portion of said casing, a motor rotor on the drive shaft, the compressor discharging compressed fluid into the interior of said casing below said rotor, said motor rotor having openings therethrough which dynamically unbalance said motor rotor with respect to itself but dynamically balance said motor rotor and said compressor rotor as a unit, means for conveying gas to said compressor and means for withdrawing compressed gas from the space above said motor rotor whereby said openings serve as gas passageways.

2. In a motor-compressor unit, the combination of a sealed casing, a motor stator in said casing, a compressor stator in said casing, bearing means in said casing, a drive shaft on said bearing means, a motor rotor on said shaft, a dynamically unbalanced compressor rotor on said shaft, said motor rotor being located above said compressor rotor and having openings placed and proportioned for dynamically unbalancing said motor rotor but dynamically balancing said motor rotor and compressor rotor as a unit, means for ingress and egress of gas to and from said compressor so constructed and arranged that at least a portion of the compressed gas passes through said motor rotor openings.

3. In a motor-compressor unit, the combination of a sealed casing, a motor stator in said casing, a compressor stator in said casing, a drive shaft in said casing, a motor rotor on said shaft, a dynamically unbalanced compressor rotor on said shaft, said motor rotor having openings placed and proportioned for dynamically unbalancing said motor rotor but dynamically balancing said motor rotor and compressor rotor as a unit, means for ingress and egress of gas to and from said compressor so constructed and arranged that at least a portion of the compressed gas passes through said motor rotor openings.

4. In a motor-compressor unit, the combination of a sealed casing, a motor stator in said casing, a compressor stator in said casing below said

motor stator, bearing means in said casing, a drive shaft on said bearing means, a motor rotor on said shaft; a dynamically unbalanced compressor rotor on said shaft, said motor rotor having openings therethrough which dynamically unbalance said motor rotor with respect to itself but dynamically balance said motor rotor and said compressor rotor as a unit, means for conveying gas to said compressor and means for withdrawing compressed gas from within the sealed casing, said last named means comprising an outlet located above said motor rotor whereby at least a portion of the compressed gas passes through said motor rotor openings.

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