COMPRESSOR

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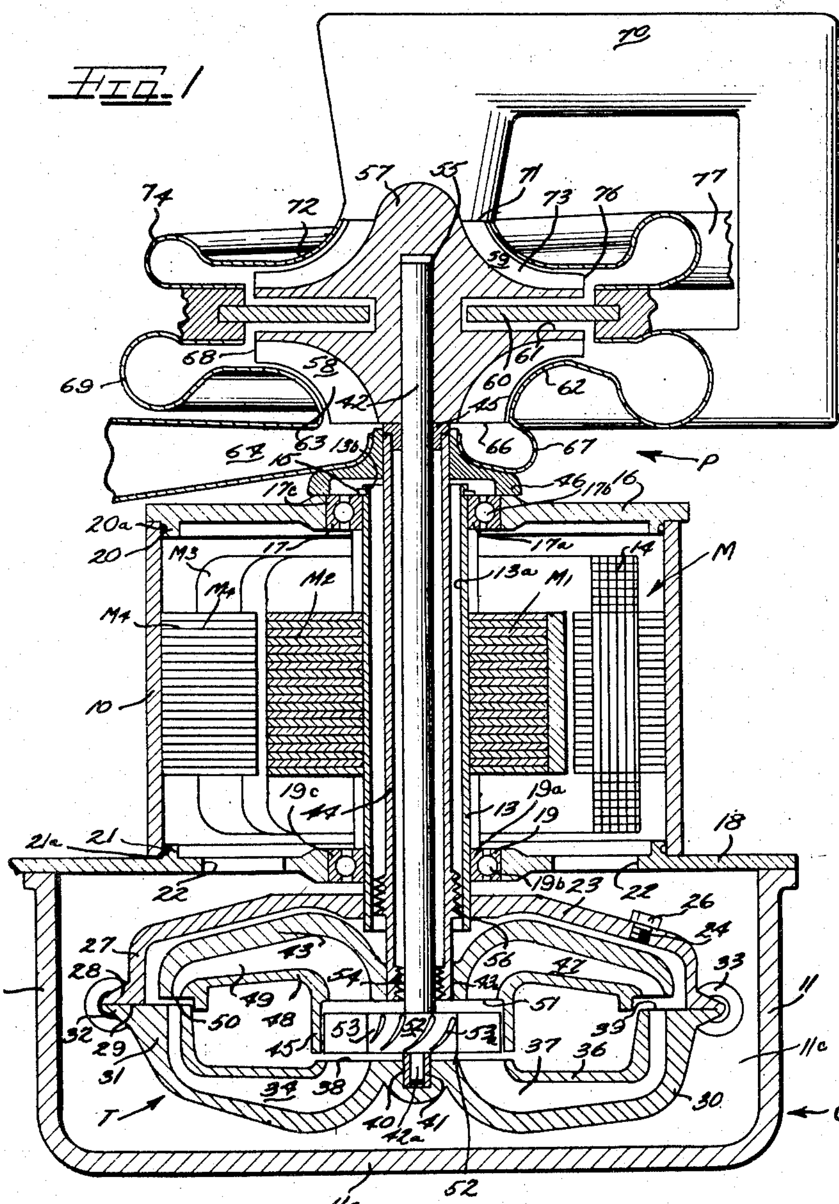
Fig. 1



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Jan. 13, 1959 H. M. GAMMON ET AL 2,868,438

COMPRESSOR

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FIG. 2

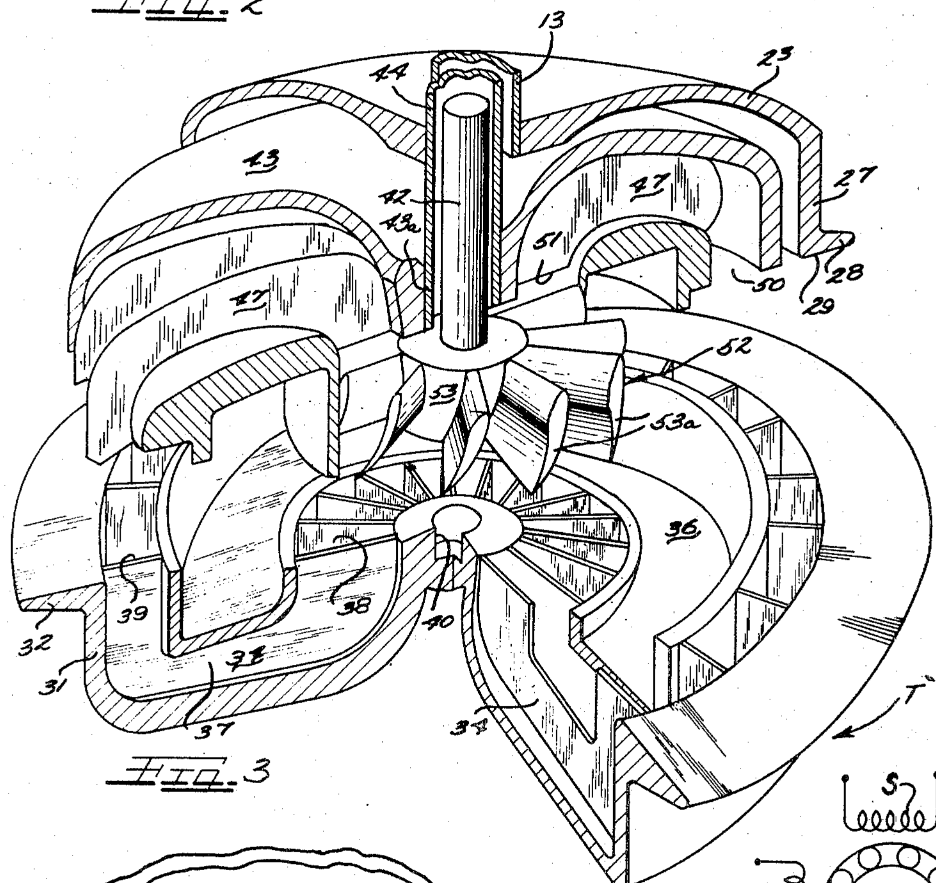
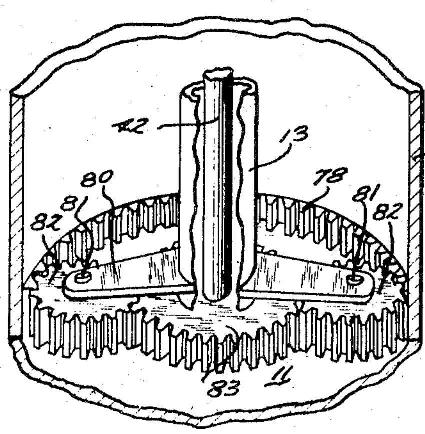


FIG. 3



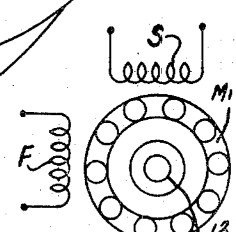


FIG. 5

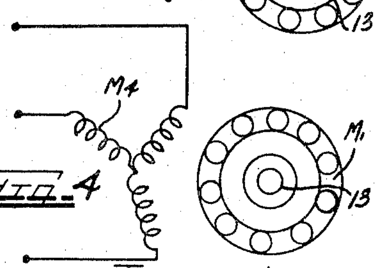


FIG. 4

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COMPRESSOR

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2 Claims. (Cl. 230—117)

This invention relates generally to a centrifugal flow refrigerant compressor and specifically relates to a vertically mounted centrifugal compressor in which a standard constant speed electric motor such as a squirrel cage motor is utilized to drive a centrifugal compressor at a substantially greater rotational speed than the electric motor is capable of turning at maximum speed, through speed increasing means taking the form of a fluid torque converter or epicyclic gear train.

The pump element of a refrigerating or air conditioning machine when directly connected to a standard squirrel cage motor can never exceed the synchronous speed of the motor, for example, a 60 cycle per second input current and a 3600 R. P. M. synchronous speed limit because the rotational speed of the pump is a direct function of the maximum speed of the motor.

Many improved refrigeration and air conditioning systems utilize refrigerants similar to dichloro difluoro methane, hereinafter referred to as "Freon." The compression cycle of some such refrigerants is most advantageously performed by a high speed centrifugal type pump. However, for efficient use of centrifugal pumps it is desirable to drive the compressor at higher speeds than are available through the use of a pump directly coupled to a standard squirrel cage motor.

According to the principles of the present invention, a substantial increase in the rotational speed of a centrifugal pump assembly over that of an electric driving motor is obtained by combining with the pump and the motor a speed increasing means such as a torque converter constructed in accordance with the present invention or an epicyclic gear train.

Briefly described, the present invention comprises a sealed vertically mounted compressor assembly having a centrally disposed electric drive motor having a hollow shaft and being situated vertically with the speed increaser at the bottom and the centrifugal pump at the top. The speed increaser is enclosed in a heat dissipating, moisture and rust resistant casing and is connected to the pump by a shaft running through the center of the motor.

It is an object of the present invention to provide an improved refrigerant compressor which overcomes the deficiencies of the prior art.

Still another object of the present invention is to provide an improved type of electric motor driven refrigerant compressor, in which speed increasing means are operatively interposed between the electric motor and pump to obtain a pump speed greater than maximum electric motor speed.

A further object of the present invention is to provide a compact sealed refrigerant compressor for refrigerating or air conditioning machines, which is provided with an integrated speed increasing device, such as a torque converter or epicyclic gear train, to obtain a relative rotational velocity increase of the pumping element over that of the driving element.

Many other objects and advantages will be realized by

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those versed in the art upon making reference to the detailed description which follows and the accompanying sheets of drawings.

On the drawings:

Figure 1 is a cross-sectional view, with parts in elevation, of a compressor unit of the present invention.

Figure 2 is an exploded fragmentary view, with parts shown in perspective elevation and with parts broken away and other parts in section showing additional details of construction of the torque converter embodied in the unit of Figure 1;

Figure 3 is a fragmentary perspective view, with parts in elevation, and with parts broken away and other parts in cross section of an alternative form of the invention wherein an epicyclic gear train is employed as a speed increaser;

Figure 4 is a schematic diagram showing the windings of a three-phase squirrel cage motor used in the present invention; and

Figure 5 is a view similar to Figure 4 but illustrating a single phase squirrel cage induction motor.

As shown on the drawings:

In Figure 1 a refrigerant compressor embodying the principles of the present invention is comprised generally of an upright unit having vertically aligned components including a centrally disposed electric motor assembly M, a torque converter assembly T at the bottom of the unit and a rotary centrifugal pump assembly P at the top of the unit.

According to the principles of the present invention, the motor M takes the form of a squirrel cage induction motor consisting of a cylindrical squirrel rotor M1 formed by the usual rings and bars M2. A stator M3 is formed by an encircling annular core of laminated steel and carries a primary winding M4 in slots on its inner periphery.

In this form of the invention, the primary winding is arranged for three-phase power supply and in accordance with electrical practice, is provided with three sets of exactly similar multipolar coil groups spaced one-third of a pole pitch apart. The super position of the three stationary, but alternating, magnetic fields produced by the three-phase windings produces a sinusoidally distributed magnetic field revolving in synchronism with the power supply frequency, the time of travel of the field crest from one phase winding to the next being fixed by the time interval between the reaching of their crest values by the corresponding phase currents.

The speed of the rotating field or the synchronous speed is a function of the frequency and the number of poles and since both of these values are fixed for any given motor M of the squirrel cage type, it will be appreciated that the maximum attainable speed is at some constant value. For example, at the usual frequency of 60 cycles per second, a common synchronous speed for a squirrel cage induction motor would be 3600 R. P. M.

Figures 4 and 5 show the windings for both a three-phase squirrel cage induction motor (Figure 4) and a single phase squirrel cage induction motor (Figure 5). The primary windings M4 are shown in a Y connection, however, it will be understood that the primary windings could also be provided in a delta connection if desired. The armature shaft is indicated at **13** and the squirrel cage rotor is indicated generally at **M1**.

In Figure 5, a single phase arrangement is illustrated wherein a field winding is indicated at F and a starting winding is indicated at S. The armature shaft is again indicated at 13 and the rotor is indicated at M1.

It is contemplated according to the principles of the present invention, however, to employ a standard squirrel cage fixed constant speed motor to drive high speed centrifugal compressors, especially of the type used for compressing refrigerants such as Freon, at a greater angular velocity than the maximum attainable angular velocity of the rotor M1 of the squirrel cage induction motor M.

To effect that objective, the motor M is coupled to a speed-increaser. In the form of the invention illustrated in Figure 1, the speed increaser constitutes a hydraulic means and more specifically a torque converter assembly indicated generally by the reference character T.

As shown in Figure 1, there is connected in corotatable assembly with the rotor M_1 an armature shaft 13 which is generally tubular in configuration, the shaft constituting an open-ended cylindrical member having a bore 13*a* of uniform cross-section extending throughout the length thereof.

At longitudinally spaced portions on the outer periphery of the armature shaft 13 is provided the inner race ring 17*a* and 19*a*, respectively, of a pair of bearing assemblies indicated generally at 17 and 19. Adjacent the inner race ring 17*a*, the armature shaft 13 is grooved as at 13*b* and receives a retainer snap ring 15 therein which may abut against one side of the inner race ring 17*a*.

Each of the bearing assemblies 17 and 19 includes a plurality of shiftable members such as anti-friction balls 17*b* and 19*b*. The bearing assemblies 17 and 19 further include outer race rings 17*c* and 19*c*, respectively. The outer race ring 17*c* is received in firm assembly with a casing member 16 disposed on a generally horizontal plane and extending radially outwardly of the axis of the armature shaft 13. The outer race ring 19*c* is received in firm assembly in a casing member 18 which is likewise disposed on a generally horizontal plane and extends radially outwardly of the axis of the armature shaft 13 but in axially spaced relation from the casing member 16.

A continuous annular ring 10 is received between the upper and lower casing members 16 and 18. As shown in Figure 1, the casing member 16 is provided with a downwardly projecting annular boss 20 which is peripherally grooved to receive an O-ring sealing member 20*a*, while the casing member 18 is provided with an upwardly projecting annular boss 21 to receive an O-ring sealing member 21*a*. The continuous annular ring 10 is thus placed in sealed assembly and completes the enclosure for the squirrel cage induction motor M.

A bottom enclosure member indicated generally at 11 and including a bottom wall 11*a* and upstanding side wall portions 11*b* is connected in firm assembly with the casing member 18 and provides a housing 11*c* for the speed increaser of the present invention. It will be appreciated, therefore, that the armature shaft 13 is journaled for rotation by the bearing assemblies 17 and 19 carried in the casing members 16 and 18 and supported by the enclosure 11 in upright position.

The armature shaft 13 extends into the casing enclosure 11*c* of the speed increaser and is connected in corotatable assembly with an upper cover member 23 of the torque converter T which constitutes a generally annular inverted trough shaped element.

The upper cover member 23 has a threaded filler port 24 receiving a removable filler plug 26 by means of which hydraulic fluid is introduced to the converter T. Thereafter, the port 24 is closed and sealed by the plug 26. A substantially cylindrical side wall portion 27 is flanged at 28 to form a transverse hydraulic sealing surface 29.

The pump element of the converter likewise has a portion shaped in a generally annular trough shape and is connected to the cover member 23. In the form of the invention illustrated, the pump element comprises a pump vane assembly member 30 which abuts against the cover member 23 at the sealing surface 29 and includes a cylindrical side wall portion 31 flanged as at 32 and engaged in firm assembly with the cover member 23 by means of a divided "V-clip" 33, thereby to maintain a hydraulic sealed engagement at the sealing surface 29.

The pumping member 30 is provided with a plurality of radially extending circumferentially spaced impeller passages 37 formed between spaced pairs of blade members 34 carried by the outer portion of the pumping member 30 and, in turn, carrying the inner portion of the pumping member 30 provided by an inner channel member indicated at 36.

The reaction member or stator of the torque converter T of the present invention is indicated at 43 and includes a plurality of circumferentially spaced passages 49 formed between pairs of stator vanes or blades 47 carried by the outer portion of the stator indicated at 43 and, in turn, carrying the inner portion of the stator formed by a channel member 48.

The stator 43 has a centrally disposed aperture 43*a* in which is received one end of a generally tubular cylindrical support shaft 44. The support shaft 44 extends upwardly through the bore 13*a* and is secured at its upper end in an upper bearing support and cover member 46.

Operatively interposed between the pump element 30 and the stator element 43 is a turbine runner indicated generally at 52 and being preferably of the axial-helical type driven by the fluid discharging onto it from the stator element 43. In this connection, it may be noted that the stator element 43 has formed at the inner end of the passages 49 a plurality of outlets indicated at 51. At the corresponding inner end of the passages 37 on the pumping element 30, there is provided a plurality of inlets 38.

The turbine runner 52 includes a hub 53 and a plurality of circumferentially spaced radially outwardly extending turbine blades 53*a* having a profile characterized by a curved entry portion and elongated in the direction of flow.

The hub 53 of the turbine runner 52 is connected in corotatable assembly with a shaft indicated generally at 42 having a reduced end 42*a* journaled in a bearing 41 seated within a bearing recess 40 formed in the pump element 30.

In operation, therefore, the squirrel cage induction motor M rotatably drives the pump element 30 through the cover member 23 and fluid impelled through the passages 37 of the pump element 30 and through the passages 49 of the stator 43 will impinge against the curved reaction surfaces of the turbine blade 53*a* carried by the turbine runner 52. The size and configuration of the blades 53*a* on the turbine runner 52 are selected with respect to the velocity head produced by the pump element 30 so that the turbine runner and the shaft 42 driven thereby will be rotated at an angular velocity much higher than the angular velocity of the armature shaft 13 and the pump element 30.

It will be understood that the torque converted T is preferably filled for once and for all through the filling opening 24 whereupon the plug 26 seals the filling opening. To insure against leakage out of the coupling T, the shaft member 44 is provided with inner and outer thread seals. For example, as indicated at 54, there is provided a plurality of "threads" forming a labyrinth-type tortuous passage adjacent the peripheral surface of the shaft 42, thereby effecting a seal between the shaft 42 and the shaft 44 and preventing leakage of coupling fluid therebetween. As indicated at 56, a plurality of "threads" are formed on the outer surface of the shaft 44 and closely abut the inner bore surface of the bore 13*a* of the armature shaft 13, thereby forming a seal to prevent leakage of fluid between the shaft 44 and the armature shaft 13.

The compartment in which the motor M is enclosed and the compartment 11*c* in which the speed increaser is enclosed are intercommunicated by one or more apertures 22 formed in the casing member 18, thereby permitting the circulation of air around the electric motor M and assisting in the dissipation of thermal energy throughout the entire casing structure formed by the casing members 16, 18, 10 and 11.

The shaft 42 is journalled in a bearing bushing 45 carried at the upper end of the shaft **44** and projects therethrough for connection to an impeller **57**.

The refrigerant pump assembly **P**, is comprised generally of a two-stage centrifugal flow impeller **57** having a lower first stage vane assembly **58** and an upper second stage vane assembly **59**. The impeller **57** is axially bored as at **55** to receive the drive shaft **42**, and an annular baffle **60** which is segmented for ease of assembly is positioned in a slot **61** between the first and second stage compressor vane assemblies to reduce interstage compressor efficiency losses resulting from recirculation. This construction insures that second stage leakage will occur only to the discharge pressure level of the first stage, rather than all the way down to inlet pressure of the first stage.

The first stage vane assembly **58** is enclosed by a housing **62** to define a flow passage **63** which receives a supply of vaporized refrigerant from a conduit **64** through an axial flow inlet **66** in register with an annular inlet volute **67** around the vane assembly **58**.

The refrigerant is discharged through an annular peripheral flow outlet **68** into a first-stage discharge volute **69**. A conduit **70** carries pressurized refrigerant from the volute **69** to an annular second stage axial flow inlet **71** on the second stage vane assembly **59**. A housing **72** encloses the second stage vane assembly **59**, to form a second stage flow passage **73** for the pressurized refrigerant and an annular second stage volute **74** receives pressurized refrigerant leaving the vane assembly **59** through a peripheral outlet **76**.

Pressurized refrigerant in the circumferential volute **74** is delivered to a point of utilization through a conduit **77**.

In Figure 3, an epicyclic gear train E is substituted as a speed increasing device for the unit of the present invention.

The epicyclic gear train E is comprised generally of an annular internal ring gear **78**, which is integrally formed in an internal side wall **79** of the casing **11**.

A planet gear carrier **80** is secured in corotatable assembly to the rotatable hollow armature shaft **13** of the electric motor assembly M, and carries a plurality of planet gear pins or shafts **81** to rotatably journal a corresponding plurality of planet gears **82**. The planet gears **82** are positioned in meshed engagement with the internal ring gear **78**.

A centrally disposed sun gear **83** is secured to the main pump drive shaft **42** and is rotatably driven by the planet gears **82** at a greater speed than the motor M. The rotation of the sun gear **83** is transmitted through the shaft **42** to the pump assembly **P**.

It will be understood that modifications and variations may be effected by those skilled in the art without departing from the scope of the novel concepts of the present invention.

We claim as our invention:

1. In a speed increaser for a refrigerant pump, a pump element comprising upper and lower annular trough-shaped members having abutting peripheral edges and together providing an annular space therebetween, the lower member having formed therein a plurality of circumferentially spaced pumping passages extending radially outwardly from a center inlet zone to a discharge zone, a hollow drive shaft connected at one end to said upper member and extending upwardly therefrom for attachment to a prime mover, a stator in said annular space having a plurality of circumferentially spaced passages disposed in superjacent relation to said pumping passages and extending radially inwardly from said discharge zone, and a turbine runner comprising a shaft extending through said hollow shaft into said annular space and being supported for rotation by said lower member, said shaft having a hub connected thereto and a plurality of turbine blades between the radially inward portion of said stator passages and the inlet zone of said pumping passages, whereby the fluid impelled by said pump element rotatably drives said runner at a higher speed than the speed of said hollow drive shaft.

2. A refrigerant compressor unit comprising a squirrel cage induction motor having a rotor and an open-ended hollow shaft projecting through said rotor and disposed on an upright vertical axis, speed-increasing means at the bottom of said unit having a driven connection with the lower end of said hollow shaft and having a power take-off shaft extending upwardly through said hollow shaft, and centrifugal pumping means at the top of said unit having a driven connection with said power take-off shaft, whereby the pumping means is driven at a faster speed than the rated synchronous speed of said motor, said speed increaser comprising a pump element having upper and lower annular trough-shaped members together forming an annular space, the lower member having formed therein a plurality of circumferentially spaced pumping passages extending radially outwardly from a center inlet zone to a discharge zone, said hollow shaft connected at one end to said upper member to provide said driven connection, a stator in said annular space having a plurality of circumferentially spaced passages disposed in superjacent relation to said pumping passages extending radially inwardly from said discharge zone, and a turbine runner connected to said power take-off shaft having a hub and a plurality of turbine blades operatively interposed between the radially inward portion of said stator passages and the inlet zone of said pumping passages, whereby the fluid accelerated by said pump element rotatably drives said turbine runner and said pumping means at a higher speed than said hollow shaft.

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