

May 10, 1966

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3,250,460

COMPRESSOR WITH LIQUID REFRIGERANT INJECTION MEANS

Filed June 4, 1964

2 Sheets-Sheet 1

Fig. 1

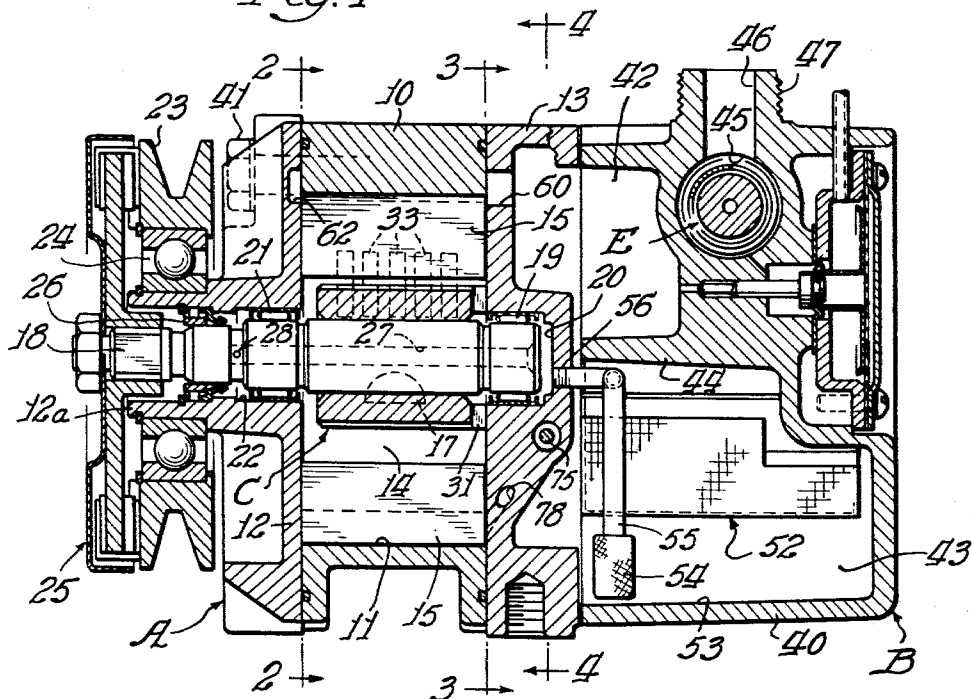
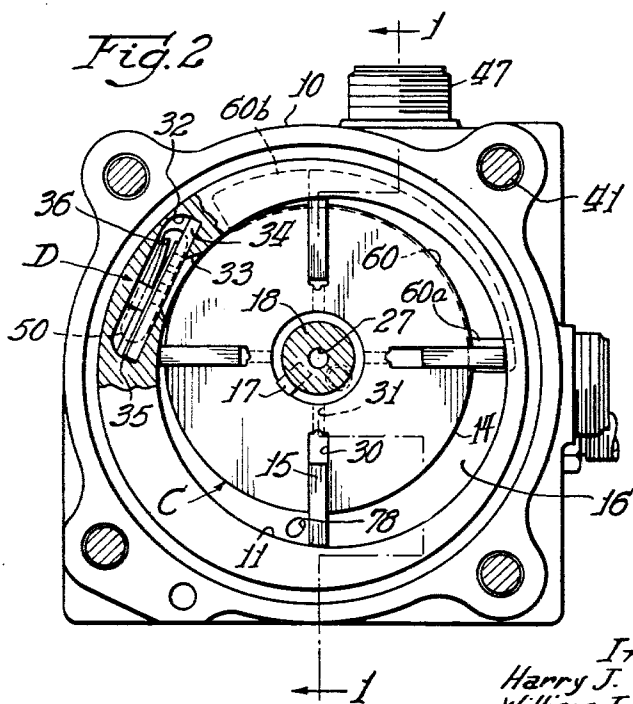


Fig. 2



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Fig. 3

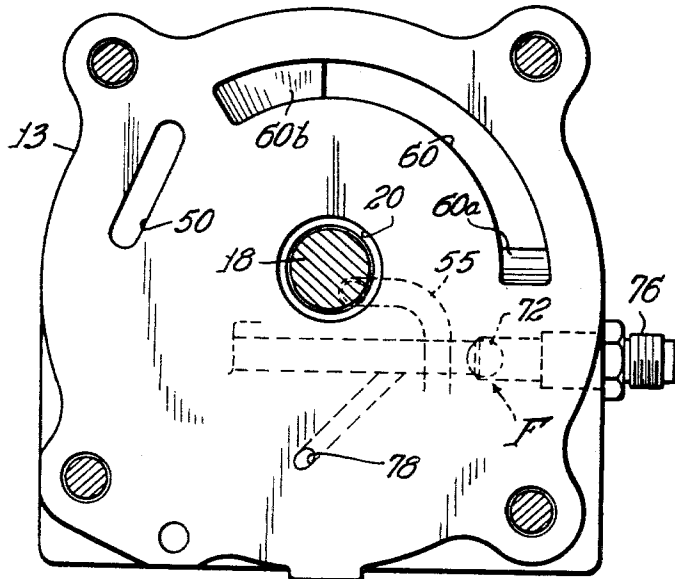
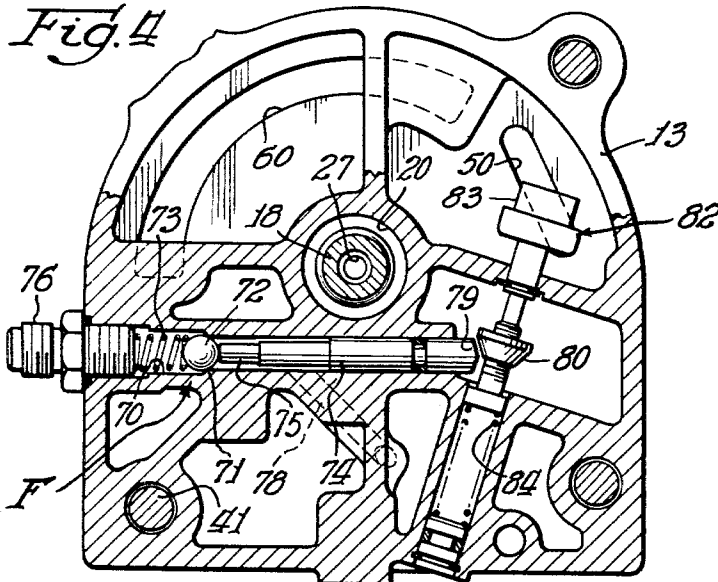


Fig. 4



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3,250,460 COMPRESSOR WITH LIQUID REFRIGERANT INJECTION MEANS

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1 Claim. (Cl. 230-210)

This invention relates to improvements in refrigerant compressors and more particularly to a rotary compressor including means for injecting liquid refrigerant into the compression cavity in response to thermal conditions within the compressor.

Liquid refrigerant injection for use in cooling compressors is shown in the prior art, for example, in U.S. Patent 3,105,633. However, in some applications, such as automotive air-conditioning systems, the requirements for injection cooling may vary considerably depending on operating conditions. For example, when the compressor is operating at high speeds and at partial capacity, there is a serious danger of overheating which might cause failure of the rotor bearings, seizure of the rotor, or damage to other components of the compressor. On the other hand, refrigerant injection for cooling inherently results in some loss of efficiency due to internal leakage and to additional refrigerant being carried in the oil. Since the oil and refrigerant are partially miscible, the cooler the operating conditions, the more oil that is carried in the refrigerant and vice versa. It is therefore desirable to operate at the highest temperature consistent with safety so that the refrigerant can be more readily separable from the lubricant thereby insuring both the effectiveness of the lubricant and the satisfactory performance of the refrigerant in the system.

During operations when the suction line is completely closed and no flow is realized from the evaporator, the increased temperature of the lubricant will also trigger the liquid injection mechanism. Thus, the combination of lubricant and liquid injection flow will then maintain the proper discharge outlet and compressor temperatures under these conditions.

It is therefore a principal object of the present invention to provide an improved refrigerant compressor in which refrigerant is injected directly into the compression cavity for cooling purposes, the flow of injected refrigerant being controlled in response to the temperature of either the discharge gas or lubricant.

Additional objects and advantages will be apparent from a reading of the following detailed description taken in conjunction with the drawings wherein:

FIGURE 1 is a cross-sectional view of a preferred embodiment of a compressor incorporating the principles of the present invention;

FIGURE 2 is a cross-sectional view taken along the plane of line 2-2 of FIGURE 1;

FIGURE 3 is a cross-sectional view taken along the plane of line 3-3 of FIGURE 1; and

FIGURE 4 is a cross-sectional view taken along the plane of line 4-4 of FIGURE 1.

Referring now to the drawings, and particularly to FIGURE 1, a preferred embodiment of a compressor which utilizes the principles of the present invention comprises a housing which is divided into a first section A and a second section B. For convenience, sections A and B will be referred to herein as the compressor section and the gas chamber section respectively.

Compressor section A comprises a casing 10 having a cylindrical bore 11 extending therethrough, a front bearing plate 12, a rear bearing plate 13, and a rotor assembly C, received within the casing bore 11. The rotor

assembly C includes a slotted rotor element 14 which carries a plurality of substantially radially extending and reciprocating vanes 15. The axis of rotor element 14 is offset or eccentrically arranged with respect to the axis of bore 11 so that the bore, the front bearing plate 12, the rear bearing plate 13, and the rotor element 14 cooperate to provide a crescent-shaped compression chamber or cavity 16. Rotor element 14 is keyed at 17 to a drive shaft 18 which is journaled in an anti-friction bearing 19 supported by rear bearing plate 13 in recessed portion 20 and an anti-friction bearing 21 supported within a counterbore 22 in the front bearing plate 12.

Inasmuch as the preferred embodiment is especially adapted for automotive use, the compressor rotor is driven by a V-belt pulley 23 rotatably journaled on a bearing 24, the inner race of which is carried on an axial extension 12a of the front bearing plate 12 and arranged for driving connection with the engine fan belt (not shown). Pulley 23 is preferably connected to the rotor drive shaft 18 through a vibration dampener 25 of any suitable construction. The front bearing plate extension 12a is provided with a lip-type seal 26 engaging a boss on the drive shaft to prevent loss of refrigerant and lubricant through the front bearing plate journal bearing. The drive shaft 18 further includes an axially extending bore 27 which intersects a transversely extending bore 28. These two bores fluidly interconnect the recessed portion 20 in the rear bearing plate and the space between the seal 26 and the front bearing 21 to assist in balancing the rotor assembly and provide a flow passage for lubricating oil.

Attention is now directed to FIGURE 2 which is a cross-sectional view showing the details of the rotor assembly C and illustrating the manner in which the rotor assembly cooperates with the compression cavity. The rotor assembly C, as previously noted, includes a cylindrical rotor element 14 which is furnished with a plurality of radially extending slots 30, each of which are adapted to receive a vane member 15 reciprocatively slidable therein. The vane members, preferably fabricated from a graphite compound, are arranged so that their radially outermost or tip portions extend transversely across the compression cavity and are in constant engagement with the cylindrical surface of the bore 11. Oil for lubricating and sealing purposes is supplied to the space underneath each vane by means of grooves 31 cut in the back face of rotor element 14. The oil pressure also serves to hold the vanes outwardly against the surface of the cavity.

The casing 10 is provided with an elongated gas discharge passage 32 which is spaced radially outwardly from the internal surface of cylindrical bore 11 adjacent to the point where the rotor and the casing bore are almost contiguous. Passage 32 extends the full length of the casing 10 and communicates with a gas discharge compartment in the gas chamber section B in a manner which will be more fully described below. Fluid passage means to fluidly interconnect the compression cavity 16 with the gas discharge passage 32 are provided in the form of a plurality of slots 33 through the thin partition separating passage 32 from the compression cavity 16.

A valve assembly, designated generally by reference character D, is disposed within the gas discharge passage 32, said assembly including a perforated valve plate 34, a plurality of flexible, reed-type valve elements 35 normally overlying the perforations in the valve plate and a backing plate 36 which limits movement of the valve elements 35.

As best illustrated in FIGURE 1, the gas chamber section B comprises a casing 40, preferably in the form of an integral casting, which is connected to the compressor section A by means of a plurality of elongated cap screws

41 located around the periphery thereof. The cap screws extend through registered holes (not shown) in the front bearing plate 12, the casing 10, and the rear bearing plate 13, and are adapted to be threaded into a series of tapped holes (not shown) in the gas chamber casing 40. The volume enclosed by casing 40 is divided into an inlet compartment 42 and a discharge compartment 43 by an integral partition 44. This arrangement is more particularly described in copending application Serial No. 372,616, filed concurrently herewith and assigned to the same assignee as the present invention.

The inlet compartment 42 communicates with the cold gas or suction line leading to the evaporator through a capacity control valve E, port 45, and fluid passage 46, the latter extending through an external nipple 47 to which the suction gas line is connected. A detailed description of the capacity control system is found in copending application Serial No. 372,614 filed concurrently herewith and assigned to the same assignee of the present application.

The gas discharge compartment 43 has a generally L-shaped configuration and communicates at its upper end with a discharge port 50 in the rear bearing plate 13 (see FIGURES 2 to 4) which is registered with the discharge gas passage 32 in the compressor casing 10. The discharge gas flows downwardly through an oil coalescing and separating unit 52, so that any oil carried with the discharge gas is separated and collected in a sump 53 in the lower portion of casing 40. The discharge gas then passes out through an outlet (not shown) in the casing while the oil from sump 53 is returned through a screen-covered (54) oil return tube 55 which is connection at 56 to the recessed portion 20 of the rear bearing plate. The operation of the oil separating unit is more fully described in the aforementioned application Serial No. 372,616.

The inlet compartment 42 in the gas chamber section B is in fluid communication with the inlet portion of the compression cavity 16 through an arcuate inlet port 60 in the rear bearing plate 13, said port having chamfered end portions 60a, 60b so that the opening of said inlet port on the compression cavity side is of greater arcuate length (approximately 110° of arc) than the back side of the bearing plate 13 which communicates with the inlet compartment 42. The front bearing plate 12 is also provided with an arcuate groove or slot 62 which is symmetrically arranged with respect to the inlet port in the rear bearing plate 13, said groove also providing a path for suction gas into the compression cavity.

As pointed out in the preliminary remarks, an important aspect of the present invention is concerned with a means, designated generally by the reference character F for injecting liquid refrigerant directly into the compression cavity 16 in response to the temperature of the discharge gas. As shown most clearly in FIGURE 4, the rear bearing plate 13 is provided with a transversely extending passage 70 having a seat 71 formed therein. A ball valve element 72 is received within the passage and is resiliently urged against the seat by spring 73. A ball valve element engaging pin 74 is slidably received within the passage and has an end portion 75 adapted to engage and unseat said ball valve element when moved to the left as viewed in FIGURE 4. A liquid refrigerant supply line connected at external nipple 76 is adapted to permit liquid refrigerant to flow through the passage 70 when the ball valve element is unseated and through a slanted passage 78 which opens into the compression cavity 16 immediately beyond the point where the gas admitted to the compression cavity begins to be compressed. This point at which the passage opens into the compression cavity 16 is also beyond the point at which the suction is com-

pletely closed. In other words, the injection port must be circumferentially spaced from suction port 60 by more than the distance between two adjacent vanes. This feature is extremely important since the rapid expansion of the liquid refrigerant as it enters the compression cavity will tend to slow up the flow of suction gas from the evaporator into the compression cavity or working space if the suction is not completely closed.

The right-hand end of pin member 74 is provided with a cam follower surface 79 which is adapted to be engaged by cam element 80 operatively connected to a temperature responsive device 82. One particular temperature responsive device which has been found to be suitable for use in the invention is known as a Vernatherm. The Vernatherm, manufactured by the Detroit Controls Division of American Standard Company, is a combination thermostat-actuator device which responds to slight temperature changes and supplies sufficient power to operate a mechanical linkage or the like. These devices comprise a casing containing a mass of wax material having metallic granules dispersed therein. At the control temperature, the wax material expands to push downwardly on the rod carrying cam element 80.

The thermal sensing portion 83 of said device is located immediately in front of the gas discharge port so that the sensitivity of the actuating means is improved. As the temperature of the discharge gas increases, the cam element 80 is moved downwardly against the biasing action of spring 84 to engage the cam follower surface 79 on the ball valve actuating pin 74. As the pin moves to the left, the ball valve element is unseated to permit flow of liquid refrigerant directly into the compression cavity through passage 78. When the suction line is closed and the rotor still pumping, the oil mist being discharged from port 50 will pass in heat exchange relation with the Vernatherm. As a result, the cooling system will operate even though no refrigerant is passing from the evaporator to the compressor.

While this invention has been described in connection with a certain specific embodiment thereof, it is to be understood that this is by way of illustration and not by way of limitation; and the scope of this invention is defined solely by the appended claim which should be construed as broadly as the prior art will permit.

What is claimed is:

A compressor comprising a casing having a compression cavity therein and an exhaust chamber; means defining suction and discharge ports communicating with said compression cavity, said discharge port providing a passage between said compression cavity and said exhaust chamber; means defining a fluid passage in said casing adapted to be fluidly interconnected with a source of liquid refrigerant, said fluid passage having a valve seat formed therein; a valve element resiliently biased against said seat; a valve element actuating means including an elongated member having one end in engagement with said valve element and another end having a cam follower surface formed thereon; temperature responsive means located within said exhaust chamber including a linearly movable element associated therewith; and cam means carried by said linearly movable element engageable with said cam follower surface.

References Cited by the Examiner

UNITED STATES PATENTS

2,470,655	5/1949	Shaw	230—210 X
3,105,633	10/1963	Dellario	230—210 X

70 ROBERT M. WALKER, *Primary Examiner*.