

REFRIGERANT COMPRESSOR

5 In conventional piston type refrigerant compressors, pistons reciprocate in cylinders which are generally made of iron casting. Iron casting is utilized because iron is durable and resists abrasion. These characteristics of iron have been especially important in the case of a compressor for an automotive air conditioning system. Generally, iron cylinders, or alternatively a cylinder liner made of iron casting, are inserted into a casing made of an aluminum alloy.

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15 When a cylinder or cylinder liner made of iron casting is used in a compressor, the weight of the cylinder or cylinder liner cannot be decreased more than a certain amount. The cylinder or cylinder liner must be more than a certain thickness to achieve sufficient strength to avoid any deformation when the cylinder liner is inserted in the casing. The cylinder or cylinder liner also must be thick enough to prevent the cylinder liner from undergoing heat deformation. However, when the cylinder liner is made sufficiently thick to achieve the above advantages, the weight of the casing including the cylinder liner is larger than desired. Also, since the above type cylinder liner involves two manufacturing steps, i.e., manufacturing a separate iron cast cylinder liner followed by the assembly of the cylinder liner and casing, the manufacturing cost is high.

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35 To resolve the above mentioned problems, cylinder liners have been made of the same aluminium alloy used in the casing. However, the use of an aluminium alloy in the cylinder liner makes it difficult to use piston rings in the compressor.

5 Piston rings generally are disposed on the outer surface of the pistons to improve the seal between the cylinder chamber and crank chamber of the compressor. Piston rings generally cannot be used in cylinder liners made of an aluminium alloy, because piston rings generally have high hardness as compared to the hardness of aluminium cast cylinder liners. Hard piston rings damage the softer aluminium cylinder liner.

10 Figure 6 of the accompanying drawing shows a portion of a wobble plate type compressor. A piston 16', which is connected to a connecting rod 15', a piston ring 17' and a cylinder liner 19', are shown. In a wobble plate type compressor, the piston 16'
15 does not reciprocate perfectly, as depicted by the slightly canted positioned of the piston in Figure 6, because the connecting rod 15' connected to the piston 16' does not remain parallel with the centre line of the cylinder liner 19' throughout its cycle.
20 Side pressure F is produced on an outer surface 18' of the piston 16' forcing the bottom end of the piston 16' towards the cylinder liner 19'. Accordingly, the side surface of the piston 16' can contact the cylinder liner and damage the liner
25 during reciprocation of the piston.

30 To mitigate the above problems, an improved piston construction was previously proposed in our Japanese Utility Model Application No. 58-197942, in which two grooves are formed on the outer surface of a piston at the top and bottom thereof. Piston rings, which are made of plastics material and conical in shape, are disposed in those grooves. Although the canting of the piston is overcome by the above construction, the edges of the piston rings can
35 still slide on the surfaces of the cylinder liners causing abrasion between the piston rings and the cylinder liner.

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- 3 -

According to the invention, in a refrigerant compressor comprising a compressor housing having a plurality of cylinders and a crank chamber adjacent to the cylinders; a respective reciprocable piston
5 slidably fitted within each of the cylinders; a driving mechanism coupled to the pistons to move the pistons in a reciprocating motion; a valve plate with valve openings covering one end of the cylinders; and a head covering the valve plate and including a
10 suction chamber and a discharge chamber aligned with the valve openings; two annular grooves are provided adjacent to the opposite ends of the outer peripheral surface of each of the pistons and a piston ring is disposed within each of the annular grooves and has
15 an outer diameter larger than the outer diameter of the piston at normal temperatures, each piston ring being generally flared in one axial direction and having a radially outer, axially convex, curved surface formed so that the outer diameter of the
20 curved surface at one end of the piston ring is shorter than that at the other end, and at least the piston ring closer to the valve plate being disposed so that its wider axial end faces the adjacent axial end of the piston and is spaced from the surface of
25 the piston.

This provides a piston seal which is responsive to high speed and pressure, particularly if the annular groove provided adjacent to that end of the piston which is nearer to the plate is beveled at its
30 edge nearer to that end of the piston.

Abrasion with the cylinder wall is minimized by the curved shape of the piston rings, particularly if each piston ring contacts the cylinder at a ring of contact spaced from both axial ends of the radially
35 outer curved surface.

The invention will now be described in more detail, by way of example, with reference to the

accompanying drawings, in which:-

Figure 1(a) is a cross-sectional view of a piston and cylinder of a compressor in accordance with the present invention;

5 Figure 1(b) is an enlarged view of portion A in Figure 1(a);

Figure 2 is an enlarged cross-sectional view of a piston ring of a compressor in accordance with the present invention;

10 Figure 3 is an enlarged cross-section view of another example of a piston ring in accordance with the present invention;

Figure 4 is an enlarged cross-sectional view to illustrate the operation of a piston ring of a compressor in accordance with the present invention;

15 Figure 5 is a cross-sectional view of a compressor in accordance with the present invention; and,

Figure 6 is a cross-sectional view of a piston and cylinder of a conventional compressor.

20 Figure 5 shows a wobble plate type compressor which includes a cylindrical casing 1 made of an aluminium alloy, a cylinder head 6 connected to one end of the casing 1 through a valve plate 3 and a front housing 8 connected to the other end of the casing 1. A plurality of cylinders 2 are radially disposed around the axis of the compressor at equal angles. The valve plate 3 is adjacent to the open ends of the cylinders 2 in the casing 1. A suction chamber 4 and a discharge chamber 5 are formed in the cylinder head 6. A drive shaft 7 is centrally supported by the front housing 8, which is attached to the front end of the casing 1 opposite to the open ends of cylinders 2. A wedge shaped rotor 9 is attached to the inner end of the drive shaft 7 and supported in an axial direction against the housing 8 by a thrust bearing 21. A wobble plate 11 is

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disposed on the inclined face of the wedge shaped rotor 9 via a thrust bearing 10. A bevel gear 12 is attached at the centre of the wobble plate 11. The bevel gear 12 meshes with a bevel gear 14 mounted in a hole 1a at the centre of the casing 1 through a steel ball 13. One end of a connecting rod 15 is connected to the wobble plate 11 at the outer surface of the wobble plate. The other end of the connecting rod 15 is connected to a piston 16 disposed in the cylinder 2. Though not shown in Figure 5, a plurality of pistons 16 and connecting rods 15 are coupled to the wobble plate 11 and disposed in respective cylinders 2.

Referring to Figures 1(a) and (b), two grooves 16a and 16b are formed on the outer circumferential surface of the piston 16. One of the grooves is located near to the top end of the piston and the other near to the bottom end. A flared, quasi-conical piston ring 17a, with an outer axially convex curved surface, is disposed in the groove 16a with its larger diameter axial end facing the most proximate axial end of the piston 16. A flared piston ring 17b is disposed in the groove 16b with its larger diameter axial end facing the most proximate axial end of the piston 16, which is opposite to the end faced by the piston ring 17a. In other words, the larger diameter axial ends of the piston rings 17a and 17b face opposite ends of the piston 16. Also, the outer diameter of the piston rings 17a and 17b is greater than that of the piston 16 at normal temperatures.

Figure 2 shows the shape of the piston rings 17a and 17b which have a flared shape with an outer axially convexly curved surface, with a larger diameter at one axial end than the other so that the piston ring projects laterally. In the preferred example the piston rings are made of plastics

material, for example, polytetrafluoroethylene resin.

Figure 3 shows an alternative pre-assembly shape for piston rings 17a and 17b. In its pre-assembly shape, the inner diameter of each of the piston rings 17a and 17b is less than that of the inner surfaces of the grooves 16a and 16b of the piston 16. In installing the piston rings 17a and 17b into the grooves 16a and 16b, the inner diameter of each piston ring 17a and 17b is forced to enlarge to conform to the diameter of the inner surface of the grooves 16a and 16b. For example, the piston rings 17a and 17b are first pressed onto a tapered surface in a direction opposite to arrow A in Figure 3 until the inner diameter expands and the ring takes on a shape similar to the shape of the ring shown in Figure 2. The enlarged ring of Figure 3 is then placed on an intermediate cylindrical holder from which it is inserted on the piston in the direction of the arrow A. Accordingly, the piston rings 17a and 17b are placed in the grooves 16a and 16b in an almost conical shape with the curved surface projecting radially outwards, much like the piston ring shown in Figure 2.

When the piston rings 17a and 17b of either of Figures 2 and 3, both of which have outer curved surfaces, are placed in the grooves 16a and 16b, the outer curved surfaces of these piston rings contact the inner surface of the cylinder 2 as shown in Figure 4. Accordingly, the end edges of the piston rings 17a and 17b do not contact the inner surface of the cylinder 2. Rather there is a smooth surface with a limited ring of contact with the wall of the cylinder 2, spaced from both axial ends of the piston ring, to prevent abrasion between the piston rings 17a and 17b and the inner surface of the cylinder 2.

When the piston 16 reciprocates in the cylinder 2, the shape and position of the curved piston ring

17a disposed in the groove 16a prevents refrigerant from leaking from the inside of the cylinder 2 to the inside of crank chamber 20. As shown in Figure 1(b), the piston ring 17a is positioned so that its wider end opens towards the nearer axial end of the piston 16a. A bevel 21 is positioned along the outermost side of the groove 16a of the piston 16. Accordingly, during the compression stroke, the gas pressure within the cylinder 2 operates against the inner surface of the piston ring 17a to force the outer curved surface of the piston ring 17a against the inner wall 19 of cylinder 2. This greatly improves the sealing between the piston 16 and the cylinder 2 during operation of the piston, particularly in the range between low and middle speed. The piston ring 17b restrains the canting of the piston 16 to help prevent contact between the inner surface 19 of the cylinder 2 and the outer surface 18 of the piston 16.

Figure 4 shows the operation of the piston ring 17a in greater detail, and is described below in connection with the middle to high speed range. The piston 16 with the bevel 21 and piston ring 17a are shown. Compressed fluid normally flows in the direction of arrow (a) and is divided at the top edge of the piston ring 17a as shown by arrows (b) and (c) because of the curved shape of the piston ring 17a. When the sliding speed of the piston 16 changed from middle to high speed, the volume of compressed fluid flowing in the direction of the arrow (b) increases so that the volume of the blow-by gas gradually increases. Therefore, the compression capacity of the compressor maximizes in the range between middle and high speed, and an extreme high pressure does not occur, which prevents loss of horsepower.



CLAIMS

1. A refrigerant compressor comprising a compressor housing having a plurality of cylinders and a crank chamber adjacent to the cylinders; a respective reciprocable piston slidably fitted within each of the cylinders; a driving mechanism coupled to the pistons to move the pistons in a reciprocating motion; a valve plate with valve openings covering one end of the cylinders; and a head covering the valve plate and including a suction chamber and a discharge chamber aligned with the valve openings; wherein two annular grooves are provided adjacent to the opposite ends of the outer peripheral surface of each of the pistons and a piston ring is disposed within each of the annular grooves and has an outer diameter larger than the outer diameter of the piston at normal temperatures, each piston ring being generally flared in one axial direction and having a radially outer, axially convex, curved surface formed so that the outer diameter of the curved surface at one end of the piston ring is shorter than that at the other end, and at least the piston ring closer to the valve plate being disposed so that its wider axial end faces the adjacent axial end of the piston and is spaced from the surface of the piston.
2. A compressor according to claim 1, wherein the annular groove provided adjacent to that end of the piston which is nearer to the valve plate is beveled at its edge nearer to that end of the piston.
3. A compressor according to any one of the preceding claims, wherein each of the piston rings has a natural inner diameter less than the diameter of the bottom surface of the respective groove.

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- 9 -

4. A compressor according to any one of the preceding claims, wherein the piston rings are made of a plastics material.
- 5 5. A compressor according to any one of the preceding claims, wherein each piston ring contacts the cylinder at a ring of contact spaced from both axial ends of the radially outer curved surface.
- 10 6. A refrigerant compressor, substantially as described with reference to Figures 1 to 5 of the accompanying drawings.

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