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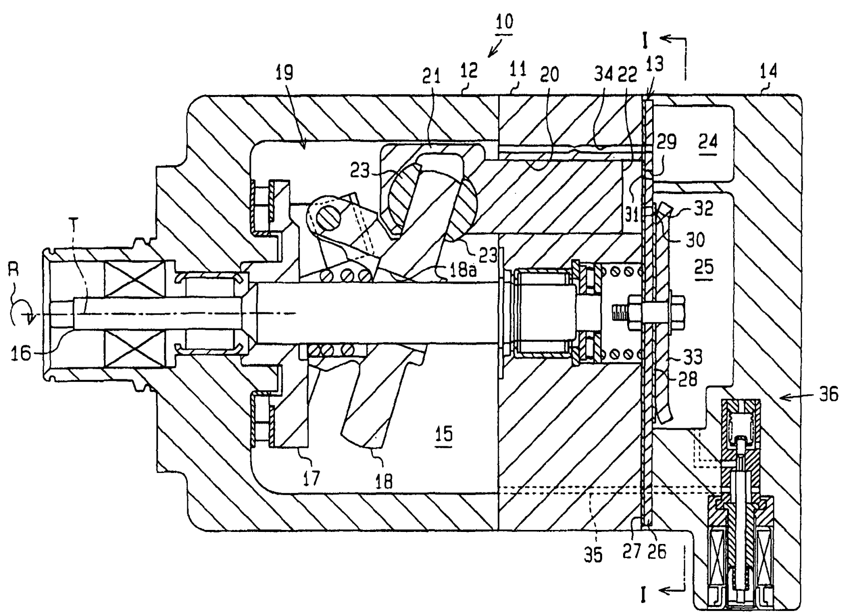
(54) Compressor

(57) A compressor has a valve port plate made of a steel, through which heat of compressed gas having a relatively higher temperature is transmitted to suction gas having a relatively lower temperature. The valve port plate is carburized to have a carburized layer for reducing heat transmission from the compressed gas to the suction gas.

FIG. 1



EP 1 577 554 A1

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a compressor having a valve port plate made of a steel.

[0002] In a piston type compressor, a piston is received in a cylinder bore which is formed in a cylinder block and a housing is connected to the end surface of the cylinder block through a valve port plate and has formed therein a suction chamber and a discharge chamber. The valve port plate has formed therethrough a suction port and a discharge port. The rotation of a rotary shaft of the compressor is converted through a drive mechanism into the reciprocation of the piston. The reciprocation of the piston causes refrigerant gas in the suction chamber to be introduced through the suction port into a compression chamber in the cylinder bore for compression therein, and the compressed refrigerant gas is discharged through the discharge port into the discharge chamber.

[0003] The discharge chamber in the housing is heated to a high temperature by the compressed refrigerant gas (discharged gas). Therefore, a low-temperature refrigerant gas flowing from external refrigerant circuit into the suction chamber is heated by heat transmitted through the wall surfaces of the housing and the valve port plate which cooperate to define the discharge chamber and the suction chamber. The refrigerant gas in the suction chamber is heated to expand before it is introduced into the compression chamber of the cylinder bore. This results in a decrease in the amount of refrigerant gas that substantially flows into the compression chamber and hence causes a decrease in volumetric efficiency of the compressor. If the suction refrigerant gas is thus heated, the temperature of the gas compressed in the compression chamber also increases, accordingly. Thus, there has been a problem that a seal member for the compressor or the refrigerant circuit tends to be degraded by the heat.

[0004] A solution for the above problem is disclosed by Unexamined Japanese Patent Publication No. 5-164042, according to which thermal insulation means is provided in a partition wall between suction chamber and discharge chamber of a piston type compressor. As shown in FIG. 8 of the above-cited Publication, the compressor has a housing 53 having formed therein a suction chamber 51 and a discharge chamber 52 and connected through a valve port plate 57 to the end surface of a cylinder block 54 of the compressor. The valve plate assembly 57 has formed therethrough a suction port 55 and a discharge port 56. The suction chamber 51 and the discharge chamber 52 are partitioned by a partition wall 58 which has formed therein a thermal insulation groove 58a as a thermal insulation means.

[0005] A compressor disclosed in Unexamined Japanese Utility Model Publication No. 2-31382 is provided with a cylinder head which has formed therein a suction chamber and a discharge chamber on one end of a cylinder and is made of a material having a higher heat radiation, and the suction chamber in the cylinder head is formed by a thermal insulation material.

[0006] The compressor in the above-cited Publication No. 5-164042 is disadvantageous in that the housing 53 is different in structure from a housing of conventional compressor because the thermal insulation groove 58a is formed in the partition wall 68, with the result that an existing housing is not usable in a compressor. Furthermore, the compressor disclosed in the above-cited Publication No. 2-31382, whose suction chamber is formed by a thermal insulation material, requires the structure of suction chamber to be changed accordingly if a conventional housing is to be used for the compressor. The present invention is directed to provide a compressor which prevents an increase in temperature of suction refrigerant gas while improving the compression efficiency thereof by providing an appropriate treatment to the valve port plate without structural change to any part of the compressor.

SUMMARY OF THE INVENTION

[0007] In accordance with the present invention, a compressor has a valve port plate made of a steel. The valve port plate is carburized to have a carburized layer.

[0008] Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The features of the present invention that are believed to be novel are set forth with particularity in the appended claims. The invention together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

FIG. 1 is a longitudinal cross-sectional view of a variable displacement piston type compressor according to a preferred embodiment of the present invention;

FIG. 2 is a partially enlarged longitudinal cross-sectional view around a valve plate assembly of FIG. 1;

FIG. 3 is a cross-sectional view that is taken along the line I-I in FIG. 1;

FIG. 4 is a graph showing the relation between a carburized ratio and a thermal conductivity and the relation between a carburized ratio and a coefficient of thermal expansion according to the preferred embodiment of the present invention;

FIG. 5 is a partially enlarged longitudinal cross-sectional view around a valve plate assembly of a compressor according to an alternative embodiment;

FIG. 6 is a partially enlarged longitudinal cross-sectional view around a valve plate assembly of a compressor according to an alternative embodiment;

FIG. 7 is a partially longitudinal cross-sectional view of a compressor according to an alternative embodiment; and

FIG. 8 is a partially longitudinal cross-sectional view of a compressor according to a prior art.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0010] The following will describe a preferred embodiment of a variable displacement piston type compressor 10 according to the present invention which is used for a refrigerant circuit in a vehicle air conditioner with reference to FIGS. 1 through 4.

[0011] Referring to FIG. 1 showing a longitudinal cross-sectional view of the variable displacement compressor 10, in which the left side and the right side of the drawing correspond to the front side and the rear side of the compressor 10, respectively, the compressor 10 has a housing, which includes a cylinder block 11, a front housing 12 and a rear housing 14. The front housing 12 is fixedly connected to the front end of the cylinder block 11. The rear housing 14 is fixedly connected through a valve plate assembly 13 to the rear end of the cylinder block 11.

[0012] The housing has formed therein a crank chamber 15 between the cylinder block 11 and the front housing 12. Between the cylinder block 11 and the front housing 12 is rotatably supported a drive shaft 16 for extension through the crank chamber 15. The drive shaft 16 is operatively connected to a vehicle engine (not shown) for rotation thereby in arrow direction R.

[0013] In the crank chamber 15, a substantially disc-shaped lug plate 17 is secured to the drive shaft 16 for integral rotation therewith. In the crank chamber 15 is accommodated a swash plate or a cam plate 18. The swash plate 18 has formed at the center thereof a through hole 18a, through which the drive shaft 16 is inserted. Between the lug plate 17 and the swash plate 18 is interposed a hinge mechanism 19. The swash plate 18 is connected to the lug plate 17 through the hinge mechanism 19 and supported by the drive shaft 16 through the through hole 18a. This permits the swash plate 18 to rotate integrally with the lug plate 17 and the drive shaft 16 and incline with respect to the drive shaft 16 while sliding in the direction of the axis T of the drive shaft 16.

[0014] The cylinder block 11 has formed therein a plurality of cylinder bores 20 (only one of them being shown in FIG. 1) around the drive shaft 16 at equiangular spaced intervals, extending in the direction of the axis T. Each cylinder bore 20 receives therein a single-headed piston 21 for reciprocation. The front and rear openings of the cylinder bore 20 are closed by the piston 21 and the valve plate assembly 13, respectively. In each cylinder bore 20, a compression chamber 22 is defined, the volume of which varies in accordance with the reciprocation of the piston 21.

[0015] The piston 21 engages with the outer periphery of the swash plate 18 through a pair of shoes 23. The housing has formed therein a suction chamber 24 and a discharge chamber 25 between the valve plate assembly 13 and the rear housing 14.

[0016] The valve plate assembly 13 includes a valve port plate 26, a suction valve plate 27 provided on one side of the valve port plate 26 adjacent to the cylinder block 11, and a discharge valve plate 28 provided on the other side of the valve port plate 26 adjacent to the rear housing 14. As shown in FIGS. 1 and 3, the valve port plate 26 has formed therethrough suction ports 29 and discharge ports 30. The suction ports 29 are located in radially outward positions of the valve port plate 26 in correspondence with the respective cylinder bores 20. The discharge ports 30 are located radially inward of the suction port 29 in correspondence with the respective cylinder bores 20. The suction valve plate 27 has formed therein suction valves 31 in correspondence with the respective suction ports 29. The discharge valve plate 28 has formed therein discharge valves 32 in correspondence with the respective discharge ports 30. The degree of opening of the discharge valves 32 is regulated by a retainer 33 which is fixed to the valve port plate 26.

[0017] The compressor 10 has a bleed passage 34, a supply passage 35 and a control valve 36 in the housing. The bleed passage 34 connects the crank chamber to the suction chamber 24. The supply passage 35 connects the discharge chamber 25 to the crank chamber 15. The control valve 36 which is a known electromagnetic valve is located in the supply passage 35.

[0018] The valve port plate 26 will now be described more in detail. The valve port plate 26 is made of steel (cold-rolled steel plate in the preferred embodiment) and carburized. The cold-rolled steel plate may include SPCC (or steel plate cold commercial), SPCD (or steel plate cold deep drawn), and SPCE (or steel plate cold deep drawn extra), of which the SPCD is the most preferable. Though not shown in FIG. 1 for the sake of convenience of illustration, the valve port plate 26 has carburized layers 26a formed on both front and rear surfaces thereof, as shown in FIG. 2. The carburized layers 26a are formed in such a way that the total thickness of these two layers is 50 percent or more of the thickness of the valve port plate 26. In other words, the valve port plate 26 is carburized to such depths on opposite sides thereof that the total carburized thickness corresponds to at least 50 percent of the thickness of the valve port plate 26. In the preferred embodiment, the valve port plate 26 is carburized in such a way that iron carbide layer is not precipitated in the carburized layer 26a, that is, carbon atoms are mixed in the crystal structure of the steel. Additionally, the carburizing is accomplished by vacuum carburizing.

[0019] The valve port plate 26 is formed with a thickness of, for example, 2 to 3 mm, and the carburized layers 26a has a thickness of, for example, 1.2 to 1.8 mm which corresponds to about 60 percent of the thickness of the valve port plate 26. Since a thickness of the valve port plate 26 ranges from 2 to 3 mm, it is preferable that a total thickness of the carburized layers 26a is about 1 mm or more which corresponds to about 50 percent or more of the thickness of the valve port plate 26. An increase in temperature of suction refrigerant gas can be prevented more effectively by increasing the carburized layer thickness and, therefore, forming the carburized layers 26a across the entire thickness of the valve port plate 26 is preferable in terms of the prevention of an increase in temperature of suction refrigerant gas. However, the thicker carburized layers 26a require a longer time for carburizing and hence more treatment cost. The thickness of the carburized layers 26a in the preferred embodiment has been determined by the trade-off between the effectiveness to prevent temperature rise of the carburized layers and the treatment cost thereof.

[0020] The vacuum carburizing may be performed by a known method. For example, after the interior of a furnace is evacuated, carburizing gas such as decompressed methane gas (or CH_4) and decompressed propane gas (or C_3H_8) is introduced into the furnace for carburizing. Carburizing is applied to a valve port plate 26 which has been machined to have been finished machining suction ports 29 and discharge ports 30.

[0021] FIG. 4 shows the relation between carburized ratio and thermal conductivity, and the relation between carburized ratio and coefficient of thermal expansion, as measured when the valve port plate 26 is carburized under the condition that no iron carbide is precipitated in the carburized layers 26a. In FIG. 4, the lozenge figures indicate the relation between the carburized ratio and the thermal conductivity, while the square figures indicate the relation between the carburized ratio and the coefficient of thermal expansion. It is noted that the carburized ratio is a ratio of a thickness of the carburized layer to a thickness of the valve port plate, expressed in percentage, as carburized ratio (%) = (thickness of carburized layer/thickness of valve port plate) x 100.

[0022] **FIG. 4** confirms that the coefficient of thermal expansion is substantially constant (plus or minus two percent) when the carburized ratio is varied from zero percent (non-carburized) to 100 percent. FIG. 4 also confirms that the thermal conductivity decreases with an increase in the carburized ratio. That is, a carburized valve port plate has a lower thermal conductivity than a non-carburized valve port plate. Additionally, the thermal conductivity becomes substantially equal to or less than 60 W/mK with the carburized ratio of 50 percent or more.

[0023] The following will describe the operation of the compressor. As the drive shaft 16 is rotated, the swash plate 18 rotates therewith, and the rotation of the swash plate 18 is converted through a pair of the shoes 23 into the reciprocation of each piston 21 in its associated cylinder bore for a stroke length corresponding to the inclination angle of the swash plate 18. Thus, refrigerant gas is drawn from the suction chamber 24 into the compression chamber 22 for compression therein, and the compressed refrigerant gas is discharged into the discharge chamber 25, repeatedly. As the piston 21 moves from the top dead center toward the bottom dead center, the refrigerant gas in the suction chamber 24 (carbon dioxide in the preferred embodiment) flows into the compression chamber 22 through the suction port 29 while pushing open the suction valve 31. As the piston 21 moves from the bottom dead center toward the top dead center, on the other hand, the refrigerant gas introduced into the compression chamber 22 is compressed to a predetermined pressure and discharged into the discharge chamber 25 through the discharge port 30 while pushing open the discharge valve 32. The refrigerant gas discharged into the discharge chamber 25 is sent to the external refrigerant circuit through a discharge hole (not shown).

[0024] The control valve 36 is operable to control the opening degree thereof for adjustment of the balance between the amount of high-pressure discharged gas through the supply passage 35 into the crank chamber 15 and the amount of gas from the crank chamber 15 through the bleed passage 34, thus determining the pressure in the crank chamber 15. As the pressure in the crank chamber 15 is varied, the pressure difference between the crank chamber 15 and the compression chambers 22 across the pistons 21 is varied, accordingly, so that the inclination angle of the swash plate 18 (that is, the angle which the swash plate 18 makes with a plane perpendicular to the axis T of the drive shaft 16) is altered, thereby changing the stroke of the piston 21 and hence the displacement of the compressor 10.

[0025] For example, a decrease in the pressure in the crank chamber 15 increases the inclination angle of the swash plate 18, thereby increasing the stroke of the piston 21, resulting in an increase in the displacement of the compressor 10. On the other hand, an increase in the pressure in the crank chamber 15 reduces the inclination angle of the swash plate 18, thereby reducing the stroke of the piston 21, resulting in a reduction in displacement of the compressor 10.

[0026] In operation of the compressor 10, compressed refrigerant gas is temporarily reserved in the discharge chamber 25 under high pressure and temperature. If the valve port plate 26 is made of non-carburized cold-rolled steel plate having a thermal conductivity of approximately 80 W/mK, the heat of the refrigerant gas in the discharge chamber 25 is easily transmitted through the valve port plate 26. Accordingly, the refrigerant gas in the suction chamber 24 or passing through the suction port 29 is heated, resulting in a decrease in the amount of refrigerant gas substantially introduced into the compression chamber 22, thus reducing a volumetric efficiency of the compressor.

[0027] However, the valve port plate 26 of the preferred embodiment is so carburized that the total thickness of the carburized layers 26a is 50 percent or more of the thickness of the valve port plate 26. Accordingly, the thermal conductivity is 60 W/mK or less, with the result that transmission of the heat of the refrigerant gas in the discharge chamber 25 through the valve port plate 26 to the refrigerant gas in the suction chamber 24 is prevented. Additionally, the suction refrigerant gas passing through the suction port 29 is prevented from being heated, so that the amount of the refrigerant gas substantially introduced into the compression chamber 22 is increased and the volumetric efficiency and compression efficiency of the compressor are improved, accordingly.

[0028] According to the preferred embodiment, the following advantageous effects are achieved.

(1) The valve port plate 26 of the compressor 10 is carburized in such a way that the total thickness of the carburized layers 26a is 50 percent or more of the thickness of the valve port plate 26. Accordingly, the valve port plate 26 made of an inexpensive ferrous material may also have a thermal conductivity of 60 W/mK or less, so that transmission of the heat of the refrigerant gas in the discharge chamber 25 through the valve port plate 26 to the refrigerant gas in the suction chamber 24 is inhibited, thus preventing an increase in temperature of the suction refrigerant gas and improving the compression efficiency of the compressor. The carburized valve port plate 26 is made harder and, therefore, may be made thinner in comparison with a non-carburized valve port plate.

(2) Since the valve port plate 26 is carburized without any precipitation of an iron carbide layer in the carburized layer 26a, the coefficient of thermal expansion of the valve port plate 26 is maintained substantially the same as that of a non-carburized valve port plate and, therefore, the valve port plate 26 can be assembled in the same manner as the non-carburized valve port plate.

(3) Since the valve port plate 26 is vacuum-carburized, a required thickness (or depth) for carburized layer 26a can be formed more quickly in comparison to other carburizing processes, such as solid carburizing, liquid carburizing, and gas carburizing. Additionally, the carburizing without any precipitation of an iron carbide layer in the carburized layer 26a may be performed easier than other carburizing processes.

(4) The valve port plate 26 is made of cold-rolled steel plate which is low in cost and easy to machine, thus providing a suitable material for the valve port plate 26 in terms of the manufacturing cost thereof.

(5) The compressor 10 is of a piston type, having the cylinder block 11 and the piston 21 received in the cylinder bore 20 that is formed in the cylinder block 11, in which refrigerant gas is introduced into the cylinder bore 20 for compression therein and discharge therefrom in conjunction with the reciprocation of the piston 21 in the cylinder bore 20. In such piston type compressor, the discharge chamber 25 is located relatively close to the suction chamber 24 in comparison to other types of compressor, and the heat in the discharge chamber 25 is easily transmitted through the valve port plate 26 to the suction refrigerant gas in the suction chamber 24. However, by using a carburizing process which is low in cost and easy to perform, an increase in temperature of suction refrigerant gas due to the heat conduction is prevented.

(6) The valve port plate 26 is located between the cylinder block 11 and the rear housing 14 which has formed therein the suction chamber 24 and the discharge chamber 25, and the carburized layers 26a are formed on the opposite front and rear surfaces of the valve port plate 26. With the valve port plate 26 having on opposite surfaces thereof the carburized layers 26a of substantially the same thickness, an increase in temperature of the suction refrigerant gas is prevented more effectively than with a valve port plate having a carburized layer only on one surface thereof. To put in other words, the suction valve plate 27 is disposed on the surface of the valve port plate 26 on the side which is adjacent to the cylinder bore 20, and the valve port plate 26 is exposed directly to the refrigerant gas in the compression chamber 22 in the region of the valve port plate 26 adjacent to the suction valve 31. Therefore, the valve port plate 26 is exposed to the high-temperature refrigerant gas which is compressed to a discharge pressure in the compression stroke, so that the heat of the refrigerant gas is transmitted to the suction port 29 through the contact portion and then to the suction refrigerant gas. In the above-described preferred embodiment of the present invention, however, the valve port plate 26 having the carburized layers 26a on both front and rear surfaces thereof can prevent the heat transmission through the above path to the suction refrigerant gas.

(7) Carbon dioxide which is often used as refrigerant for vehicle air conditioner has a higher refriger-

ating performance per unit volume in comparison to fluorocarbon refrigerant, and the cylinder bores of a compressor using such carbon dioxide refrigerant are made smaller than those of a fluorocarbon refrigerant compressor, accordingly. Therefore, when the refrigerant gas in the suction chamber 24 expands by heat and the amount of refrigerant gas substantially introduced into the compression chambers 22 is reduced, a decrease in volumetric efficiency of a carbon dioxide refrigerant compressor is larger than that of a fluorocarbon refrigerant compressor. Accordingly, in the compressor 10 using carbon dioxide refrigerant, the improvement in volumetric efficiency by preventing the expansion of refrigerant gas due to heating of the suction refrigerant gas is larger than that of a fluorocarbon refrigerant compressor. Thus, the present invention is particularly suitable for the compressor 10 which is designed for compressing carbon dioxide refrigerant.

[0029] The present invention is not limited to the embodiments described above but may be modified into the following alternative embodiments.

[0030] In an alternative embodiment, the valve port plate 26 is so carburized that the total thickness of the carburized layers 26a is 50 percent or more of the thickness of the valve port plate 26. For example, as shown in FIG. 5, the carburized layer 26a is formed only on the rear surface of the valve port plate 26 adjacent to the rear housing 14. FIG. 6 shows another alternative embodiment wherein the carburized layer 26a is formed only on the front surface of the valve port plate 26 adjacent to the cylinder block 11. Alternatively, the carburized layer 26a is formed across the entire thickness of the valve port plate 26. If the carburized layer 26 is formed only on one surface of the valve port plate 26, the carburized layer 26a is preferably formed on the rear surface of the valve port plate 26 adjacent to the rear housing 14 because the rear surface of the valve port plate 26 has a larger area exposed to discharged gas.

[0031] The present invention is not limited to a valve port plate which is so carburized that a total thickness of a carburized layer is 50 percent or more of the thickness of the valve port plate. In an alternative embodiment, a valve port plate is carburized to have a carburized layer as a minimum requirement. In another alternative embodiment, a total thickness of the carburized layer is about 10 percent or more of the thickness of the valve port plate.

[0032] In an alternative embodiment, the suction chamber 24 is formed in radially outer region of the rear housing 13, while the discharge chamber 25 is formed in radially inner region, as shown in FIG. 7.

[0033] The carburizing is not limited to the process in which no iron carbide layer is precipitated in the carburized layer 26a. In an alternative embodiment, the carburizing with a precipitation of an iron carbide layer in the carburized layer 26a is usable.

[0034] The carburizing is not limited to the vacuum carburizing. In an alternative embodiment, other carburizing processes such as solid carburizing, liquid carburizing and gas carburizing are usable.

[0035] The carburizing gas in the vacuum carburizing is not limited to saturated chain hydrocarbon, such as methane gas and propane gas. In an alternative embodiment, unsaturated chain hydrocarbon such as ethylene and acetylene is used.

[0036] The material for the valve port plate 26 is not limited to cold-rolled steel plate, but any steel material that is suitable for carburizing is usable. In view of machinability and ease of carburizing, the material for the valve port plate 26 includes a hot-rolled mild steel plate and an electromagnetic soft iron plate other than the cold-rolled steel plate.

[0037] The present invention is not limited to the above-described swash plate type variable displacement compressor, but it is also applicable to a swash plate type compressor with a double-headed piston or a fixed displacement. Additionally, the compressor of the present invention may be of a wobble type in which the swash plate wobbles with the rotation of the drive shaft without making integral rotation with the drive shaft.

[0038] In an alternative embodiment, the housing of the compressor 10 is not limited to the structure in which the front housing 12 and the rear housing 14 hold the cylinder block 11 therebetween. For example, the housing of the compressor includes a front housing and a rear housing, and either one of the front and rear housings has formed therein a crank chamber, while the other receives therein a cylinder that has formed therein a cylinder bore.

[0039] Alternatively, the present invention is applicable to a compressor having a piston which is operated by means other than the swash plate. Additionally, the present invention is not limited to a piston type compressor but is usable for a scroll type compressor.

[0040] The present invention is not limited to a compressor that uses carbon dioxide as refrigerant for vehicle air conditioner but is usable for a compressor that uses fluorocarbon refrigerant.

[0041] The present invention is not limited to a compressor whose drive shaft is rotated by the power of the engine, but the drive shaft of the compressor may be driven by a motor.

[0042] The present invention is not limited to a compressor which is designed to be used in a vehicle air conditioner, but it is applicable to a motor-driven compressor for domestic air conditioner.

[0043] The present invention is not limited to a compressor used for air conditioning, but it is applicable to a compressor for other refrigerant circuits, such as a compressor used for a refrigerant circuit of a refrigerator or a freezer.

[0044] Therefore, the present examples and embodiments are to be considered as illustrative and not restrictive, and the invention is not to be limited to the details given herein but may be modified within the scope of the appended claims.

[0045] A compressor has a valve port plate made of a steel, through which heat of compressed gas having a relatively higher temperature is transmitted to suction gas having a relatively lower temperature. The valve port plate is carburized to have a carburized layer for reducing heat transmission from the compressed gas to the suction gas.

Claims

1. A compressor having a valve port plate made of a steel, **characterized in that**:

the valve port plate is carburized to have a carburized layer.

2. The compressor according to claim 1, wherein a total thickness of the carburized layer is about 10 percent or more of the thickness of the valve port plate.

3. The compressor according to claim 2, wherein a total thickness of the carburized layer is about 50 percent or more of the thickness of the valve port plate.

4. The compressor according to claim 3, wherein a total thickness of the carburized layer is about 60 percent or more of the thickness of the valve port plate.

5. The compressor according to any one of claims 1 through 4, wherein the valve port plate is so carburized that no iron carbide layer is precipitated in the carburized layer.

6. The compressor according to any one of claims 1 through 5, wherein the carburizing of the valve port plate is selected from a group comprising vacuum carburizing, solid carburizing, liquid carburizing, and gas carburizing.

7. The compressor according to any one of claims 1 through 6, wherein the valve port plate is made of cold-rolled steel plate.

8. The compressor according to any one of claims 1 through 6, wherein the valve port plate is made of hot-rolled mild steel plate.

9. The compressor according to any one of claims 1 through 6, wherein the valve port plate is made of electromagnetic soft iron plate.

10. The compressor according to any one of claims 1 through 9, wherein the compressor is of a piston type, **characterized in that**:

a cylinder block has formed therethrough a cylinder bore; and

a piston is received in the cylinder bore for reciprocation therein, whereby gas is introduced, compressed and discharged.

11. The compressor according to claim 10, wherein the gas is refrigerant gas.

12. The compressor according to any one of claims 10 and 11, **characterized in that**:

a housing has formed therein a suction chamber and a discharge chamber, **in that** the valve port plate is located between the housing and the cylinder block, and **in that** the carburized layer is formed on at least one surface of the valve port plate.

13. The compressor according to claim 12, wherein the carburized layer is formed on the surface of the valve port plate adjacent to the housing.

14. The compressor according to claim 12, wherein the carburized layer is formed on the surface of the valve port plate adjacent to the cylinder block.

15. The compressor according to claim 12, wherein the carburized layer is formed on opposite surfaces of the valve port plate.

16. The compressor according to any one of claims 1 through 12, wherein the carburized layer is formed across the entire thickness of the valve port plate.

17. The compressor according to any one of claims 1 through 16, wherein carbon dioxide is used as refrigerant for the compressor.

18. The compressor according to claim 1, wherein a total thickness of the carburized layer is about 1 mm or more.

19. The compressor according to claim 18, wherein a total thickness of the carburized layer is about 1.2 mm or more.

FIG. 1

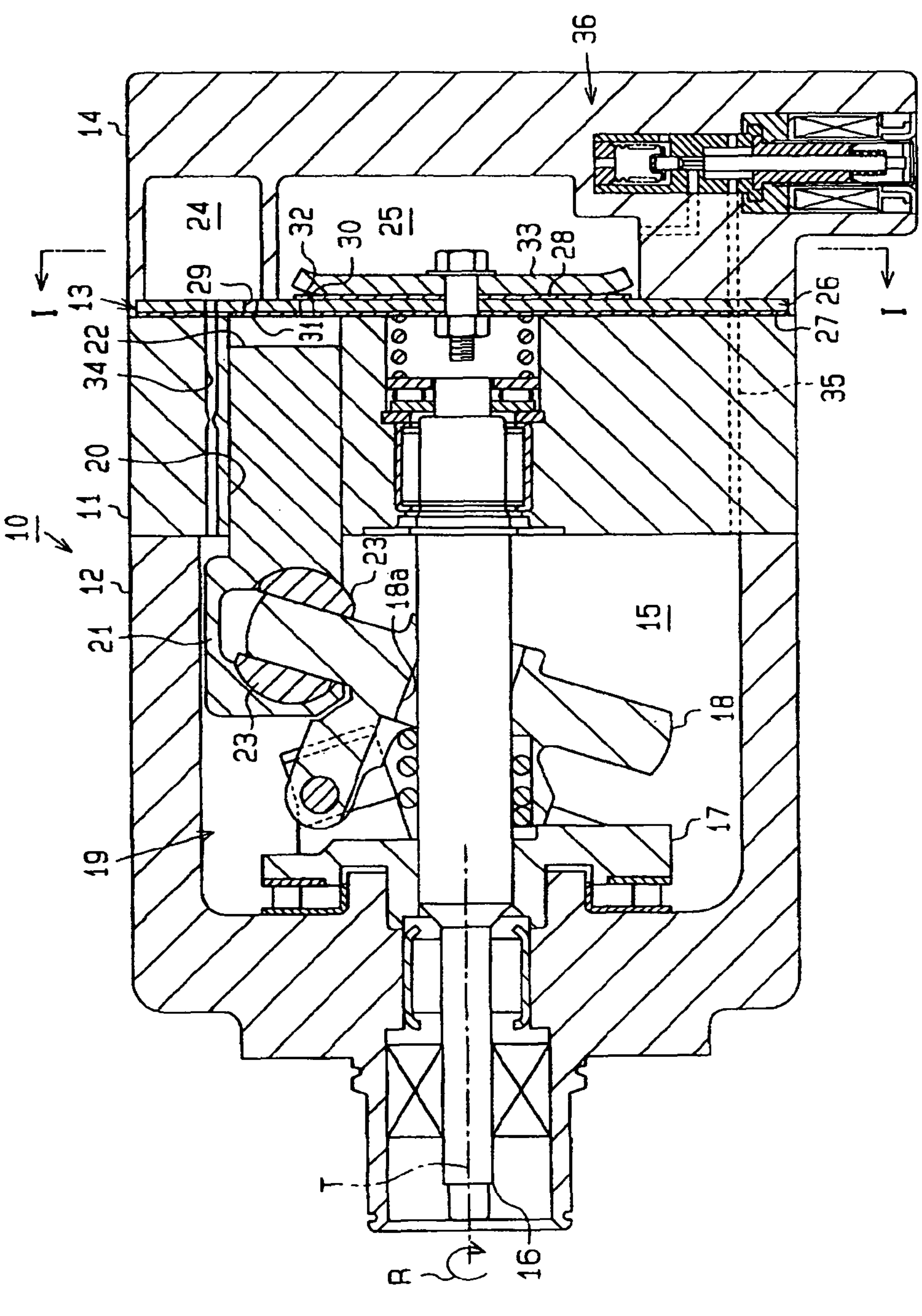

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FIG. 3

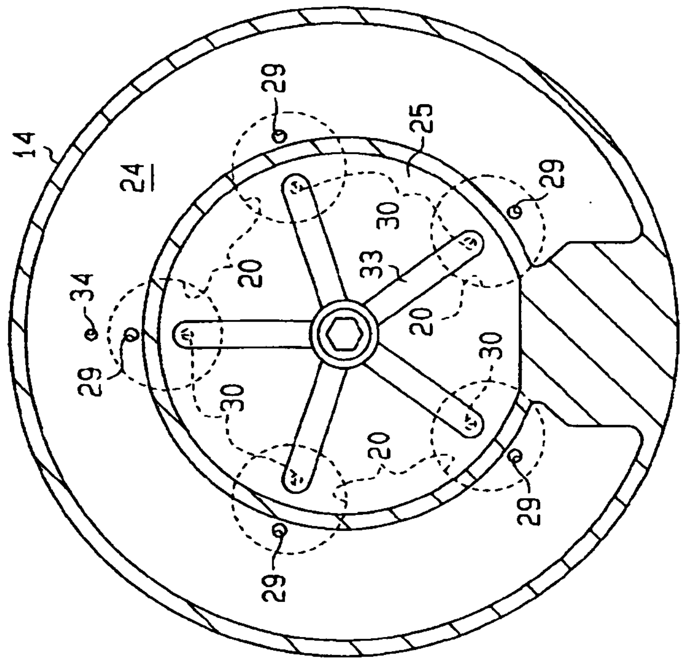
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FIG. 2

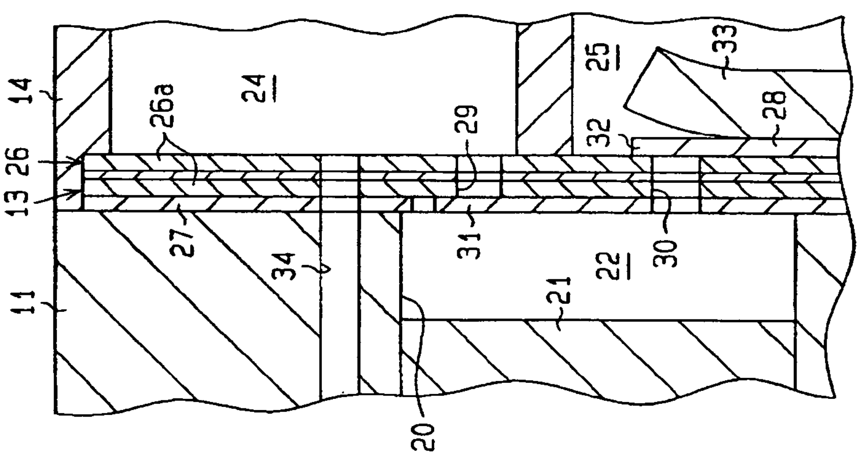
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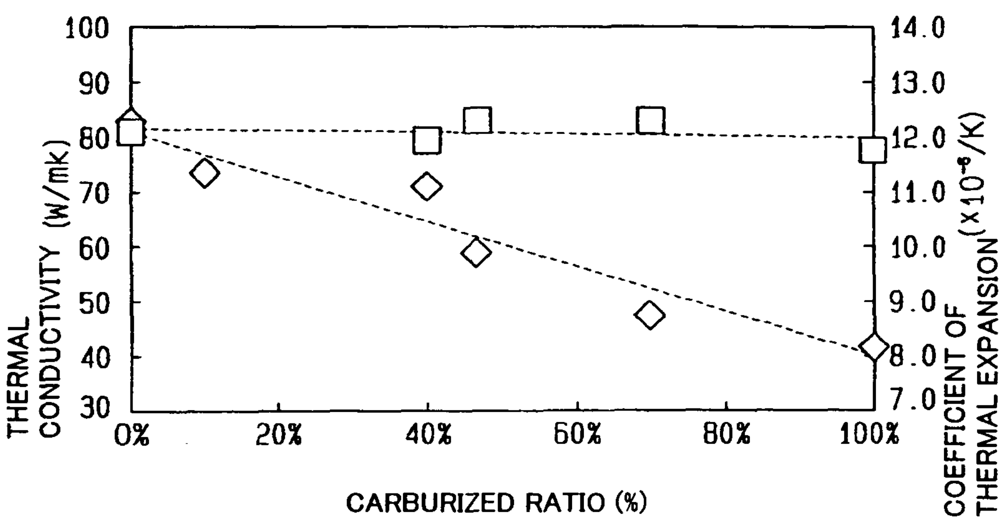
FIG. 4



◇: THERMAL CONDUCTIVITY RELATIVE TO CARBURIZED RATIO

□: COEFFICIENT OF THERMAL EXPANSION RELATIVE TO CARBURIZED RATIO

FIG. 6

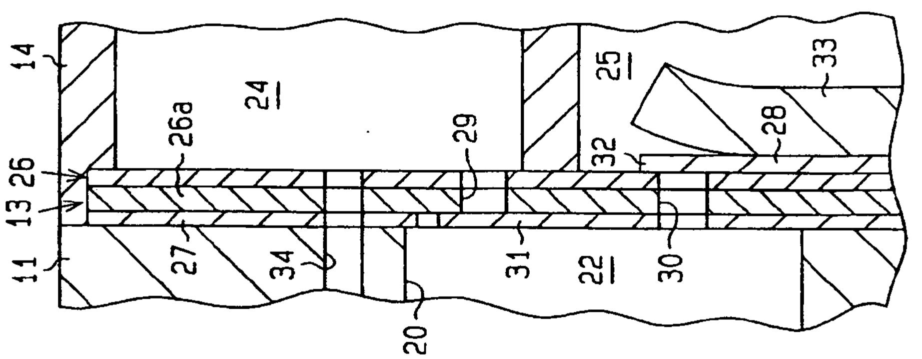

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FIG. 5

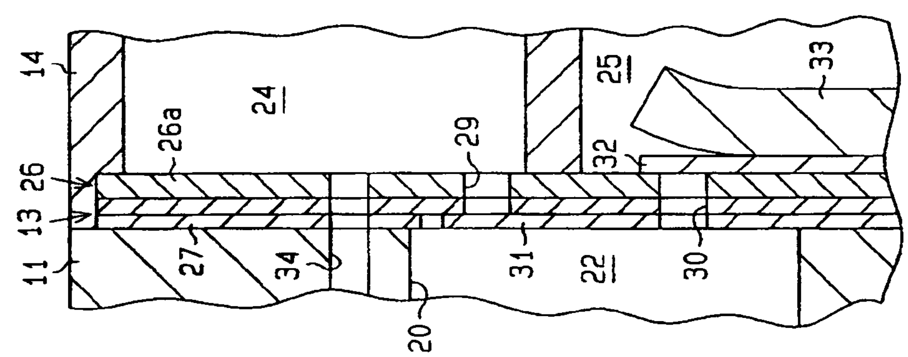
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FIG. 7

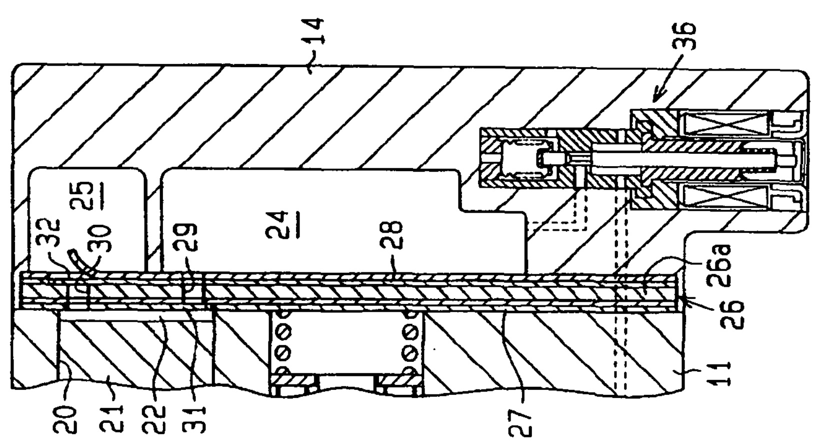
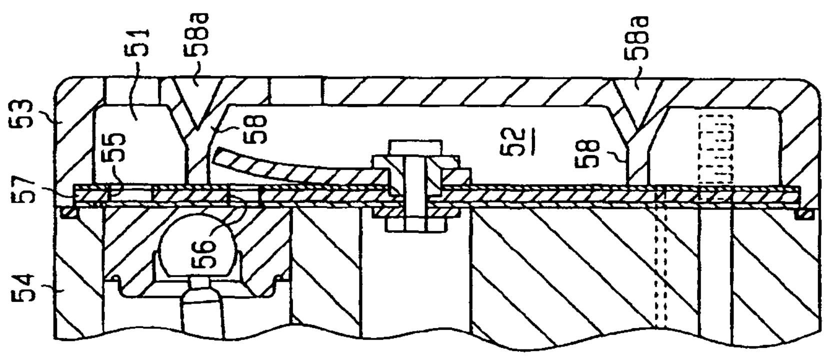


FIG. 8 (PRIOR ART)



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EUROPEAN SEARCH REPORT

Application Number
EP 05 00 5188

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The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
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