(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 159 540 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
26.04.2017 Bulletin 2017/17

(21) Application number: **15808895.5**

(22) Date of filing: **18.06.2015**

(51) Int Cl.:
F04B 39/10 *(2006.01)*

(86) International application number:
PCT/JP2015/003052

(87) International publication number:
WO 2015/194181 (23.12.2015 Gazette 2015/51)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA

(30) Priority: **19.06.2014 JP 2014125906**
13.11.2014 JP 2014230818

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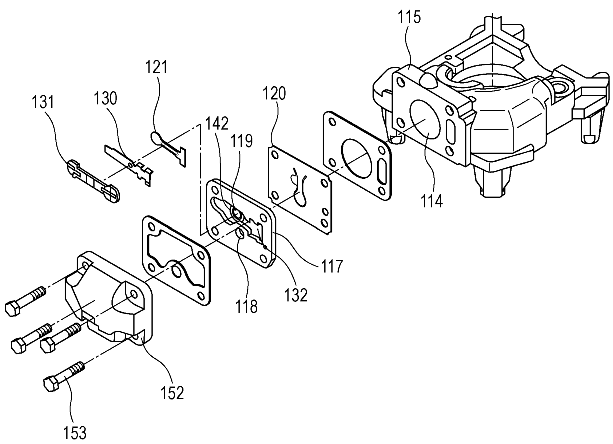
(54) REFRIGERANT COMPRESSOR AND REFRIGERATION APPLIANCE USING SAME

(57) A synthetic resin film is formed on a region of a valve plate (117) which is brought into contact with an arm portion of a suction valve (120) or a region of the valve plate (117) which is brought into contact with an arm portion of a discharge valve (121). With such a configuration, delay in opening of the suction valve (120) or the discharge valve (121) caused by adhesion force of refrigerating oil is suppressed so that a pressure loss in a suction stroke or a discharge stroke can be reduced whereby compressor efficiency is enhanced. Further, a striking sound generated at the time of closing the suction valve (120) or the discharge valve (121) is reduced by an elastic effect of the synthetic resin film so that the reduction of noises is realized.

FIG. 2



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Description

TECHNICAL FIELD

[0001] The present invention relates to enhancement of efficiency and reduction of noises of a refrigerant compressor used mainly in a household-use refrigerator.

BACKGROUND ART

[0002] In keeping with a trend of energy saving of household-use refrigerator, along with the progress of a variable-speed operation using an inverter or a sensor control and the expansion of the scope of the variable-speed operation, there has been a demand for steady increase of efficiency of a refrigerant compressor.

[0003] As a conventional refrigerant compressor, there has been known a refrigerant compressor where a valve plate is disposed on an opening end of a cylinder, has a suction valve seat disposed so as to surround a suction hole and a discharge valve seat disposed so as to surround a discharge hole, and is formed by molding using a sintered metal material (see Patent Literature (PTL) 1, for example).

[0004] FIG. 22 is a cross-sectional view of the conventional refrigerant compressor described in PTL 1, and FIG. 23 is an exploded perspective view of the valve plate and parts around the valve plate of the conventional refrigerant compressor.

[0005] As shown in FIG. 22 and FIG. 23, in the refrigerant compressor, refrigeration oil 2 is accumulated on a bottom portion of the inside of sealed container 1, sealed container 1 is filled with working fluid 3, and compressor body 4 is housed in sealed container 1. Electrically-operated element 6 and compressive element 9 are resiliently supported by suspension spring 5 in sealed container 1.

[0006] Electrically-operated element 6 includes stator 7 and rotor 8.

[0007] Compressive element 9 includes: crankshaft 12 provided with eccentric shaft 10 and main shaft 11, cylinder 14 in which compressor chamber 13 is formed, bearing portion 23 which supports main shaft 11; and piston 16 which reciprocates in cylinder 14. Compressive element 9 also includes: valve plate 17 which seals an end surface of cylinder 14; suction valve 20 and discharge valve 21 which are mounted on valve plate 17 and respectively open and close suction hole 18 and discharge hole 19 which allow the inside and the outside of compression chamber 13 to communicate with each other; and a connecting portion (not shown) which connects eccentric shaft 10 and piston 16 to each other.

[0008] On a side of valve plate 17 opposite to compression chamber 13, cylinder head 52 is disposed so as to cover valve plate 17 as a cover, and head space 56 is formed by valve plate 17 and cylinder head 52.

[0009] Main shaft 11 of crankshaft 12 is rotatably and pivotally supported by bearing portion 23, and is fixed with rotor 8.

[0010] Next, the operation of a conventional refrigerant compressor is described.

[0011] In the refrigerant compressor, when a magnetic field is generated by supplying an electric current to stator 7 and rotor 8 fixed to main shaft 11 is rotated, crankshaft 12 is rotated, and piston 16 reciprocates in cylinder 14 by way of a connecting portion (not shown) mounted on eccentric shaft 10 so that a series of cycles including a suction stroke, a compression stroke, and an discharge stroke is repeated.

[0012] In the suction stroke, when piston 16 is operated in a direction that a volume of cylinder 14 is increased, working fluid 3 in compression chamber 13 expands, and when a pressure in compression chamber 13 becomes lower than a pressure on a low pressure side of a refrigeration cycle (not shown), suction valve 20 is started to open. Then, working fluid 3 of a low temperature which returns from the refrigeration cycle flows into compression chamber 13 through suction hole 18. At this stage of operation, discharge valve 21 closes discharge hole 19 formed in valve plate 17.

[0013] Then, in the compression stroke, when piston 16 turns the direction of movement to the direction that the volume of compression chamber 13 is decreased from the position of bottom dead center where the volume of compression chamber 13 becomes largest, the pressure in compression chamber 13 is elevated, and due to the pressure difference between the pressure in compression chamber 13 and the pressure of the refrigeration cycle lower-pressure side (not shown), suction valve 20 is closed so that compression chamber 13 is closed.

[0014] Thereafter, when piston 16 is further operated in the direction that the volume of compression chamber 13 is decreased, working fluid 3 is compressed and the pressure in compression chamber 13 is elevated to a predetermined pressure.

[0015] In the discharge stroke, when pressure of working fluid 3 in compression chamber 13 is elevated and becomes higher than a pressure in head space 56 formed by valve plate 17 and cylinder head 52, discharge valve 21 is started to open due to the pressure difference. Then, working fluid 3 in compression chamber 13 passes through discharge hole 19 and flows out to head space 56. Thereafter, working fluid 3 is discharged to a high pressure side (not shown) of the refrigeration cycle from head space 56 through a discharge muffler (not shown).

[0016] In general, recessed portions are formed on valve plate 17 so as to arrange suction hole 18, discharge hole 19, and discharge valve 21 and hence, valve plate 17 has a complicated shape whereby valve plate 17 is made of a sintered metal material for enhancing productivity.

[0017] However, in the conventional configuration, valve plate 17 is made of a sintered metal material and hence, open pores peculiar to a sintered metal material are present in the sintered metal material in a scattered manner. Accordingly, when refrigeration oil 2 in the compressor pools on a surface of valve plate 17 and impregnates into the inside of valve plate 17. Impregnated refrigeration oil 2 exudes to the surface of valve plate 17 due to a change in pressure or the like. Such refrigeration oil 2 is interposed in a gap formed between valve plate 17 and suction valve 20 and discharge valve 21. Accordingly, a valve opening operation is obstructed by an adhesion force of refrigeration oil 2 interposed between contact surfaces of valve plate 17 and the respective valves and hence, resistance which a passing working fluid receives is increased and a pressure loss is generated thus giving rise to a drawback that efficiency of the compressor is lowered.

[0018] Further, valve plate 17 and suction valve 20 as well as valve plate 17 and discharge valve 21 generate a striking sound when the valve is closed. The striking sound leaks to the outside of the sealed container thus giving rise to a drawback that noises are generated. Particularly, electrically-operated element 6 adopts inverter driving to satisfy a demand for high efficiency so that electrically-operated element 6 is operated at a low speed whereby noises which electrically-operated element 6 generates are decreased. As a result, a striking sound generated between valve plate 17 and suction valve 20 as well as between valve plate 17 and discharge valve 21 become conspicuous thus making a noise problem more serious.

[0019] It is an object of the present invention to enhance efficiency of a compressor by suppressing delay in opening of suction valve 20 and discharge valve 21 thus decreasing a pressure loss in a suction stroke and a discharge stroke. It is another object of the present invention to realize the reduction of noises by lowering a striking sound generated between valve plate 17 and suction valve 20 as well as between valve plate 17 and discharge valve 21 in the valve closing operation.

Citation List

Patent Literature

[0020] PTL 1: Unexamined Japanese Patent Publication No. 2000-45949

SUMMARY OF THE INVENTION

[0021] A refrigerant compressor according to the present invention includes, inside a sealed container: a cylinder which houses a piston movable in a reciprocating manner; a valve plate which is disposed on an opening end of the cylinder and has a suction valve seat formed so as to surround a suction hole; and a suction valve configured to open and close the suction hole. The suction valve includes an opening and closing portion, and an arm portion to be operated along with opening and closing of the opening and closing portion, and the refrigerant compressor further comprises a synthetic resin film in at least a region of the valve plate which is brought into contact with the arm portion of the suction valve.

[0022] With such a configuration, it is possible to suppress delay in opening of the suction valve caused by an adhesive force generated by refrigeration oil interposed in the gap formed between the valve plate and the suction valve. By suppressing delay in opening of the suction valve, it is possible to provide a refrigerant compressor which enhances compressor efficiency and a refrigeration appliance using the same.

[0023] Further, a striking force generated between the valve plate and the suction valve at the time of closing the suction valve can be reduced by an elastic effect of the synthetic resin film applied to the valve plate and hence, a striking sound can be reduced thus realizing the reduction of noises.

[0024] A refrigerant compressor according to the present invention includes, inside a sealed container: a cylinder which houses a piston movable in a reciprocating manner; a valve plate which is disposed on an opening end of the cylinder and has a discharge valve seat formed so as to surround a discharge hole; and a discharge valve configured to open and close the discharge hole. The discharge valve includes an opening and closing portion, and an arm portion to be operated along with opening and closing of the opening and closing portion, and a synthetic resin film is applied to at least a region of the valve plate which is brought into contact with the arm portion of the discharge valve.

[0025] With such a configuration, it is possible to suppress delay in opening of the discharge valve caused by an adhesive force generated by refrigeration oil interposed in the gap formed between the valve plate and the discharge valve. By suppressing delay in opening of the discharge valve, it is possible to provide a refrigerant compressor which enhances compressor efficiency and a refrigeration appliance using the same.

[0026] Further, a striking force generated between the valve plate and the discharge valve at the time of closing the discharge valve can be reduced by an elastic effect of the synthetic resin film applied to the valve plate and hence, a striking sound can be reduced thus realizing the reduction of noises.

BRIEF DESCRIPTION OF DRAWINGS

[0027]

FIG. 1 is a cross-sectional view of a refrigerant compressor according to a first exemplary embodiment of the present invention.

FIG. 2 is an exploded perspective view showing a valve plate of the refrigerant compressor and parts around the valve plate according to the first exemplary embodiment of the present invention.

FIG. 3 is a cross-sectional view showing a main part of the refrigerant compressor according to the first exemplary embodiment of the present invention.

FIG. 4 is a plan view of a suction valve of the refrigerant compressor according to the first exemplary embodiment of the present invention.

FIG. 5 is a plan view of a discharge valve of the refrigerant compressor according to the first exemplary embodiment of the present invention.

FIG. 6 is a plan view of the valve plate on a suction side of the refrigerant compressor according to the first exemplary embodiment of the present invention.

FIG. 7 is a cross-sectional view of a synthetic resin film of the refrigerant compressor according to the first exemplary embodiment of the present invention.

FIG. 8 is a characteristic view showing a value of collision impact accompanying with opening and closing of a valve of the refrigerant compressor according to the first exemplary embodiment of the present invention.

FIG. 9 is a cross-sectional view of a main part of a refrigerant compressor according to a second exemplary embodiment of the present invention.

FIG. 10 is a plan view of a valve plate on a discharge side of the refrigerant compressor according to the second exemplary embodiment of the present invention.

FIG. 11 is a schematic view showing a configuration of a refrigeration appliance according to a third exemplary embodiment of the present invention.

FIG. 12 is a cross-sectional view of a refrigerant compressor according to a fourth exemplary embodiment of the present invention.

FIG. 13 is an exploded perspective view of a valve plate of the refrigerant compressor and parts around the valve plate according to the fourth exemplary embodiment of the present invention.

FIG. 14 is a cross-sectional view showing a main part of the valve plate of the refrigerant compressor according to the fourth exemplary embodiment of the present invention.

FIG. 15 is a plan view of the valve plate of the refrigerant compressor according to the fourth exemplary embodiment of the present invention.

FIG. 16 is a cross-sectional view showing a surface treatment film of the refrigerant compressor according to the fourth exemplary embodiment of the present invention.

FIG. 17 is a cross-sectional view of a main part of a valve plate of a refrigerant compressor according to a fifth exemplary embodiment of the present invention.

FIG. 18 is a plan view of the valve plate of the refrigerant compressor according to the fifth exemplary embodiment of the present invention.

FIG. 19 is a cross-sectional view of a main part of a valve plate of a refrigerant compressor according to a sixth exemplary embodiment of the present invention.

FIG. 20 is a plan view of the valve plate of the refrigerant compressor according to the sixth exemplary embodiment of the present invention.

FIG. 21A is a cross-sectional view of a main part of a valve plate of a refrigerant compressor according to a seventh exemplary embodiment of the present invention.

FIG. 21B is a cross-sectional view of the valve plate of the refrigerant compressor according to the seventh exemplary embodiment of the present invention.

FIG. 22 is a cross-sectional view of a conventional refrigerant compressor.

FIG. 23 is an exploded perspective view showing a valve plate and parts around the valve plate of the conventional refrigerant compressor.

DESCRIPTION OF EMBODIMENT

[0028] Hereinafter, exemplary embodiments of the present invention are described with reference to drawings. The present invention is not limited by these exemplary embodiments.

FIRST EXEMPLARY EMBODIMENT

[0029] FIG. 1 is a cross-sectional view of a refrigerant compressor according to a first exemplary embodiment of the present invention. FIG. 2 is an exploded perspective view showing a valve plate of the refrigerant compressor and parts around the valve plate according to the first exemplary embodiment of the present invention. FIG. 3 is a cross-sectional view showing a main part of the refrigerant compressor according to the first exemplary embodiment of the present invention. FIG. 4 is a plan view of a suction valve of the refrigerant compressor according to the first exemplary embodiment of the present invention. FIG. 5 is a plan view of a discharge valve of the refrigerant compressor according to the first exemplary embodiment of the present invention. FIG. 6 is a plan view of the valve plate on a suction side of the refrigerant compressor according to the first exemplary embodiment of the present invention. FIG. 7 is a cross-sectional view of a surface treatment applied to the refrigerant compressor according to the first exemplary embodiment of the present invention.

[0030] In FIG. 1 to FIG. 6, in the refrigerant compressor according to the first exemplary embodiment of the present invention, for example, mineral oil having low viscosity is accumulated on a bottom portion of sealed container 101 as refrigeration oil 102. For example, R600a or the like which is a hydrocarbon refrigerant having a low global warming coefficient is filled in sealed container 101 as working fluid 103.

[0031] Sealed container 101 is formed by drawing a steel plate. Sealed container 101 includes: suction pipe 150 having one end thereof communicating with the inside of sealed container 101 and the other end thereof connected to a low pressure side of a refrigeration cycle (not shown); and discharge pipe 157 having one end thereof penetrating sealed container 101 and communicating with a discharge muffler (not shown) and the other end thereof connected to a high pressure side of the refrigeration cycle (not shown).

[0032] In the inside of sealed container 101, compressor body 104 provided with compressive element 109 and electrically-operated element 106 is housed in a resiliently supported manner with respect to sealed container 101 by suspension spring 105.

[0033] Compressive element 109 is formed of crankshaft 112, block 115, piston 116, connecting portion 122, and the like. Crankshaft 112 includes eccentric shaft 110 and main shaft 111. Crankshaft 112 also includes oil supply mechanism 151 formed of a spiral groove formed on a surface of main shaft 111.

[0034] Electrically-operated element 106 is formed of stator 107 threadedly fixed to a lower side of block 115 by bolts (not shown), and rotor 108 which is disposed coaxially inside stator 107 and is fixed to main shaft 111 by shrinkage fitting. Electrically-operated element 106 is driven by an inverter drive circuit at a plurality of operation frequencies including an operation frequency (for example, 25Hz=1500r/min) below a commercial power source frequency.

[0035] In block 115, cylinder 114 which forms compression chamber 113 therein and bearing portion 123 which rotatably and pivotally supports main shaft 111 are integrally formed with each other.

[0036] On an end surface of cylinder 114 are mounted valve plate 117 which is is formed by molding using a sintered metal material and has suction hole 118 and discharge hole 119 which allow the inside and the outside of compression chamber 113 to communicate with each other; suction valve 120 which opens and closes suction hole 118; and cylinder head 152 which forms a lid for valve plate 117. All of valve plate 117, suction valve 120, and cylinder head 152 are pressed and fixed to the end surface of cylinder 114 by head bolts 153 so as to seal the end surface of cylinder 114. Suction muffler 154 is held and fixed between valve plate 117 and cylinder head 152.

[0037] Suction valve seat 141 is formed around suction hole 118 of valve plate 117 such that suction valve seat 141 surrounds suction hole 118, and discharge valve seat 142 is formed around discharge hole 119 such that discharge valve seat 142 surrounds discharge hole 119.

[0038] Suction valve 120 includes opening and closing portion 120a which opens and closes suction hole 118, and arm portion 120b to be operated along with opening and closing of opening and closing portion 120a.

[0039] Further, on a surface of valve plate 117 disposed on cylinder head 152 side, a discharge valve unit is mounted. The discharge valve unit is formed of spring lead 130 on which discharge valve 121 which opens and closes discharge hole 119 is disposed and which resiliently supports discharge valve 121; and valve stop 131 which fixes discharge valve 121 and spring lead 130. Head space 156 is formed by valve plate 117 and cylinder head 152.

[0040] Discharge valve 121 includes opening and closing portion 121a which opens and closes discharge hole 119, and arm portion 121b to be operated along with opening and closing of opening and closing portion 121a.

[0041] The operation and function of the refrigerant compressor having the above-mentioned configuration are described hereinafter.

[0042] In the refrigerant compressor, when a magnetic field is generated by supplying an electric current to stator 107 so that rotor 108 fixed to main shaft 111 is rotated, crankshaft 112 is rotated, and piston 116 reciprocates in cylinder 114 by way of connecting portion 122 rotatably mounted on eccentric shaft 110. Along with the reciprocating movement of piston 116, working fluid 103 is sucked into compression chamber 113 through suction muffler 154, and after being compressed, working fluid 103 is discharged to a refrigeration cycle (not shown) through discharge hole 119 and head space 156.

[0043] Next, a suction stroke, a compression stroke, and a discharge stroke of compressor body 104 are described.

[0044] In the suction stroke, when piston 116 is operated in a direction that a volume of compression chamber 113 is increased, working fluid 103 in the inside of compression chamber 113 is expanded, and a pressure in compression chamber 113 becomes lower than a pressure in suction muffler 154, due to the difference between the pressure in compression chamber 113 and the pressure in suction muffler 154, suction valve 120 is started to open. Then, arm portion 120b of suction valve 120 is operated and hence, working fluid 103 of a low temperature which has returned from the refrigeration cycle (not shown) is temporarily released into sealed container 101 from suction pipe 150 and, thereafter, flows into compression chamber 113 through suction muffler 154.

[0045] Thereafter, in the compression stroke, when piston 116 turns the direction of movement to the direction that the capacity of compression chamber 113 is decreased from the bottom dead center, the pressure in compression chamber 113 is elevated, and due to the difference between the pressure in compression chamber 113 and the pressure in suction muffler 154, suction valve 120 is closed. Then, compression chamber 113 is closed, and piston 116 is operated in the direction that the volume of compression chamber 113 is decreased and hence, working fluid 103 is compressed, and the pressure in compression chamber 113 is elevated to a predetermined pressure.

[0046] Then, in the discharge stroke, when the pressure of working fluid 103 in compression chamber 113 is elevated and becomes higher than a pressure in head space 156 formed by valve plate 117 and cylinder head 152. When a force generated by the pressure difference exceeds a force for resiliently deforming discharge valve 121, discharge hole 119 is opened. Then, arm portion 121b of discharge valve 121 is operated and hence, working fluid 103 in compression chamber 113 passes through discharge hole 119 and flows out into head space 156.

[0047] Thereafter, working fluid 103 passes through a discharge muffler (not shown) from head space 156, and is discharged to a high-pressure side of the refrigeration cycle (not shown) through discharge pipe 157.

[0048] When the pressure difference between head space 156 and compression chamber 113 is decreased, a force which is generated by the pressure difference and is applied to discharge valve 121 becomes smaller than a restoring force of spring lead 130 and discharge valve 121, discharge valve 121 is closed so that compression chamber 113 is closed. As a result, piston 116 moves in a direction toward the bottom dead center, and the refrigerant compressor is shifted to the suction stroke again.

[0049] In the refrigerant compressor of this exemplary embodiment, synthetic resin film 160 is formed on at least a region of valve plate 117 which is brought into contact with arm portion 121b of suction valve 120.

[0050] Synthetic resin film 160 contains a synthetic resin made of fluororubber as binder 161, and contains a fluororesin as solid lubricant 162 in an approximately-uniformly scattered manner.

[0051] Synthetic resin film 160 having the above-mentioned structure is formed by a following method.

[0052] Firstly, a temperature of valve plate 117 is elevated to a predetermined temperature by applying preheating to valve plate 117. The preheating is performed for evaporating a solvent dissolved in synthetic resin film 160 which is applied by coating to the region of valve plate 117 which is brought into contact with arm portion 120b of suction valve 120 thus applying synthetic resin film 160 to valve plate 117 uniformly.

[0053] A surface treatment agent which contains solid lubricant 162 and whose composition is adjusted is applied by spraying to the region of valve plate 117 which is brought into contact with arm portion 120b of suction valve 120. In applying the surface treatment agent, a masking jig having a shape suitable for preventing adhesion of a coating agent to an undesired place is mounted on valve plate 117.

[0054] Thereafter, preliminary drying is performed for several minutes at a temperature substantially equal to a temperature used at the time of preheating thus drying a surface of synthetic resin film 160. By applying light buffing to the surface at a stage where the surface of synthetic resin film 160 is dried, a surface roughness of an outermost surface of synthetic resin film 160 is finely adjusted and hence, a favorable surface condition can be obtained.

[0055] Although nylon buffing which contains abrasive grains and buffing which uses relatively hard steel may be considered as buffing, it is desirable to apply horsehair buffing to synthetic resin film 160.

[0056] Lastly, the synthetic resin film is baked at a temperature of approximately 150°C to 230°C for approximately 30 minutes to 2 hours. With such baking, all diluent in the coating agent is evaporated so that synthetic resin film 160 can be completely fixedly adhered to the region of valve plate 117 which is brought into contact with arm portion 120b of suction valve 120.

[0057] In general, suction valve seat 141 and discharge valve seat 142 are formed on valve plate 117 so that valve plate 117 has a complicated shape whereby valve plate 117 is made of a sintered metal material for enhancing productivity and the reduction of cost.

[0058] However, usually, a sintered metal material is formed by molding by a filling powdery metal into a mold, by applying a pressure to the metal powder and by heating a metal powder compact and hence, open pores which continuously communicate with a surface and the inside of the sintered metal material are present in the sintered metal material in a scattered manner. Accordingly, when refrigeration oil 102 in the refrigerant compressor pools on a surface of valve plate 117 and impregnates into the inside of valve plate 117. Impregnated refrigeration oil 102 exudes to the surface of valve plate 117 due to a change in pressure or the like. Such refrigeration oil 102 is interposed in a gap formed between valve plate 117 and arm portion 120b of suction valve 120. An adhesion force is generated due to refrigeration oil 102 interposed in the gap, and this adhesion force sucks arm portion 120b of suction valve 120 to valve plate 117.

[0059] Accordingly, an amount of an extra force for removing an adhesion force becomes necessary to ensure an operation of suction valve 120 and hence, a valve opening operation of suction valve 120 is obstructed whereby delay in opening is generated. As a result, a pressure loss is generated thus giving rise to a drawback that efficiency of the refrigerant compressor is lowered.

[0060] To overcome this drawback, by repeating a pressure applying step and a heating step for molding a sintered metal material plural times, density of the sintered metal material can be increased so that open pores can be made small. However, such a process increases a manufacturing cost and also workability is deteriorated. On the other hand, when a cast iron material is used, a number of portions to be worked increases so that a working cost is pushed up.

[0061] In view of the above, in this exemplary embodiment, synthetic resin film 160 is formed on at least the region of valve plate 117 which is brought into contact with arm portion 120b of suction valve 120.

[0062] With such a configuration, open pores peculiar to a sintered metal material can be sealed by synthetic resin film 160. Further, by applying synthetic resin film 160 to valve plate 117, oil repellency of a surface of valve plate 117 can be made higher than that of a metal surface.

[0063] Due to these actions, it is possible to suppress delay in opening of suction valve 120 caused by an adhesive force generated by refrigeration oil 102 interposed in a gap formed between valve plate 117 and arm portion 120b of suction valve 120. Accordingly, a pressure loss in a suction stroke can be reduced and hence, compressor efficiency of the refrigerant compressor can be enhanced.

[0064] This advantageous effect is also confirmed by the observation of behavior of suction valve 120 by an actual refrigerant compressor. The description is made hereinafter based on result shown in FIG. 8.

[0065] FIG. 8 shows the result of the measurement of an impact generated by opening and closing of a valve obtained by an acceleration pickup. A indicates the result obtained with respect to a refrigerant compressor of the present invention which uses valve plate 117 on which synthetic resin film 160 is formed, and B indicates the result obtained with respect to a conventional refrigerant compressor which uses valve plate 117 on which synthetic resin film 160 is not formed.

[0066] As shown in FIG. 6, it is understood that an impact is generated at an earlier rotational angle in the valve plate on which the synthetic resin film is formed than that of the conventional valve plate. That is, the valve plate to which surface treatment is applied exhibits earlier timing at which suction valve 120 opens compared to the conventional valve plate and hence, it is proved that delay in opening of suction valve 120 can be suppressed.

[0067] Next, to compare and study oil repellency of synthetic resin film 160 and oil repellency of a metal surface, a spreading speed of refrigeration oil 102 on valve plate 117 on which synthetic resin film 160 is formed is compared with a spreading speed of refrigeration oil 102 on conventional valve plate 117 on which synthetic resin film 160 is not formed.

[0068] Refrigeration oil 102 is dropped on the respective surfaces, and a speed at which refrigeration oil 102 spreads is measured. As a result, it is confirmed that valve plate 117 on which synthetic resin film 160 is formed exhibits a slower spreading speed than that of the conventional valve plate 117 on which synthetic resin film 160 is not formed by 10% or more. When oil repellency is high, the flow of refrigeration oil 102 is suppressed so that a spreading speed of refrigeration oil 102 is lowered. This observation of behavior proves that valve plate 117 on which synthetic resin film 160 is formed exhibits higher oil repellency.

[0069] From the above-mentioned result of study, the inventors of the present invention have found that delay in opening of suction valve 120 can be decreased by forming synthetic resin film 160 on the region of valve plate 117 which is brought into contact with arm portion 120b of suction valve 120.

[0070] On the other hand, as a conventional technique of decreasing delay in opening, there has been known a technique which lowers the rigidity of suction valve 120 by decreasing a thickness of suction valve 120 or narrowing a width of arm portion 120b. However, when the rigidity of suction valve 120 is lowered, durability of suction valve 120 against repeated operations is lowered so that suction valve 120 is liable to be broken. That is, a lifetime of the refrigerant compressor is lowered.

[0071] When the rigidity of suction valve 120 is lowered, a timing at which suction valve 120 opens becomes earlier. However, a time necessary for closing suction valve 120 becomes longer to the contrary. That is, delay occurs in closing suction valve 120. When delay in closing occurs, a leakage occurs in a compression stroke so that refrigerating ability is lowered.

[0072] However, according to the present invention, delay in opening can be decreased without lowering rigidity of suction valve 120 and hence, it is possible to provide a refrigerant compressor which can enhance compressor efficiency without lowering a lifetime of suction valve 120.

[0073] Next, the description is made with respect to a phenomenon that a striking sound occurs between suction valve 120 and valve plate 117 when suction valve 120 is closed, and noises are generated due to leakage of the striking sound to the outside of sealed container 101. Particularly, electrically-operated element 106 adopts inverter driving to satisfy a demand for high efficiency so that electrically-operated element 106 is operated at a low speed whereby noises which electrically-operated element 106 generates are decreased. As a result, a striking sound generated between valve plate

117 and suction valve 120 becomes conspicuous thus making a noise problem more serious. Further, this type of refrigerant compressor is mounted on the household-use refrigerator and is installed indoors in most cases and hence, the reduction of noises is indispensable.

[0074] According to this exemplary embodiment, a striking force generated between valve plate 117 and suction valve 120 at the time of closing suction valve 120 can be reduced due to an elastic effect of synthetic resin film 160 applied to valve plate 117 and hence, the striking sound can be reduced so that it is possible to provide a refrigerant compressor which can realize low noises.

[0075] Further, due to the reduction of a striking force generated between valve plate 117 and suction valve 120 at the time of closing suction valve 120, breaking such as cracks or chippings of suction valve 120 can be suppressed and hence, it is possible to provide a highly reliable refrigerant compressor.

[0076] Synthetic resin film 160 uses fluororubber as a binder, and a fluororesin as solid lubricant 162. Synthetic resin film 160 which uses fluorine exhibits high resiliency compared to other synthetic resin films 160, and exhibits high oil repellency property. On the other hand, the utilization of synthetic resin film 160 which uses fluorine to equipment which uses refrigerant oil has been limited due to high oil repellency of synthetic resin film 160.

[0077] According to the present invention, the inventors of the present invention have realized the utilization of synthetic resin film 160 by specifying portions which are not required to surely possess lubrication property by refrigerant oil and sealing property. With such a configuration, resiliency of synthetic resin film 160 can be further enhanced and hence, a striking sound can be further reduced so that it is possible to provide a refrigerant compressor which can realize low noises.

[0078] Further, oil repellency can be also enhanced and hence, delay in opening can be effectively suppressed whereby it is possible to provide a refrigerant compressor which can enhance compressor efficiency.

[0079] Since synthetic resin film 160 contains solid lubricant 162, a shearing force generated when valve plate 117 and suction valve 120 are closed is reduced due to a lubrication effect of solid lubricant 162. Accordingly, peeling off of synthetic resin film 160 applied to valve plate 117 from a surface of a base material of valve plate 117 can be suppressed and hence, it is possible to provide a refrigerant compressor which exhibits high durability for a long period.

[0080] In this exemplary embodiment, with respect to the structure of synthetic resin film 160, as binder 161, a synthetic resin made of fluororubber is used. However, with the use of a polyamide-imide resin, an epoxy resin, or a phenol resin which is a thermosetting resin and possesses excellent oil resistance, heat resistance, refrigerant resistance, and organic solvent resistance, it is possible to acquire substantially the same advantageous effects as fluororubber.

[0081] In this exemplary embodiment, as solid lubricant 162 scattered in synthetic resin film 160, a fluororesin is used. However, even with the use of molybdenum disulfide (MoS2), polytetrafluoroethylene resin (PTFE), and graphite (C) in a single form or in mixture, it is possible to acquire substantially the same advantageous effects as a fluororesin.

[0082] Further, when molybdenum disulfide or graphite is used as solid lubricant 162, by using antimony trioxide (Sb2O3) together with these materials, antimony trioxide captures air and oxygen which intrude into synthetic resin film 160 and these materials per se are oxidized first so that the degradation by oxidation of solid lubricant 162 in synthetic resin film 160 can be suppressed so that synthetic resin film 160 can sufficiently exhibit a wear suppression effect.

[0083] In this exemplary embodiment, with the use of an appropriate masking jig, a pneumatic-cylinder-type dispenser device or the like, it is possible to apply synthetic resin film 160 by coating only to portions which require synthetic resin film 160 and hence, a coating amount can be reduced whereby productivity of a refrigerant compressor can be enhanced, and the reduction of cost can be achieved.

[0084] A total film thickness of synthetic resin film 160 is set to a value which falls within a range of 1 μm to 100 μm. Particularly, when the total film thickness of synthetic resin film 160 is set to a value which falls within a range of 20 μm to 70 μm, synthetic resin film 160 can acquire the most balanced specification. This is because synthetic resin film 160 contains fluororubber as a binder and a fluororesin as the solid lubricant and hence, even when a film thickness is increased, in-film strength of synthetic resin film 160 and adhesion strength of synthetic resin film 160 with an interface of the base material can be maintained. Accordingly, a striking sound reduction effect can be increased, and wear and peeling off of synthetic resin film 160 can be also suppressed. Accordingly, it is possible to provide a refrigerant compressor which can reduce surface roughness of synthetic resin film 160 while ensuring durability thus exhibiting high productivity while ensuring reliability for a long period.

[0085] It is needless to say that substantially the same advantageous effects can be acquired even when synthetic resin film 160 is applied to arm portion 120b of suction valve 120 in the same manner. Further, in this case, rigidity of arm portion 120b of suction valve 120 can be increased and hence, delay in closing suction valve 120 can be suppressed. Accordingly, the backflow of a sucked refrigerant gas can be prevented, and a volume efficiency can be enhanced and hence, compressor efficiency of the refrigerant compressor can be enhanced.

SECOND EXEMPLARY EMBODIMENT

[0086] FIG. 9 is a cross-sectional view of a main part of a refrigerant compressor according to a second exemplary embodiment of the present invention. FIG. 10 is a plan view of a valve plate on a discharge side of the refrigerant compressor according to the second exemplary embodiment of the present invention.

[0087] The basic configuration of this exemplary embodiment is equal to the configuration in FIG. 1 to FIG. 5 showing the first exemplary embodiment of the present invention and hence, the description of the basic configuration of this exemplary embodiment is omitted. The constitutional parts identical with the constitutional parts described in FIG. 1 to FIG. 5 are given the same symbols, and the description of these constitutional parts is partially omitted.

[0088] In the refrigerant compressor of this exemplary embodiment, synthetic resin film 160 is formed on at least a region of valve plate 117 which is brought into contact with arm portion 121b (see FIG. 5) of discharge valve 121.

[0089] Synthetic resin film 160 contains a synthetic resin made of fluororubber as binder 161, and contains a fluororesin as solid lubricant 162 in an approximately-uniformly scattered manner.

[0090] With such a configuration, open pores peculiar to a sintered metal material can be sealed by synthetic resin film 160. Further, by applying synthetic resin film 160 to valve plate 117, oil repellency of a surface of valve plate 117 can be made higher than that of a metal surface.

[0091] Due to these actions, it is possible to suppress delay in opening of discharge valve 121 caused by an adhesive force generated by refrigeration oil 102 interposed in the gap formed between valve plate 117 and arm portion 121b of discharge valve 121. Accordingly, a pressure loss in a discharge stroke can be reduced and hence, compressor efficiency of the refrigerant compressor can be enhanced.

[0092] This advantageous effect is also confirmed by the observation of behavior of discharge valve 121 by an actual refrigerant compressor. The description is made hereinafter based on the result shown in FIG. 8. FIG. 8 shows the result of the measurement of an impact generated by opening and closing of a valve obtained by an acceleration pickup. A indicates the result obtained with respect to a refrigerant compressor of the present invention which uses valve plate 117 on which synthetic resin film 160 is formed, and B indicates the result obtained with respect to a conventional refrigerant compressor which uses valve plate 117 on which synthetic resin film 160 is not formed.

[0093] As shown in FIG. 8, it is understood that an impact is generated at an earlier rotational angle in the valve plate on which the synthetic resin film is formed than that of the conventional valve plate. That is, it is proved that the valve plate to which the surface treatment is applied exhibits earlier timing at which discharge valve 121 opens compared to the conventional valve plate, and delay in opening of discharge valve 121 can be suppressed.

[0094] Next, to compare and study oil repellency of synthetic resin film 160 and oil repellency of a metal surface, a spreading speed of refrigeration oil 102 on valve plate 117 on which synthetic resin film 160 is formed is compared with a spreading speed of refrigeration oil 102 on conventional valve plate 117 on which synthetic resin film 160 is not formed.

[0095] Refrigeration oil 102 is dropped on the respective surfaces, and a speed at which refrigeration oil 102 spreads is measured. As a result, it is confirmed that valve plate 117 on which synthetic resin film 160 is formed exhibits a slower spreading speed than that of the conventional valve plate 117 on which synthetic resin film 160 is not formed by 10% or above. When oil repellency is high, the flow of refrigeration oil 102 is suppressed so that a spreading speed of refrigeration oil 102 is lowered. This observation of behavior proves that valve plate 117 on which synthetic resin film 160 is formed exhibits higher oil repellency.

[0096] From the above-mentioned study of the result, the inventors of the present invention have found that delay in opening of discharge valve 121 can be decreased by forming synthetic resin film 160 on the region of valve plate 117 which is brought into contact with arm portion 121b of discharge valve 121.

[0097] On the other hand, as a conventional technique of decreasing delay in opening, there has been known a technique which lowers the rigidity of discharge valve 121 by decreasing a thickness of discharge valve 121 or by narrowing a width of arm portion 121b. However, when the rigidity of discharge valve 121 is lowered, durability of discharge valve 121 against repeated operations is lowered so that discharge valve 121 is liable to be broken. That is, a lifetime of the refrigerant compressor is lowered.

[0098] When the rigidity of discharge valve 121 is lowered, a timing at which discharge valve 121 opens becomes earlier. However, a time necessary for closing discharge valve 121 becomes longer to the contrary. That is, delay occurs in closing discharge valve 121. When delay in closing occurs, the backflow of a refrigerant occurs in a suction stroke so that a re-expansion loss is increased.

[0099] However, according to the present invention, delay in opening can be decreased without lowering rigidity of discharge valve 121 and hence, it is possible to provide a refrigerant compressor which can enhance compressor efficiency without lowering a lifetime of discharge valve 121.

[0100] Next, the description is made with respect to a phenomenon that a striking sound occurs between discharge valve 121 and valve plate 117 when discharge valve 121 is closed, and noises are generated due to leakage of the striking sound to the outside of sealed container 101. Particularly, electrically-operated element 106 adopts inverter driving to satisfy a demand for high efficiency so that electrically-operated element 106 is operated at a low speed whereby noises which electrically-operated element 106 generate are decreased. As a result, a striking sound generated between valve plate 117 and discharge valve 121 becomes conspicuous thus making a noise problem more serious. Further, this type of refrigerant compressor is mounted on the household-use refrigerator and is installed indoors in most cases and hence, the reduction of noises is indispensable.

[0101] According to this exemplary embodiment, a striking force generated between valve plate 117 and discharge valve 121 at the time of closing discharge valve 121 can be reduced due to an elastic effect of synthetic resin film 160 applied to valve plate 117 and hence, the striking sound can be reduced so that it is possible to provide a refrigerant compressor which can realize low noises.

[0102] It is needless to say that substantially the same advantageous effects can be acquired even when synthetic resin film 160 is applied to arm portion 121b of discharge valve 121 in the same manner. Further, in this case, rigidity of arm portion 121b of discharge valve 121 can be increased and hence, delay in closing discharge valve 121 can be suppressed. Accordingly, the backflow of a discharged refrigerant gas can be prevented, and a re-expansion loss can be decreased and hence, compressor efficiency of the refrigerant compressor can be enhanced.

THIRD EXEMPLARY EMBODIMENT

[0103] FIG. 11 is a schematic view showing a configuration of a refrigeration appliance according to a third exemplary embodiment of the present invention. In this exemplary embodiment, the refrigeration appliance has a configuration that the refrigerant compressor described in the first exemplary embodiment or the second exemplary embodiment of the present invention is mounted on a refrigerant circuit, and only the basic configuration of the refrigeration appliance is schematically described.

[0104] In FIG. 11, the refrigeration appliance includes: body 201 formed of a heat-insulating box body having one surface thereof opened and a door body which opens and closes the opening; partition wall 207 which partitions the inside of body 201 into article storage space 203 and machine chamber 205; and refrigerant circuit 209 which cools the inside of storage space 203.

[0105] Refrigerant circuit 209 is formed by annularly connecting the refrigerant compressor described in the first exemplary embodiment or the second exemplary embodiment as compressor 211, radiator 213, pressure reduction device 215, and heat absorber 217 by a pipe.

[0106] Heat absorber 217 is disposed in the inside of storage space 203 equipped with a blower (not shown). Cooling heat of heat absorber 217 is stirred by the blower so that cooling heat circulates in storage space 203 as indicated by an arrow. With such an operation, storage space 203 is cooled.

[0107] On the refrigeration appliance described above, the refrigerant compressor according to the first exemplary embodiment or the second exemplary embodiment of the present invention is mounted as compressor 211. Compressor 211 is configured such that synthetic resin film 160 is formed on the region of valve plate 117 which is brought into contact with arm portion 120b of suction valve 120 or on the region of valve plate 117 which is brought into contact with arm portion 121b of discharge valve 121. With such a configuration, delay in opening of suction valve 120 or delay in opening of discharge valve 121 caused by an adhesive force generated by refrigeration oil 102 can be suppressed thus reducing a pressure loss in a suction stroke and a discharge stroke and hence, compressor efficiency is enhanced and, at the same time, a striking sound generated at the time of closing suction valve 120 and discharge valve 121 can be reduced due to an elastic effect of synthetic resin film 160. Accordingly, the reduction of noises can be realized and hence, power consumption of the refrigeration appliance can be reduced thus realizing the energy saving and, at the same time, the reduction of noises.

FOURTH EXEMPLARY EMBODIMENT

[0108] FIG. 12 is a cross-sectional view of a refrigerant compressor according to a fourth exemplary embodiment of the present invention. FIG. 2 is an exploded perspective view of a valve plate of the refrigerant compressor and parts around the valve plate according to the fourth exemplary embodiment of the present invention. FIG. 12 is a cross-sectional view of a main part of the valve plate of the refrigerant compressor according to the fourth exemplary embodiment of the present invention. FIG. 13 is a plan view of the valve plate of the refrigerant compressor according to the fourth exemplary embodiment of the present invention. FIG. 14 is a cross-sectional view showing a surface treatment film of the refrigerant compressor according to the fourth exemplary embodiment of the present invention.

[0109] As shown in FIG. 12 to FIG. 15, in the refrigerant compressor according to this exemplary embodiment, for example, mineral oil having low viscosity is accumulated on a bottom portion of sealed container 301 as refrigeration oil 302. For example, R600a or the like which is a hydrocarbon refrigerant having a low global warming coefficient is filled in sealed container 301 as working fluid 303.

[0110] Sealed container 301 is formed by drawing a steel plate. Sealed container 301 includes: suction pipe 350 having one end thereof communicating with the inside of sealed container 301 and the other end thereof connected to a low pressure side of a refrigeration cycle (not shown); and discharge pipe 357 which has one end thereof penetrating sealed container 301 and communicating with a discharge muffler (not shown) and the other end thereof connected to a high pressure side of the refrigeration cycle (not shown).

[0111] In the inside of sealed container 301, compressor body 304 which is provided with compressive element 309 and electrically-operated element 306 is housed in a resiliently supported manner with respect to sealed container 301 by suspension spring 305.

[0112] Compressive element 309 is formed of crankshaft 312, block 315, piston 316, connecting portion 322, and the like. Crankshaft 312 includes eccentric shaft 310 and main shaft 311. Crankshaft 312 also includes oil supply mechanism 351 formed of a spiral groove or the like formed on a surface of main shaft 311.

[0113] Electrically-operated element 306 is formed of: stator 307 which is threadedly fixed to a lower side of block 315 by bolts (not shown), and rotor 308 which is disposed coaxially inside stator 307 and is fixed to main shaft 311 by shrinkage fitting. Electrically-operated element 306 is driven by an inverter drive circuit at a plurality of operation frequencies including an operation frequency (for example, 25Hz=1500r/min) below a commercial power frequency.

[0114] In block 315, cylinder 314 which forms compression chamber 313 therein and bearing portion 323 which rotatably and pivotally supports main shaft 311 are integrally formed with each other.

[0115] On an end surface of cylinder 314 are mounted valve plate 317 which has suction hole 318 and discharge hole 319 which allow the inside and the outside of compression chamber 313 to communicate with each other; and suction valve 320 which opens and closes suction hole 318. Further, cylinder head 352 which seals valve plate 317 is also pressed and fixed to the end surface of cylinder 314 by head bolts 353 so as to seal the end surface of cylinder 314. Suction muffler 354 is held and fixed between valve plate 317 and cylinder head 352.

[0116] Suction valve 320 is made of a spring steel material and a stainless steel material. Suction valve 320 is formed of: fixed portion 320a which is fixed to valve plate 317; opening and closing portion 320b which opens and closes suction hole 318 formed in valve plate 317; and arm portion 320c which connects fixed portion 320a and opening and closing portion 320b to each other.

[0117] Valve plate 317 is formed by molding using a sintered metal material. On a surface of valve plate 317 disposed on a cylinder head 352 side, discharge valve 321 which opens and closes discharge hole 319 is disposed. Valve plate 317 further includes a discharge valve unit which is formed of spring lead 330 which resiliently supports discharge valve 321, and valve stop 331 which fixes discharge valve 321 and spring lead 330 to each other. Head space 356 is formed by valve plate 317 and cylinder head 352.

[0118] The operation and function of a reciprocation compressor having the above-mentioned configuration are described hereinafter.

[0119] In the refrigerant compressor, when a magnetic field is generated by supplying an electric current to stator 307 so that rotor 308 fixed to main shaft 311 is rotated, crankshaft 312 is rotated, and piston 316 reciprocates in cylinder 314 by way of connecting portion 322 mounted on eccentric shaft 310 in a rotatable manner. Along with the reciprocating movement of piston 316, working fluid 303 is sucked into compression chamber 313 through suction muffler 354, and after being compressed, working fluid 303 is discharged to a refrigeration cycle (not shown) through discharge hole 319 and head space 356.

[0120] Next, a suction stroke, a compression stroke, and a discharge stroke of compressor body 304 are described.

[0121] In the suction stroke, when piston 316 is operated in a direction that a volume of compression chamber 313 is increased, working fluid 303 in the inside of compression chamber 313 is expanded. When a pressure in compression chamber 313 becomes lower than a pressure in suction muffler 354, due to the difference between the pressure in compression chamber 313 and the pressure in suction muffler 354, suction valve 320 is started to open. Then, working fluid 303 of a low temperature which has returned from the refrigeration cycle is temporarily released into sealed container 301 from suction pipe 350 and, thereafter, working fluid 303 flows into compression chamber 313 through suction muffler 354.

[0122] Thereafter, in the compression stroke, when piston 316 turns the direction of movement to the direction that the capacity of compression chamber 313 is decreased from the bottom dead center, the pressure in compression chamber 313 is elevated. Due to the difference between the pressure in compression chamber 313 and the pressure in suction muffler 354, suction valve 320 is closed. Then, compression chamber 313 is closed, and piston 316 is operated in the direction that the volume of compression chamber 313 is decreased and hence, working fluid 303 is compressed, and the pressure in compression chamber 313 is elevated to a predetermined pressure.

[0123] Then, in the discharge stroke, when the pressure of working fluid 303 in compression chamber 313 is elevated and becomes higher than a pressure in head space 356 formed by valve plate 317 and cylinder head 352. When a force generated by the pressure difference exceeds a force for resiliently deforming discharge valve 321, discharge hole 319 is opened. Then, working fluid 303 in compression chamber 313 passes through discharge hole 319 and flows out into head space 356. Working fluid 303 passes through a discharge muffler (not shown) from head space 356, and is discharged to a high-pressure side of the refrigeration cycle (not shown) through discharge pipe 357.

[0124] When the pressure difference between head space 356 and compression chamber 313 is decreased, and a force which is generated by the pressure difference and is applied to discharge valve 321 becomes smaller than a restoring force of spring lead 330 and discharge valve 321, discharge valve 321 is closed so that compression chamber 313 is closed. As a result, piston 316 moves in a direction toward the bottom dead center, and the refrigerant compressor is shifted to the suction stroke again.

[0125] In the refrigerant compressor of this exemplary embodiment, as shown in FIG. 14 to FIG. 16, surface treatment film 360 which contains synthetic resin 361 is formed on a region of valve plate 317 which is formed by molding using a sintered metal material and opposes arm portion 320c of suction valve 320.

[0126] Surface treatment film 360 contains synthetic resin 361 made of polyamide-imide (PAI) as a binder, and also contains molybdenum disulfide which is solid lubricant 362 in a substantially uniformly scattered manner.

[0127] Surface treatment film 360 having the above-mentioned structure is formed by a following method.

[0128] Firstly, a temperature of valve plate 317 is elevated to a predetermined temperature by applying preheating to valve plate 317. The preheating is performed for evaporating a solvent dissolved in surface treatment film 360 which is applied by coating to the region of valve plate 317 which opposedly faces arm portion 320c thus applying surface treatment film 360 to valve plate 317 uniformly.

[0129] Next, a surface treatment agent which contains solid lubricant 362 and whose composition is adjusted is applied by spraying to the region of valve plate 317 which opposes arm portion 320c of suction valve 320. In applying the surface treatment agent, a masking jig having a shape suitable for preventing adhesion of a coating agent to an undesired place is mounted on valve plate 317.

[0130] Thereafter, preliminary drying is performed for several minutes at a temperature substantially equal to a temperature used at the time of preheating thus drying a surface of surface treatment film 360. By applying light buffing to the surface at a stage where the surface of surface treatment film 360 is dried, a surface roughness of an outermost surface of surface treatment film 360 is finely adjusted and hence, a favorable surface condition can be obtained. Although nylon buffing which contains abrasive grains and buffing which uses relatively hard steel may be considered as buffing, it is desirable to apply horsehair buffing to surface treatment film 360.

[0131] Lastly, the surface treatment film is baked at a temperature of approximately 180°C to 230°C for approximately 30 minutes to 2 hours. With such baking, all diluent in the coating agent is evaporated so that surface treatment film 360 can be completely fixedly adhered to the region of valve plate 317 which opposes arm portion 320c of suction valve 320.

[0132] In general, suction valve seat 341, discharge valve seat 342, and the like are formed on valve plate 317 so that valve plate 317 has a non-uniform thickness and a complicated shape whereby valve plate 317 is formed by molding using a sintered metal material for enhancing productivity and the reduction of cost. Further, recessed portion 332 is formed on valve plate 317 on a side opposite to the suction valve seat for mounting the discharge valve unit having discharge valve 321 on valve plate 317, and valve plate 317 has a convex shape toward a suction valve 320 side (for example, projecting approximately 10 μm to 100 μm) due to a working strain or the like.

[0133] Accordingly, when suction valve 320 closes suction hole 318 formed in valve plate 317, arm portion 320c of suction valve 320 is brought into contact with valve plate 317 at a position in the vicinity of a peak portion of the convex shape of valve plate 317 and, thereafter, opening and closing portion 320b closes suction hole 318 and hence, a striking force is generated due to a contact of arm portion 320c with valve plate 317.

[0134] Further, there is a possibility that arm portion 320c of suction valve 320 is broken thus bringing about a compression failure. That is, as described previously, to satisfy a recent demand for high efficiency, the refrigerant compressor is in a situation where a wall thickness of suction valve 320 made of a spring steel material is reduced, and the refrigerant compressor is operated in a variable-speed rotation mode available by adopting inverter driving so that metal fatigue is accumulated more in suction valve 320. Accordingly, when the refrigerant compressor having such a configuration is used for a long time, arm portion 320c of suction valve 320 is broken thus bringing about compression failure.

[0135] To overcome such a drawback, conventionally, it has been proposed a technique where a thickness of valve plate 317 is increased so as to increase rigidity of valve plate 317 thus suppressing deformation of valve plate 317 caused by working. However, in such a technique, a volume in discharge hole 319 is increased so that a compressed refrigerant is re-expanded whereby performance of the refrigerant compressor is lowered.

[0136] Accordingly, in this exemplary embodiment, by applying surface treatment film 360 which contains synthetic resin 361 to the region of valve plate 317 which opposes arm portion 320c of suction valve 320, valve plate 317 has a convex shape toward a suction valve 320 side and hence, when suction valve 320 closes suction hole 318, arm portion 320c of suction valve 320 is brought into contact with valve plate 317 at a position in the vicinity of the peak portion of the convex shape. Accordingly, even when a striking force is generated, the striking force is attenuated due to an elastic effect of surface treatment film 360 which contains synthetic resin 361 and is applied to the region of valve plate 317 which opposes arm portion 320c of suction valve 320. Further, the breaking of suction valve 320 brought about by the striking force can be prevented.

[0137] With such a configuration, it is possible to provide a highly reliable refrigerant compressor and a refrigeration appliance using the refrigerant compressor.

[0138] A total thickness of surface treatment film 360 which contains synthetic resin 361 is set to a value which falls within a range of 1 μm to 50 μm. By setting the total film thickness to 1 μm or more, the refrigerant compressor can acquire a striking force reducing effect due to an elastic effect, and surface treatment film 360 can be uniformly formed. Further, by setting the total film thickness to 50 μm or less, the refrigerant compressor can ensure both in-film strength of surface treatment film 360 and adhesion strength of surface treatment film 360 with an interface of a base material of valve plate 317, and surface size tolerance and surface roughening of surface treatment film 360 can be suppressed while ensuring durability. Accordingly, it is possible to provide a refrigerant compressor which exhibits excellent productivity in addition to ensuring reliability for a long period by suppressing wear and peeling-off of surface treatment film 360. It is also possible to provide the refrigeration appliance using the refrigerant compressor.

[0139] In this exemplary embodiment, synthetic resin 361 made of polyamide-imide is used as a binder of surface treatment film 360. However, also with the use of an epoxy resin or a phenol resin which is a thermosetting resin and possesses excellent oil resistance, heat resistance, refrigerant resistance, and organic solvent resistance, it is possible to acquire substantially the same advantageous effects as polyamide-imide.

[0140] In surface treatment film 360 in this exemplary embodiment, as solid lubricant 362 scattered in synthetic resin film 360, molybdenum disulfide (MoS2) is used. However, also with the use of polytetrafluoroethylene (PTFE) and graphite (C) in a single form or in mixture, it is possible to acquire substantially the same advantageous effects as molybdenum disulfide (MoS2).

[0141] Further, when molybdenum disulfide or graphite is used as solid lubricant 362, by using antimony trioxide (Sb2O3) together with these materials, antimony trioxide captures air and oxygen which intrude into surface treatment film 360 and these materials per se are oxidized first so that the degradation by oxidation of solid lubricant 362 in surface treatment film 360 can be suppressed so that surface treatment film 360 can sufficiently exhibit a wear suppression effect. Accordingly, the use of antimony trioxide is effective.

[0142] In this exemplary embodiment, with the use of an appropriate masking jig or a pneumatic-cylinder-type dispenser device or the like (not shown), it is possible to apply a surface treatment agent by coating only to portions which require surface treatment film 360 and hence, a coating amount can be reduced whereby it is possible to provide a refrigerant compressor exhibiting high productivity at a low cost.

[0143] It is needless to say that substantially the same advantageous effects can be acquired even when surface treatment film 360 which contains synthetic resin 361 is formed on arm portion 320c of suction valve 320.

FIFTH EXEMPLARY EMBODIMENT

[0144] FIG. 17 is a cross-sectional view of a main part of a valve plate of a refrigerant compressor according to a fifth exemplary embodiment of the present invention. FIG. 18 is a front view of the valve plate of the refrigerant compressor according to the fifth exemplary embodiment of the present invention.

[0145] The basic configuration of this exemplary embodiment is equal to the configuration shown in FIG. 12 and hence, the description of the basic configuration of this exemplary embodiment is omitted. The constitutional parts identical with the constitutional parts described in FIG. 12 are given the same symbols and the description of these constitutional parts is partially omitted.

[0146] In the refrigerant compressor according to this exemplary embodiment, surface treatment film 360 which contains synthetic resin 361 is formed on a region of valve plate 317 made of a sintered metal material which opposes opening and closing portion 320b of suction valve 320, that is, on suction valve seat 341 which is disposed so as to surround suction hole 318.

[0147] As in the case of this exemplary embodiment, by applying surface treatment film 360 which contains synthetic resin 361 to suction valve seat 341, a striking force at the time of closing suction valve seat 341 and suction valve 320 can be reduced and hence, breaking such as cracks or chippings of suction valve 320 can be suppressed. Accordingly, it is possible to provide a highly reliable refrigerant compressor and a refrigeration appliance using the same.

[0148] A striking force generated between suction valve seat 341 and suction valve 320 at the time of closing suction valve 320 can be reduced due to an elastic effect of surface treatment film 360 which contains synthetic resin 361 and is applied to suction valve seat 341 and hence, the striking sound can be reduced so that it is possible to provide a refrigerant compressor which can realize low noises, and a refrigeration appliance using the same. Particularly, in the refrigerant compressor, electrically-operated element 306 adopts inverter driving to satisfy a demand for high efficiency so that electrically-operated element 306 is operated at a low speed whereby noises which electrically-operated element 306 generates is decreased. As a result, a striking sound generated between suction valve seat 341 and suction valve 320 is liable to become conspicuous. Further, this type of refrigerant compressor is mounted on the household-use refrigerator which is installed indoors in most cases and hence, the striking sound is liable to become conspicuous and hence, the reduction of noises is indispensable. Accordingly, such a configuration is effective.

[0149] A usual sintered metal material is molded by filling powdery metal into a mold, by applying a pressure to the metal powder and by heating a metal powder compact and hence, open pores which continuously communicate with a surface and the inside of the sintered metal material are present in the sintered metal material in a scattered manner. Accordingly, a refrigerant leaks through the open pores and hence, sealing property between suction valve seat 341 and suction valve 320 is deteriorated whereby compressor efficiency is lowered. Particularly, to cope with energy saving, refrigerating oil 302 of low viscosity has been adopted and hence, sealing property between suction valve seat 341 and suction valve 320 has been lowered steadily due to refrigerating oil 302 whereby lowering of performance of the refrigerant compressor due to the backflow of working fluid 303 is conspicuous.

[0150] To overcome this drawback, conventionally, by repeating a pressure applying step and a heating step for molding a sintered metal material plural times, density of the sintered metal material is increased so that open pores can be made small. However, such a process increases a manufacturing cost and also workability is deteriorated. On the other hand, when a cast iron material is used, a number of portions to be worked increases so that a working cost is pushed up.

[0151] However, in this exemplary embodiment, surface treatment film 360 which contains 361 is applied to suction valve seat 341 and hence, open pores peculiar to a sintered metal material which are scattered in suction valve seat 341 can be sealed by surface treatment film 360 which contains synthetic resin 361. Accordingly, leakage of a refrigerant between suction valve seat 341 and suction valve 320 can be reduced and hence, sealing property can be enhanced whereby the backflow of working fluid 303 in a compression stroke and a discharge stroke can be suppressed. Accordingly, lowering of refrigerating capacity can be suppressed and hence, it is possible to provide a refrigerant compressor which can enhance compressor efficiency at a low cost and a refrigeration appliance using the refrigerant compressor.

[0152] Further, solid lubricant 362 is contained in surface treatment film 360 which contains synthetic resin 361 and hence, a shearing force generated when suction valve seat 341 and suction valve 320 are closed is reduced due to a lubrication effect of solid lubricant 362. Accordingly, peeling off of surface treatment film 360 applied to suction valve seat 341 from a surface of a base material of suction valve seat 341 can be suppressed. Accordingly, it is possible to provide a refrigerant compressor which can ensure high durability for a long period and a refrigeration appliance using the refrigerant compressor.

[0153] Further, due to an effect of solid lubricant 362, coarse crests of the valve seat surface are removed and the valve seat surface becomes smooth at an early stage and hence, sealing property between suction valve seat 341 and suction valve 320 can be enhanced. Accordingly, lowering of refrigerating capacity caused by leakage can be suppressed at an early stage and hence, it is possible to provide a refrigerant compressor which can enhance compressor efficiency and a refrigeration appliance using the refrigerant compressor.

[0154] A total film thickness of surface treatment film 360 which contains synthetic resin 361 is set to a value which falls within a range of 1 μm to 50 μm. By setting the total film thickness to 1 μm or more, the refrigerant compressor can acquire a striking force reducing effect brought about by a sealing property enhancing effect and an elastic effect, and surface treatment film 360 can be uniformly formed. Further, by setting the total film thickness to 50 μm or less, the refrigerant compressor can ensure durability by ensuring both in-film strength of surface treatment film 360 and adhesion strength of surface treatment film 360 with an interface of a base material of valve plate 317 and, at the same time, surface size tolerance and surface roughening of surface treatment film 360 can be suppressed. Accordingly, it is possible to provide a refrigerant compressor which exhibits excellent productivity in addition to ensuring reliability for a long period by suppressing wear and peeling-off of surface treatment film 360 and a refrigeration appliance using the refrigerant compressor.

[0155] In this exemplary embodiment, synthetic resin 361 made of polyamide-imide is used as a binder of surface treatment film 360. However, also with the use of an epoxy resin or a phenol resin which is a thermosetting resin and possesses excellent oil resistance, heat resistance, refrigerant resistance, and organic solvent resistance, it is possible to acquire substantially the same advantageous effects as synthetic resin 361.

[0156] In surface treatment film 360 of this exemplary embodiment, as solid lubricant 362 scattered in surface treatment film 360, molybdenum disulfide (MoS2) is used. However, also with the use of polytetrafluoroethylene (PTFE) and graphite (C) in a single form or in mixture, it is possible to acquire substantially the same advantageous effects as molybdenum disulfide (MoS2). Further, when molybdenum disulfide or graphite is used as solid lubricant 362, by using antimony trioxide (Sb2O3) together with these materials, antimony trioxide captures air and oxygen which intrudes into surface treatment film 360 and these materials per se are oxidized first so that the degradation by oxidation of solid lubricant 362 in surface treatment film 360 can be suppressed so that surface treatment film 360 can sufficiently exhibit a wear suppression effect. Accordingly, the use of antimony trioxide together with these materials is effective.

[0157] In this exemplary embodiment, with the use of an appropriate masking jig or a pneumatic-cylinder-type dispenser device (not shown) or the like, it is possible to apply a surface treatment agent by coating only to portions which require the surface treatment agent and hence, a coating amount can be reduced whereby it is possible to provide a refrigerant compressor exhibiting high productivity at a low cost.

[0158] It is needless to say that substantially the same advantageous effects can be acquired even when surface treatment film 360 which contains synthetic resin 361 is applied to opening and closing portion 320b of suction valve 320.

SIXTH EXEMPLARY EMBODIMENT

[0159] FIG. 19 is a cross-sectional view of a main part of a valve plate of a refrigerant compressor according to a sixth exemplary embodiment of the present invention. FIG. 20 is a plan view of the valve plate of the refrigerant compressor according to the sixth exemplary embodiment of the present invention.

[0160] The basic configuration of this exemplary embodiment is equal to the configuration shown in FIG. 12 and hence, the description of the basic configuration of this exemplary embodiment is omitted. The constitutional parts identical with the constitutional parts described in FIG. 12 are given the same symbols and the description of these constitutional parts is partially omitted.

[0161] The refrigerant compressor according to this exemplary embodiment is characterized in that, in addition to the configuration of the fourth exemplary embodiment of the present invention or the fifth exemplary embodiment of the present invention, a surface treatment film 360 which contains synthetic resin 361 is formed on a region of a valve plate 317 which is formed by molding using a sintered metal material and opposes fixed portion 320a of a suction valve 320.

[0162] With such a configuration, vibrations which are generated by a striking force generated between suction valve seat 341 and suction valve 320 at the time of closing suction valve 320 and propagate through valve plate 317 can be attenuated by surface treatment film 360 which contains synthetic resin 361 and is applied to the region of valve plate 317 which opposes fixed portion 320a of suction valve 320. Accordingly, the vibrations and the striking sound can be lowered and hence, it is possible to provide a refrigerant compressor which realizes the reduction of noises and a refrigeration appliance using the refrigerant compressor. Particularly, as described previously, the reduction of noises is indispensable for a refrigerant compressor and hence, such a configuration is effective.

[0163] A total film thickness of surface treatment film 360 which contains synthetic resin 361 is set to a value which falls within a range of 1 μm to 50 μm. By setting the total film thickness to 1 μm or more, the refrigerant compressor can acquire an effect of attenuating vibrations generated by a striking force, and surface treatment film 360 can be uniformly formed. Further, by setting the total film thickness to 50 μm or less, the refrigerant compressor can ensure durability by ensuring both in-film strength of surface treatment film 360 and adhesion strength of surface treatment film 360 with an interface of a base material of valve plate 317 and, at the same time, surface size tolerance and surface roughening of surface treatment film 360 can be suppressed.

[0164] Accordingly, it is possible to provide a refrigerant compressor which exhibits excellent productivity in addition to ensuring reliability for a long period by suppressing wear and peeling-off of surface treatment film 360, and a refrigeration appliance using the refrigerant compressor.

[0165] In this exemplary embodiment, synthetic resin 361 made of polyamide-imide is used as a binder of surface treatment film 360. However, also with the use of an epoxy resin or a phenol resin which is a thermosetting resin and possesses excellent oil resistance, heat resistance, refrigerant resistance, and organic solvent resistance, it is possible to acquire substantially the same advantageous effects as synthetic resin 361.

[0166] In surface treatment film 360 of this exemplary embodiment, as solid lubricant 362 scattered in surface treatment film 360, molybdenum disulfide (MoS2) is used. However, also with the use of polytetrafluoroethylene (PTFE) and graphite (C) in a single form or in mixture, it is possible to acquire substantially the same advantageous effects as molybdenum disulfide (MoS2). Further, when molybdenum disulfide or graphite is used as solid lubricant 362, by using antimony trioxide (Sb2O3) together with these materials, antimony trioxide captures air and oxygen which intrude into surface treatment film 360 and these materials per se are oxidized first so that the degradation by oxidation of solid lubricant 362 in surface treatment film 360 can be suppressed so that surface treatment film 360 can sufficiently exhibit a wear suppression effect. Accordingly, the use of antimony trioxide together with these materials is effective.

[0167] In this exemplary embodiment, with the use of an appropriate masking jig, a pneumatic-cylinder-type dispenser device (not shown) or the like, it is possible to apply a surface treatment agent by coating only to portions which require surface treatment film 360 and hence, a coating amount can be reduced whereby it is possible to provide a refrigerant compressor exhibiting high productivity at a low cost.

[0168] It is needless to say that substantially the same advantageous effects can be acquired even when surface treatment film 360 which contains synthetic resin 361 is formed on fixed portion 320a of suction valve 320.

SEVENTH EXEMPLARY EMBODIMENT

[0169] FIG. 21A is a plan view of a valve plate of a refrigerant compressor according to a seventh exemplary embodiment of the present invention. FIG. 21B is a cross-sectional view of the valve plate of the refrigerant compressor according to the seventh exemplary embodiment of the present invention.

[0170] The basic configuration of this exemplary embodiment is also equal to the configuration shown in FIG. 12 and hence, the description of the basic configuration of this exemplary embodiment is omitted. The constitutional parts identical with the constitutional parts described in FIG. 12 are given the same symbols and the description of these constitutional parts is partially omitted.

[0171] In the refrigerant compressor according to this exemplary embodiment, recessed portion 332 is formed on a region of valve plate 317 which opposes arm portion 320c of suction valve 320 on a side opposite to suction valve seat 341 of valve plate 317.

[0172] A discharge valve device is mounted on recessed portion 332. The discharge valve device includes: discharge valve 321 which opens and closes discharge hole 319 and is disposed on recessed portion 332; spring lead 330 which resiliently supports discharge valve 321; and valve stop 331 which fixes discharge valve 321 and spring lead 330.

[0173] Due to the formation of recessed portion 332, a thickness of valve plate 317 becomes partially thin. Accordingly, valve plate 317 is formed into a convex shape toward suction valve 320 side due to a distortion generated at the time of molding and applying finish working to valve plate 317. Particularly, region of valve plate 317 which opposes arm portion 320c of suction valve 320 becomes a convex-shaped apex.

[0174] When suction valve 320 closes suction hole 318, arm portion 320c of suction valve 320 is brought into contact with an area near the convex-shaped apex of valve plate 317 so that a strong striking force is liable to be generated. However, due to an elastic effect of surface treatment film 360 which contains synthetic resin 361 which is applied to a region of valve plate 317 which opposes arm portion 320c of suction valve 320, the striking force is alleviated and hence, it is possible to provide a refrigerant compressor which enhances reliability of suction valve 320 and a refrigeration appliance using refrigerant compressor.

[0175] As has been described heretofore, the refrigerant compressor according to the present invention includes, inside a sealed container: a cylinder which houses a piston movable in a reciprocating manner; a valve plate which is disposed on an opening end of the cylinder and has a suction valve seat formed so as to surround a suction hole; and a suction valve configured to open and close the suction hole, wherein the suction valve includes an opening and closing portion, and an arm portion configured to be operated along with opening and closing of the opening and closing portion, and a synthetic resin film is applied to at least a region of the valve plate which is brought into contact with the arm portion of the suction valve.

[0176] With such a configuration, oil repellency of the region of the valve plate with which the arm portion of the suction valve is brought into contact is enhanced and hence, refrigerant oil is minimally interposed in a gap formed between the valve plate and the arm portion of the suction valve whereby it is possible to suppress delay in opening of the suction valve caused by an adhesion force of refrigerant oil. Accordingly, a pressure loss in a suction stroke can be reduced and hence, compressor efficiency of the refrigerant compressor can be enhanced.

[0177] A striking force generated at the time of closing the suction valve can be reduced by an elastic effect acquired by surface treatment and hence, the reduction of noises of the refrigerant compressor can be realized.

[0178] The refrigerant compressor according to the present invention includes, inside a sealed container: a cylinder which houses a piston movable in a reciprocating manner; a valve plate which is disposed on an opening end of the cylinder and has a discharge valve seat formed so as to surround a discharge hole; and a discharge valve configured to open and close the discharge hole. Further, the discharge valve may include an opening and closing portion, and an arm portion configured to be operated along with opening and closing of the opening and closing portion, and a synthetic resin film may be applied to at least a region of the valve plate which is brought into contact with the arm portion of the discharge valve.

[0179] With such a configuration, oil repellency of the region of the valve plate with which the arm portion of the discharge valve is brought into contact is enhanced and hence, refrigerant oil is minimally interposed in a gap formed between the valve plate and the arm portion of the discharge valve. Accordingly, it is possible to suppress delay in opening of the discharge valve caused by an adhesion force of refrigerant oil and hence, a pressure loss in a discharge stroke can be reduced whereby compressor efficiency of the refrigerant compressor can be enhanced.

[0180] A striking sound generated at the time of closing the discharge valve can be reduced by an elastic effect acquired by surface treatment and hence, the reduction of noises of the refrigerant compressor can be realized.

[0181] The refrigerant compressor according to the present invention includes, inside a sealed container: a cylinder which houses a piston movable in a reciprocating manner; a valve plate which is disposed on an opening end of the cylinder and has a suction valve seat formed so as to surround a suction hole; and a suction valve configured to open and close the suction hole. The suction valve may include an opening and closing portion, and an arm portion configured to be operated along with opening and closing of the opening and closing portion, and a synthetic resin film may be applied to at least a region of the arm portion of the suction valve which is brought into contact with the valve plate.

[0182] With such a configuration, oil repellency of the arm portion of the suction valve is enhanced and hence, refrigerant oil is minimally interposed in a gap formed between the valve plate and the arm portion of the suction valve whereby it is possible to suppress delay in opening of the suction valve caused by an adhesion force of refrigerant oil. Accordingly, a pressure loss in a suction stroke can be reduced, and rigidity of the arm portion of the suction valve can be increased and hence, delay in closing of the suction valve can be suppressed. Accordingly, the backflow of a sucked refrigerant gas can be prevented, and a volume efficiency can be enhanced and hence, compressor efficiency of the refrigerant compressor can be enhanced.

[0183] A striking sound generated at the time of closing the suction valve can be reduced by an elastic effect acquired by surface treatment and hence, the reduction of noises of the refrigerant compressor can be realized.

[0184] The refrigerant compressor according to the present invention includes, inside a sealed container: a cylinder which houses a piston movable in a reciprocating manner; a suction valve plate which is disposed on an opening end of the cylinder and has a discharge valve seat formed so as to surround a discharge hole; and a discharge valve configured to open and close the discharge hole. The discharge valve may include an opening and closing portion, and an arm portion configured to be operated along with opening and closing of the opening and closing portion, and a synthetic resin film may be applied to at least a region of the arm portion of the discharge valve which is brought into contact with the valve plate.

[0185] With such a configuration, oil repellency of the arm portion of the discharge valve is enhanced and hence, refrigerant oil is minimally interposed in a gap formed between the valve plate and the arm portion of the discharge valve whereby it is possible to suppress delay in opening of the discharge valve caused by an adhesion force of refrigerant oil. Accordingly, a pressure loss in a suction stroke can be reduced, and rigidity of the arm portion of the discharge valve can be increased and hence, delay in closing of the discharge valve can be suppressed. Accordingly, the backflow of a discharged refrigerant gas can be prevented, and a re-expansion loss can be reduced and hence, compressor efficiency of the refrigerant compressor can be enhanced.

[0186] A striking sound generated at the time of closing the discharge valve can be reduced by an elastic effect acquired by surface treatment and hence, the reduction of noises of the refrigerant compressor can be realized.

[0187] In the refrigerant compressor according to the present invention, the synthetic resin film may contain fluororubber as a binder, and a solid lubricant may contain a fluororesin.

[0188] With such a configuration, resiliency of the synthetic resin film can be further enhanced and hence, a striking sound can be further reduced whereby the reduction of noises of the refrigerant compressor can be realized. Further, oil repellency can be also enhanced and hence, delay in opening can be further effectively suppressed so that compressor efficiency of the refrigerant compressor can be enhanced.

[0189] In the refrigerant compressor according to the present invention, a total film thickness of the synthetic resin film may be set to a value which falls within a range of 1 μm to 100 μm.

[0190] With such a configuration, a striking sound reduction effect can be increased, and wear and peeling off of synthetic resin film can be also suppressed. Accordingly, it is possible to provide a refrigerant compressor which can reduce surface roughness of synthetic resin film while ensuring durability thus exhibiting high productivity while ensuring reliability for a long period.

[0191] The refrigeration appliance according to the present invention may have a refrigerant circuit which is formed by annularly connecting the refrigerant compressor according to the present invention, a radiator, a pressure reduction device, and a heat absorber by a pipe.

[0192] With such a configuration, the compressor efficiency can be enhanced. Further, power consumption of the refrigeration appliance can be reduced by mounting the refrigerant compressor which achieves the reduction of noises on the refrigeration appliance thus realizing energy saving as well as the reduction of noises.

[0193] The refrigerant compressor according to the present invention may include: a cylinder which houses a piston movable in a reciprocating manner; a valve plate which is disposed on an opening end of the cylinder and has a suction valve seat formed so as to surround a suction hole; and a suction valve configured to open and close the suction hole, and a surface treatment film which contains a synthetic resin may be applied to a region of the valve plate which opposes an opening and closing portion of the suction valve or the opening and closing portion of the suction valve.

[0194] With such a configuration, a striking force generated between the region of the valve plate which opposes the opening and closing portion of the suction valve and the opening and closing portion of the suction valve can be alleviated by an elastic effect of the surface treatment film which contains a synthetic resin and is disposed in either one of the region of the valve plate which opposes the opening and closing portion of the suction valve or the opening and closing portion of the suction valve. Accordingly, the reliability of the suction valve can be enhanced and a striking sound can be reduced and hence, it is possible to provide a refrigerant compressor which realizes high reliability and the reduction of noises.

[0195] Further, when the surface treatment film is applied to the region of the valve plate which opposedly faces the opening and closing portion of the suction valve, that is, to the suction valve seat, open pores peculiar to a sintered metal material which are scattered in the suction valve seat can be sealed by the surface treatment film which contains a synthetic resin and hence, leakage of a refrigerant between the suction valve seat and the suction valve can be reduced whereby sealing property can be enhanced. Accordingly, the backflow of a working fluid in a compression stroke and a discharge stroke can be suppressed and hence, it is possible to provide a refrigerant compressor which can reduce lowering of refrigerating capacity and can enhance compressor efficiency.

[0196] In the refrigerant compressor according to the present invention, a surface treatment film which contains synthetic resin may be disposed in either one of a region of the valve plate which opposedly faces a fixed portion of the suction valve or the fixed portion of the suction valve.

[0197] With such a configuration, vibrations which are generated by a striking force generated between the suction valve seat and the suction valve at the time of closing the suction valve can be attenuated in the course of propagation of vibrations through the valve plate by the surface treatment film which contains a synthetic resin and is applied to the fixing portion or the fixing portion of the suction valve. Accordingly, the vibrations and the striking sound can be lowered and hence, it is possible to provide a refrigerant compressor which realizes the reduction of noises.

[0198] In the refrigerant compressor according to the present invention, the recessed portion may be formed on a region of the valve plate which opposedly faces the arm portion of the suction valve on a side opposite to the suction valve seat.

[0199] Due to the formation of the recessed portion, a thickness of the valve plate becomes partially thin. Accordingly, the valve plate is formed into a convex shape toward a suction valve side due to a distortion generated at the time of molding and applying finish working to the valve plate and hence, a striking force is liable to be generated when the suction valve closes the suction hole. However, the striking force is alleviated by an elastic effect of a surface treatment film which contains a synthetic resin and hence, it is possible to provide a refrigerant compressor which enhances reliability of the suction valve.

[0200] In the refrigerant compressor according to the present invention, the surface treatment film which contains a synthetic resin may be a surface treatment film which contains a solid lubricant.

[0201] With such a configuration, a shearing force generated when the suction valve seat and the suction valve or when the discharge valve seat and the discharge valve are closed is reduced due to a lubrication effect of the solid lubricant contained in the surface treatment film. Accordingly, peeling off of the surface treatment film applied to the valve seat from a surface of a base material of the valve seat can be suppressed and hence, it is possible to provide a refrigerant compressor which exhibits high durability for a long period. Further, due to an effect of the solid lubricant, coarse crests of the valve seat surface are removed and the valve seat surface becomes smooth at an early stage and hence, sealing property between the suction valve seat and the suction valve can be enhanced. Accordingly, lowering of refrigerating capacity caused by leakage stage can be suppressed at an early stage and hence, it is possible to provide a refrigerant compressor which can enhance compressor efficiency.

[0202] Further, since a synthetic resin contains a solid lubricant, wettability of the surface treatment film to refrigerant oil is enhanced and hence, lubrication oil can be held between the valve plate and the valve whereby a striking force is reduced by an oil film. Accordingly, it is possible to provide a refrigerant compressor which can further enhance reliability of the suction valve.

INDUSTRIAL APPLICABILITY

[0203] As has been described heretofore, the refrigerant compressor according to the present invention exhibits high efficiency and exhibits low noises and hence, the refrigerant compressor according to the present invention is applicable to various fields using a refrigeration cycle such as an air conditioner, a dehumidifier, a show case, and a vending machine, not to mention, a household-use refrigerator.

REFERENCE MARKS IN THE DRAWINGS

[0204]

1, 101, 301:	sealed container
2, 102, 302:	refrigeration oil
3, 103, 303:	working fluid
4, 104, 304:	compressor body
5, 105, 305:	suspension spring
6, 106, 306:	electrically-operated element
7, 107, 307:	stator
8, 108, 308:	rotor
9, 109, 309:	compressive element
10, 110, 310:	eccentric shaft
11, 111, 311:	main shaft
12, 112, 312:	crankshaft
13, 113, 313:	compression chamber
14, 114, 314:	cylinder
16, 116, 316:	piston
17, 117, 317:	valve plate
18, 118, 318:	suction hole
19, 119, 319:	discharge hole
20, 120, 320:	suction valve
21, 121, 321:	discharge valve
23, 123, 323:	bearing portion
52, 152, 352:	cylinder head
56, 156, 356:	head space

115, 315:	block
120a, 121a, 320b:	opening and closing portion
120b, 121b, 320c:	arm portion
122, 322:	connecting portion
141, 341:	suction valve seat
142, 342:	discharge valve seat
150, 350:	suction pipe
151, 351:	oil supply mechanism
157, 357:	discharge pipe
160:	synthetic resin film
161:	binder
162, 362:	solid lubricant
209:	refrigerant circuit
211:	compressor
213:	heat radiator
215:	pressure reduction device
217:	hear absorber
320a:	fixed portion
332:	recessed portion
360:	surface treatment film
361:	synthetic resin

Claims

1. A refrigerant compressor comprising, inside a sealed container:

a cylinder which houses a piston movable in a reciprocating manner;
a valve plate which is disposed on an opening end of the cylinder and has a suction valve seat formed so as to surround a suction hole; and
a suction valve configured to open and close the suction hole,
wherein
the suction valve includes an opening and closing portion, and an arm portion to be operated along with opening and closing of the opening and closing portion, and
the refrigerant compressor further comprises a synthetic resin film in at least a region of the valve plate which is brought into contact with the arm portion of the suction valve.

2. A refrigerant compressor comprising, inside a sealed container:

a cylinder which houses a piston movable in a reciprocating manner;
a valve plate which is disposed on an opening end of the cylinder and has a discharge valve seat formed so as to surround a discharge hole; and
a discharge valve configured to open and close the discharge hole,
wherein
the discharge valve includes an opening and closing portion, and an arm portion to be operated along with opening and closing of the opening and closing portion, and
the refrigerant compressor further comprises a synthetic resin film in at least a region of the valve plate which is brought into contact with the arm portion of the discharge valve.

3. A refrigerant compressor comprising, inside a sealed container:

a cylinder which houses a piston movable in a reciprocating manner;
a valve plate which is disposed on an opening end of the cylinder and has a suction valve seat formed so as to surround a suction hole; and
a suction valve configured to open and close the suction hole,
wherein
the suction valve includes an opening and closing portion, and an arm portion to be operated along with opening and closing of the opening and closing portion, and

the refrigerant compressor further comprises a synthetic resin film in at least a region of the arm portion of the suction valve which is brought into contact with the valve plate.

4. A refrigerant compressor comprising, inside a sealed container:

a cylinder which houses a piston movable in a reciprocating manner;
a valve plate which is disposed on an opening end of the cylinder and has a discharge valve seat formed so as to surround a discharge hole; and
a discharge valve configured to open and close the discharge hole,
wherein
the discharge valve includes an opening and closing portion, and an arm portion to be operated along with opening and closing of the opening and closing portion, and
the refrigerant compressor further comprises a synthetic resin film in at least a region of the arm portion of the discharge valve which is brought into contact with the valve plate.

5. A refrigerant compressor comprising, inside a sealed container:

a cylinder which houses a piston movable in a reciprocating manner;
a valve plate which is disposed on an opening end of the cylinder and has a suction valve seat formed so as to surround a suction hole; and
a suction valve configured to open and close the suction hole,
wherein
the suction valve includes an opening and closing portion, and an arm portion to be operated along with opening and closing of the opening and closing portion, and
the refrigerant compressor further comprises a surface treatment film containing a synthetic resin, in a region of the valve plate which opposes the opening and closing portion of the suction valve or on the opening and closing portion of the suction valve.

6. The refrigerant compressor according to claim 5, wherein the surface treatment film containing the synthetic resin is disposed in either one of a region of the valve plate which opposes a fixed portion of the suction valve or the fixed portion of the suction valve.

7. The refrigerant compressor according to claim 5, wherein a recessed portion is formed on a region of the valve plate which opposes the arm portion of the suction valve on a side opposite to the opening and closing portion.

8. The refrigerant compressor according to claim 1, wherein the synthetic resin film is disposed in either one of a region of the valve plate which opposes opening and closing portion of the suction valve or the opening and closing portion of the suction valve.

9. The refrigerant compressor according to claim 1, wherein the synthetic resin film contains fluororubber as a binder, and a fluororesin as a solid lubricant.

10. The refrigerant compressor according to claim 2, wherein the synthetic resin film contains fluororubber as a binder, and a fluororesin as a solid lubricant.

11. The refrigerant compressor according to claim 3, wherein the synthetic resin film contains fluororubber as a binder, and a fluororesin as a solid lubricant.

12. The refrigerant compressor according to claim 4, wherein the synthetic resin film contains fluororubber as a binder, and a fluororesin as a solid lubricant.

13. The refrigerant compressor according to any one of claims 1 to 4 or claims 9 to 12, wherein a total film thickness of the synthetic resin film is set to a value which falls within a range of 1 μm to 100 μm.

14. A refrigeration appliance comprising a refrigerant circuit which is formed by annularly connecting the refrigerant compressor according to any one of claims 1 to 12, a radiator, a pressure reduction device, and a heat absorber, by a pipe.

FIG. 1

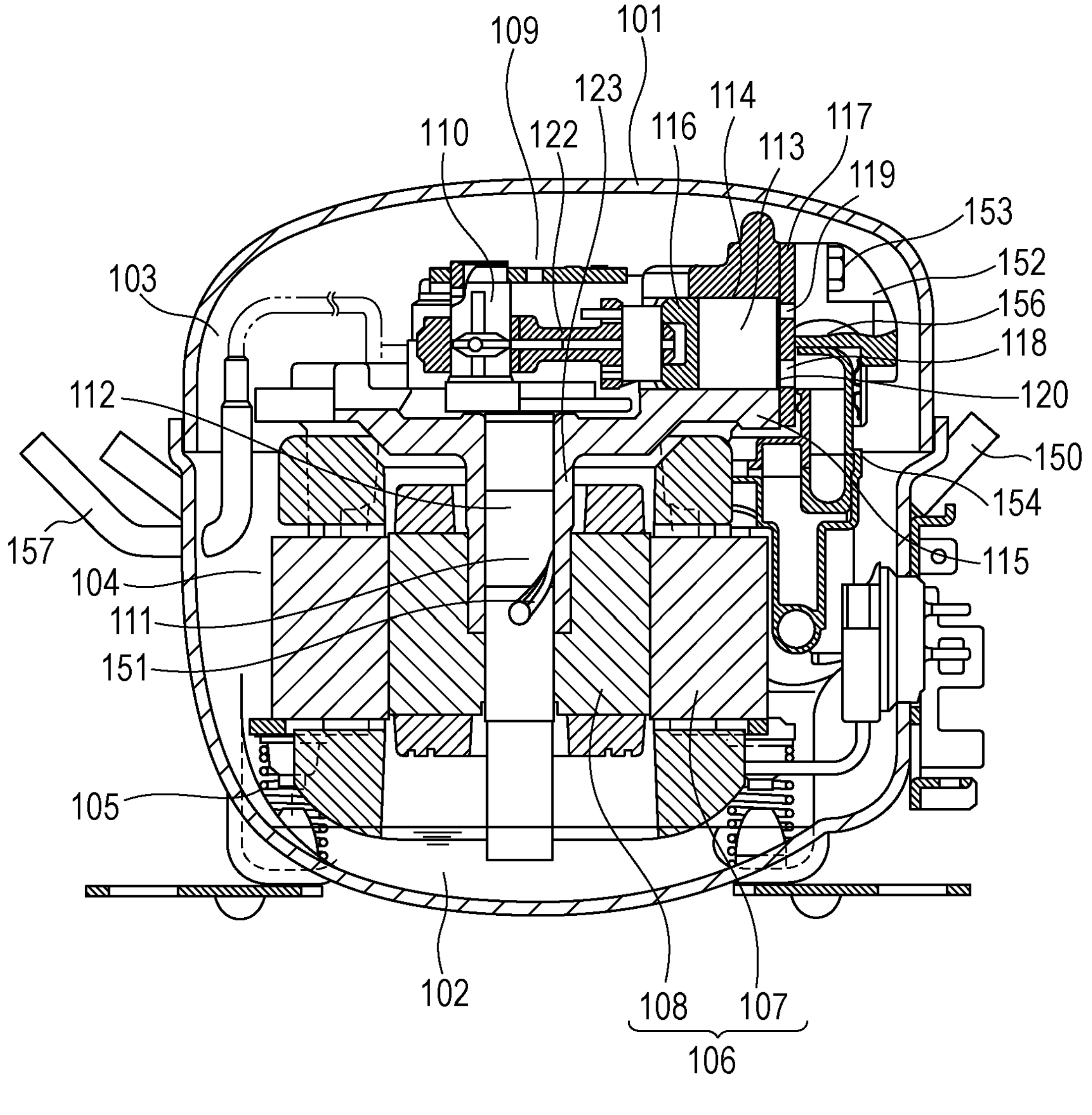
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FIG. 2

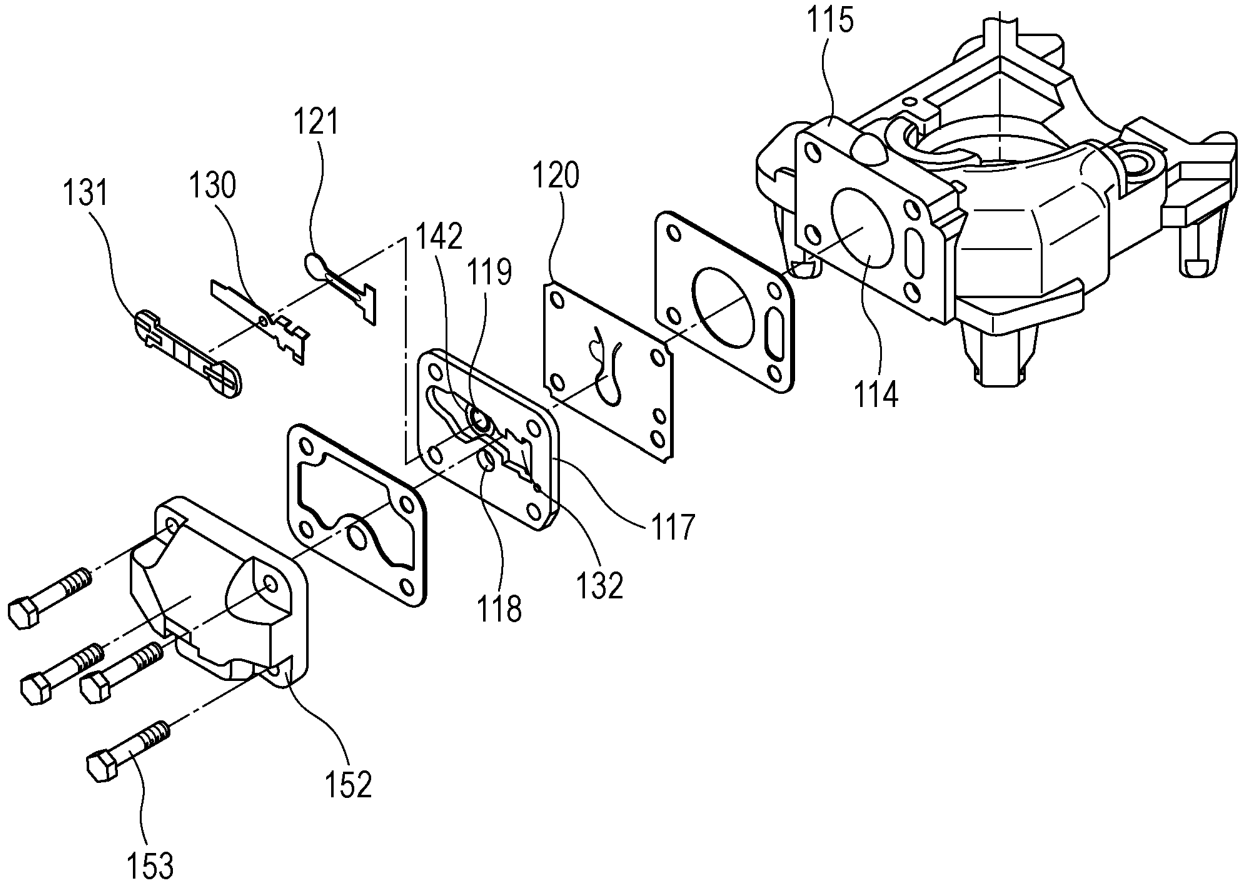


FIG. 3

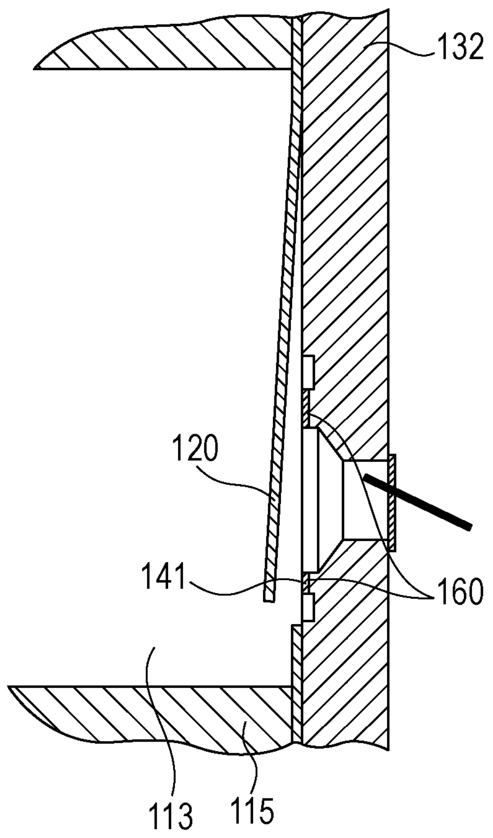


FIG. 4

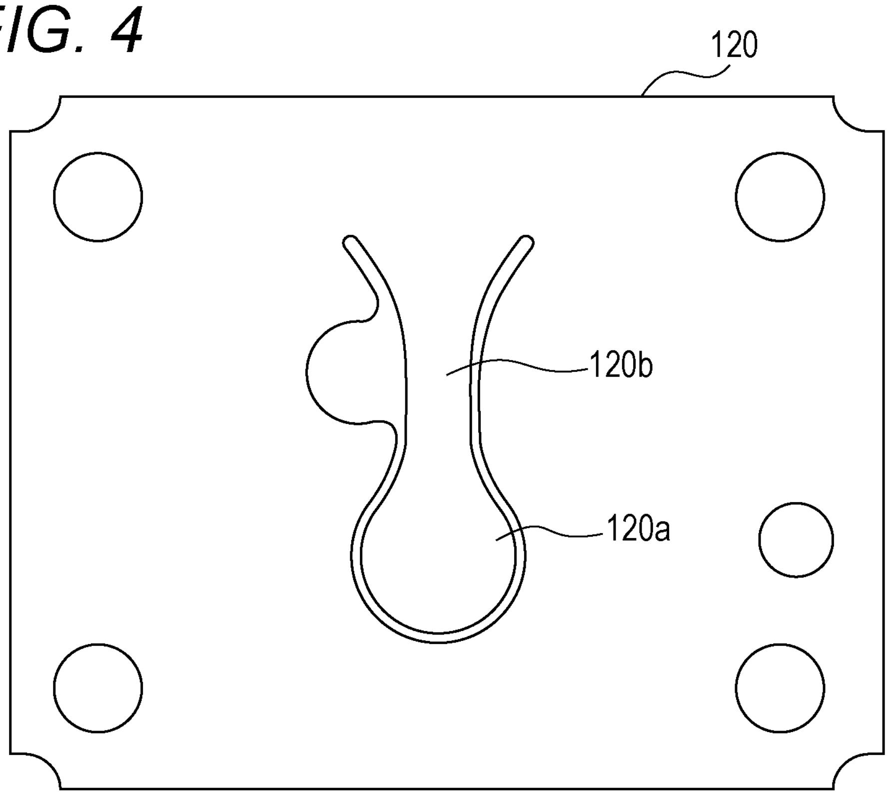


FIG. 5

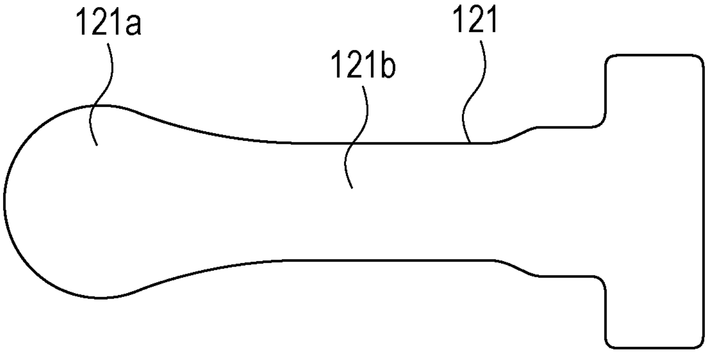


FIG. 6

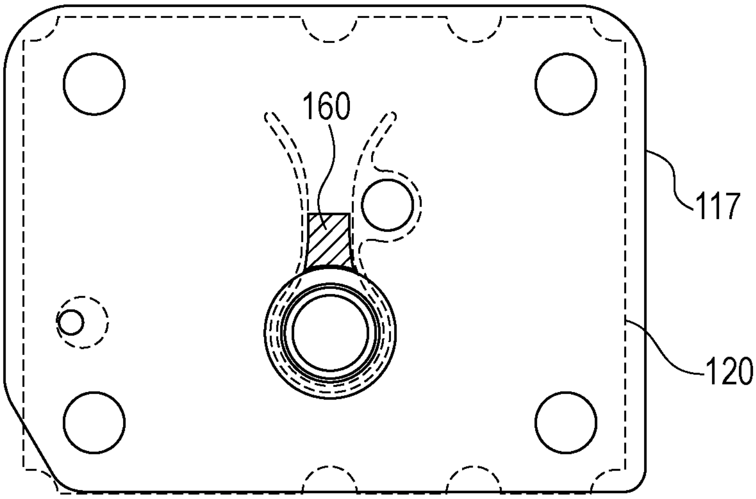


FIG. 7

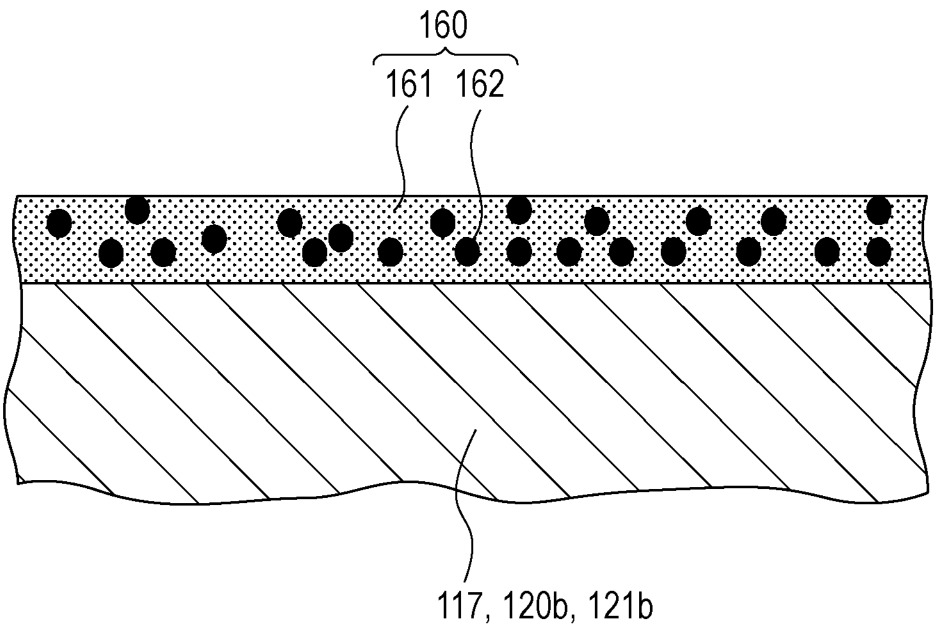
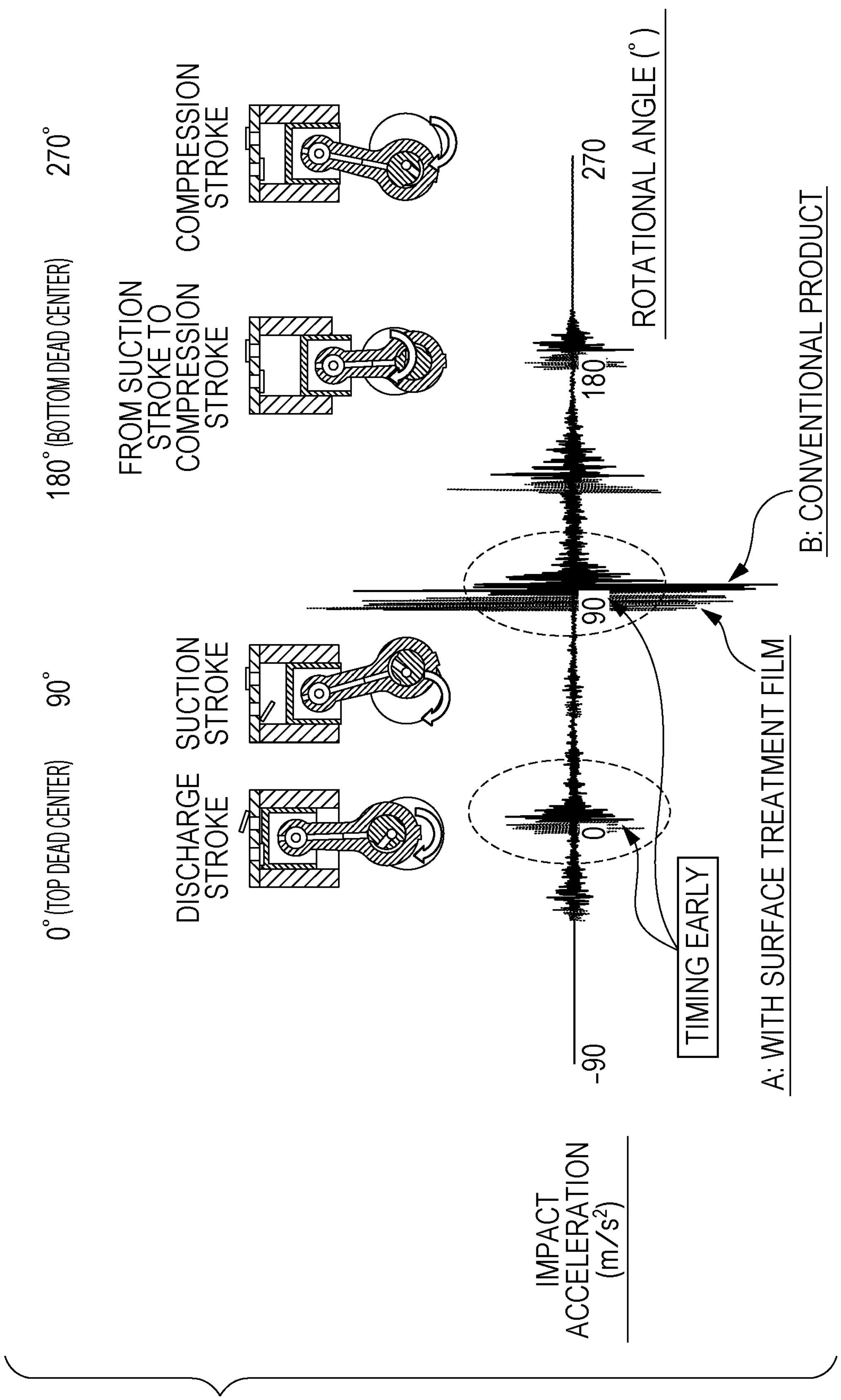


FIG. 8


0° (TOP DEAD CENTER)
90°
180° (BOTTOM DEAD CENTER)
270°
DISCHARGE STROKE
SUCTION STROKE
FROM SUCTION STROKE TO COMPRESSION STROKE
COMPRESSION STROKE
IMPACT ACCELERATION (m/s²)
-90
0
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270
ROTATIONAL ANGLE (°)
TIMING EARLY
A: WITH SURFACE TREATMENT FILM
B: CONVENTIONAL PRODUCT

FIG. 9

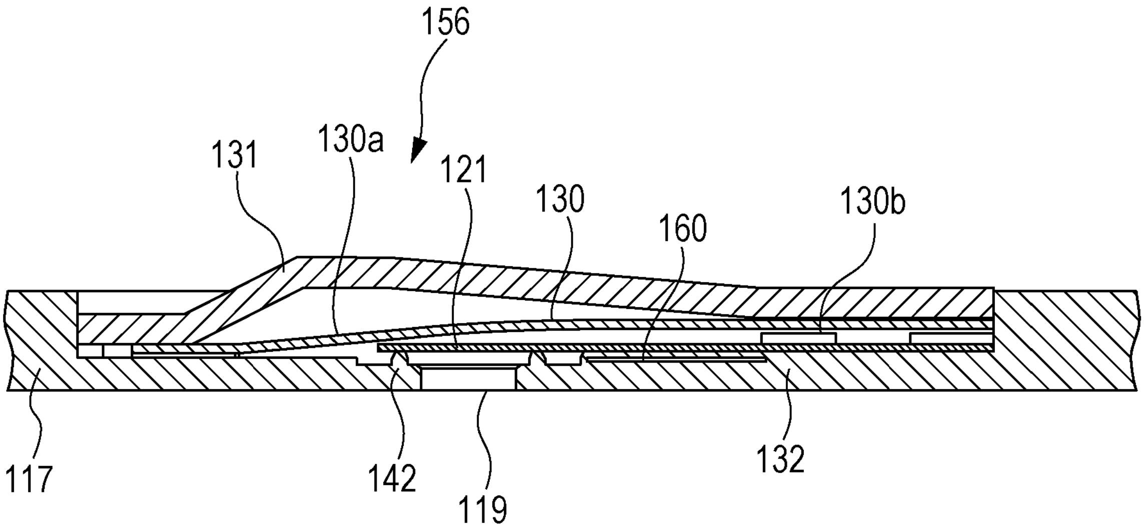

FIG. 10

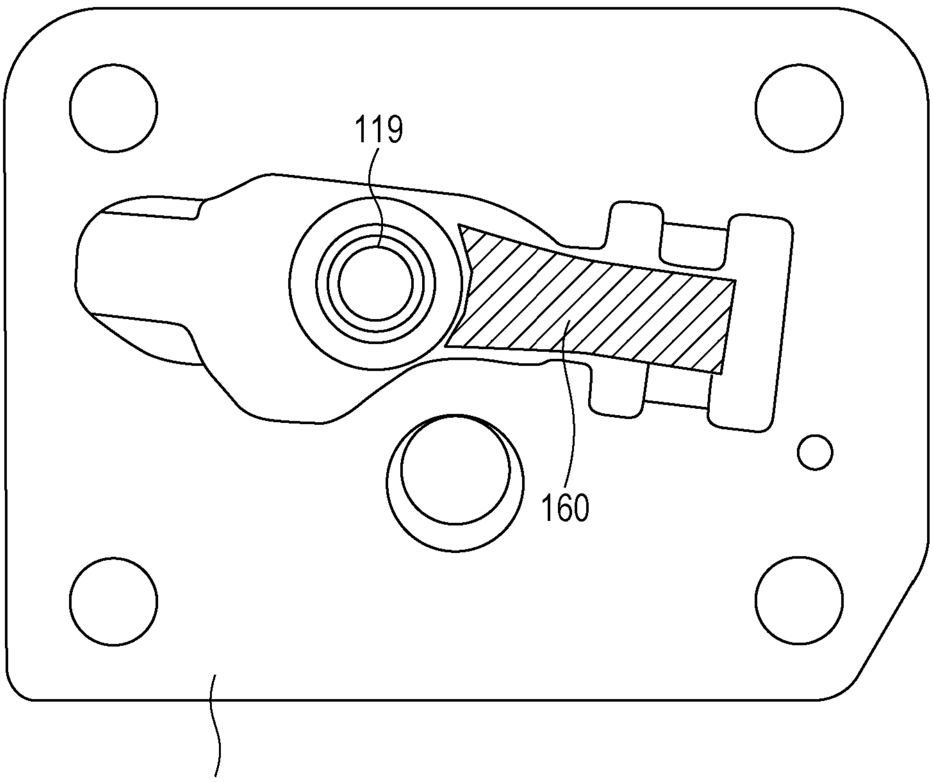

FIG. 11

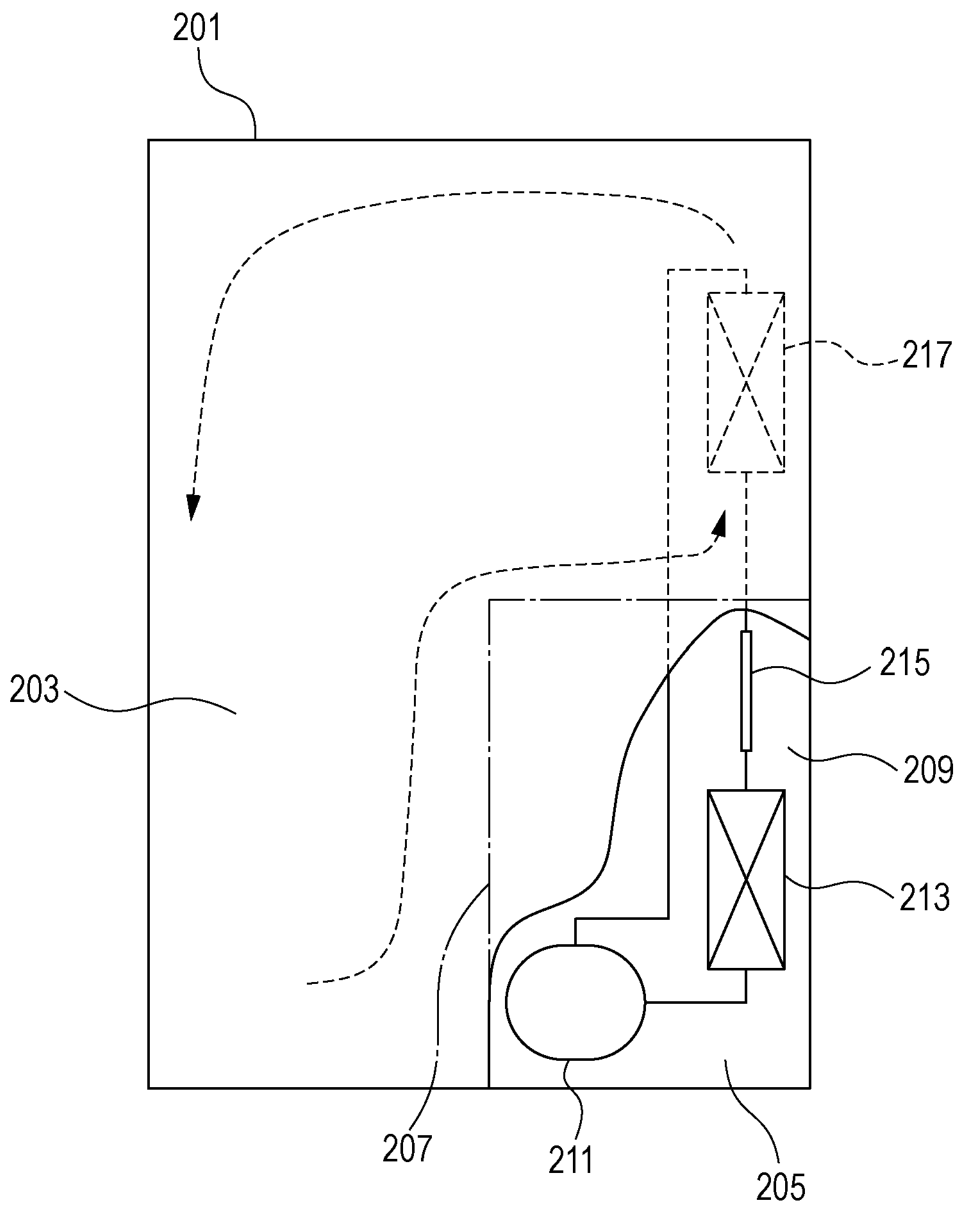

FIG. 12

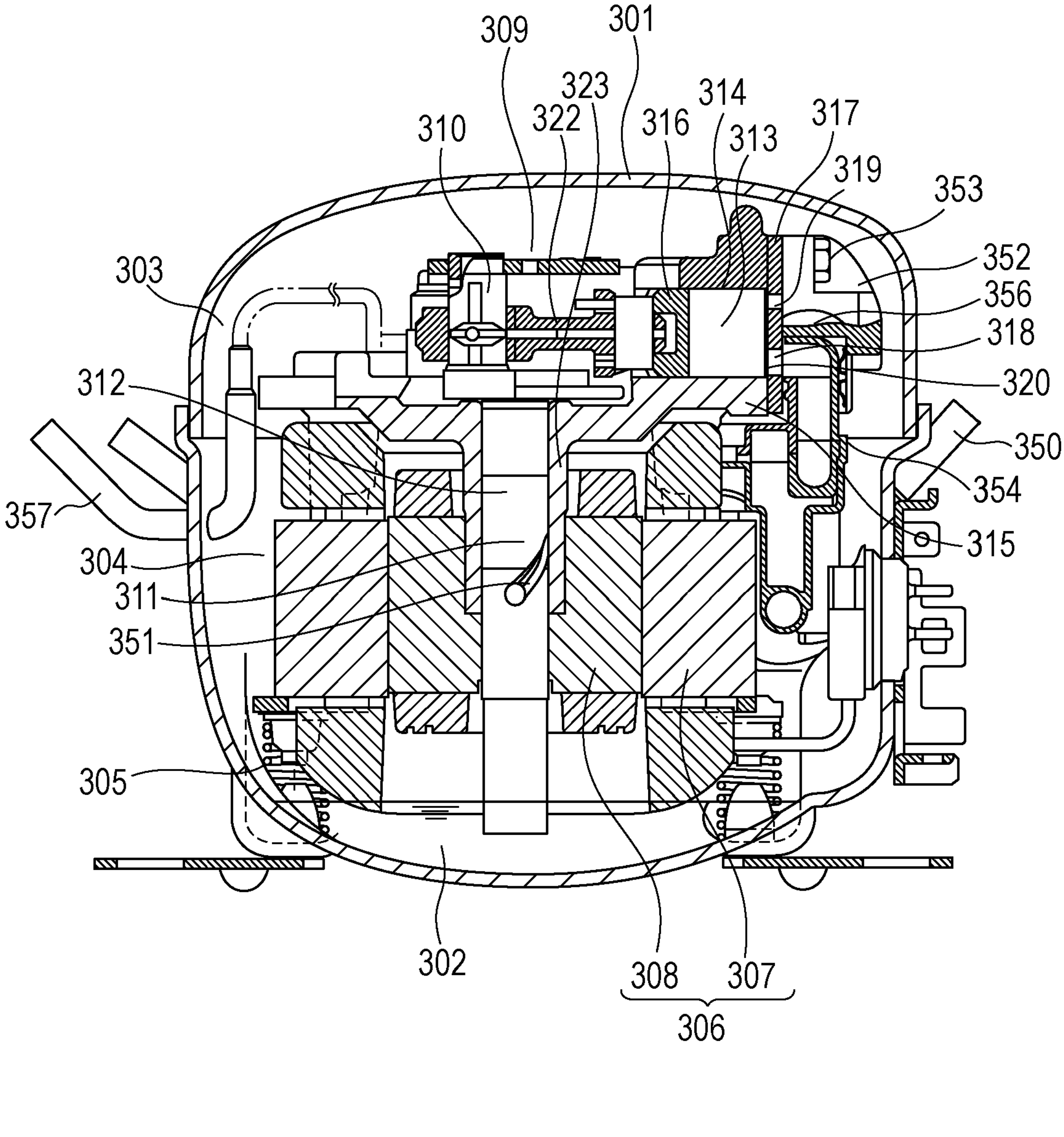
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FIG. 13

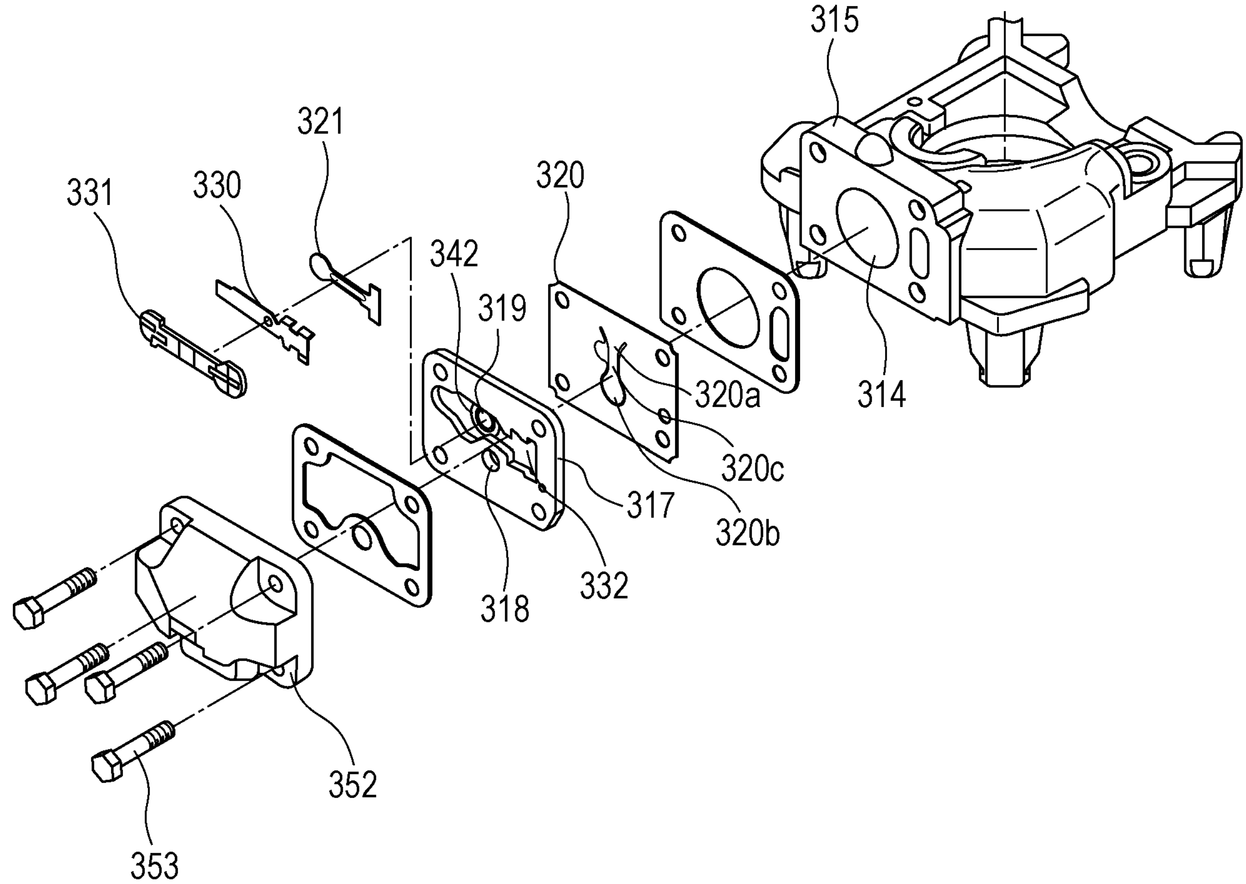
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FIG. 14

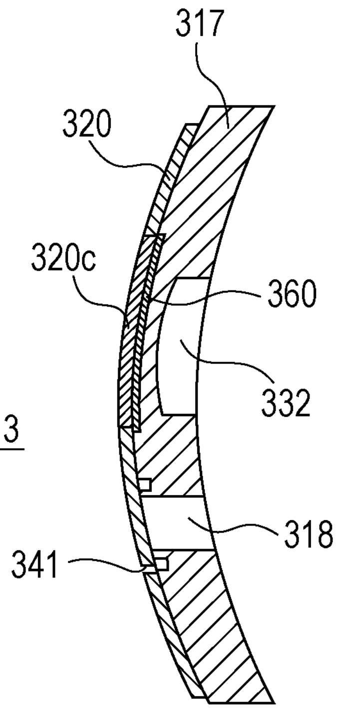


FIG. 15

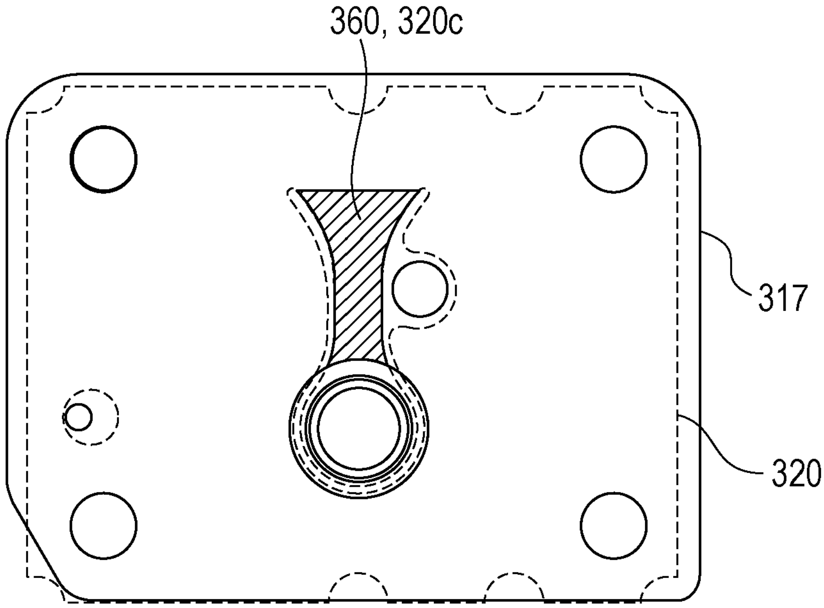


FIG. 16

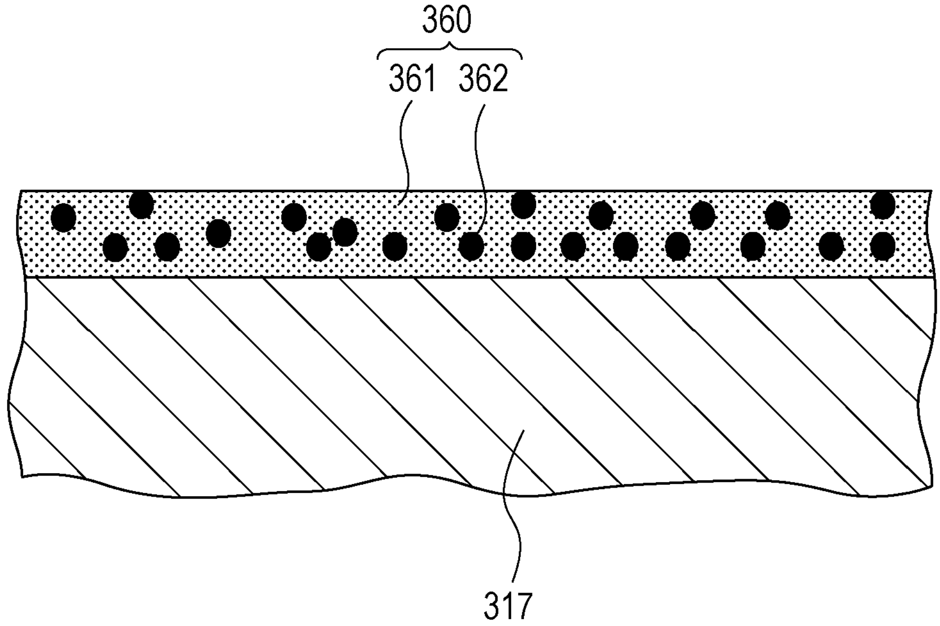


FIG. 17

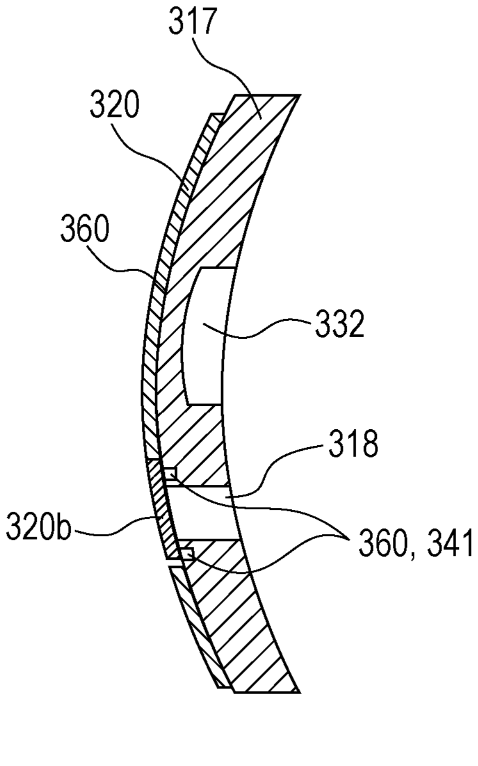


FIG. 18

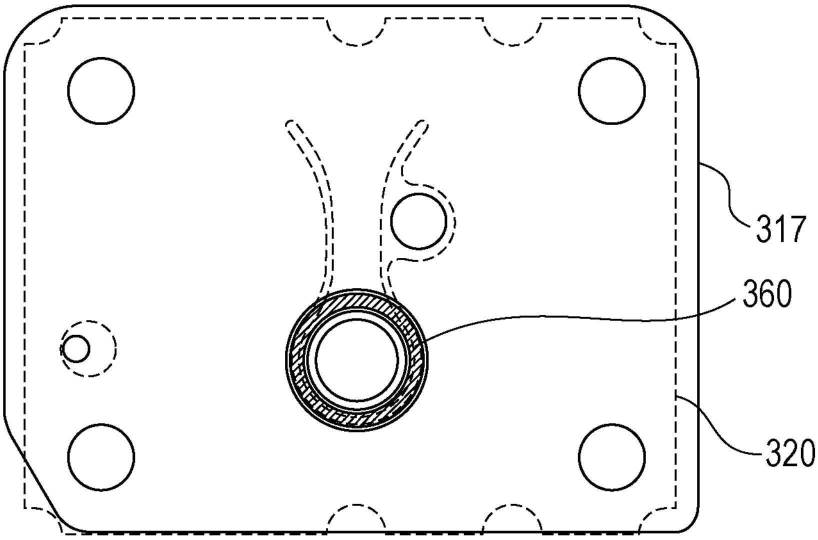


FIG. 19

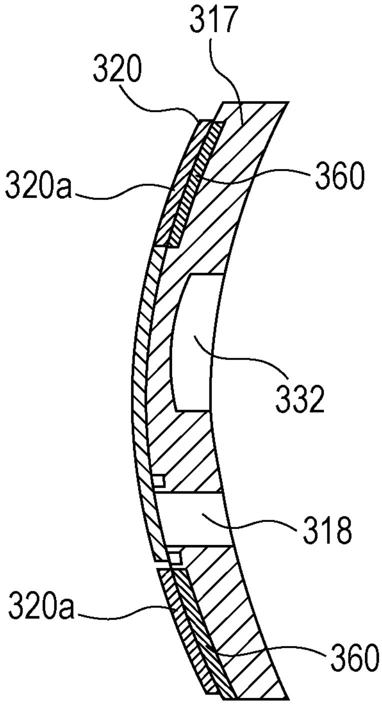


FIG. 20

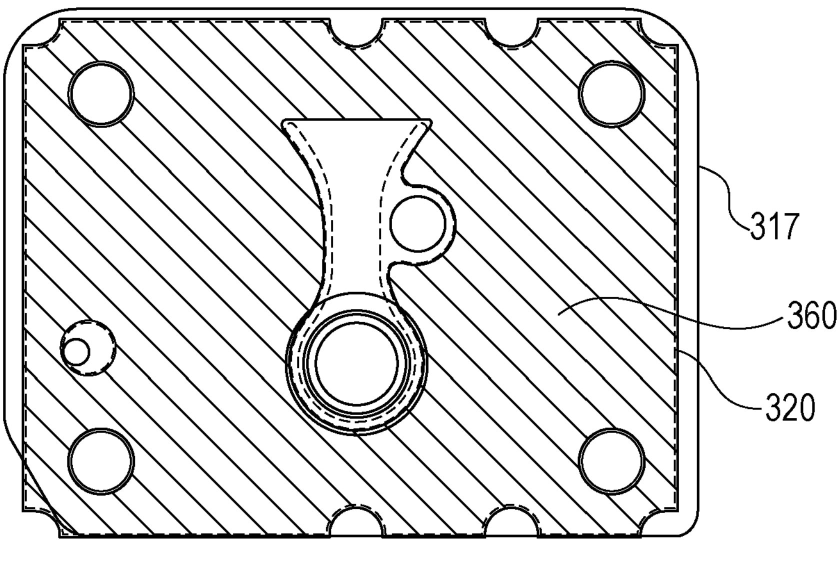


FIG. 21A

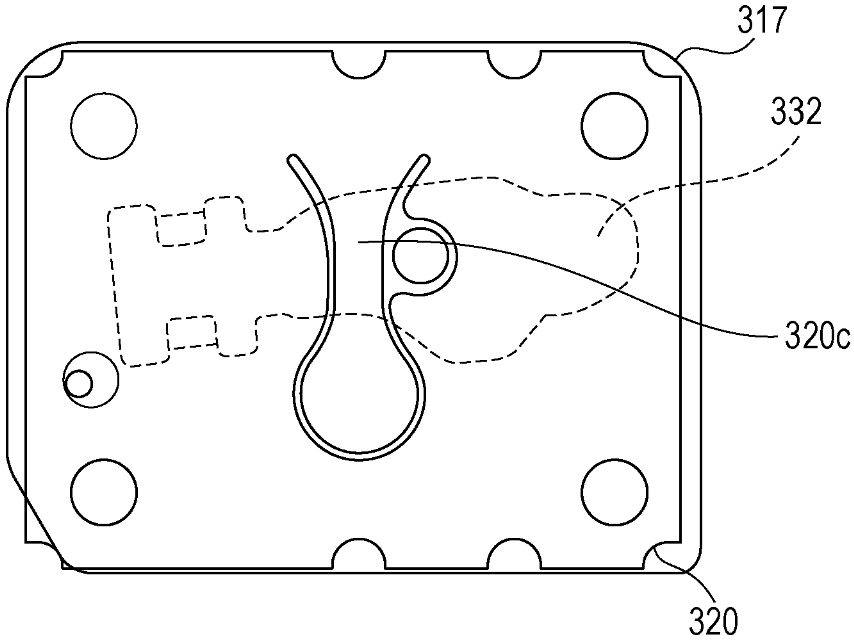


FIG. 21B

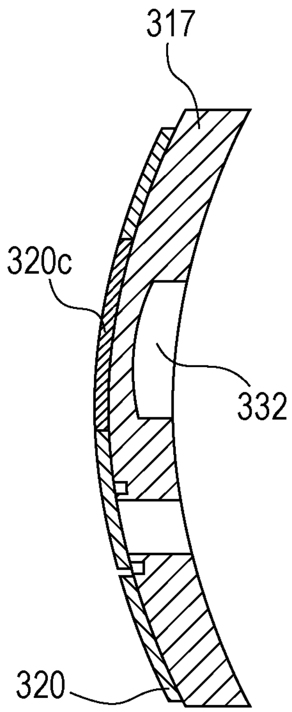


FIG. 22

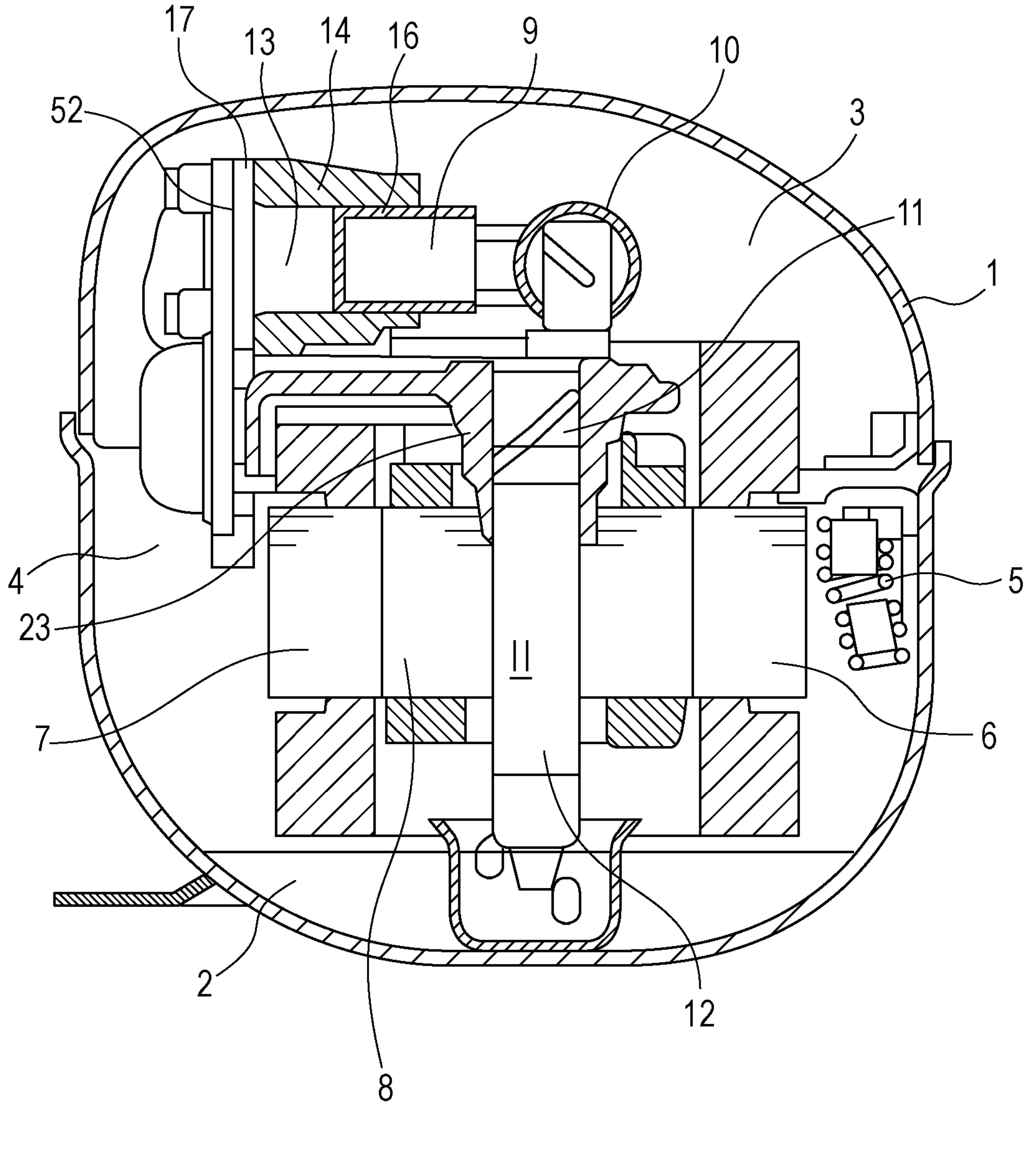
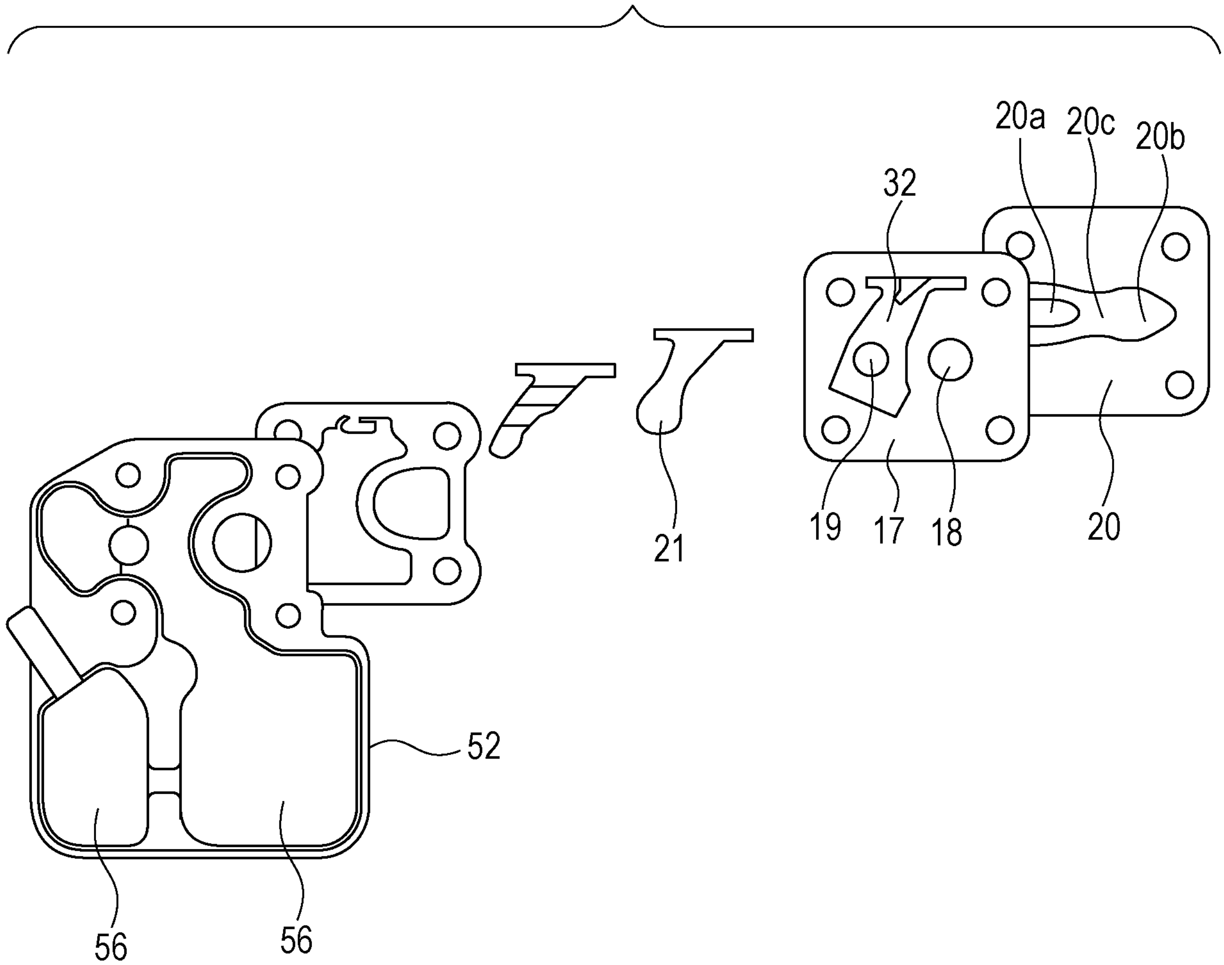


FIG. 23



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/003052

A. CLASSIFICATION OF SUBJECT MATTER
F04B39/10(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04B39/10

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2015
Kokai Jitsuyo Shinan Koho	1971-2015	Toroku Jitsuyo Shinan Koho	1994-2015

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	WO 2004/055371 A1 (Matsushita Refrigeration Co.), 01 July 2004 (01.07.2004), description, page 38, line 12 to page 45, line 10; fig. 1, 33 to 43 & US 2005/0172646 A1 & EP 1574712 A1 & CN 1685154 A & KR 10-2004-0085159 A	1-6,8,14 7,9-13
Y	JP 7-167058 A (Toyoda Automatic Loom Works, Ltd.), 04 July 1995 (04.07.1995), paragraphs [0012] to [0015]; fig. 1 to 4 (Family: none)	1-2,5-6,8,14

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 September 2015 (11.09.15)	29 September 2015 (29.09.15)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/003052

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 9-137774 A (Toyoda Automatic Loom Works, Ltd.), 27 May 1997 (27.05.1997), paragraph [0044]; fig. 1 to 6 (Family: none)	1-2,5-6,8,14
Y	JP 2000-161228 A (Toyoda Automatic Loom Works, Ltd.), 13 June 2000 (13.06.2000), paragraphs [0012] to [0016]; fig. 1 to 3 (Family: none)	3-6,8,14
Y	JP 2005-36694 A (Zexel Valeo Climate Control Corp.), 10 February 2005 (10.02.2005), paragraph [0019]; fig. 1 (Family: none)	3-6,8,14
A	WO 2007/135956 A1 (Daikin Industries, Ltd.), 29 November 2007 (29.11.2007), claims 1 to 4 & JP 2009-190171 A	9-13
A	US 3994319 A (Tom P. AIRHART), 30 November 1976 (30.11.1976), entire text; all drawings (Family: none)	1-14
A	US 5192200 A (Dietmar E. B. LILIE), 09 March 1993 (09.03.1993), entire text; all drawings & DE 4117644 A1	1-14
P,X	WO 2014/091752 A1 (Panasonic Corp.), 19 June 2014 (19.06.2014), paragraphs [0023] to [0174]; fig. 1 to 5, 9 to 10, 12 to 13, 15 to 16 & CN 104838142 A	5,14

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2000045949 A **[0020]**