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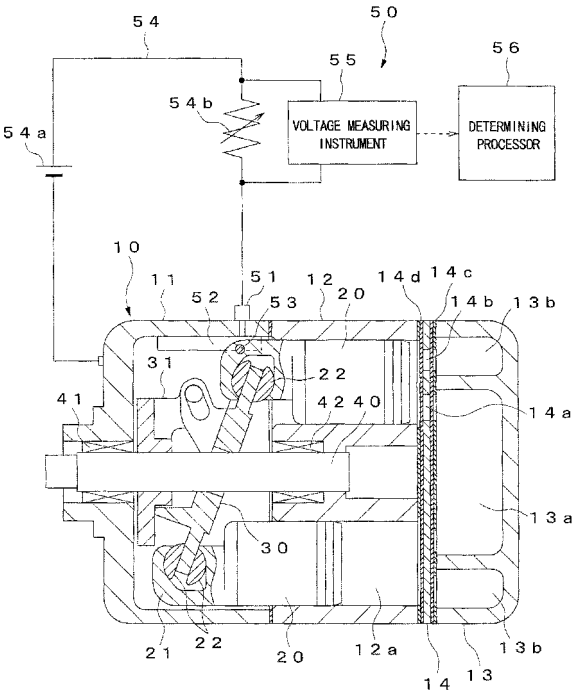
(54) Method and equipment for detecting failure in oil film formation of swash plate compressor

(57) A swash plate compressor is provided with first conducting means conductive to a shoe 22 of a piston 20 and second conducting means conductive to a swash plate 30, a voltage with a predetermined intensity is applied from the outside to each of the shoes 22 and the swash plate 30 by a voltage application circuit 54, and a voltage value of the voltage application circuit 54 is measured by a voltage measuring instrument 55 so that a failure in oil film formation between the shoe 22 and the swash plate 30 can be detected. Thus, there is no need to install precision equipment such as a sensor, a camera or a transmitter inside the compressor body 10, and the failure in oil film formation can be detected more surely with a simple structure.

F i g. 1



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Description

[0001] The present invention relates to a method and equipment for detecting failure in oil film formation of a swash plate compressor used in a refrigerant circuit of an air conditioner for a vehicle, for example.

[0002] Generally, this type of swash plate compressor is known as comprising a plurality of cylinders provided with an interval to each other in the circumferential direction in a compressor body, a plurality of pistons reciprocating in each cylinder, respectively, a swash plate slidably engaging with one end side of each piston, and a driving shaft for rotating the swash plate, in which the one end side of each piston is slidably brought into contact with the swash plate through a pair of shoes opposed to each other having the swash plate between them (See Japanese Utility Model Laid-Open No. 4-125682, for example).

[0003] Also, in the above compressor, an oil film of a lubricant is formed between each shoe and the swash plate, but since the shoe and the swash plate mutually slide at a high speed, the lubrication condition is demanding, and there is a problem that seizing between metal easily occurs due to lack of oil film. Then, in order to detect a failure in oil film formation between the shoe and the swash plate, there are proposed a method of measuring a clearance from the shoe by embedding a sensor in the swash plate, a method of direct monitoring of a sliding portion using a high-speed camera, a method of external detection by outputting an optical signal or an electric wave signal when the shoe and the swash plate are brought into contact with each other and the like.

[0004] However, in each of the above detecting methods, since precision equipment such as a sensor, camera or transmitter is installed inside the compressor, there are various problems in making it into practice on whether accurate detection is possible while the compressor is operating, various operating conditions can be met or detection without affecting performance of the compressor is possible or not.

[0005] The present invention was made in view of the above problems, and its object is to provide a method and equipment for detecting failure in oil film formation of a swash plate compressor which can detect a failure in oil film formation with accuracy in operation of the compressor, respond to various operating conditions and is further capable of detection without affecting performance of the compressor.

[0006] In order to achieve the above object, in a method for detecting a failure in oil film formation of a swash plate compressor comprising a plurality of cylinders provided with an interval to each other in the circumferential direction in a compressor body, a piston reciprocating in each cylinder, a swash plate slidably engaging with one end side of the piston, and a driving shaft for rotating the swash plate, in which the one end side of the piston is slidably engaged with the swash plate through a pair of shoes opposing each other with the swash plate between them, a voltage of a predetermined constant voltage power supply is applied from outside through a voltage application circuit to conducting means for conducting electricity to the shoe of the piston and the swash plate and a voltage value of the voltage application circuit is measured so as to determine if a value of the measured voltage is equal to or larger than a predetermined reference value or not.

[0007] By this, when a voltage of power supply of the voltage application circuit is applied to the shoe and the swash plate, a clearance by an oil film between the shoe and the swash plate forms electric resistance and the value of the voltage application circuit becomes smaller than the voltage of constant voltage power supply. But if the thickness of the oil film becomes smaller, the electric resistance drops and the voltage value becomes larger. Thus, in the state of lack of oil film or close to it, the voltage value of the voltage application circuit becomes substantially equal to the voltage value of the constant voltage power supply. By this, since it is determined that the value of measured voltage becomes equal to or larger than the reference voltage value when the voltage value of the voltage application circuit becomes equal to or larger than a reference voltage value, detection of a failure in oil film formation becomes possible based on the determination result. Therefore, detection of a failure in the oil film formation can be made without installing precision equipment such as a sensor, camera or transmitter inside the compressor body.

[0008] Also, in order to achieve the above object, in equipment for detecting failure in oil film formation of a swash plate compressor comprising a plurality of cylinders provided with an interval to each other in the circumferential direction in a compressor body, a piston reciprocating in each cylinder, a swash plate slidably engaging with one end side of the piston, and a driving shaft for rotating the swash plate, in which the one end side of the piston is slidably engaged with the swash plate through a pair of shoes opposing each other with the swash plate between them, there are provided first conducting means for conducting electricity to the shoe of the piston, second conducting means for conducting electricity to the swash plate, a voltage application circuit connected from the outside to the first and the second conducting means for applying a voltage of a predetermined intensity to the first and the second conducting means, a voltage measuring instrument for measuring a voltage value of the voltage application circuit, and a determining processor for determining if the value of the measured voltage of the voltage measuring instrument is equal to or larger than a predetermined reference value.

[0009] By this, when a voltage of power supply of the voltage application circuit is applied to the shoe and the swash plate through the first and the second conducting means, a clearance by the oil film between the shoe and the swash plate forms electric resistance and the value of the voltage application circuit becomes smaller than

the voltage of constant voltage power supply, but if the thickness of the oil film becomes smaller, the electric resistance drops and the voltage value increases. Thus, in the state of lack of oil film or close to it, the voltage value of the voltage application circuit becomes substantially equal to the voltage value of the constant voltage power supply. By this, when the voltage value of the voltage application circuit becomes equal to or larger than the reference voltage value, it is determined by the determining processor that the value of the measured voltage of the voltage measuring instrument becomes equal to or larger than the reference voltage value, and detection of a failure in oil film formation can be made possible based on the determination result. Therefore, detection of a failure in the oil film formation can be made without installing precision equipment such as a sensor, camera or transmitter inside the compressor body.

[0010] According to the present invention, since a failure in the oil film formation can be detected without installing precision equipment such as a sensor, camera or transmitter inside the compressor body, the failure in oil film formation can be detected more surely with a simple structure. Therefore, the failure in the oil film formation canbe detected with accuracy in operation of the compressor, diversified operating conditions can be responded, and moreover, the failure in oil film formation can be detected without affecting performance of the compressor, which is extremely advantageous in practical application.

[0011] The above object as well as the other objects, features and advantages of the present invention will be made clear in the following description and the attached drawings.

[0012] In the Drawings;

FIG. 1 is an outline side view of equipment for detecting failure in oil film formation showing an embodiment of the present invention;
FIG. 2 is a sectional view of an essential part of the equipment for detecting failure in oil film formation;
FIG. 3 is an enlarged sectional view of the essential part of the equipment for detecting failure in oil film formation;
FIG. 4 is a side view of a piston;
FIG. 5 is a partially exploded side view of the piston;
FIG. 6 is a graph showing a relation between a voltage and a clearance; and
FIG. 7 is a partially exploded side view showing another embodiment of the present invention.

[0013] FIGS. 1 to 6 show an embodiment of the present invention. A swash plate compressor shown in them comprises a compressor body 10 suctioning and discharging a refrigerant, a plurality of pistons 20 provided inside the compressor body 10, a swash plate 30 slidably engaged with one end side of each piston 20, and a driving shaft 40 for rotating the swash plate 30.

[0014] The compressor body 10 comprises a housing 11, a cylinder block 12, a cylinder head 13 and a valve plate 14, which are coupled with each other in the axial direction by a bolt, not shown.

[0015] The housing 11 is formed in the cylindrical state with one end side blocked, while the other end side is opened on the cylinder block 12 side.

[0016] The cylinder block 12 has a plurality of cylinders 12a extending in the axial direction of the compressor body 10, and both ends of each cylinder 12a are opened on the housing 11 side and the valve plate 14 side, respectively.

[0017] The cylinder head 13 has a refrigerant discharge chamber 13a and a refrigerant suction chamber 13b, and the refrigerant discharge chamber 13a and the refrigerant suction chamber 13b are opened on the cylinder block 12 side, respectively. The refrigerant discharge chamber 13a is provided at a center portion of the cylinder head 13 and communicates with a discharge port (not shown) to the outside. The refrigerant suction chamber 13b is provided in the periphery of the refrigerant discharge chamber 13a and communicates with a suction port (not shown) from the outside.

[0018] The valve plate 14 is arranged between the cylinder block 12 and the cylinder head 13 and has a plurality of refrigerant discharge holes 14a and refrigerant suction holes 14b communicating with each cylinder 12a. On one face side of the valve plate 14 (on the side of the cylinder head 13), a discharge-side plate 14c is arranged, and on the discharge-side plate 14c, a discharge valve (not shown) for opening/closing each refrigerant discharge hole 14a is provided. Also, on the other face side of the valve plate 14 (on the side of the cylinder block 12), a suction-side plate 14d is arranged, and on the suction-side plate 14d, a suction valve (not shown) for opening/closing each refrigerant suction hole 14b is provided.

[0019] Each piston 20 is provided slidably in each cylinder 12a with an engagement portion 21 to be engaged with the swash plate 30 formed at its one end. The engagement portion 21 has a pair of semispherical faces opposed to each other, and a semispherical shoe 22 is slidably provided between each semispherical face.

[0020] The swash plate 30 is provided capable of inclination with respect to the axial direction of the driving shaft 40, and with its peripheral edge portion, the engagement portion 21 of each piston 20 is engaged slidably through the shoe 22. The swash plate 30 is coupled capable of inclination to a rotating plate 31 rotating integrally with the driving shaft 40 so as to rotate around the driving shaft 40 by the rotating plate 31 and to reciprocate each piston 20 by a stroke amount corresponding to its inclination angle. Also, between each shoe 22 and the swash plat 30 is formed an oil film by a lubricant circuiting inside the compressor body 10. In this case, a non-compressed surface (the surface not receiving a reaction force of the piston 20) of the swash plate 30 is covered by a thin-film insulating member 30a so that the non-compressed surface of the swash plate 30 and one of the shoes 22 are electrically insulated by the insulating

member 30a. By this, electricity is conducted only through the compressed surface (the surface receiving the reaction force of the piston 20) of the swash plate 30 and the other shoe 22. Instead of the insulating member 30a, the non-compressed surface of the swash plate 30 may be given surface processing made of insulating coating.

[0021] The driving shaft 40 is rotatably supported by the housing 11 at its one end side through a bearing 41, while the other end side is rotatably supported by the cylinder block 12 through a bearing 42.

[0022] Next, the equipment for detecting a failure in oil film formation of this embodiment will be described. This equipment for detecting failure in oil film formation 50 comprises a terminal 51 provided on the outer face side of the housing 11, a conductive member 52 provided on the side of the piston 20, a contact pin 53 as a contact member provided at the piston 20, a voltage application circuit 54 for applying a voltage of a predetermined intensity to each shoe 22 and the swash plate 30, a voltage measuring instrument 55 for measuring a voltage value of the voltage application circuit 54, and a determining processor 56 for determining if the measured voltage of the voltage measuring instrument 55 is equal to or larger than a predetermined reference value or not, and the terminal 51, the conductive member 52 and the contact pin 53 are provided on both sides in the width direction of the piston 20, respectively.

[0023] The terminal 51 has a screw hole 51a for bolt screwing, and a conductor, not shown, of the voltage application circuit 54 is connected.

[0024] The conductive member 52 is made of a metal member extending in the sliding direction of the piston 20 and fastened to the housing 11 by a bolt 52a screwed to the terminal 51. In this case, the bolt 52a is screwed to the terminal 51 by insertion through a through hole 11a provided at the housing 11, and a sleeve 52b which insulates the bolt 52a and the housing 11 is inserted through the through hole 11a. Also, an insulating film 52c is formed on the inner circumferential face of the housing 11, and the conductive member 52 and the housing 11 are insulated by the insulating film 52c.

[0025] The contact pin 53 is made of conductive metal and slidably inserted into a hole 20a provided on the side face of the piston 20. In this case, a spring 53a is provided within the hole 20a so that the contact pin 53 is pressed into contact with the side face of the conductive member 52 by the spring 53a.

[0026] Also, at the piston 20, a conducting spring 57 as an elastic member conductive with the shoe 22 is provided, and the conducting spring 57 is fixed to the piston 20 so that its one end contacts the other shoe 22.

[0027] The voltage application circuit 54 comprises a constant voltage power supply 54a and a variable resistor 54b connected in series, and the constant voltage power supply 54a generates a direct current voltage with a predetermined intensity (2.0 [V], for example). The voltage application circuit 54 is connected to the terminal 51 at one end side (the variable resistor 54b side) with the other end side (the power supply 54a side) to the housing 11 of the compressor body 10.

[0028] The voltage measuring instrument 55 is connected to the voltage application circuit 54 in parallel with the variable resistor 54b so as to measure the voltage of the variable resistor 54b.

[0029] The determining processor 56 is connected to the voltage measuring instrument 55 so as to determine whether the voltage value measured by the voltage measuring instrument 55 is equal to or larger than a predetermined reference voltage value V (1.9 [V], for example) or not.

[0030] In the equipment for detecting a failure in oil film formation 50, the terminal 51, the conductive member 52, the contact pin 53, the piston 20 and the shoe 22 are conducted sequentially as first conducting means, and the housing 11 of the compressor body 10, the driving shaft 40 and the swash plate 30 are conducted sequentially as second conducting means. In this case, the piston 20 and the shoe 22 are also conducted by the conducting spring 57.

[0031] In the compressor constructed as above, when the driving shaft 40 is rotated by a driving force from the outside, each piston 20 reciprocates within each cylinder 12a according to the inclination angle of the swash plate 30. By this, the refrigerant of the refrigerant suction chamber 13b is sucked into each cylinder 12a and discharged into the refrigerant discharge chamber 13a. At that time, a pressure inside the housing 11 is regulated by pressure control means, not shown, and by a differential pressure generated between the refrigerant suction chamber 13b and the inside of the housing 11, the inclination angle of the swash plate 30 is changed according to the pressure applied on the other end side (the side of the housing 11) of each piston 20. By this, a stroke amount of each piston 20 is increased or decreased, and the discharge amount of the refrigerant is changed.

[0032] Also, in the equipment for detecting failure in oil film formation 50 of this embodiment, the voltage of the power supply 54a of the voltage application circuit 54 is applied to each shoe 22 and the swash plate 30, and the voltage of the variable resistor 54b is measured by the voltage measuring instrument 55. At that time, since a clearance is formed by an oil film of lubricant between the shoe 22 and the swash plate 30, this clearance becomes electric resistance and the value of the measured voltage becomes smaller than the voltage of the power supply 54a. That is, as shown in FIG. 5, if the thickness of the oil film is equal to or larger than a normal value (6 [μm], for example), it becomes substantially 0 [V], but if the thickness of the oil film becomes smaller, the voltage value becomes larger and in the case of lack of the oil film or in the state close to it, the voltage value becomes substantially the voltage value of the power supply 54a (2 [V], for example). At that time, whether the value of the measured voltage is larger than the reference voltage value V (1.9 [V], for example) or not is determined by the

determining processor 56, and a failure in oil film formation is detected based on the determination result. That is, if the value of the measured voltage is determined as being equal to or larger than the reference voltage value V by the determining processor 56, predetermined abnormality processing actions including stop of driving of the compressor or actuation of an alarm device, not shown, are taken.

[0033] In this way, according to this embodiment, the voltage of a predetermined intensity is applied by the voltage application circuit 54 to each shoe 22 of the piston 20 and the swash plate 30 from the outside and the voltage value of the voltage application circuit 54 is measured by the voltage measuring instrument 55. And since the failure in formation of an oil film between the shoe 22 and the swash plate 30 is detected by determining whether the value of the measured voltage is equal to or larger than the predetermined reference value or not by the determining processor 56, there is no need to install precision equipment such as a sensor, camera or transmitter inside the compressor body 10, and the failure in oil film formation can be detected more surely with a simple structure. Therefore, the failure in oil film formation can be detected with accuracy in operation of the compressor, diversified operating conditions can be responded, and moreover, the failure in oil film formation can be detected without affecting performance of the compressor, which is extremely advantageous in practical realization.

[0034] In this case, since a failure in oil film formation can be easily detected by connecting the voltage application circuit 54 to the compressor from the outside, not only that it can be provided in an air conditioning device for a vehicle for detecting a failure in oil film formation of a compressor mounted on a vehicle but even though it is not provided in the air conditioning device for a vehicle, the failure in oil film formation can be easily detected by connecting the voltage application circuit 54 to the compressor at shipment from a plant or maintenance, which can improve versatility.

[0035] Also, since it is so constructed that the terminal 51, the conductive member 52, the contact pin 53, the piston 20 and the shoe 22 are sequentially conducted by providing the terminal 51 to which the one end side of the voltage application circuit 54 can be connected on the outer surface side of the compressor body 10, providing the conductive member 52 conductive to the terminal 51 on the side of the piston 20, and by providing the conductive contact pin 53 slidably contacting the conductive member 52 at the piston 20, the one end side of the voltage application circuit 54 can be made conductive to the shoe 22 only by adding a simple part such as the terminal 51, the conductive member 52 and the contact pin 53, which is extremely advantageous for cost reduction.

[0036] Moreover, since the compressor body 10, the driving shaft 40 and the swash plate 30 are sequentially conducted, the other end side of the voltage application circuit 54 can be conducted to the swash plate 30 only by connecting the other end side of the voltage application circuit 54 to the compressor body 10 without adding an exclusive conductive part, which is extremely advantageous for cost reduction.

[0037] Also, since each contact pin 53 is pressed into contact with the conductive member 52 by the spring 53a, the contact pin 53 can be surely brought into contact with the conductive member 52, and conducting between the conductive member 52 and the contact pin 53 can be made surely.

[0038] In this case, since the conductive member 52 and the contact pin 53 are provided on both sides in the width direction of the piston 20, respectively, even if the piston 20 is displaced in the width direction during a reciprocating motion, one of the contact pins 53 can be brought into contact with either one of the conductive members 52 all the time, and conducting between the conductive member 52 and the contact pin 53 can be made more surely. Moreover, since the circumferential rotation of the piston 20 can be regulated by each conductive member 52 arranged on both sides in the width direction, the piston 20 can be reciprocated stably all the time without separately providing a part for preventing rotation.

[0039] Also, since the conducting spring 57 with the one end in contact with the other shoe 22 is provided at the piston 20 so that the piston 20 and the other shoe 22 are also conducted by the conducting spring 57, the conducting between the piston 20 and the shoe 22 can be made more surely, and drop of conductivity caused by the oil film between the piston 20 and the other shoe 22 can be surely prevented.

[0040] Moreover, since the voltage value of the variable resistor 54b provided at the voltage application circuit 54 is measured by the voltage measuring instrument 55, the correlation between the voltage and the clearance between the swash plate/shoe shown in FIG. 6 can be arbitrarily set by regulating the resistance value of the variable resistor 54b.

[0041] Also, since the one face (non-compressed surface) of the swash plate 30 is insulated from the one shoe 22 by the insulating member 30a, only between the other face (compressed surface) of the swash plate 30 and the other shoe 22 can be conducted, and a failure in oil film formation on the compressed surface side of the swash plate 30 where lubrication state is demanding can be surely detected.

[0042] The conductive member 52 and the contact pin 53 of the equipment for detecting failure in oil film formation in the above embodiment may be provided at each piston 20, but they may be provided only some of the pistons 20.

[0043] Also, in the above embodiment, an example that the one face (non-compressed surface) of the swash plate 30 is insulated from the one shoe 22 is shown, but as shown in FIG. 7, if the other face (compressed surface) of the swash plate 30 is insulated from the other shoe 22 by an insulating member 30b, the failure in oil film forma-

tion on the non-compressed surface of the swash plate 30 can be detected.

[0044] The example described in this specification is only for an example and not limiting. The scope of the invention is indicated in the appended claims and all the variations included in the meaning of the claims are included in the present invention.

Claims

1. A method for detecting failure in oil film formation of a swash plate compressor comprising a plurality of cylinders (12a) provided with an interval to each other in the circumferential direction in a compressor body (10), a piston (20) reciprocating in each cylinder (12a), a swash plate (30) slidably engaging with one end side of the piston (20), and a driving shaft (40) for rotating the swash plate (30), in which the one end side of the piston (20) is slidably engaged with the swash plate (30) through a pair of shoes (22) opposing each other with the swash plate (30) between them,
   wherein a voltage of a predetermined constant voltage power supply (54a) is applied through a voltage application circuit (54) to conducting means for conducting electricity to the shoe (22) of the piston (20) and the swash plate (30); and
   a voltage value of the voltage application circuit (54) is measured so as to determine if a value of the measured voltage is equal to or larger than a predetermined reference value or not.

2. Equipment for detecting failure in oil film formation of a swash plate compressor comprising a plurality of cylinders (12a) provided with an interval to each other in the circumferential direction in a compressor body (10), a piston (20) reciprocating in each cylinder (12a), a swash plate (30) slidably engaging with one end side of the piston (20), and a driving shaft (40) for rotating the swash plate (30), in which the one end side of the piston (20) is slidably engaged with the swash plate (30) through a pair of shoes (22) opposing each other with the swash plate (30) between them, comprising:

   first conducting means for conducting electricity to the shoe (22) of the piston (20);
   second conducting means for conducting electricity to the swash plate (30);
   a voltage application circuit (54) connected from the outside to the first and the second conducting means for applying a voltage of a predetermined constant voltage power supply (54a) to the first and the second conducting means;
   a voltage measuring instrument (55) for measuring a voltage value of the voltage application circuit (54); and
   a determining processor (56) for determining if the value of the measured voltage of the voltage measuring instrument (55) is equal to or larger than a predetermined reference value.

3. The equipment for detecting failure in oil film formation of a swash plate compressor according to claim 2, further comprising:

   a terminal provided on the outer face side of the compressor body (10) and to which the voltage application circuit (54) can be connected;
   a conductive member (52) provided on the side of the piston (20) for conducting electricity to the terminal; and
   a conductive contact member (53) provided at the piston (20) and slidably contacting the conductive member (52),

   wherein the first conducting means is formed so that the terminal (51), the conductive member (52), the contact member (53), the piston (20) and the shoe (22) are sequentially conducted.

4. The equipment for detecting failure in oil film formation of a swash plate compressor according to claim 2, wherein the second conducting means is formed so that the compressor body (10), the driving shaft (40) and the swash plate (30) are sequentially conducted.

5. The equipment for detecting failure in oil film formation of a swash plate compressor according to claim 2, wherein the contact member (53) is provided so that it is pressed into contact with the conductive member (52) by a spring (53a).

6. The equipment for detecting failure in oil film formation of a swash plate compressor according to claim 2, wherein the conductive member (52) and the contact member (53) are provided on both sides in the width direction of the piston (20), respectively.

7. The equipment for detecting failure in oil film formation of a swash plate compressor according to claim 6, wherein each of the conductive members (52) is provided so as to regulate rotation of the piston (20) in the circumferential direction.

8. The equipment for detecting failure in oil film formation of a swashplate compressor according to claim 2, wherein a conductive elastic member (57) having one end side fixed to the piston (20) so that the other end is in contact with the shoe (22) is provided at the piston (20).

9. The equipment for detecting failure in oil film formation of a swash plate compressor according to claim

2, wherein the voltage measuring instrument (55) measures a voltage value of a variable resistor (54b) provided at the voltage application circuit (54).

10. The equipment for detecting failure in oil film formation of a swash plate compressor according to claim 2, wherein the swash plate (30) is insulated from one of the shoes (22) by an insulating member (30b).

11. Equipment for detecting failure in oil film formation of a swash plate compressor comprising a plurality of cylinders (12a) provided with an interval to each other in the circumferential direction in a compressor body (10), a piston (20) reciprocating in each cylinder (12a), a swash plate (30) slidably engaging with one end side of the piston (20), and a driving shaft (40) for rotating the swash plate (30), in which the one end side of the piston (20) is slidably engaged with the swash plate (30) through a pair of shoes (22) opposing each other with the swash plate (30) between them, comprising:

first conducting means for conducting electricity to the shoe (22) of the piston (20);
second conducting means for conducting electricity to the swash plate (30);
a voltage application circuit (54) connected from the outside to the first and the second conducting means for applying a voltage of a predetermined constant voltage power supply (54a) to the first and the second conducting means;
a voltage measuring instrument (55) for measuring a voltage value of the voltage application circuit (54);
a determining processor (56) for determining if the value of the measured voltage of the voltage measuring instrument (55) is equal to or larger than a predetermined reference value;
a terminal provided on the outer face side of the compressor body (10) and to which the voltage application circuit (54) can be connected;
a conductive member (52) provided on the side of the piston (20) for conducting electricity to the terminal; and
a conductive contact member (53) provided at the piston (20) and slidably contacting the conductive member (52),
wherein the first conducting means is formed so that the terminal (51), the conductive member (52), the contact member (53), the piston (20) and the shoe(22) are sequentially conducted;
the second conducting means is formed so that the compressor body (10), the driving shaft (40) and the swash plate (30) are sequentially conducted;
the contact member (53) is provided so that it is pressed into contact with the conductive member (52) by a spring (53a);
the conductive member (52) and the contact member (53) are provided on both sides in the width direction of the piston (20), respectively;
each of the conductive members (52) is provided so as to regulate rotation of the piston (20) in the circumferential direction;
a conductive elastic member (57) having the other end side fixed to the piston (20) so that one end is in contact with the shoe (22) is provided at the piston (20);
the voltage measuring instrument (55) is constructed to measure a voltage value of a variable resistor (54b) provided at the voltage application circuit (54); and
the swash plate (30) is insulated from one of the shoes (22) by an insulating member (30b).

Fig. 1

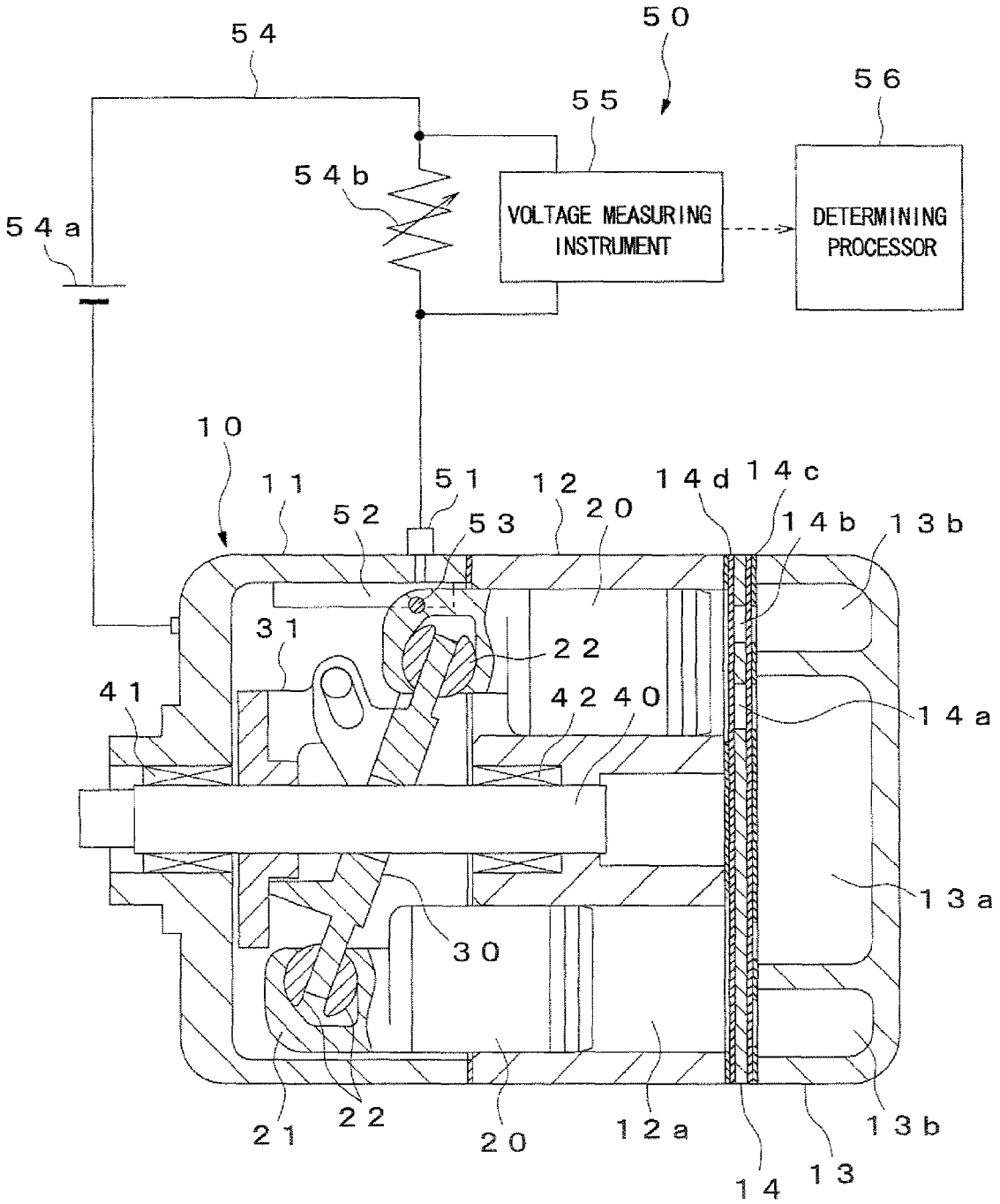

54
50
56
55
54b
54a
VOLTAGE MEASURING INSTRUMENT
DETERMINING PROCESSOR
10
11
51
12
14d
14c
52
53
20
14b
13b
31
22
41
42
40
14a
13a
30
21
22
20
12a
14
13
13b

Fig. 2

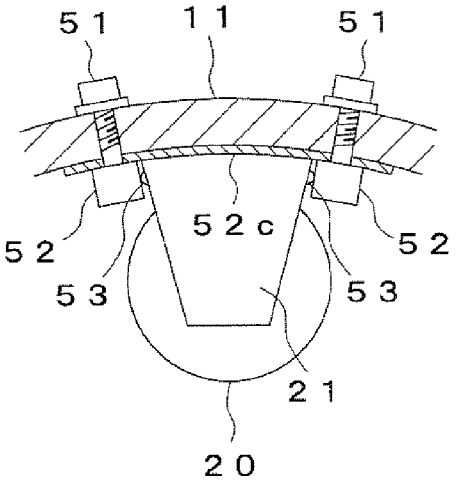
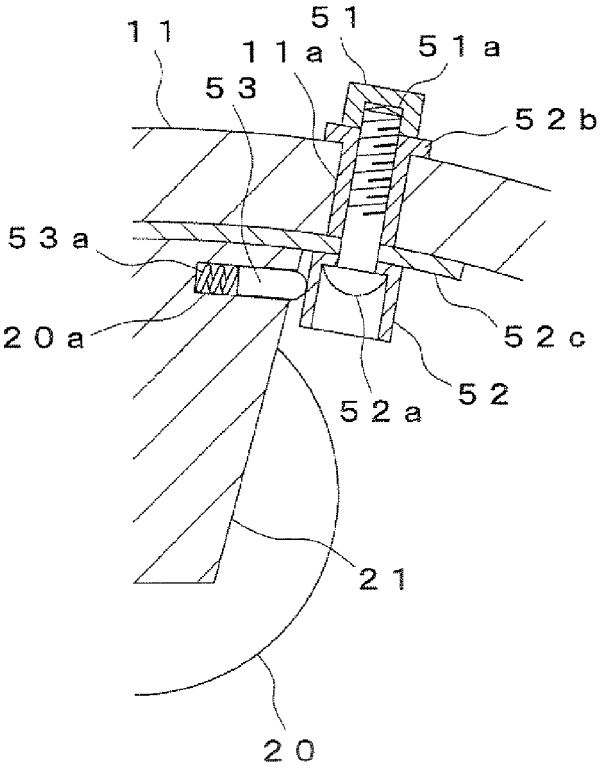

51
11
51
52c
52
52
53
53
21
20

Fig. 3


11
51
11a
51a
53
52b
53a
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52c
52
52a
21
20

Fig. 4

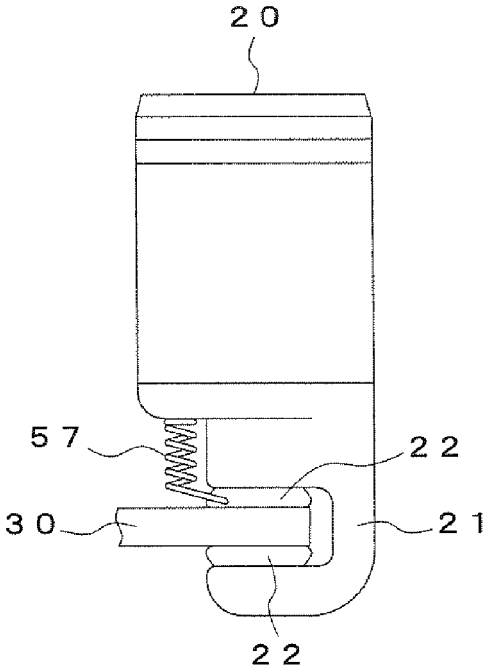


Fig. 5

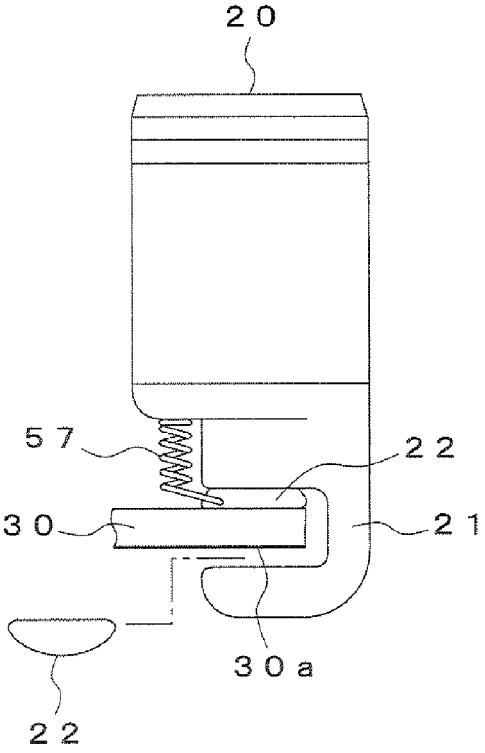


Fig. 6

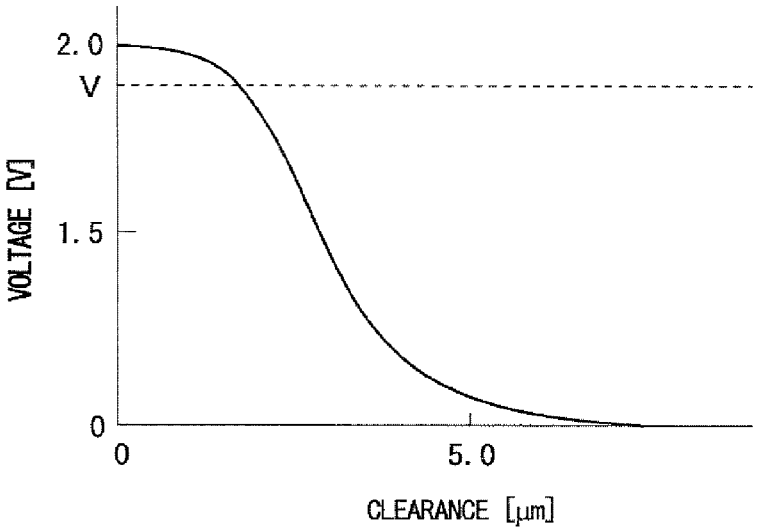
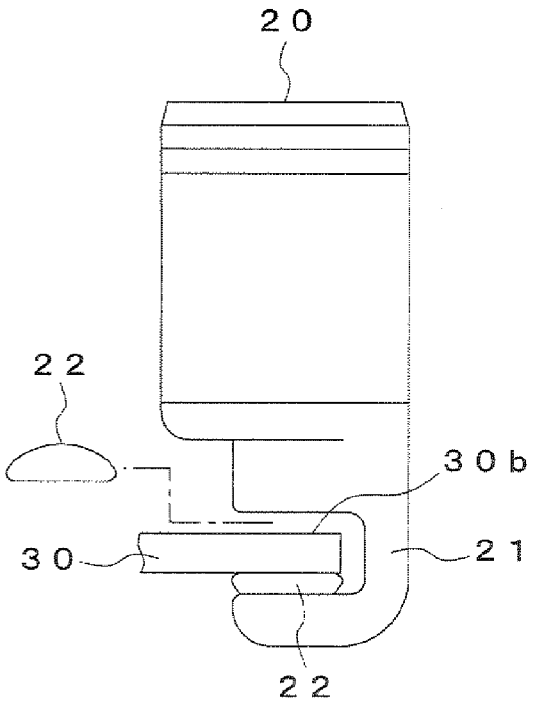


Fig. 7



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Patent documents cited in the description

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