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

(11) EP 1 130 259 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
05.09.2001 Bulletin 2001/36

(51) Int Cl.[7]: **F04B 27/10**

(21) Application number: **01104209.0**

(22) Date of filing: **22.02.2001**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **29.02.2000 JP 2000053513**

(71) Applicant: **Kabushiki Kaisha Toyoda Jidoshokki Seisakusho**
Aichi-ken 448-8671 (JP)

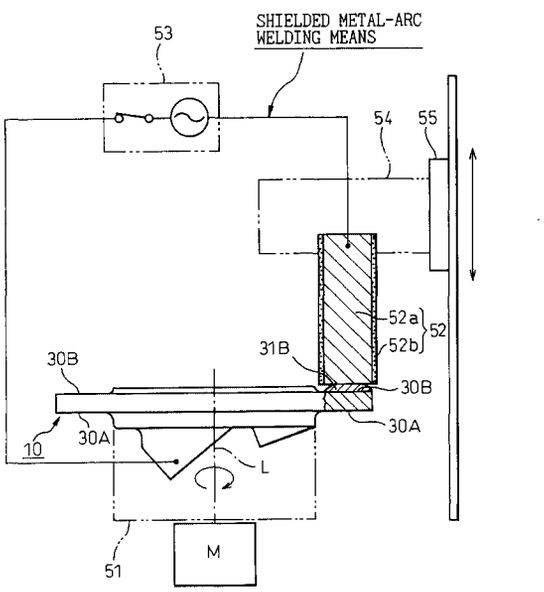
(72) Inventors:
- **Sugiura, Manabu,**
  K.K.Toyoda Jidoshokki Seisakusho
  Kariya-shi, Aichi-ken, 448-8671 (JP)
- **Iwama, Kazuaki,**
  K.K.Toyoda Jidoshokki Seisakusho
  Kariya-shi, Aichi-ken, 448-8671 (JP)
- **Isomura, Naohiko,**
  K.K.Toyoda Jidoshokki Seisakusho
  Kariya-shi, Aichi-ken, 448-8671 (JP)
- **Kawachi, Shigeki,**
  K.K.Toyoda Jidoshokki Seisakusho
  Kariya-shi, Aichi-ken, 448-8671 (JP)

(74) Representative: **Hoeger, Stellrecht & Partner**
Uhlandstrasse 14 c
70182 Stuttgart (DE)

(54) Coating applied by electric arc welding for a compressor swash plate

(57) A coating forming method, which has an excellent versatility as a forming art of a metal material coating on the sliding contact surface of a swash plate, with shoes, can maintain a good working environment in the field and can effectively reduce the working processes, time, and cost is provided. The coatings 31A and 31B are formed in the shielded metal-arc welding padding method on the surfaces 30A and 30B of the swash plate 10, which slidably contact with the shoes 20A and 20B.

Fig. 3



EP 1 130 259 A2

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a swash plate, which is used in a swash plate compressor that constitutes the refrigerating cycle of an air conditioner, for example, and is connected to a piston via a shoe. More particularly, the present invention relates to a coating forming method in which a metal material coating is formed on a surface of the swash plate slidably in contact with shoes.

2. Description of the Related Art

[0002] Normally, the lubrication between a swash plate and shoes that constitute the inner structure of a swash plate compressor is carried out by a mist of lubricating oil which is retained internally, is turned into mist by the gas (for example, refrigerant gas such as chlorofluorocarbon gas) that circulates while a compressor is in operation and is distributed to the sliding portions between the swash plate and the shoes.

[0003] In such a case, however, when the compressor resumes operation after a long period of non-operation state, the lubricating oil attached to the sliding portions may have been washed away by the refrigerant gas. Therefore, though the compressor is already in operation, the lubricating oil is not supplied sufficiently to the sliding portions between the swash plate and the shoes, where lubrication is necessary, until the lubricating oil is turned into mist by the refrigerant gas that is fed back to the compressor after the compressor is activated (about one minute).

[0004] In order to ensure lubrication, at the minimum, between the swash plate and the shoes during the period in which oil is not supplied sufficiently, an art to apply (form) a coating on the sliding contact surface of a swash plate, with shoes, has been already presented. Even if only the art of applying a coating on the sliding contact surface of a swash plate is considered, there are still various methods. The electrolytic or electroless plating of a metal such as tin and the flame spraying method of applying copper-base or aluminum-base alloy are examples among the coating arts, which are not only disclosed in patent documents but also used practically in a product (swash plate).

[0005] Though it is not difficult to form a very thin coating (of a few micrometers) with the electrolytic or electroless plating of a metal such as tin, it is not necessarily easy to form a relatively thick coating of tens of micrometers or more. Moreover, because a problem relating to the electrochemical relation between the base metal and the bonded metal occurs when carrying plating, it is not possible to adopt this method in some cases.

[0006] On the other hand, according to the flame spraying method in which a powdered metal material in a fused state, and the like, is sprayed on the processed surface of a work with a flame, it is not difficult to form a thick coating or match two metals electrochemically, but there intrinsically exist the following problems relating to operative works such as A and B.

(A) In many cases, it is necessary to apply a scabrous surface treatment in advance on the sliding contact surface of a swash plate by shot blasting, or the like, before flame spraying. The necessity of the surface preparation and the expenditure of hardened particles (sub material) used for the scabrous surface treatment is one of the factors that causes the period of time and the cost for the flame spraying process to increase. Moreover, the scabrous surface treatment produces considerable noise, resulting in a deterioration of the working environment.

(B) It is necessary to mask the portions on which flame spraying is not necessary in advance, resulting in one of the factors that causes the period of time and cost to further increase.

[0007] As explained above, the flame spraying method has excellent versatility as a metal coating forming method for the processed surface of a metal work, but it also has many problems such as in that the working environment is deteriorated in the field as well as the required working processes, time and cost are increased, as described above.

SUMMARY OF THE INVENTION

[0008] The objective of the present invention is to provide: a coating forming method for a swash plate of a swash plate compressor, which not only has an excellent versatility as a forming method of a metal material coating on the sliding contact surface of a swash plate, with shoes, but also is able to maintain a proper working condition in the working field and to effectively reduce the required working processes, time and cost; and a swash plate having a coating formed by the present coating forming method on the sliding contact surface of a swash plate, with shoes.

[0009] In order to achieve the above-mentioned objective, the first aspect of the present invention is a coating forming method for a swash plate of a swash plate compressor, wherein a welding padding method is used to form the coating on the swash plate, which is used in a swash plate compressor, is connected to pistons via shoes and has a coating of metal material on the sliding contact surface thereof, with the shoes.

[0010] In the present method, a coating is formed by directly padding the fused metal material onto the sliding contact surface of a swash plate, therefore, a large noise that is produced when the metal material is sprayed in a method such as a flame spraying method can be

avoided and the degradation of yield of materials due to the powered metal material scattered around during spraying and the deterioration of working environment can be also avoided.

[0011] The second aspect of the present invention provides a method in that the welding padding method in the first aspect of the present invention is a padding method using an electric arc welding.

[0012] The third aspect of the present invention includes a swash plate having a coating formed, on the sliding contact surface of a swash plate, with the shoes, by the coating forming method described in the first or the second aspect.

[0013] The present invention may be more fully understood from the description of the preferred embodiments of the invention set forth below, together with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] In the drawings:

FIG.1 is the longitudinal sectional view of a variable displacement type swash plate compressor.

FIG.2 is the enlarged sectional view of the vicinity of the circumferential part of a swash plate in contact with shoes.

FIG.3 is a pictorial illustration of a coating forming device.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0015] An embodiment, in which the present invention is embodied in a coating forming method for a swash plate of a swash plate compressor, to be used in an air conditioner, is explained below.

(Swash plate compressor)

[0016] As shown in FIG.1, the swash plate compressor comprises a cylinder block 1, a front housing 2 coupled to the front end of the cylinder block 1, and a rear housing 4 coupled to the rear end of the cylinder block 1 via a valve forming body 3, and all these parts are fixingly connected to each other, constituting the housing of the compressor.

[0017] In the housing, a crank chamber 5, a suction chamber 6, and a discharge chamber 7 are defined. Plural cylinder bores la (only one is shown) are formed in the cylinder block 1 and a single-headed piston 8 is housed in each bore la, allowed a reciprocating motion. The suction chamber 6 and the discharge chamber 7 are selectively communicated with each bore la through various flapper valves equipped in the valve forming body 3.

[0018] In the crank chamber 5, a drive shaft 9 is rotatably supported and a swash plate 10 is housed as a cam plate. An insertion hole 10a penetrates through the center of the swash plate 10 and the drive shaft 9 is inserted through the insertion hole 10a. The swash plate 10 is operatively connected to the drive shaft 9 via a hinge device 13 and a lug plate 11, and able to rotate synchronously with the drive shaft 9 and to move and incline against the drive shaft 9 with a sliding motion in the axial direction of the drive shaft 9. Since the circumferential part of the swash plate 10 is slidably connected to the end of each piston 8 via a pair of shoes, a front shoe 20A and a rear shoe 20B, all the pistons 8 are operatively connected to the swash plate 10.

[0019] When the swash plate 10, which inclines at a required angle, rotates with the drive shaft 9, each piston 8 reciprocates with a stroke corresponding to the inclination angle of the swash plate 10, and in each bore la, the refrigerant gas is sucked from the suction chamber 6 (a region with suction pressure Ps) and is compressed, the compressed refrigerant gas is discharged to the discharge chamber 7 (a region with discharge pressure Pd), and these processes are repeated in turn.

[0020] The swash plate 10 is biased in the direction to come close to the cylinder block 1 (the direction to reduce an inclination angle of the swash plate) by an inclination angle reducing spring 14. The minimum inclination angle θ min of the swash plate 10 (to 3 to 5°, for example), however, is limited by a circlip 15 and so on which is fixed on the drive shaft 9 and restricts the inclination of the swash plate 10 to the direction in which the inclination angle decreases. On the other hand, the maximum inclination angle θ max of the swash plate is limited, for example, by a counterweighted portion 10b of the swash plate 10 which comes into contact with a limiting portion 11a of the lug plate 11.

[0021] The inclination angle of the swash plate 10 is determined by the interactive balance between various moments such as the moment of the rotational motion based on the centrifugal force when the swash plate rotates, the moment of the spring force based on the biasing effect of the inclination angle reducing spring 14, the moment of the inertia force of the reciprocating motion of the pistons 8, the moment of the gas pressure, and so on. The moment of the gas pressure is produced by the interactive relation between the internal pressure of the cylinder bore la and the internal pressure of the crank chamber 5 (crank pressure Pc), which is the back pressure of the piston 8, and applied to both directions in which the inclination angle decreases and increases according to the crank pressure Pc.

[0022] In the swash plate compressor in FIG.1, the moment of the gas pressure can be changed appropriately by adjusting the crank pressure Pc using a control valve 16, which is not described here in detail, and the inclination angle of the swash plate 10 can be adjusted to any angle θ between the minimum inclination angle θ min and the maximum inclination angle θ max.

(Swash plate)

[0023] As shown in FIGs.1 and 2, annular sliding contact surfaces 30A and 30B are formed respectively at the front side and the rear side of the circumferential part of the swash plate 10. The annular sliding contact surfaces 30A and 30B at the front and rear sides slidably contact with a pair of shoes, 20A and 20B, respectively.

[0024] A relatively heavy iron-base material (cast iron such as FCD700, for example) is used for the swash plate 10 in order to appropriately produce the moment of the rotational motion based on the centrifugal force when the swash plate rotates. On the other hand, an iron-base material (bearing steels, for example) is also used for the shoes 20A and 20B in consideration of the mechanical strength thereof, and so on. If two members made of the same type of metal material (in this case, the swash plate 10 and the shoes 20A and 20B) slidably contact with each other under severe conditions, burning is caused by the so-called "friction phenomenon of the same metals", therefore in the present embodiment, coatings 31A and 31B are formed at least on the sliding contact surfaces 30A and 30B of the swash plate 10, as shown in FIG.2, as sliding layers to improve the quality of sliding contact with the shoes 20A and 20B.

[0025] Each coating 31A and 31B is made of a metal material other than the iron-base material that constitutes the base metal of the swash plate 10 and the shoes 20A and 20B. The metal materials that constitute the coatings 31A and 31B include, for example, an aluminum alloy that contains silicon and a metallic compound of aluminum and silicon (both are referred to as "Al-Si-base metal material" hereinafter). Physical properties such as the hardness or the melting point of an Al-Si-base metal material, as an aluminum-base material, differ variously according to the silicon content of the material. The silicon content of the Al-Si-base metal material to be used here is 10~20% by weight (about 17% by weight is preferable).

[0026] By forming the coatings 31A and 31B made of the above-mentioned Al-Si-base metal material, the burning due to the "friction phenomenon of the same metals" can be avoided and at the same time the quality of sliding contact between the swash plate 10 and the shoes 20A and 20B is improved. That is, by forming the coatings 31A and 31B, lubrication to a certain extent is ensured between the swash plate 10 and the shoes 20A and 20B even under oilless conditions.

[0027] While the iron-base material used for the swash plate 10 and the shoes 20A and 20B has a very high hardness and a relatively high melting point temperature of a thousand °C or more, the Al-Si-base metal material that constitutes the coatings 31A and 32B has a relatively lower hardness than the iron-base material and a melting point temperature of 600~700°C, which is lower than that of the iron-base material. It is unquestionably true that the difference in physical properties of the Al-Si-base metal material against the iron-base material contributes to the improvement of the quality of sliding contact between the swash plate 10 and the shoes 20A and 20B.

(Coating forming method)

[0028] The procedure of forming a coating onto the sliding contact surface 30B at the rear side of the swash plate 10 is described concretely.

[0029] FIG.3 shows a coating forming device exemplarily. The coating forming device comprises a rotating support mechanism 51 (indicated pictorially by an alternate long and two short line) and a shielded metal-arc welding means. The rotating support mechanism 51 is operatively connected to a motor M and the supported swash plate 10 is rotated at a low speed (e.g. 1~10rpm), based on the drive force of the motor M, around the axial line L. In a situation where the swash plate 10 is set on the rotating support mechanism 51, the annular sliding contact surface 30B is a plane that circumscribes the axial line L and is perpendicular to the axial line L.

[0030] The shielded metal-arc welding means comprises a welding rod 52 and a welding power source 53 that impresses voltage between the welding rod 52 and the swash plate 10. The welding rod 52 comprises a core wire 52a, which is made of the Al-Si-base metal material, and a flux (coating) 52b, which is applied on the circumferential surface of the core wire 52a. The welding rod 52 is supported by an elevating support mechanism 54 (indicated pictorially by an alternate long and two short line) and at the same time the elevating support mechanism 54 is operatively connected to an elevating means 55.

[0031] In a situation where the welding rod 52 is set on the elevating support mechanism 54, the welding rod 52 is placed at an eccentric position with respect to the axial line L of the swash plate 10 set on the rotating support mechanism 51, opposing a part of the sliding contact surface 30B of a swash plate thereover. The elevating support mechanism 54 is lifted or lowered together with the supported welding rod 52 in the vertical direction in the figure by the movement of the elevating means 55, therefore, the welding rod 52 moves near to or away from a part of the sliding contact surface 30B of a swash plate.

[0032] If the welding power source 53 is activated at the same time that the welding rod 52 is lowered to (brought near to) a part of the sliding contact surface 30B of a swash plate by the elevating means 55, an arc is generated between the welding rod 52 and the swash plate 10. The heat of arc causes a part of the metal material of the welding rod 52 (core wire 52a) to melt and drop on the sliding contact surface 30B of a swash plate (that is the surface is padded with melted metal). The metal material of the welding rod 52 that has dropped on the sliding contact surface 30B of a swash plate is melted with the metal material of the sliding contact surface 30B of a swash plate that has also been melted by

the heat of the arc. In addition, the rotating support mechanism 51 rotates together with the swash plate 10 by the operation of the motor M, and the position of the welding rod 52, which opposes a part of the sliding contact surface 30B of a swash plate (that is the place on which the melted metal material of the welding rod 52 drops), changes continuously and in turn in the circumferential direction of the annular sliding contact surface 30B.

[0033] If the swash plate 10 rotates at least one turn, the melted metal material of the welding rod 52 drops on the entire circumference of the annular sliding contact surface 30B (padding) is completed in one time and the coating 31B made of Al-Si-base metal material is formed, the thickness of which (e.g. 70~100μm) is the total of the required thickness (e.g. 50μm) plus the thickness with cutting margin (e.g. 20~50μm) for post processing on the entire circumference of the annular sliding contact surface 30B.

[0034] As described above, after the coating 31B is formed on the entire circumference of the sliding contact surface 30B, the motor M and the welding power source 53 are turned off and the welding rod 52, together with the elevating support mechanism 54, is lifted (separated) from the sliding contact surface 30B of a swash plate.

[0035] The required thickness of the coating 31B is adjusted by cutting or polishing, as post processing, the coating formed by the above-mentioned welding padding method. Moreover, the coating 31A made of the Al-Si-base metal material is formed also on the sliding contact surface 30A at the front side of the swash plate 10 in the same procedure mentioned above.

[0036] The following effects can be expected in the present embodiment with the above-mentioned configuration.

(1) According to the coating forming method of the present embodiment, the coatings 31A and 31B made of the Al-Si-base metal material can be efficiently formed on the sliding contact surfaces 30A and 30B of the swash plate 10 by an easy procedure and in a short period of time.

(2) Different from the flame spraying method, the present method does not require a special preparation (scabrous surface treatment or masking) for the sliding contact surfaces 30A and 30B of the swash plate 10. Therefore, the required working processes, time, and cost can be considerably reduced.

(3) In the present method, the coatings 31A and 31B on the sliding contact surfaces 30A and 30B are basically formed by physical bonding of two kinds of melted metals and do not require perfect chemical matching of two kinds of melted metals, therefore, the present method has an excellent versatility as a coating forming method.

(4) According to the present method, the coatings 31A and 31B are formed on the sliding contact surfaces 30A and 30B of a swash plate by direct padding the metal material, therefore, loud noise, which are generated when a metal material is sprayed in the flame spraying method can be avoided, and the degradation of the yield of the material, as well as the deterioration of the working environment, due to the powered metal material which is scattered around during spraying can be avoided.

(5) According to the present method, the coating forming (welding padding) is carried out by using a rod-shaped metal material (a welding rod 52), therefore, it is not necessary to use an expensive metal material, which is used in a powder formation such as in the flame spraying method, which is a treatment using powder. Moreover, a rod-shaped metal material is easier to handle than a powered metal and this makes the work of coating forming more efficient and improves the working environment.

(6) The electric arc welding method, which is the most general welding method at the present time, is the best choice, at the present time, to carry out the coating forming on the swash plate 10 of a swash plate compressor by using the welding padding method, from the standpoint of the cost for introduction and the know-how of the coating forming device, and the like.

[0037] In addition, the following modifications can be accepted without departing from the basic concept and scope of the present invention.

- Electric arc welding methods other than the shielded metal-arc welding method include gas shield arc welding, submerged arc welding, and so on. The gas shield arc welding includes mig welding, mag welding, tig welding, and so on. Each welding method may be used to carry out the coating forming (welding padding) on the sliding contact surfaces 30A and 30B of a swash plate.
- Instead of the aluminum-base material, a copper-base material may be used for the welding rod 52 (core wire 52a).
- The coating forming method for the swash plate 10 made of the aluminum-base material rather than the iron-base material may be realized.

[0038] The technical idea, which can be grasped from the above-mentioned embodiments, is described as follows: a coating made of the metal material, which is formed on the sliding contact surface with the shoes, is used to improve the quality of sliding contact with the shoes in the coating forming methods described in the first or the second aspect or in the swash plate in the third aspect of the present invention.

[0039] As described so far, the method of the present invention has not only an excellent versatility as a form-

ing art of a metal material coating on the sliding contact surface of a swash plate, with the shoes, but also an excellent effect that enables the maintenance of a proper working environment in the field and an effective reduction in working processes, time, and cost.

[0040] While the invention has been described by reference to specific embodiments chosen for the purposes of illustration, it should be apparent that numerous modifications could be made thereto by those skilled in the art without departing from the basic concept and scope of the invention.

Claims

1. A coating forming method for a swash plate, which is used in a swash plate compressor, is connected to pistons via shoes and has a coating made of a metal material on the sliding contact surface of the swash plate, with the shoes,

   wherein, a welding padding method is employed to form the coating.

2. The coating forming method for a swash plate used in a swash plate compressor as set forth in claim 1, wherein the welding padding method employs an electric arc welding.

3. A swash plate having a coating on the surface slidably in contact with shoes, wherein the coating is formed in the coating forming method described in claim 1 or claim 2.

Fig.1

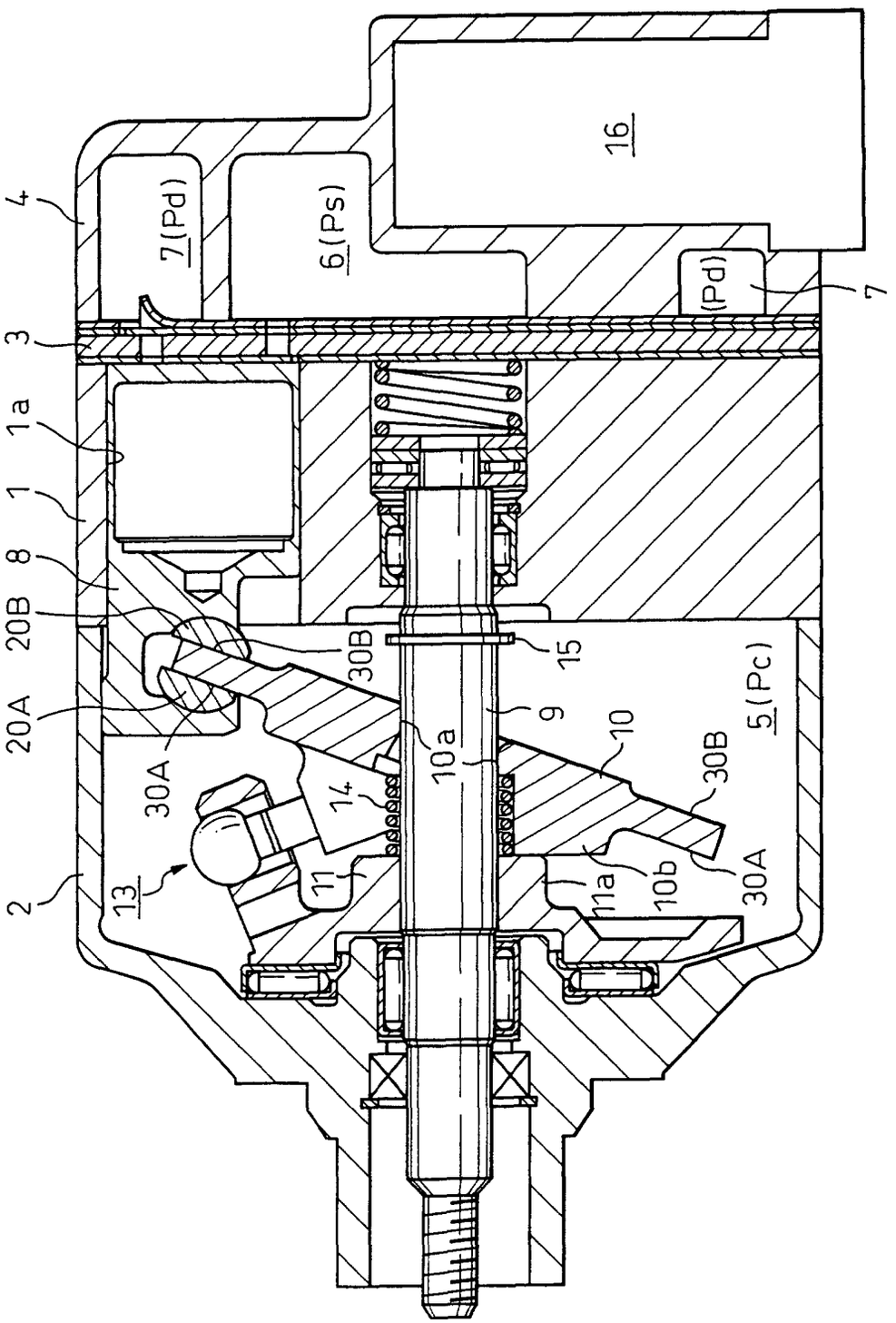

16
7(Pd)
6(Ps)
(Pd)
7
4
3
1a
1
8
20B
20A
30A
30B
15
9
10
10a
5(Pc)
14
11
13
2
11a
10b

Fig. 2

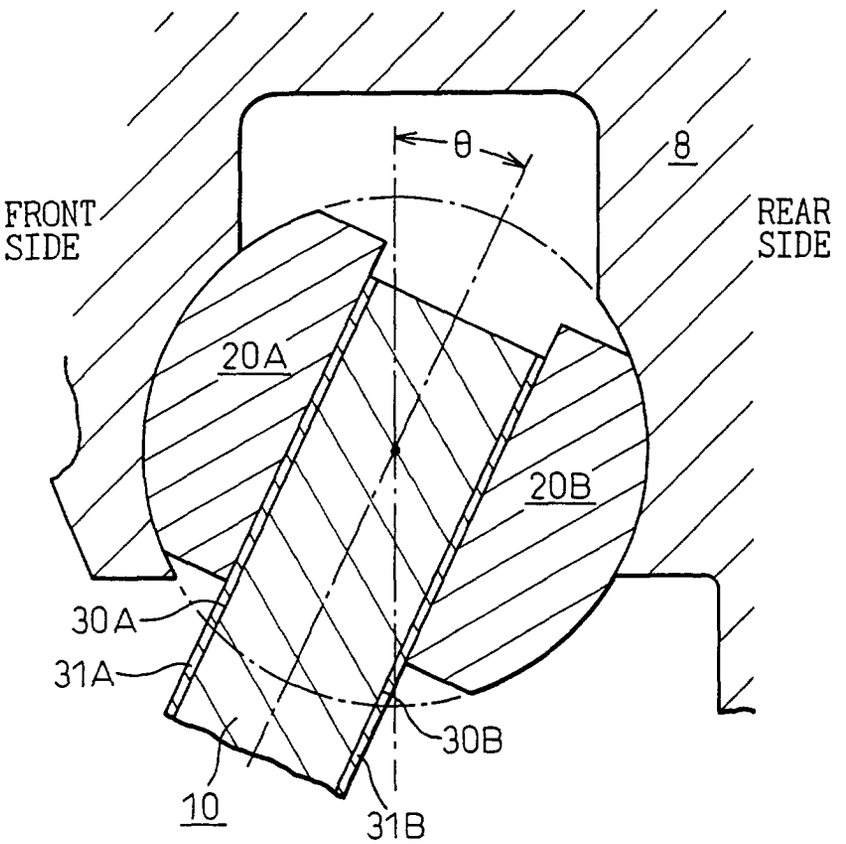
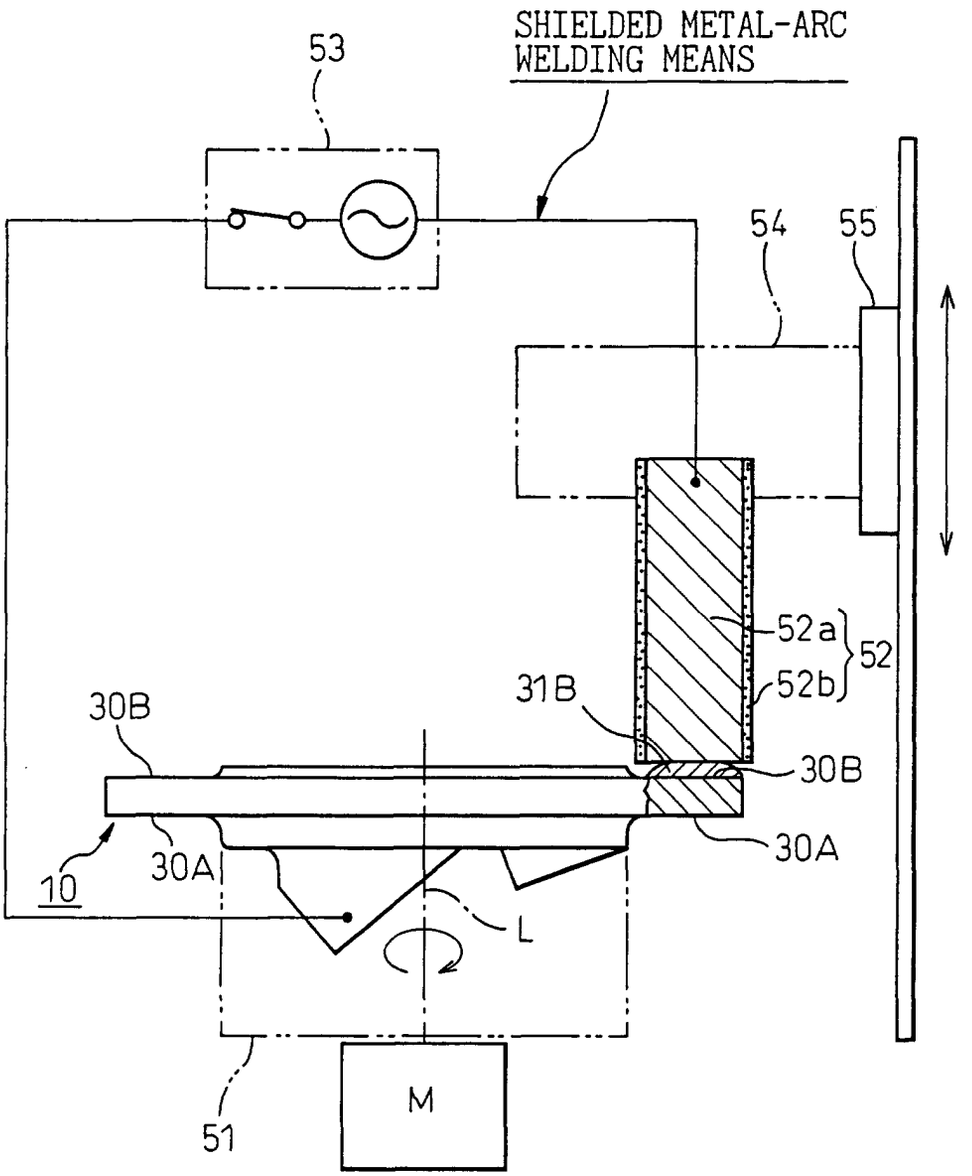


Fig. 3


SHIELDED METAL-ARC WELDING MEANS
53
54
55
52a
52b
52
31B
30B
30B
30A
30A
10
L
M
51