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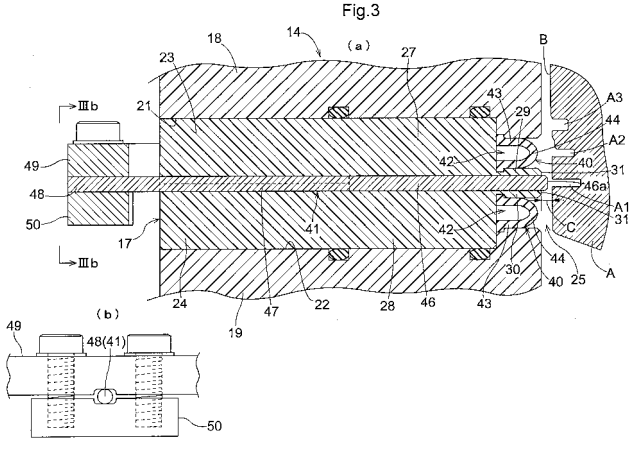
(54) SURFACE TREATMENT APPARATUS

(57) Disclosed is a surface treatment apparatus including one of a positive electrode member and a negative electrode member to be electrically connected to a treatment-object article made of metal and having an annular treatment-object area in an outer circumferential face thereof, a frame member having a non-conductive inner circumferential face opposed with a gap to the outer circumferential face and to the annular treatment-object area, a non-conductive elastic seal member capable of forming an electrolysis solution path along the annular treatment-object area by sealing the gaps between portions of the outer circumferential face opposed to each other across the annular treatment-object area and the inner circumferential face, the other one of the positive electrode member and the negative electrode member having a bar-like shape with a leading end portion that protrudes into the electrolysis solution path toward the treatment-object article, and an electrolysis solution circulating means for circulating an amount of electrolysis solution along the electrolysis solution path.

Fig.3



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Description

Technical Field

[0001] The present invention relates to a surface treatment apparatus.

Background Art

[0002] A conventional surface treatment apparatus includes e.g. a positive electrode member to be electrically connected to a treatment-object article made of metal and having a circumferential groove as an annular treatment-object area in the outer circumferential face thereof, a frame member having an inner circumferential face opposed with a gap relative to the outer circumferential face and the circumferential groove, a non-conductive elastic seal member capable of forming an electrolysis solution path along the annular treatment-object area by sealing the gaps between portions of the outer circumferential face opposed to each other across the annular treatment-object area and the inner circumferential face, a negative electrode member provided in the electrolysis solution path, and an electrolysis solution circulating means for circulating an amount of electrolysis solution along the electrolysis solution path.
With the above-described surface treatment apparatus in operation, as an electrolysis solution path is formed along the annular treatment-object area provided in the outer circumferential face of the treatment-object article and an amount of electrolysis solution is circulated along this electrolysis solution path, a surface treatment such as anodization treatment can be done on the annular treatment-object area in an efficient manner.
In the case of the conventional surface treatment apparatus described above, the frame member is made of a conductive material and this frame member constitutes a negative electrode member having an annular inner circumferential face opposed to the outer circumferential face of the treatment-object article and the annular treatment-object area (circumferential groove) with a gap relative thereto respectively (see, e.g. Patent Document 1).

Prior Art Document

Patent Document

[0003] Patent Document 1: Japanese Unexamined Patent Application Publication No. 2003-119593 (paragraph [0024]).

Summary of the Invention

Problem to be Solved by Invention

[0004] With the surface treatment apparatus described above, with supply of electricity between and across the positive electrode member and the negative electrode member at the time of a surface treatment, a metal component such as copper dissolved in the electrolysis solution that can easily changed into positive ion tends to deposit and then adhere and accumulate on the surface of the negative electrode member.
Further, with the conventional surface treatment apparatus, because of the provision of the negative electrode member having an annular inner circumferential face, there tends to occur uniform adhesion/accumulation of the deposited metal along the entire inner circumferential face of the negative electrode member. The accumulated deposited metal results not only in decrease in the path cross section area of the electrolysis solution path, but also in hindrance of smooth circulation of the electrolysis solution.
Incidentally, in case the frame member constitutes a positive electrode member having an annular inner circumferential face opposed to the outer circumferential face and the annular treatment-object area of the treatment-object article with a gap relative thereto respectively, a non-metal component such as a chloride or a sulfide dissolved in the electrolysis solution that can easily be changed into negative ion tends to deposit and then adhere/accumulate on the surface of the positive electrode member. Hence, a similar phenomenon tends to occur.
The temperature of the electrolysis solution becomes higher in the vicinity of the surface of the annular treatment-object area due to the heat generated in association with the electrode reaction. And, if smooth circulation of the electrolysis solution is hindered, increase in the temperature of the electrolysis solution tends to occur.
Such increase in the temperature of the electrolysis solution tends to result in burning of coating in the surface treatment when a coating such as an alumite coating is formed in the annular treatment-object area. More particularly, at the time of anodizing treatment, there occurs non-uniformity of electric current distribution or excess of current density, which causes a burning-like outer appearance and may pose difficulty in effecting a plurality of cycles of surface treatment operations with high voltage in repetition with high efficiency.

The present invention has been made in view of the above-described state of the art and its object is to provide a surface treatment apparatus which allows a plurality of cycles of surface treatment operations with high voltage to be effected in repetition with high efficiency.

Means for Solving the Problem

[0005] According to a first characterizing feature of a surface treatment apparatus relating to the present invention, the surface treatment apparatus comprises:

one of a positive electrode member and a negative electrode member to be electrically connected to a treatment-object article made of metal and having an annular treatment-object area in an outer circumferential face thereof;
a frame member having a non-conductive inner circumferential face opposed with a gap to the outer circumferential face and to the annular treatment-object area;
a non-conductive elastic seal member capable of forming an electrolysis solution path along the annular treatment-object area by sealing the gaps between portions of the outer circumferential face opposed to each other across the annular treatment-object area and the inner circumferential face;
the other one of the positive electrode member and the negative electrode member having a bar-like shape with a leading end portion that protrudes into the electrolysis solution path toward the treatment-object article; and
an electrolysis solution circulating means for circulating an amount of electrolysis solution along the electrolysis solution path.

[0006] With the above-described arrangement, since the frame member has a non-conductive inner circumferential face that is opposed with a gap to the outer circumferential face and to the annular treatment-object area, there occurs no deposition of a metal component or a non-metal component on the inner circumferential face of the frame member at the time of surface treatment.
Further, since the other one of the positive electrode member and the negative electrode member having a bar-like shape protrudes, the other one of the positive electrode member and the negative electrode member can have a smaller surface area as compared with the convention, so that the adhesion area for a deposited component such as a metal component or a non-metal component to the other one of the positive electrode member and the negative electrode member can be small, and the adhesion strength of the deposited component to the other of the positive electrode component and the negative electrode component can be small.
And, since the other one of the bar-like positive or negative electrode member has its leading end portion that protrudes into the electrolysis solution path toward the treatment-object article, any deposited component of weak adhesion strength which may have adhered and accumulated on the other one of the positive electrode member and the negative electrode member can be gushed away by the impetus of the amount of electrolysis solution that circulates along the electrolysis solution path, thus being removed from the other one of the positive electrode member and the negative electrode member. Hence, there will hardly occur growth of any deposited component accumulated on the other one of the bar-like positive or negative electrode member.
Therefore, smooth circulation of the electrolysis solution in the electrolysis solution path can be maintained for an extended period of time, whereby undesirable increase in the temperature in the vicinity of the surface of the annular treatment-object area can be restricted for an extended period of time, also.
Consequently, the inventive surface treatment apparatus makes it possible to effect a plurality of cycles of surface treatment with high voltage repeatedly in an efficient manner.

[0007] According to a second characterizing feature of the present invention, the apparatus comprises a plurality of the other one of the positive electrode members and the negative electrode members having the bar-like shape disposed in distribution along the circumferential direction of the electrolysis solution path.

[0008] With the above-described arrangement, as the intensify the electric field generated between the other one of the bar-like positive or negative electrode member and the annular treatment-object area is dispersed along the annular treatment-object area, it becomes easier to form a uniform coating.

[0009] According to a third characterizing feature of the present invention, the other one of the positive electrode member and the negative electrode member having the bar-like shape is disposed to protrude, with its longitudinal direction being the direction perpendicular to the outer circumferential face.

[0010] With the above-described arrangement, an electric field can be generated in right/left symmetry between the other positive electrode member and the negative electrode member having the bar-like shape and the annular treatment-object area located on the opposed right and left sides relative thereto, so that a uniform coating can be formed easily.

[0011] According to a fourth characterizing feature of the present invention, the other one of the positive electrode member and the negative electrode member having the bar-like shape has an outer circumferential face which is formed as a concave/convex face.

[0012] With the above-described arrangement, the other bar-like one of the positive electrode member and the negative electrode member can have a large surface area for allowing conduction of a large current therethrough, so that a coating of a desired thickness can be readily formed in an efficient manner in a short time.

[0013] According to a fifth characterizing feature of the present invention, the other one of the positive electrode member and the negative electrode member having the bar-like shape has a leading end portion whose shape is a convex face.

[0014] With the above-described arrangement, occurrence of electric current concentration at the leading end portion near the treatment-object article can be restricted, so that a spark will hardly occur, and a uniform coating can be formed easily.

Brief Description of Drawings

[0015]

[Fig. 1] is a schematic showing a surface treatment apparatus (an anodization treatment apparatus),
[Fig. 2] is a plane view of a second electrode section as viewed along a line II-II in Fig. 1,
[Fig. 3] (a) is section view showing a fixing arrangement of a negative electrode member, (b) is a side view taken along a line IIIb-IIIb in (a),
[Fig. 4] is a section view showing an electrolysis solution feeding nozzle portion of the second electrode section,
[Fig. 5] is a side view showing an inner circumferential side of the second electrode section,
[Fig. 6] is a section view showing a condition when an elastic seal member of the second electrode section is spaced apart from an outer circumferential face of a piston,
[Fig. 7] is a section view showing a condition when the elastic seal member of the second electrode section is pressed against the outer circumferential face of the piston., and
[Fig. 8] is a side view showing a negative electrode member of a surface treatment apparatus (an anodization treatment apparatus) according to a second embodiment.

Modes of Embodying the Invention

[0016] Next, embodiments of the present invention will be described with reference to the accompanying drawings.

[First Embodiment]

[0017] Figs. 1 through 7 show an anodization treatment apparatus as an example of a surface treatment apparatus according to the present invention. This anodization treatment apparatus is configured to effect an anodization treatment for forming an alumite coating on a surface of a piston ring groove A1 of a piston A made of an aluminum alloy, as an example of a treatment-object article made of metal.

[0018] More particularly, of three piston ring grooves A1, A2, A3 formed from the top to the skirt portion of the cylindrical piston A, an anodization treatment is effected on an outer circumferential face ("piston outer circumferential face" hereinafter) B of the top side piston ring (compression ring) groove A1.
Hence, the piston ring groove A1 corresponds to "a circumferential groove" as "an annular treatment-object area" included in the piston outer circumferential face B.

[0019] The anodization treatment apparatus includes, as shown in Fig. 1, an electrolysis solution tank 1, an electrolysis solution feeding section 2, an oxidization treatment section 3 and an electric conduction section 4.

[0020] The electrolysis solution tank 1 is made of vinyl chloride or stainless steel and provided in the form of a top end open vessel. And, the tank 1 is configured to receive and collect therein an amount of electrolysis solution that has passed the oxidization treatment section 3 and includes a reflux path 5 for refluxing the solution to the electrolysis solution feeding section 2.

[0021] The electrolysis solution feeding section 2 includes a cooling tank 6 for cooling the electrolysis solution refluxed from the electrolysis solution tank 1, a feeding path 7 for feeding an amount of electrolysis solution in the cooling tank 6 to the oxidization treatment section 3, a feeding pump 8 incorporated in the feeding path 7, and a feeding control section 9 for controlling the operation of the feeding pump 8 so that an amount of the electrolysis solution may be fed to the oxidization treatment section 3 at a predetermined timing.

[0022] The cooling tank 6 includes a cooler 10 for cooling the collected electrolysis solution, and a cooling control section 12 for controlling the operation of the cooler 10 based on detection information of the electrolysis solution temperature obtained by a temperature sensor 11 so that the electrolysis solution maybe cooled to a predetermined temperature.

[0023] The electric conduction section 4 is provided for conducting electricity to the oxidization treatment section 3.

Preferably, this electric conduction section 4 is provided with a current controlling means so as to be capable of adjusting the electric current density. As such current controlling means, a device comprised of an ammeter, a voltmeter, a rectifier, or the like known in the art can be suitably employed.

[0024] The oxidization treatment section 3 includes a first electrode (positive electrode) section 13 and a second electrode (negative electrode) section 14.

The first electrode section 13 includes a positive electrode member 15 made of metal such as copper, stainless steel, etc. having conductivity and a lift device 16 for lifting up/down the positive electrode member 15 relative to the second electrode section 14.

The positive electrode member 15 functions also as a "holder" for holding the piston A, so that the positive electrode member 15 is electrically connected to a positive electrode terminal 4a of the electric conduction section 4, thus being electrically connected to the piston 4 by holding this piston 4.

[0025] The holder (positive electrode member) 15 includes, at the lower end thereof, a retention pawl (not shown) engageable/disengageable with/from the inner circumferential face of the piston A. As this engaging pawl is retained to the inner circumferential face of the piston A, the holder 15 holds the piston A under a condition of its axis being aligned along the perpendicular direction and electrically connected.

[0026] The second electrode section 14, as shown in Fig. 2, has an outer shape which is circular in its plane view and concentrically defines a piston insertion hole 25 which is circular in its plane view for allowing introduction of the piston A with its axis being aligned along the perpendicular direction.

[0027] The second electrode section 14, as shown in Figs. 1 through 3, includes a frame member 17 to which a plurality of round-bar like negative electrode members 41 are affixed, fixing plates 18, 19 disposed upwardly and downwardly of the frame member 17 respectively, and a support base 20., with these components being bolt-connected to each other. Each negative electrode member 41 is formed of platinum (Pt) or conductive stainless steel (SUS).

The number of the negative electrode members 41 to be provided ranges, preferably, from 4 to 20. In the instant embodiment, fourteen negative electrode members 41 are disposed in distribution along the circumferential direction of the frame member 17.

The frame member 17, the fixing plates 18, 19 and the support base 20 are all formed of non-conductive material (insulating material) such as vinyl chloride resin.

[0028] The frame member 17, as shown in Fig. 1, Fig. 3 and Fig. 4, is engaged and held between an annular upward concave face portion 21 which is formed by forming upwardly concave a lower face outer circumferential side of the upper fixing plate 18 and an annular downward concave face portion 22 which is formed by forming downwardly concave an upper face outer circumferential side of the lower fixing plate 19 and bolt-connected thereto, respectively.

[0029] The frame member 17, as shown in Fig 1, is formed by bolt-connecting two frame plates, i.e. an upper first frame plate 23 and a lower second frame plate 24. As shown in Fig. 3 and Fig. 5, a negative electrode member 41 is bound and affixed between the first frame member 23 and the second frame member 24.

[0030] As shown in Figs. 4 through 6, on the piston insertion hole 25 side of the first frame plate 23 and the second frame plate 24, there are formed annularly opposed plate portions 27, 28 opposing the first frame plate 23 and the second frame plate 24 to each other across a space 26 therebetween and flange plate portions 29, 30 that protrude toward the piston insertion hole 25 side along the inner circumferential sides of the opposed plate portions 27, 28.

[0031] The inner side of the inner circumferential face of each flange plate portion 29, 30 ("frame plate inner circumferential face" hereinafter) is formed as the piston insertion hole 25.

Therefore, the frame member 17 includes a frame plate inner circumferential face 31 formed as a "non-conductive annular inner circumferential face" opposed to the piston outer circumferential face B and the piston ring groove A1 along the entire circumferences thereof with a predetermined gap relative thereto respectively.

[0032] As shown in Fig. 1, the lower fixing plate 19 includes a round concave face portion 32 which has a same diameter as and is coaxial with the piston insertion hole 25 and a piston placing portion 35 on which the top face of the piston A with its axis aligned along the perpendicular direction is to be placed and supported.

Along the lower fixing plate 19 and the support base 20, there are formed a connecting flow path 33 connected to the feeding path 7 for the electrolysis solution and a discharge hole 34 for discharging an amount of electrolysis solution accumulated within the circular concave face portion 32 to the electrolysis solution tank 1 by natural (gravity) falling.

[0033] Therefore, as shown in Fig. 1, the piston A held by the holder (positive electrode member) 15 and electrically connected under the posture thereof with its axis aligned along the perpendicular direction is inserted into the piston insertion hole 25 and its top face is placed on the piston placing portion 35. With this, as shown in Fig. 3 and Fig. 4, the piston A is fixed in position coaxially with forming a predetermined gap C along the entire circumferences of the piston outer circumferential face B and the frame plate inner circumferential face 31.

[0034] On the frame plate inner circumferential face 31 side of the frame member 17, as shown in Fig. 1 and Figs. 3 through 7, there are attached two upper and lower non-conductive annular elastic seal members 40 which are mounted vertically and non-withdrawably with a gap therebetween and with leading end portions 44 thereof not protruding more toward the piston outer circumferential face B side than the frame plate inner circumferential face 31.

[0035] Each elastic seal member 40 is formed as an annular shaped non-conductive material (insulating material) such as rubber. As shown in Fig. 7, its leading end portion 44 is extended to be in pressed contact against the piston outer circumferential face B, so that the seal member 40 seals the gap C between the opposed portions of the piston outer circumferential face B across the circumferential groove A1 and the frame plate inner circumferential face 31, thereby forming an annular electrolysis solution path 45 extending along the circumferential groove A1.

[0036] Each elastic seal member 40 defines a concave portion 42 open toward its outer circumference side and continuously along the entire circumference and has a horizontally oriented U-shaped cross section including upper and lower lateral wall portions 43 and the leading end portion 44 which is brought into the pressed contact against the piston outer circumferential face B.

[0037] As shown in Fig. 1, Fig. 6 and Fig. 7, there is provided a pressurization mechanism 51 capable of feeding pressurized air as a pressurized fluid to the outer circumferential sides of the respective elastic seal members 40 simultaneously, so as to bring the inner circumferential sides (leading end portions 44) of these elastic seal member 40 into pressed contact against the piston outer circumferential face B along the entire circumference and capable also of releasing the pressed contacts when needed.

[0038] The pressurization mechanism 51 includes an air feeding/discharging device 52 capable of feeding and discharging of pressurized air, a feeding/discharging control section 53 for controlling air feeding/discharging operations of the air feeding/discharging device 52, air feeding/discharging paths 54 communicated to the respective concave portions 42 of the elastic seal members 40 and a pipe joint 56 for joining an air feeding/discharging pipe 55 of the air feeding/discharging device 52 to the air feeding/discharging path 54.

[0039] The air feeding/discharging paths 54 are provided at three circumferential portions of the second electrode section 14, and to each air feeding/discharging path 54, the air feeding/discharging pipe 55 is connected, so that for the concave portion 42 of each elastic seal member 40, pressurized air can be fed/discharged to/from the three circumferential positions.

[0040] Next, the operations of the pressurization mechanism 51 will be explained.

As shown in Fig. 6, when the piston A is inserted into the piston insertion hole 25 and placed on the piston placing portion 35, the feeding/discharging control section 53 activates the air feeding/discharging device 52 so as to feed an amount of pressurized air to each concave portion 42 of each elastic seal member 40 through the air feeding/discharging path 54.

[0041] Upon feeding of the pressurized air into the concave portion 42 of the elastic seal member 40, this elastic seal member 40 is elastically extended toward the piston outer circumferential face B and also the leading end portion 44 is elastically bulged and displaced toward the piston outer circumferential face B, whereby this leading end portion 44 is pressed against the piston outer circumferential face B, as shown in Fig. 7.

[0042] Upon establishment of this pressed contact of the leading end portion 44 of the elastic seal member 40 against the piston outer circumferential face B as shown in Fig. 7, on each of the lateral sides across the circumferential groove A1, the gap C between the piston outer circumferential face B and the frame plate inner circumferential face 31 is sealed and the annular electrolysis solution path 45 along the circumferential groove A1 is formed.

[0043] As shown in Fig. 2, Fig. 3 and Fig. 5, each one of the negative electrode members 41 is formed as a straight bar-like member including an electrode shaft portion 46 having a leading end portion 46a protruding toward the piston A into the electrolysis solution path 45, a fixing shaft portion 47 to be fixed to the frame member 17, and a connecting shaft portion 48 to be electrically connected to a negative electrode terminal 4b of the electric conduction section 4.

The leading end portion 46a of the electrode shaft portion 46 is formed as a convex curved shape having no corners.

[0044] Preferably, the plurality of negative electrode members 41 are disposed such that the longitudinal directions (axial directions) thereof be same as the direction perpendicular to the piston outer circumferential face B or be inclined within an angle range of 75 degrees relative to the perpendicular direction.

In the instant embodiment, as shown in Fig. 2, the plurality of negative electrode members 41 are arranged radially centrally about the piston insertion hole 25 with the longitudinal directions of the electrode shaft portions 46 thereof being oriented perpendicular relative to the piston outer circumferential face B and disposed in distribution equidistantly along the circumferential direction of the electrolysis solution path 45.

[0045] In each negative electrode member 41, the fixing shaft portion 47 is clamped and fixed between the first frame plate 23 and the second frame plate 24, such that the electrode shaft portion 46 protrudes toward the piston A in an electrolysis solution discharge path 38 to be described later as shown in Fig. 3 and Fig. 5 and the connecting shaft portion 48 protrudes toward the outer circumferential side of the frame member 17.

[0046] The connecting shaft portion 48 of each negative electrode member 41, as shown in Fig. 2, is electrically connected to a common connecting terminal plate 49 electrically connected to the negative electrode terminal 4b of the electric conduction section 4.

The connecting terminal plate 49 is formed as a round annular shape and each connecting shaft portion 48 is electrically connected thereto, as being clamped between the connecting terminal plate 49 and a receiving plate 50 bolt-fixed to the connecting terminal plate 49.

[0047] Therefore, for replacement of the negative electrode member 41, the connection between the connecting shaft

portion 48 and the connecting terminal plate 49 will be released and then the negative electrode member 41 to be replaced will be withdrawn from between the first fame plate 23 and the second frame plate 24. Thereafter, a new negative electrode member 41 will be inserted between the first frame member 23 and the second frame plate 24 and connected to the connecting terminal plate 49. In this way, the replacement can be carried out easily.

[0048] As shown in Fig. 2, Fig. 4 and Fig. 5, between the first frame plate 23 and the second frame plate 24, more particularly, between the opposed plate portions 27 and the flange plate portions 29 of the former and the opposed plate portions 28 and the flange plate portions 30 of the latter, there are provided a plurality of electrolysis solution feeding nozzles 36 arranged along the circumferential direction and spaced apart from each other with a predetermined distance therebetween.

The electrolysis solution feeding nozzles 36 are preferably provided in the same number as the number of the negative electrode members 41. In the instant embodiment, fourteen (14) of them are provided as the same number as the negative electrode members 41.

[0049] As shown in Fig. 4 and Fig. 5, each electrolysis solution feeding nozzle 36 is connected to a connecting path 33 and includes a feeding path 37 for feeding electrolysis solution to the electrolysis solution path 45 and this feeding path 37 is open in the frame plate inner circumferential face 31.

Preferably, the electrolysis solution feeding nozzle 36, as shown in Fig. 2, is provided such that the path axis X of its feeding path 37 is inclined by an angle within an angle range from 5 to 75 degrees relative to a tangent to the frame plate inner circumferential face 31.

[0050] As shown in Fig. 1 and Fig. 5, the electrolysis solution feeding nozzles 36 adjacent to each other along the circumferential direction delimit a space 26 between the upper and lower opposing plate portions 27, 28 as well as a space between the upper and lower flange portion 29, 30 thereof respectively. These spaces together from the electrolysis solution discharge path 38 mentioned above.

[0051] Each electrolysis solution feeding nozzle 36 is disposed so as to be capable of feeding the electrolysis solution to the electrolysis solution path 45 along a direction inclined relative to the tangent of the frame plate inner circumferential face 31 such that the electrolysis solution may flow along the electrolysis solution path 45.

[0052] Therefore, as the electrolysis solution feeding section 2 having these electrolysis solution feeding nozzles 36 is provided as an "electrolysis solution circulating means" for circulating an amount of electrolysis solution along the electrolysis solution path 45. Hence, as the electrolysis solution is caused to circulate around the surface of the electrode shaft portion 46 as indicated by the arrow (a) in Fig. 5, any deposited metal with a weak adhering strength accumulated on the electrode shaft portion 46 may be readily removed by the impetus of the gushed electrolysis solution.

[0053] Since the deposited metal accumulated on the electrode shaft portion 46 can be readily removed, there will hardly occur spark due to contact between the accumulated deposited metal and the piston outer circumferential face B or the circumferential groove A1. Hence, the possibility of melting of formed alumite coating by sparking and resultant deterioration in the treatment quality is lessened.

[0054] As shown in Fig. 2, between circumferentially adjacent electrolysis solution feeding nozzles 36, there is formed a through hole 39 extending through the lower opposed plate portion 28, the lower fixing plate 19 and the support base 20, so that the electrolysis solution of the discharge path 38 will flow down naturally through these through holes 39 to be discharged into the electrolysis solution tank 1.

[0055] With the anodization treatment apparatus according to the instant embodiment, deposited metal accumulated on the negative electrode member 41 will hardly grow. Hence, the electrode use period until the deposition thickness of deposited metal increases to a thickness requiring replacement of the negative electrode member 41 has become approximately twice as large as that of the conventional anodization treatment apparatus having a negative electrode member having an annular circumferential face opposed with a gap to the outer circumferential face B and the circumferential groove A1 of the piston A.

[0056] Further, as shown in Table 1 below, in the case of forming an alumite coating having a coating thickness of 15μm, in comparison with the conventional anodization treatment apparatus disclosed in Patent Document 1, it was found that the burning voltage becomes 50V or more higher, and by setting the voltage by 30V or more, it became possible to reduce the treatment period by 30% or more.

[0057] [Table 1]

	burning voltage	target coating thickness	set voltage	treatment period
prior art	80V	15μm	60V	30sec
invention	130V	15μm	90V	20 sec
comparison	50V higher	equivalent	30V higher	30% improved

[Second Embodiment]

[0058] Fig. 8 shows a negative electrode member 41 in a further embodiment of the surface treatment apparatus (an anodization treatment apparatus) relating to the present invention.
In the instant embodiment, for providing the electrode shaft portion 46 with a greater surface area, in its outer circumferential face, there is formed a concave/convex face 57 having convex faces and concave faces alternately along the axial direction. The convex faces and the concave faces are formed spirally along the axis of the electrode shaft portion 46.

[Other Embodiments]

[0059]

1. The surface treatment apparatus according to the present invention may be configured to effect surface treatment on a convex (ridge-like) or planar annular treatment-object area included in the outer circumferential face of the treatment-object article.
2. The surface treatment apparatus according to the present invention may include a negative electrode member electrically connected to a metal treatment-object article and a bar-like positive electrode member having a leading end portion protruding toward the treatment-object article into the electrolysis solution path.
3. The surface treatment apparatus according to the present invention may include the other one of the positive electrode member and the negative electrode member which is in the form of a bar having an oval or polygonal cross sectional shape.
4. The surface treatment apparatus according to the present invention may include a single other one of the positive electrode member and the negative electrode member in the form of a bar.
5. In the surface treatment apparatus according to the present invention, the other one of the positive electrode member and the negative electrode member having the bar-like shape may protrude with its longitudinal direction being an oblique direction relative to the outer circumferential face of the treatment-object article.
6. In the surface treatment apparatus according to the present invention, the other one of the positive electrode member and the negative electrode member having the bar-like shape may protrude with its longitudinal direction being an oblique direction toward the upstream side in the flow direction of the electrolysis solution in the electrolysis solution path or being an oblique direction toward the downstream side in the flow direction of the electrolysis solution in the electrolysis solution path.
7. The surface treatment apparatus according to the present invention may be an electroplating treatment apparatus for effecting electroplating treatment as a surface treatment.

Description of Reference Numerals/Marks

[0060]

2	electrolysis solution circulating means
15	one of positive electrode member and negative electrode member (positive electrode member)
17	frame member
31	non-conductive inner circumferential plate
40	elastic seal member
41	the other one of positive electrode member and negative electrode member (negative electrode member) having a bar-like shape
45	electrolysis solution path
46a	leading end portion
57	convex/concave face
A	treatment-object article
A1	annular treatment-object area (circumferential groove)
B	outer circumferential face
C	gap

Claims

1. A surface treatment apparatus comprising:

one of a positive electrode member and a negative electrode member to be electrically connected to a treatment-object article made of metal and having an annular treatment-object area in an outer circumferential face thereof;
a frame member having a non-conductive inner circumferential face opposed with a gap to the outer circumferential face and to the annular treatment-object area;
a non-conductive elastic seal member capable of forming an electrolysis solution path along the annular treatment-object area by sealing the gaps between portions of the outer circumferential face opposed to each other across the annular treatment-object area and the inner circumferential face;
the other one of the positive electrode member and the negative electrode member having a bar-like shape with a leading end portion that protrudes into the electrolysis solution path toward the treatment-object article; and
an electrolysis solution circulating means for circulating an amount of electrolysis solution along the electrolysis solution path.

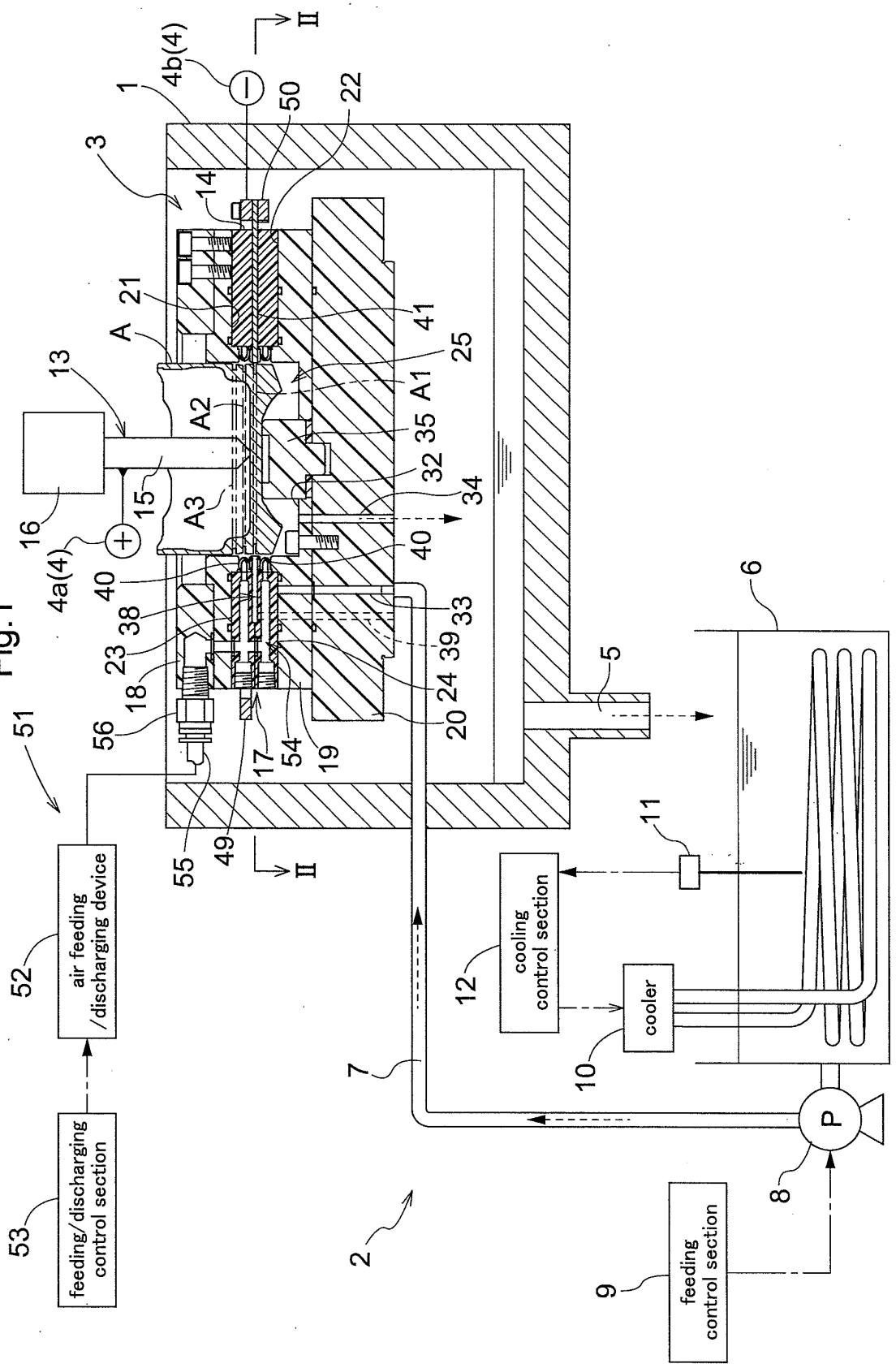
2. The surface treatment apparatus according to claim 1, wherein the apparatus comprises a plurality of the other one of the positive electrode members and the negative electrode members having the bar-like shape disposed in distribution along the circumferential direction of the electrolysis solution path.

3. The surface treatment apparatus according to claim 1 or 2, wherein the other one of the positive electrode member and the negative electrode member having the bar-like shape is disposed to protrude, with its longitudinal direction being the direction perpendicular to the outer circumferential face.

4. The surface treatment apparatus according to any one of claims 1-3, wherein the other one of the positive electrode member and the negative electrode member having the bar-like shape has an outer circumferential face which is formed as a concave/convex face.

5. The surface treatment apparatus according to any one of claims 1-4, wherein the other one of the positive electrode member and the negative electrode member having the bar-like shape has a leading end portion whose shape is a convex face.

Fig.1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3
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A2
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A3
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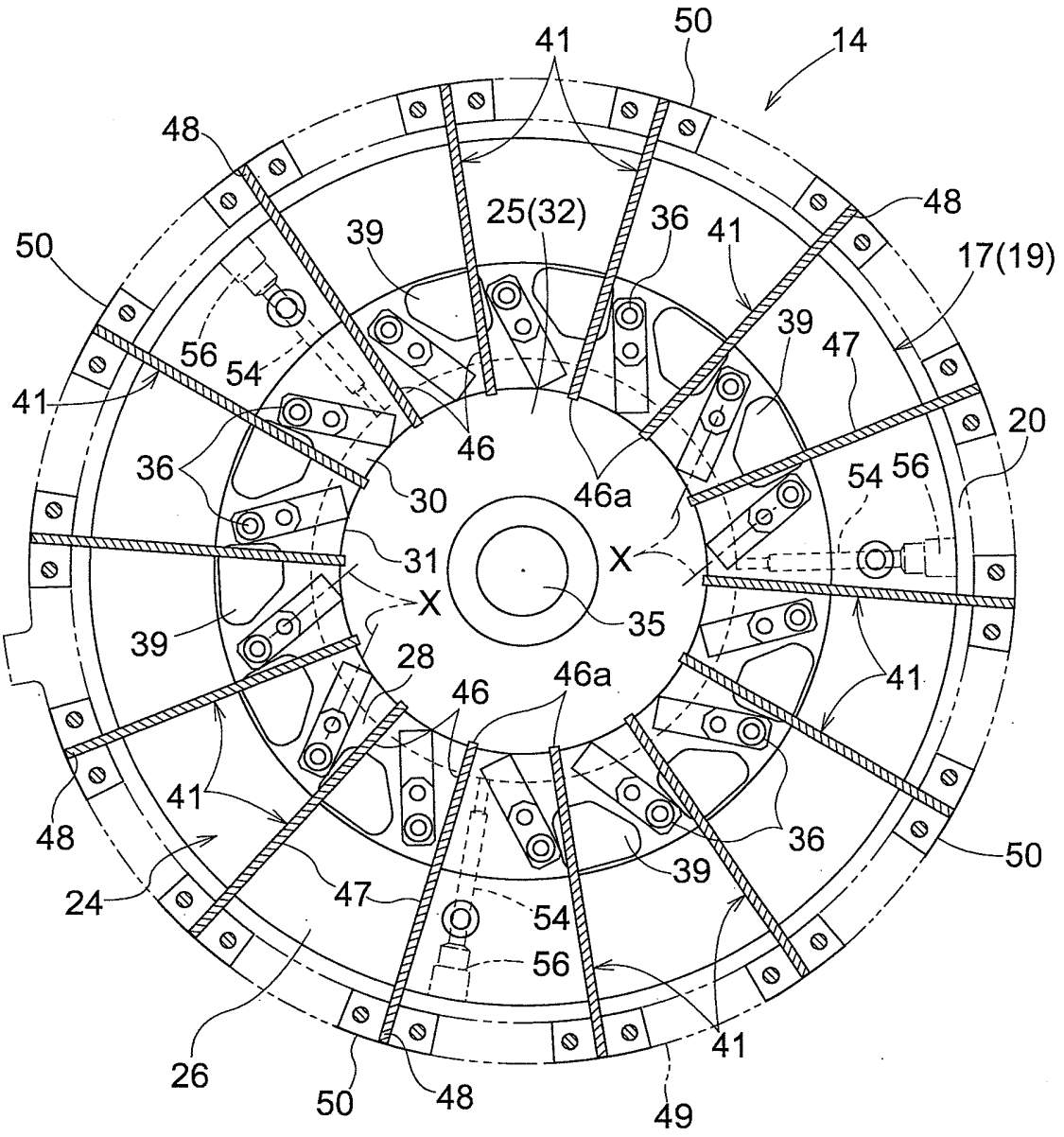
16
4a(4)
40
40
38
33
23
39
18
24
20
56
17
54
19
55
49
II
51
5
6
11
52
air feeding /discharging device
cooling control section
12
cooler
10
7
P
8
53
feeding/discharging control section
2
9
feeding control section

Fig.2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46a
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56
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31
X
X
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46a
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24
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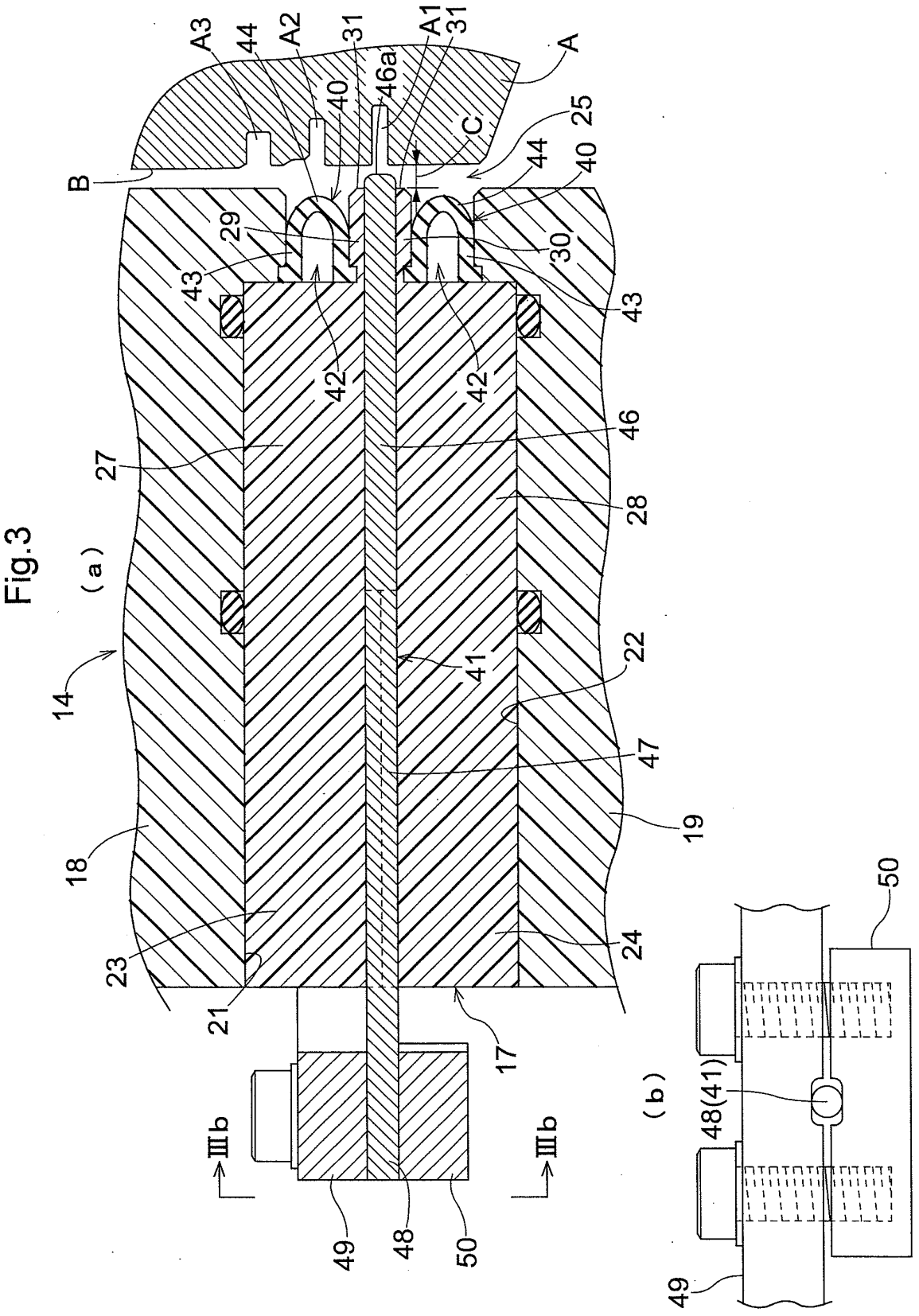
48
49

Fig.3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A3
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A2
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46a
A1
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A
B
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42
42
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28
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IIIb
IIIb
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48
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(b)
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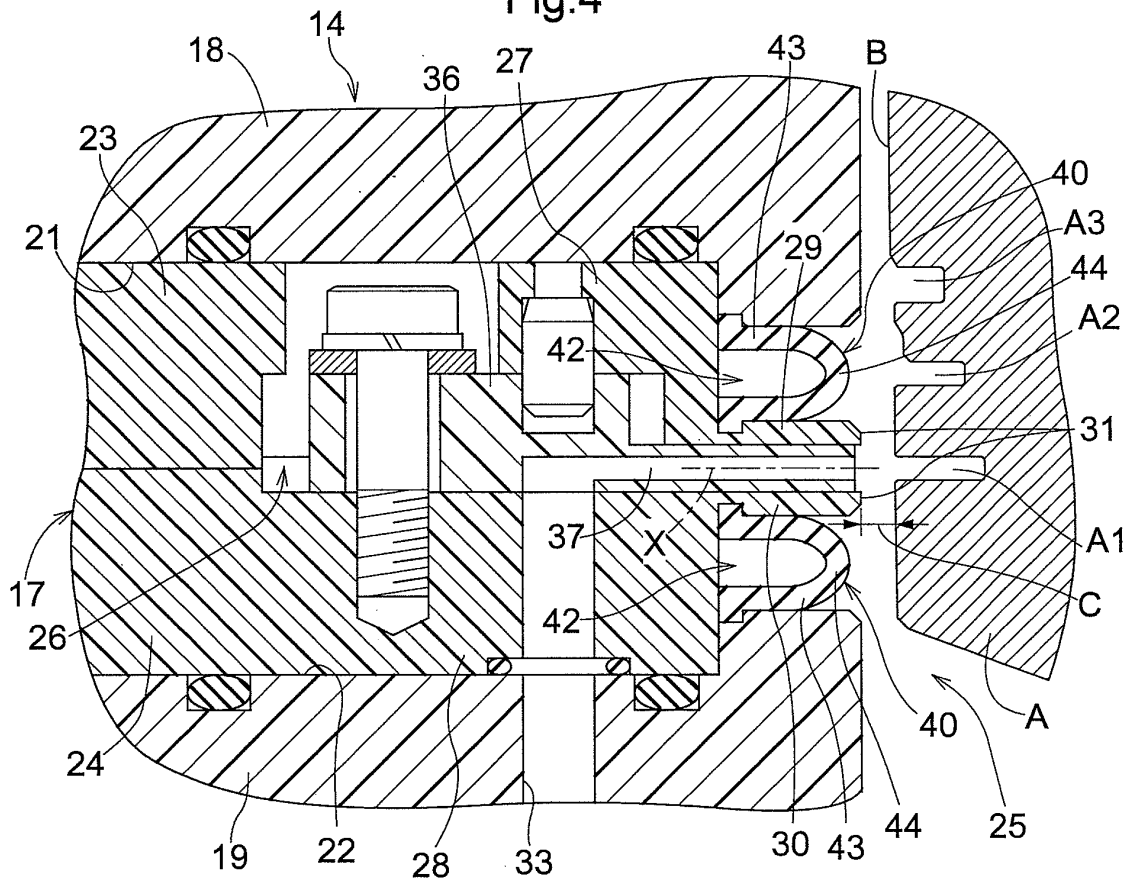
48(41)
49

Fig.4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A2
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A1
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C
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A
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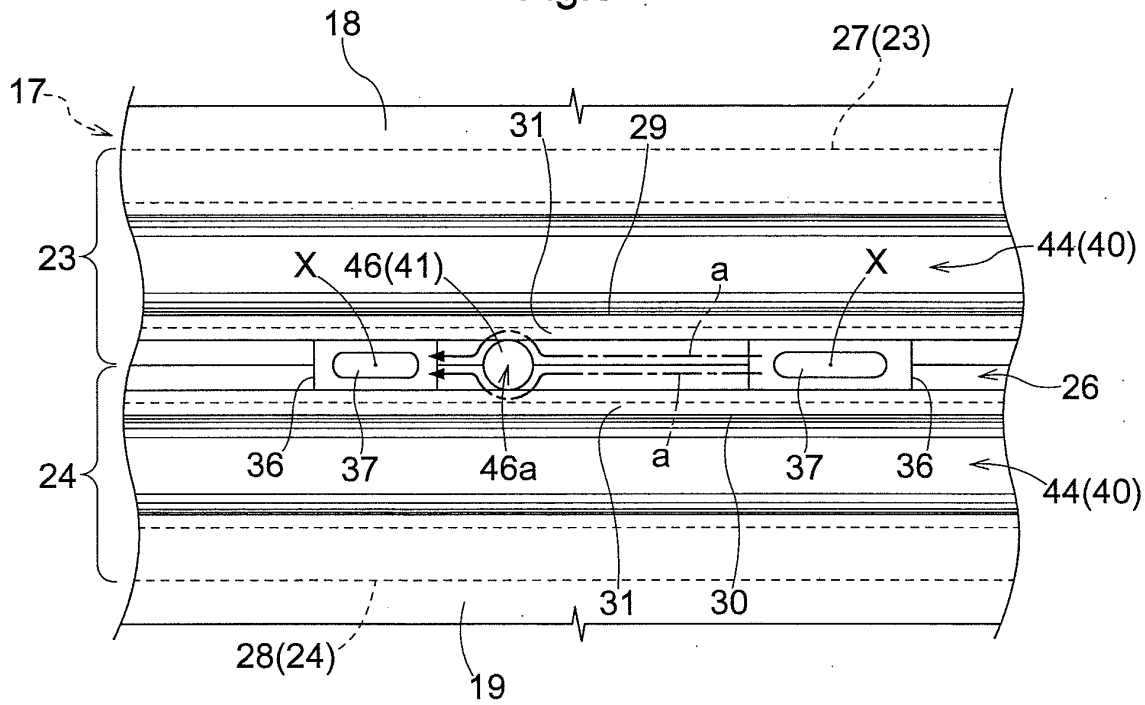
43

Fig.5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44(40)
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46(41)
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a
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44(40)
24
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28(24)
19

Fig.6

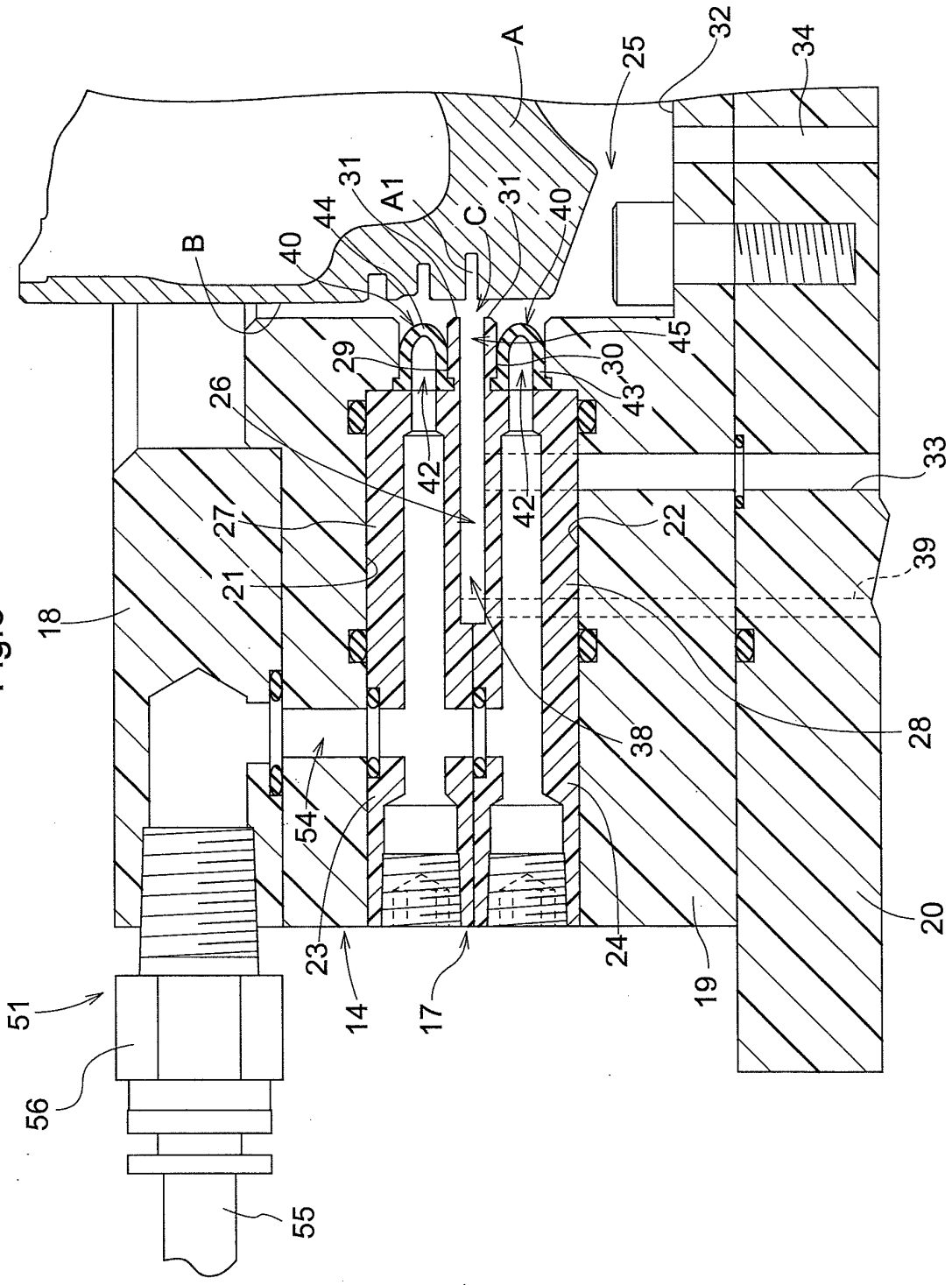
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Fig.7

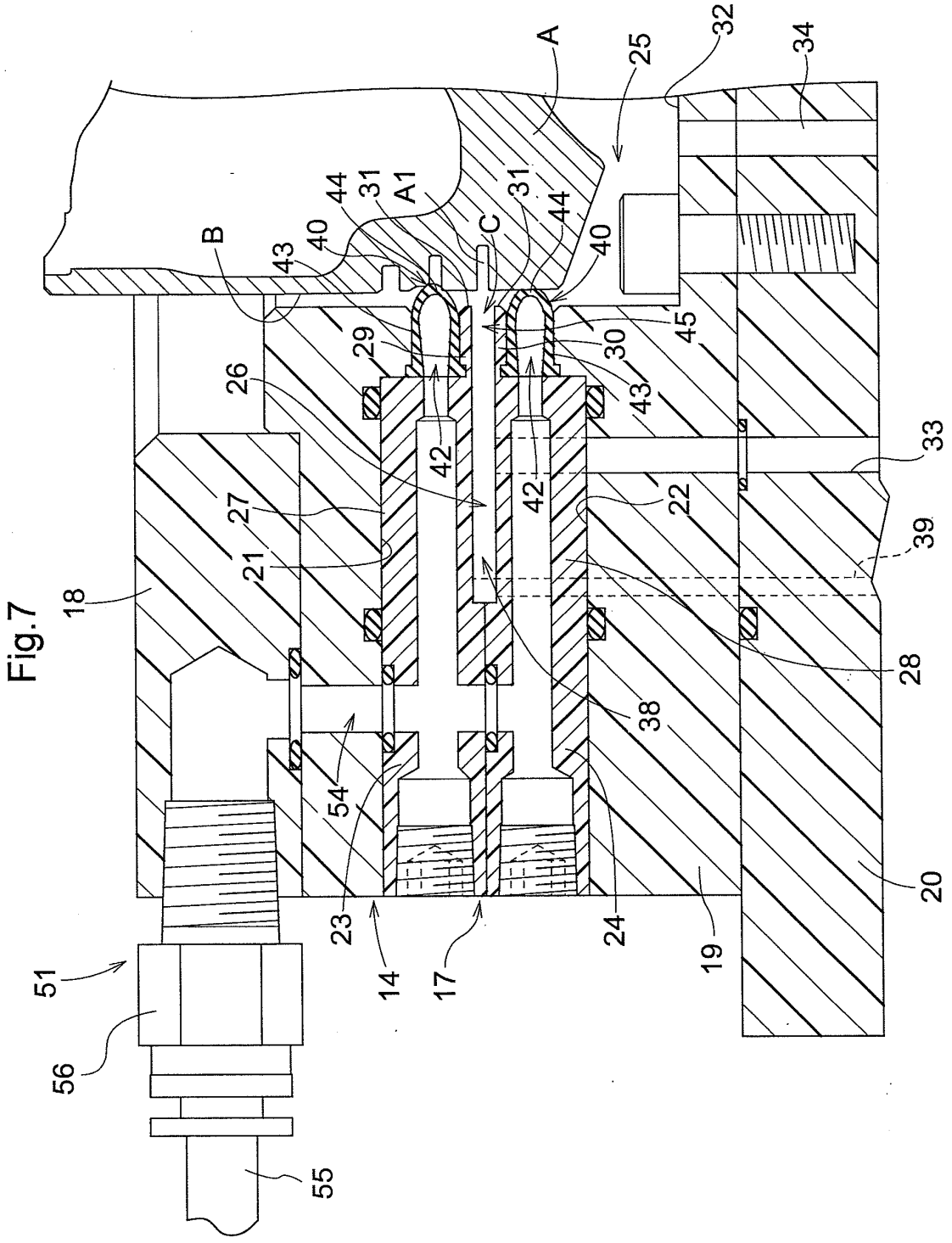
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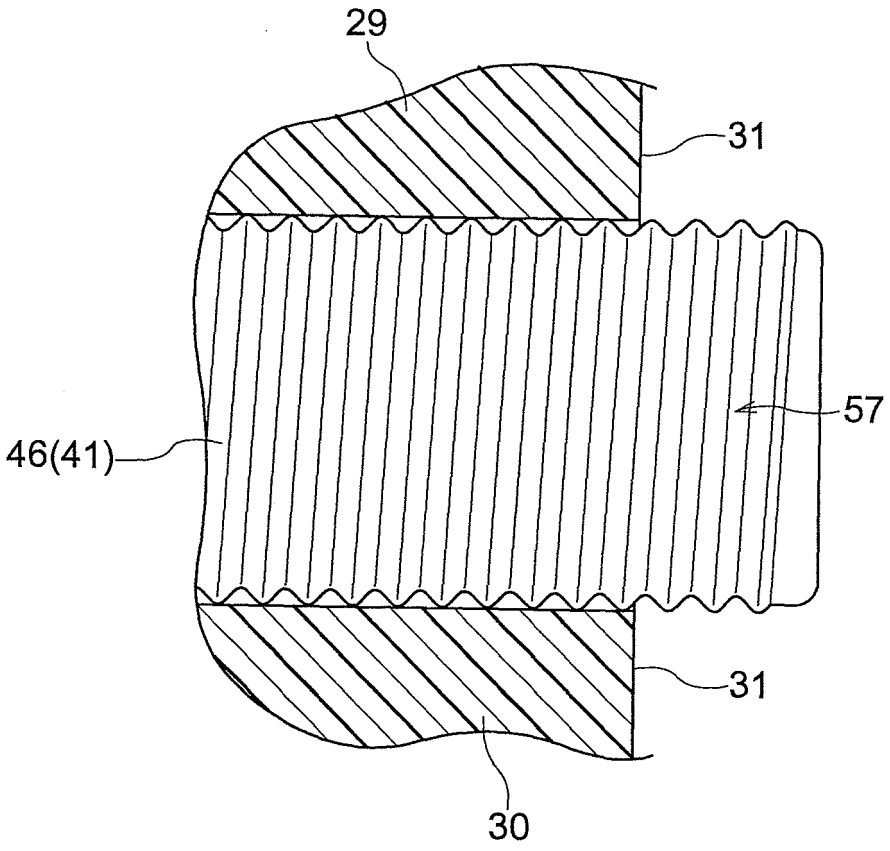
Fig.8



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/054920

A. CLASSIFICATION OF SUBJECT MATTER
C25D17/00(2006.01)i, *C25D5/02*(2006.01)i, *C25D11/00*(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)
C25D17/00, C25D5/02, C25D11/00

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 1996-2011
Kokai Jitsuyo Shinan Koho 1971-2011 Toroku Jitsuyo Shinan Koho 1994-2011

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.
A	JP 2008-291302 A (Aisin Seiki Co., Ltd.), 04 December 2008 (04.12.2008), entire text (Family: none)	1-5
A	JP 2003-147587 A (Hitachi Unisia Automotive, Ltd.), 21 May 2003 (21.05.2003), entire text & US 2003/0085134 A1 & DE 10249194 A & FR 2831894 A	1-5
A	JP 2003-119593 A (Hitachi Unisia Automotive, Ltd.), 23 April 2003 (23.04.2003), entire text (Family: none)	1-5

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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
18 April, 2011 (18.04.11)	26 April, 2011 (26.04.11)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

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Patent documents cited in the description

- JP 2003119593 A **[0003]**