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(54) Mirror finish polisher.

(57) Described herein is a mirror finish polisher, including: a tool base to be attached to the fore end of a spindle and constituted by a disk-like front plate and a rear plate forming liquid pools along the outer periphery of the front plate; a polishing liquid supply opening formed at the center of the rear plate around a spindle; a liquid supply tube opened into the liquid supply opening; a multitude of liquid outlet holes formed in the front plate along and slightly inward of the outer periphery thereof; and a liquid permeable visco-elastic polishing member attached to the front plate, the visco-elastic polishing member reteining abrasive grains thereon and being deformable in conformity with the profile of a work surface. The polishing liquid is temporarily stored in the liquid pool in the tool base through the liquid feed tube and continuously distributed into the visco-elastic polishing member by the action of centrifugal force resulting from rotation of the tool.

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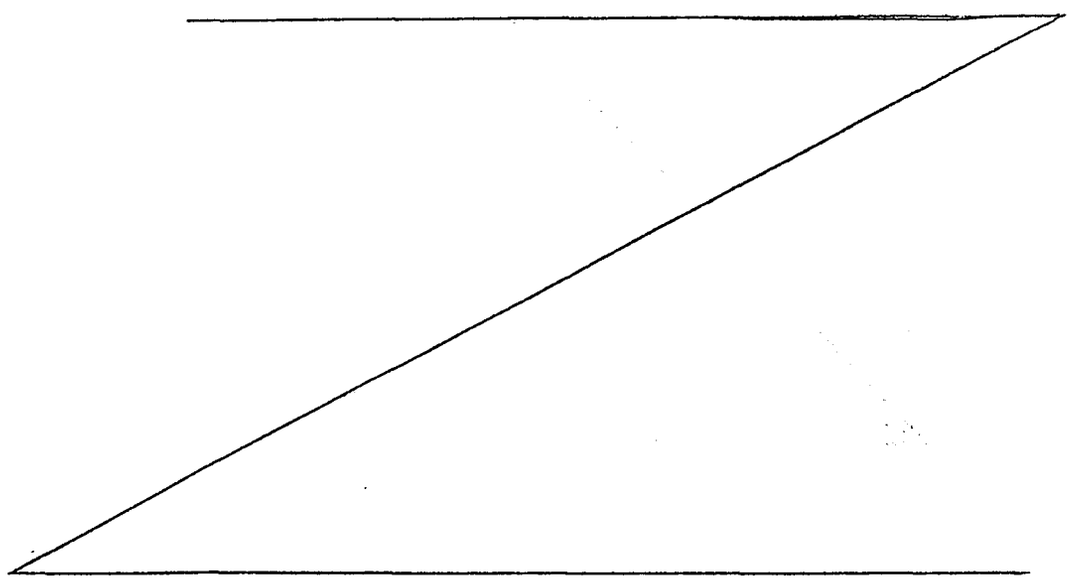
TITLE: MIRROR FINISH POLISHER

BACKGROUND OF THE INVENTION:

Field of the Invention

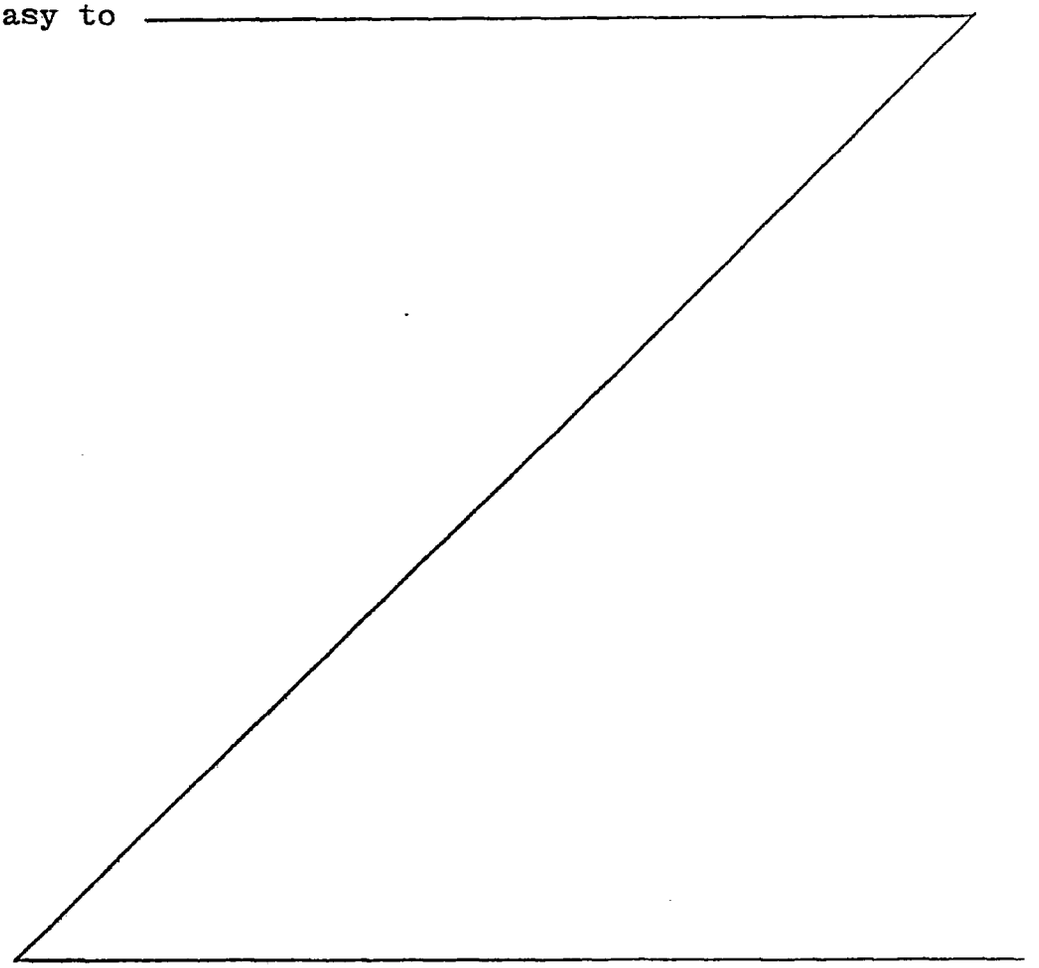
This invention relates to a polisher for mirror-finishing workpiece surfaces, and more particularly to a polisher which is extremely small in rate or in total amount of removal as compared with the case of the improvement of shape accuracy by the common electro-chemical machining and which can improve the surface roughness up to the level of 1/100 μm.

Mirror-finished stainless steel sheets are increasingly used as architectural interior and exterior furnishings and as silicon solar cell base plates. As the users have come to put more severe criteria on the degree of mirror finish to classify the products bearing grain lines as a result of the conventional buffing as "semi-mirror finish products", increasing the demands for perfect mirror finish products.



Besides, the conventional buffing operation entails another problem that it is difficult to improve the working environment by suppressing the dust which is scattered to a considerable amount during the polishing operation.

With regard to the technology which can give a perfect mirror finish to a workpiece surface instead of the above-mentioned buffing, it seems relatively easy to



develop a polishing machine which is directed to workpieces with specific geometrical surfaces such as plane or cylindrical surfaces. However, it is difficult to develop a polishing machine which can be applied to polishing of arbitrary curved free surfaces, and no satisfactory machine has been proposed in the art.

Further, it is extremely advantageous to perform the mirror finishing of a free curved surface automatically, fitting in with the undulations of the free curved surface. In order to achieve this by the techniques generally known in the art, it is necessary to move a tool along the profile of a free curved surface on the basis of dimensional data of the curved surface profile which are measured beforehand or simultaneously with the polishing operation by the use of very complicate and costly automation equipments. So that the automation of the buffing operation itself is extremely difficult and expensive.

SUMMARY OF THE INVENTION:

It is an object of the present invention to provide a mirror finish polisher which can be applied to mirror polishing of workpieces with a certain degree of irregular surface variations or arbitrary free curved surfaces, uniformly supplying a polishing liquid or solution to the machining area.

It is another object of the invention to provide

a mirror finish polisher arranged to supply a few liquid which is necessary for cooling the polishing area, for discharging fine dusts resulting from the polishing operation, for uniformly supplying free abrasive grains which may be mixed into the liquid in some cases, and/or for securing the electrolytic action in case of combined electrolytic-abrasive polishing.

It is a further object of the invention to provide a mirror finish polisher which is arranged to receive the polishing liquid through an opening formed at the center of a rear plate of a tool base to hold it temporarily in a liquid pool in the tool base opened to the atmosphere, such that the liquid will be caused to flow out by the action of the centrifugal force resulting from rotation of the rotary base, permitting to supply the liquid without needing high pressure and to simplify the polisher construction to a marked degree.

It is still another object of the invention to provide a mirror finish polisher, employing a tool base which serves as an electrode in case of combined electrolytic-abrasive polishing operation. The polisher construction which is capable of performing the combined electrolytic-abrasive polishing can be realized only after recognition of the fact that the electrolyte is used only in a small amount in the mirror finishing operation in which the machining rate is far smaller than in a profiling

operation as mentioned hereinbefore.

It is still another object of the invention to provide an apparatus for combined electrolytic-abrasive polishing, in which a tool electrode for the combined electrolytic-abrasive polishing is arranged to have an excellent electrolyte retaining capacity to permit mirror finishing of not only basically horizontal free curved surfaces but also almost vertical curved surfaces.

It is still another object of the invention to provide an apparatus, in which the combined electrolytic-abrasive polishing of a free curved surface can be performed automatically along the free curved work surface.

It is a further object of the invention to provide an apparatus capable of combined electrolytic-abrasive polishing automatically along free curved surface of a work by the use of an inexpensive automatic two-dimensional feed mechanism of simple construction.

In accordance with the present invention, the above-mentioned objects are achieved by the provision of a mirror finish polisher which comprises: a tool base to be attached to the fore end of a spindle of a rotational drive and constituted by a disk-like front plate and a rear plate integrally joined at peripheral marginal edge portions to the front plate, forming aliquid pool in peripheral portions on the back side of

the front plate; a polishing liquid inlet formed at the center of the rear plate of the tool base in such a manner as to circumvent the spindle; a liquid supply tube opened into the polishing liquid inlet; a multitude of liquid outlets opened in the front plate at positions slightly inward of the peripheral edge thereof; a liquid-permeable visco-elastic polishing member attached to the front plate and having a machining face retaining abrasive grains thereon and deformable in conformity with the shape of a work surface.

Upon rotating the polisher of the above-described construction by a rotational drive while supplying a polishing liquid through the liquid inlet, the visco-elastic polishing member fits the shape of a workpiece by deforming itself in conformity with the undulations on the surface of the workpiece if any to make it possible to give a mirror finish to an arbitrary free curved surface. In this instance, the liquid which has been supplied to the tool base is temporarily reserved in the peripheral liquid pool and distributed stably to the entire contacting area of the visco-elastic polishing member and the workpiece by the centrifugal force resulting from the rotation of the tool base. The liquid is uniformly distributed to the entire machining surface of the visco-elastic polishing member, without forming such splitted streams taking place at toward those portions

where the contact pressure of the visco-elastic polishing member with the workpiece is lower or toward at those portions where a gap is formed due to existence of undulations on the surface of the latter, that are indispensable to the flow supplied in the high pressure from the center of the tool base. Accordingly, it is possible to polish a work-piece by contacting therewith only the peripheral portions of the visco-elastic polishing member.

The above and other objects, features and advantages of the invention will become apparent from the following description and the appended claims, taken in conjunction with the accompanying drawings which show by way of examples preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS:

In the accompanying drawings:

Fig. 1 is a partly sectioned view of a combined electrolytic-abrasive polisher embodying the present invention;

Fig. 2 is a partly cutaway front view of a tool employed by the polisher of Fig. 1; and

Fig. 3 is a partly sectioned view showing a polishing operation by the polisher according to the invention.

Fig. 4 is a partly cutaway front view of an automatic electrolytic-abrasive polishing apparatus

according to the invention;

Fig. 5 is a partly cutaway side view of the apparatus of Fig. 4;

Fig. 6 is a schematic side view of an automatic two-dimensional feed mechanism mounting thereon the polisher of Fig. 1;

Fig. 7 is a schematic front view of major components of the automatic feed mechanism; and

Fig. 8 is a sectional view taken on line A-A of Fig. 7.

DESCRIPTION OF PREFERRED EMBODIMENTS:

Shown in the drawings is a polisher according to the invention, which is adapted for use as a combined electrolytic-abrasive polisher. More particularly, the electrolytic-abrasive polisher 10 shown in Fig. 1 includes a pistol-shaped housing 1 accommodating a rotational drive motor 12 and a reducer 13 coupled with the output side of the motor to rotate a spindle 14 which is protruded from the housing 11 and has a tool 20 attached to the fore end thereof.

As shown particularly in Figs. 1 and 2, the tool 20 which functions as an electrode in case of electrolytic polishing is constituted by a tool base 21 substantially of a disk-like shape and a visco-elastic polishing member 22 attached to the surface of the tool base.

The tool base 21 includes a disk-like front plate 24 to be attached to the fore end of the spindle 14, and a rear plate 25 which is integrally joined to the front plate 21 at the peripheral edges thereof to form a liquid pool around and on the back side of the front plate 24. The front plate 24 is centrally provided with a recess 29 to receive therein a head portion of a screw 28 which fastens the tool base 21 to the spindle 14, and with a multitude of liquid outlet holes 30 at positions slightly inward of its peripheral edges. The rear plate 25 is formed with a liquid supply opening 31 centrally around the spindle 14, and a sliding contact surface 32 around the opening 31 for contact with a power supply shoe 33 which supplies electrolytic current as will be described hereinlater.

The visco-elastic polishing member 22 which is attached to the surface of the tool base 21 is constituted by a liquid permeable visco-elastic material including sponge-like materials such as foamed polyurethane or other foamed synthetic resins or unwoven nylon fabric, which is in the form suitable for attachment to the surface of the tool base 21. In case where a sponge-like material is employed as in the particular embodiment shown, it is provided with a cavity 34 which fits on the tool base 21 and mounted on the spindle 14 by fastening same to the spindle together with the tool base 21 by a

screw 28 through a doubling plate 35. In case the visco-elastic polishing member 22 consists of unwoven nylon fabric or the like, its peripheral portions can be fixed to the surface of the tool base 21 by an adhesive or other suitable means and fastened to the spindle 14 through the doubling plate 35.

The visco-elastic polishing member 22 may hold abrasive grains dispersedly on its surface or in its entire body. In such a case, abrasive grains of alumina or the like may be fixedly bonded on an unwoven nylon fabric sheet or the like by the use of a synthetic resin bond which is mixed with the abrasive grains. Alternatively, instead of fixing abrasive grains in the just-mentioned manner, loose abrasive grains may be supported in meshes of unwoven fabric.

A multitude of liquid outlet holes 30 are formed in the front plate 24 at positions slightly inward of the peripheral edges of the tool base 21 for the purpose of forming a pool 26 of the polishing liquid or electrolyte in peripheral portions of the tool base 21, storing the liquid temporarily therein to feed same stably through a large number of liquid outlet holes 30. Accordingly, while the tool 20 is rotated, the liquid which flows out continuously through the liquid outlet holes 30 is fed to the contacting area between the visco-elastic polishing member 22 and a work around the

peripheral portions of the tool 20 under the influence of centrifugal force. In addition, since the tool 20 has a high liquid holding capacity, it is possible to feed the liquid stably not only to a horizontally disposed curved surface but also to almost vertically disposed curved surface.

A liquid feed pipe 38 which supplies the polishing liquid or electrolyte to polishing areas in the peripheral portions of the tool 20 has its inlet end 40 opened into one end of the housing 11 and its outlet end 41 opened into the tool base 21 through the liquid supply opening 31 which is formed centrally in the rear plate 25 around the spindle 14. In this manner, the polishing liquid or electrolyte is simply poured into the liquid pool which is open to the atmosphere, so that it is possible to simplify the equipments for feeding the liquid under pressure. For example, the liquid can be fed to the polisher without resorting to a pump, simply by locating a liquid reservoir at a slightly higher position that of the polisher.

In place of or in addition to the abrasive grains which are carried by the visco-elastic polishing member 22, free abrasive grains may be admixed into the polishing liquid or electrolyte which is supplied through the liquid feed pipe 38. Especially in case of a

polishing operation using fine grains, it is advantageous to use such free abrasive grains which can be uniformly distributed over the entire surface of the visco-elastic polishing member 22.

In case of a polishing operation using abrasive gains alone without supplying current for electrolysis, the liquid which is supplied through the liquid feed pipe 38 serves to cool the polishing portions and to discharge the fine particles of the stock which is removed by polishing, performing the intended functions by the use of a relatively small amount of liquid similarly to electrolytic polishing.

A power supply terminal 43 is provided at one end of the housing 11 to supply electrolytic current to the tool 20 through the power supply shoe 33 and the sliding surface 32 which is in contact with the shoe 33, and connectible to a power source (not shown) to conduct current across the workpiece and tool 20 serving as positive and negative electrodes, respectively.

Indicated at 44 is a switch member which is manipulatable to actuate the rotational drive 12.

The above-described electrolytic-abrasive polisher can be used as a portable machine which is lightly pressed by hand against a surface of a workpiece which need polishing, or it is mounted on a carriage which is freely movable in a horizontal plate to perform

the polishing operation. As illustrated in Fig. 3, in order to polish a free curved surface of a work 45, current of several amperes is passed across the tool electrode 20 and work 45 at a voltage of several to some ten volts, while supplying thereto an aqueous solution of $NaNO_3$ or KNO_3 through the liquid feed pipe 33 and rotating the tool electrode 20 by the rotational drive 12, with the peripheral portions of the visco-elastic polishing member 22 on the tool electrode 20 held in pressed contact with the free curved surface of the workpiece 45.

In a case where the tool electrode 20 has a diameter of about 12 cm, it can give a mirror finish even to a work surface containing a certain degree of undulations, since the peripheral portions of the visco-elastic polishing member 22 are suitably deformed into a shape which fits the surface profile of the workpiece when pressed thereagainst at a rotational speed of about several hundreds r.p.m. In this instance, the pressure which is imposed by the tool 20 on raised portions of the contacting surface of the workpiece 45 is naturally greater than the pressure imposed on lower surface portions, so that the amount of stock removal by the abrasive becomes greater on the raised surface portions. However, since relatively large raised and depressed surface portions are finished substantially to

the same degree of roughness, works can be polished efficiently in a case where accuracy in shape is not severe. It suffices to supply the electrolyte at a flow rate of one litre per minute or less.

The combined electrolytic-abrasive polishing can be suitably applied to polishing of free curved surfaces of various metallic products, particularly to surface polishing of stainless steels or the like.

Illustrated in Figs. 4 to 8 is an automatic polishing machine utilizing the above-described electrolytic-abrasive polisher 10. As seen in Figs. 4 and 5, this automatic polishing machine includes a machine frame 50 formed by joining angles which are extended along the respective edges of a rectangular parallelepiped, and a two-dimensional automatic feed mechanism 53 is mounted on a support plate 51 which is in turn mounted on top of the machine frame 50.

The automatic feed mechanism 53, which moves the polisher head 10 on a carriage 54 freely in perpendicularly intersecting X and Y directions in a horizontal plane, includes paired parallel X-direction guide rods 58 between a pair of support members 56 and 57 at the opposite ends of a base plate 55 which is fixed to the support plate 51. A feed screw 60 which is rotationally driven by a motor 58 on the support plate 55 is rotatably supported also in the support members 56 and 57 and threadedly engaged with the X-direction carriage 61 in which the guide rods 58 are slidably inserted to guide the movements of the carriage

61 in X-direction. Accordingly, upon rotating the feed screw 60 by the motor 59, the X-direction carriage 61 is moved in X-direction under guidance of the guide rods 58.

Further, slidably inserted in the X-direction carriage 61 are a pair of Y-direction guide rods 63 and a feed screw 64 which are disposed perpendicular to the X-direction guide rods 58. These guide rods 63 are fixedly mounted between support members 65 and 66 at the opposite ends of the carriage 54, and the feed screw 64 is rotatably supported on the two support members 65 and 66, with one end of the feed screw 64 coupled with a motor 68 mounted on the carriage 54. Accordingly, upon rotating the motor 68, the carriage 54 is moved in Y-direction relative to the X-direction carriage 61.

The motors 59 and 68 of the above-described feed mechanism 53 are connected to a controller, not shown, which controls the operation of these two motors to move the carriage 54 along predetermined paths of movements and which may utilize one of known controllers as used in two-dimensional feed mechanisms of this sort.

As shown particularly in Figs. 6 to 8, a pair of guides 70 and 71 are oppositely suspended from the carriage 54 to support the polisher head 10 slidably in a direction Z vertical to planes X and Y. These guides 70 and 71 are provided with slots 72 and 73 extending in the longitudinal direction thereof.

On the other hand, the polisher 10 is fixed in a holer 74 which is arranged to hold the polisher 10 in-between a pair of split members 75 and 76 with projecting support rods 77 and 78, split support members 79 and 80 located opposingly to the split members 75 and 76, and a connecting plate 81 linking the split members 75 and 76, which are integrally fastened by bolts 82 and 83. Slide members 85 and 86 of square shape on outer side are rotatably fitted on the support rods 77 and 78 which are secured to the split members 75 and 76, and fixed in position by butterfly nuts 87 and 88. These slide members 85 and 86 are slidably received in the afore-mentioned slots 72 and 73. An angle indicator plate 89 with a dial of angle of inclination is fixed on the slide member 85, and a pointer plate 90 is fitted in the support rod 77 in such a manner as to permit its axial sliding movement while blocking its rotational movement.

Consequently, as illustrated in Fig. 4, if the butterfly nuts 87 and 88 are fastened with the polisher 10 in a suitable inclined position, the square slide members 85 and 86 are fixed in the same inclined positions and the polisher 10 can be slided freely in the direction Z in the tilted state since the slide members 85 and 86 are slidable freely within the slots 72 and 73 of the guides 70 and 71. At this time, the angle of

inclination is known from the graduation on the angle indicator plate 89, on which the pointer plate 90 registers. In order to reduce the resistance of sliding movement of the slide members 85 and 86 along the slots 72 and 73, it is possible to employ various kinds of linear slide mechanisms of known arrangements.

In the automatic polishing machine of the above-described construction, a workpiece is set in the machine frame 50 and the polisher 10 is tilted suitably depending upon the surface profile of the workpiece, and, in the tilted state, peripheral portions of the visco-elastic polishing member are contacted with the work surface as explained hereinbefore in connection with Fig. 3. At the same time, the carriage 54 is moved two-dimensionally by the controller along courses which have been preset beforehand according to the surface profile of the work.

In the automatic polishing operation, it is necessary to maintain the angle of inclination of the spindle of the tool within the afore-mentioned appropriate range relative to the work surface in contact with the visco-elastic polishing member. If this is not possible, the polishing operation is once stopped, and resumed after changing the angle of inclination.

While the polisher 10 is two-dimensionally moved by the automatic two-dimensional feed mechanism 53,

the visco-elastic polishing member is pressed on the work surface by the weight of the polisher 10 itself. Therefore, it is necessary for the polisher 10 to have a suitable weight for this purpose. In a case where the weight of the polisher 10 itself is insufficient, a spring may be interposed between the carriage 54 and polisher 10. The provision of such a spring is also necessary to secure the required pressing force of the visco-elastic member when polishing a vertical surface of a workpiece by a polisher head 10 on the above-mentioned horizontal type automatic polishing machine.

The force with which the visco-elastic polishing member is pressed on the work surface is as small as several tens kPa, and the chipping action of abrasive grains is far weaker than that of the conventional solid grinder namely, not stronger than mere scratching action on the work surface, so that the major portion of the frictional resistance in the polishing operation is considered to take place between the visco-elastic polishing member and the work surface. Since the head pressing force is light as mentioned hereinbefore, the polisher head 10 can be automatically moved in Z-direction along the surface profile of a work simply by feeding the polisher head 10 two-dimensionally by the above-described two-dimensional feed mechanism 53.

Although the automatic polishing machine has been shown as having a hand-operating polisher head of Figs. 1 to 3 fixedly mounted on a holder 74, it may of course be replaced by a polisher head which is constructed exclusively for the automatic polishing machine.

Although the polisher of the invention has been described in connection with an electrolytic-abrasive polishing machine in the foregoing description, it is possible to omit the components for electrolysis and to use the polisher for mirror surface polishing by abrasive grains alone.

WHAT IS CLAIMED IS:

1. A mirror finish polisher, comprising:

a tool base to be attached to the fore end of a spindle of a rotational drive, said tool base including a disk-like front plate and a rear plate integrally joined to said front plate at the peripheral edges thereof in such a manner as to form a liquid pool peripherally on the back side of said front plate;

a polishing liquid inlet opening formed centrally in the rear plate of said tool base around said spindle;

a polishing liquid feed tube opened into said liquid inlet opening;

a multitude of liquid outlet holes formed along and on the inner side of the peripheral edge of said front plate; and

a liquid-permeable visco-elastic polishing member attached to said front plate and having a machining surface-retaining abrasive grains and deformable in conformity with the profile of a work surface.

2. The mirror finish polisher of Claim 1, wherein a liquid containing free abrasive grains is supplied to said liquid pool in said tool base through said liquid feed tube.

3. The mirror finish polisher of Claim 1, wherein abrasive grains are fixedly retained on the surface of said visco-elastic polishing member.

4. The mirror finish polisher of Claim 1, wherein said visco-elastic polishing member is constituted by a sponge-like material and detachably fixed to said tool base.

5. The mirror finish polisher of Claim 1, wherein said visco-elastic polishing member is constituted by non-woven nylon fabric having abrasive grains retained thereon by a resin and fixed to said tool base.

6. The mirror finish polisher of Claim 1, wherein said tool base is formed of a conductive material and a power supply shoe is held in contact with the rear plate of said tool base around said liquid supply opening for supply of electrolytic current.

7. The mirror finish polisher as set forth in any one of claims 1 to 6, further comprising a guide provided on a carriage movable within a two-dimensional plane of an automatic two-dimensional feed mechanism, said guide being extended in a direction perpendicular to said plane, and said tool electrode being supported

slidably along said guide and tiltable for adjustment of angle of inclination.

8. The mirror finish polisher as set forth in claim 7, wherein said tool electrode is adapted to be pressed against the surface of said workpiece by the weight of said tool electrode itself.

9. The mirror finish polisher as set forth in claim 7, wherein said tool electrode is adapted to be pressed against the surface of said workpiece by spring action.

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FIG. 1

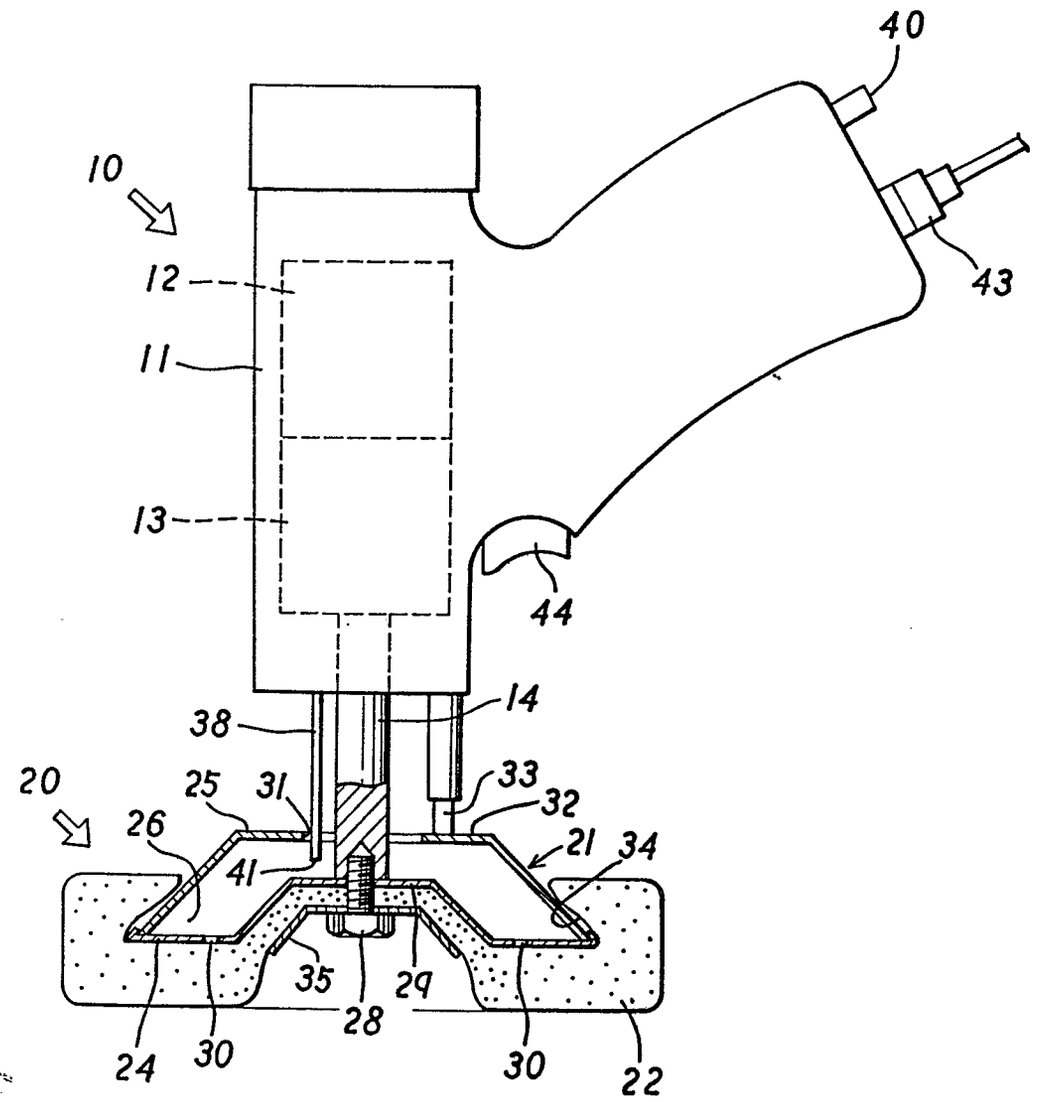

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FIG. 2

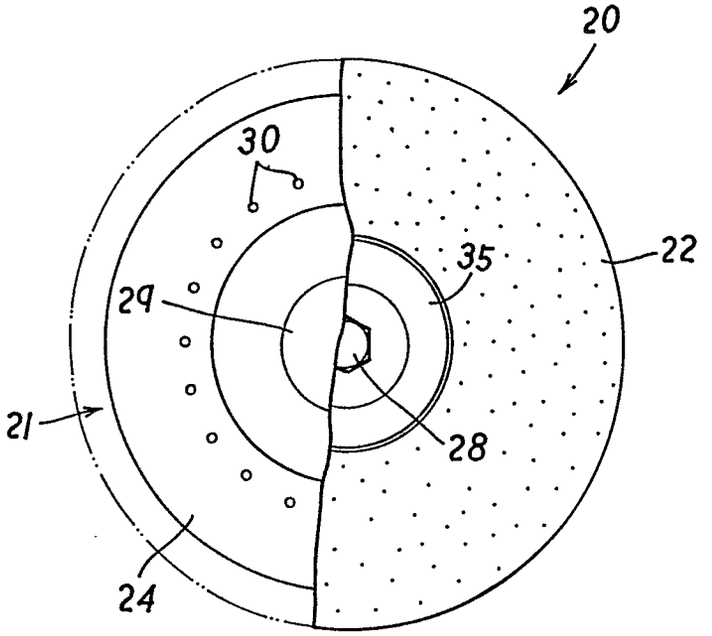


FIG. 3

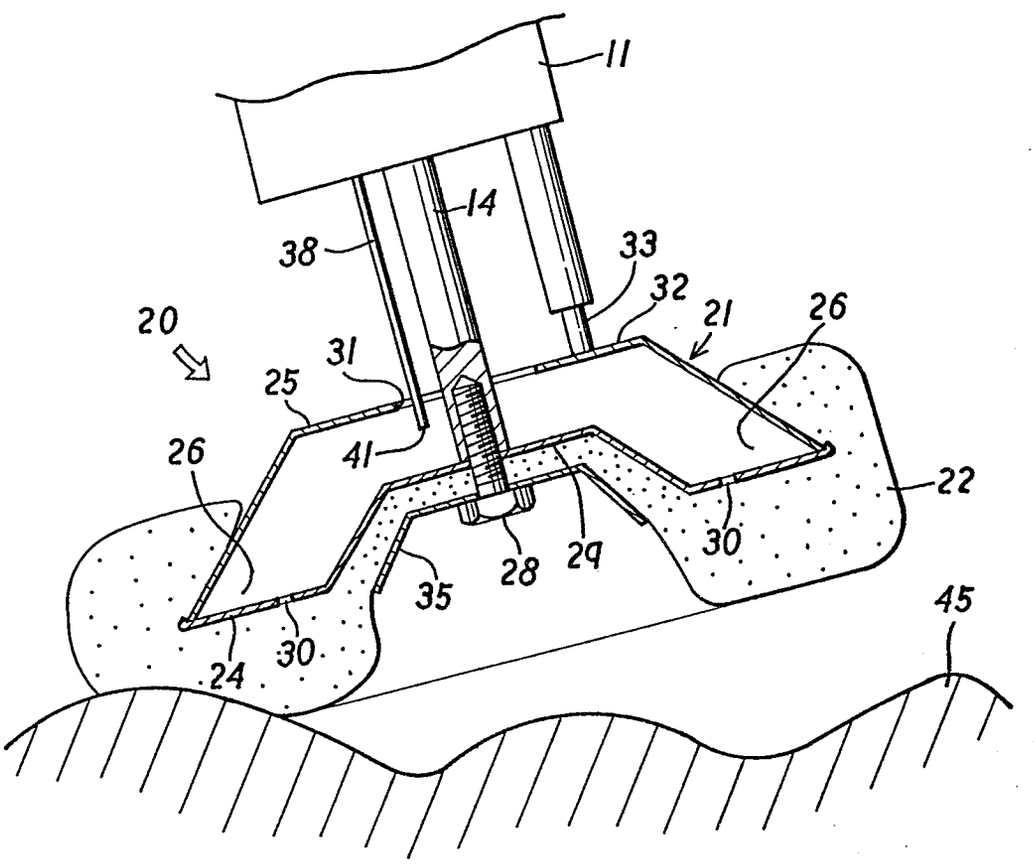


FIG.4

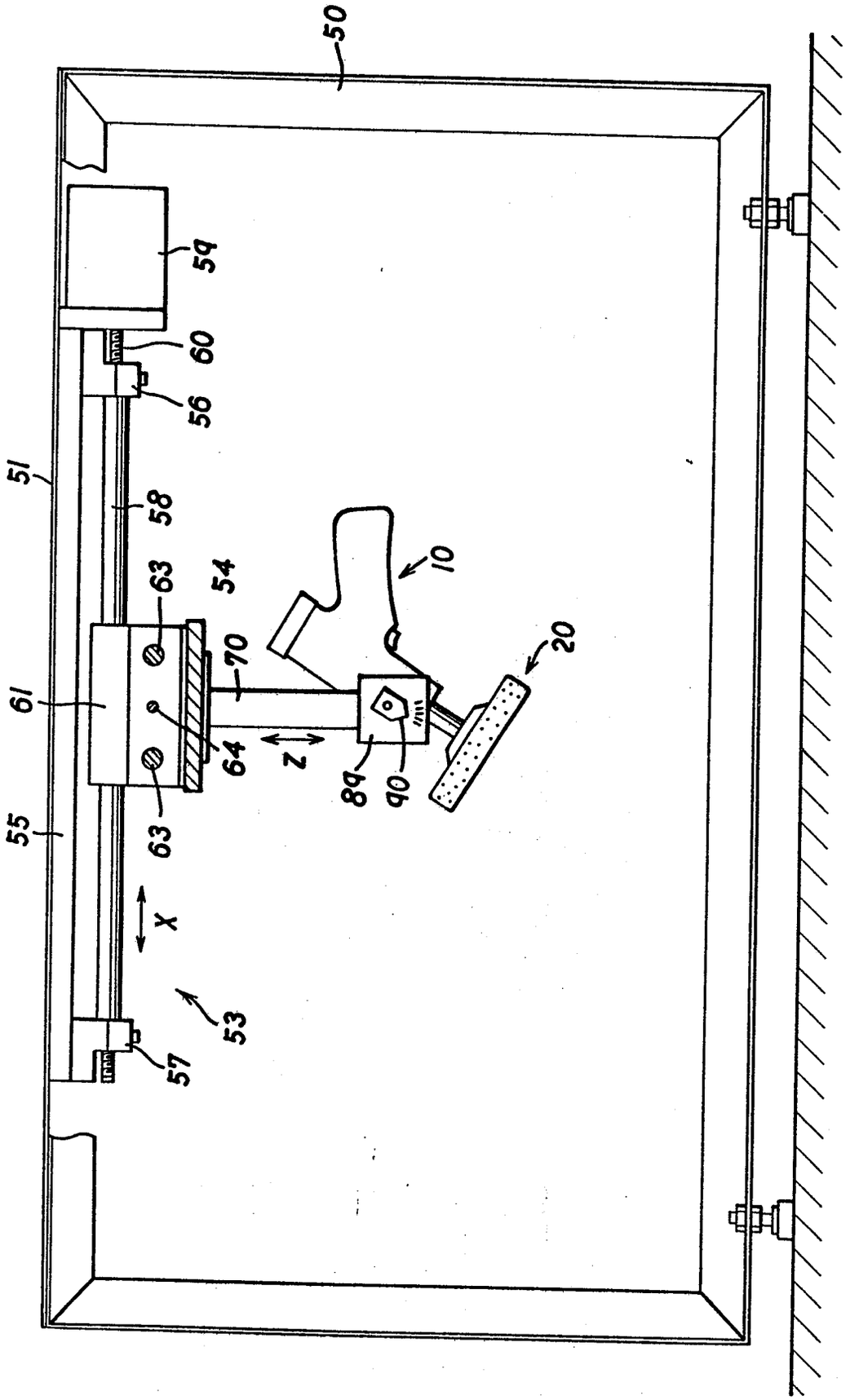
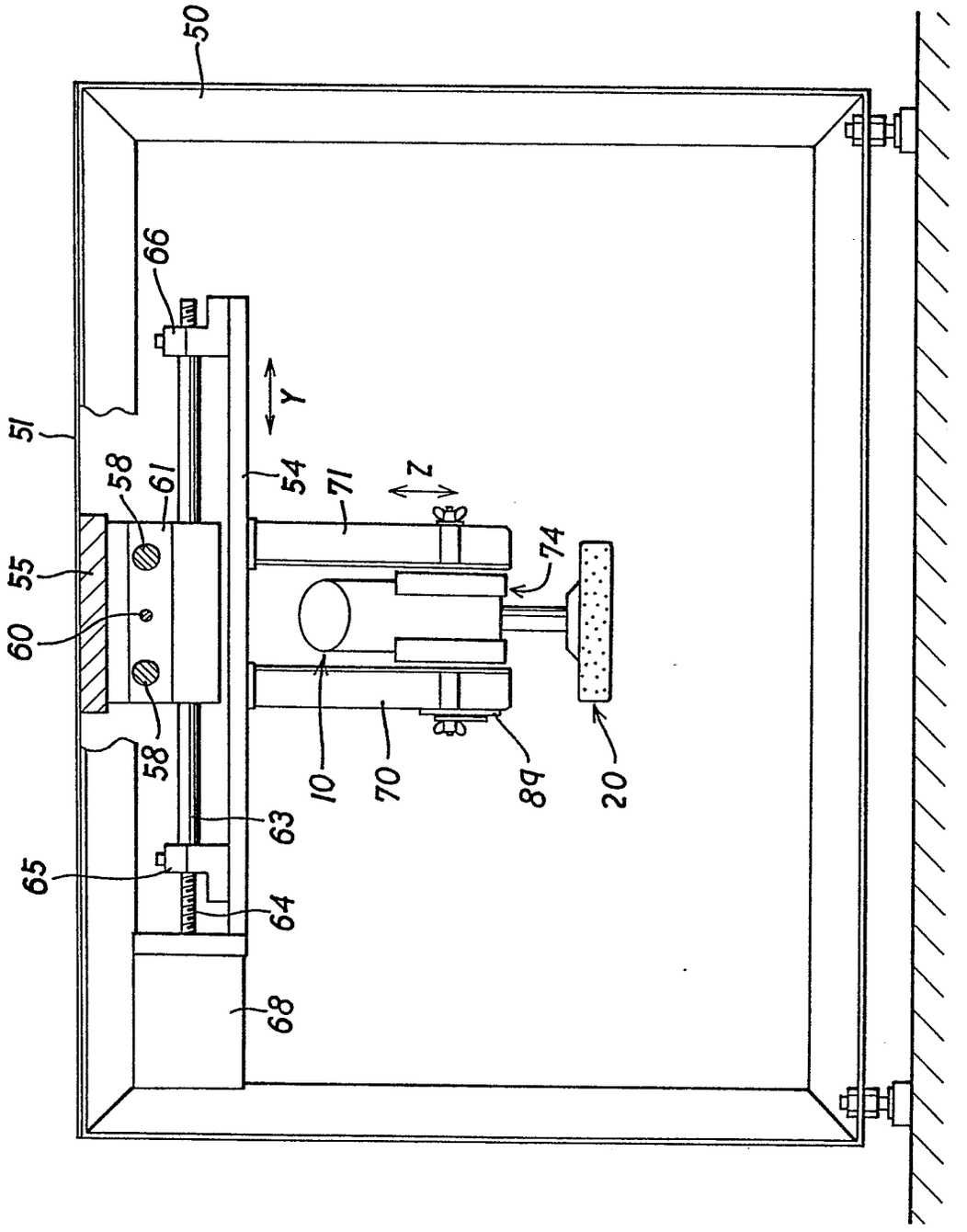


FIG. 5



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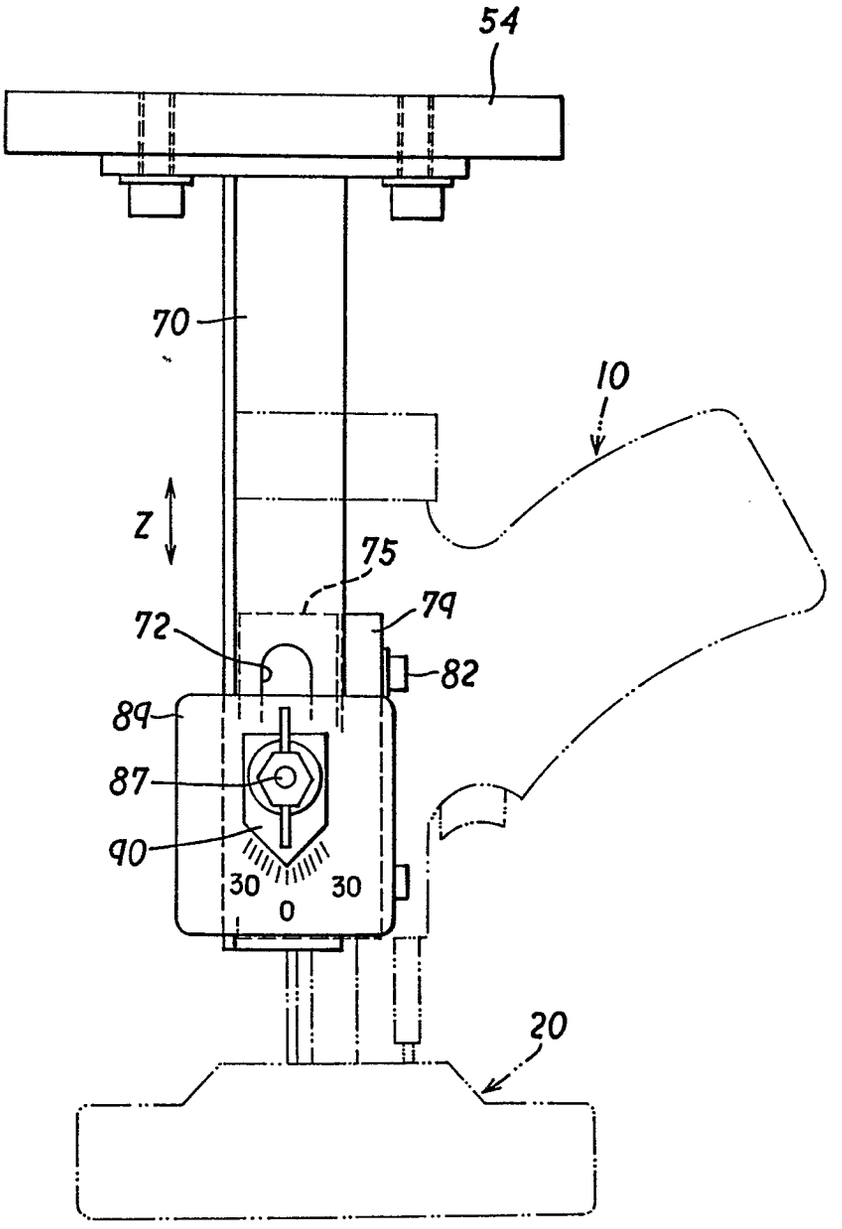

FIG. 7

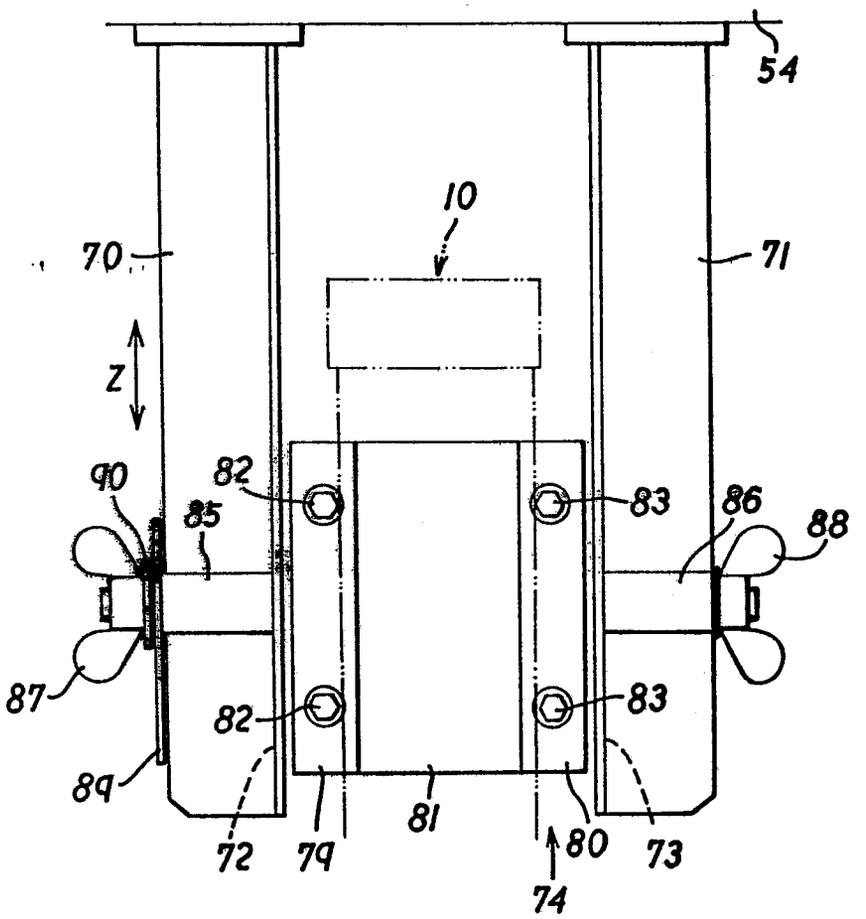
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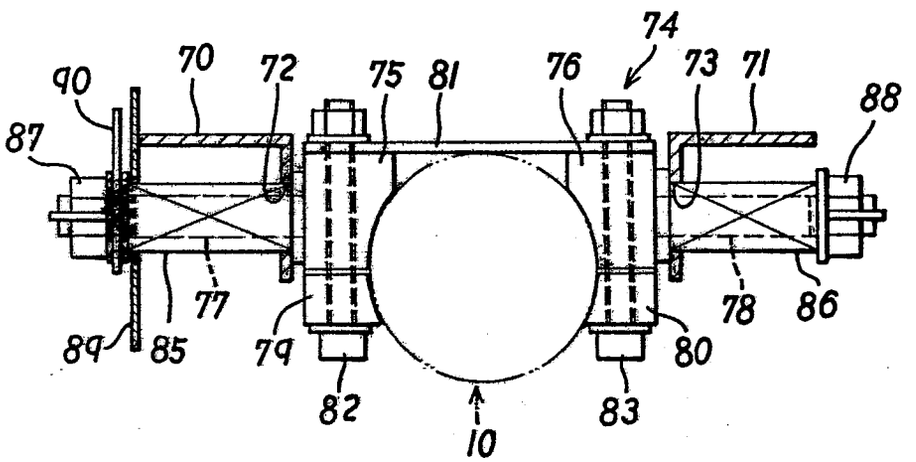
FIG. 8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