May 25, 1971 R. K. SEDGWICK 3,580,834

APPARATUS FOR MACHINING METALS ELECTROCHEMICALLY

Filed Dec. 4, 1967 2 Sheets-Sheet 1

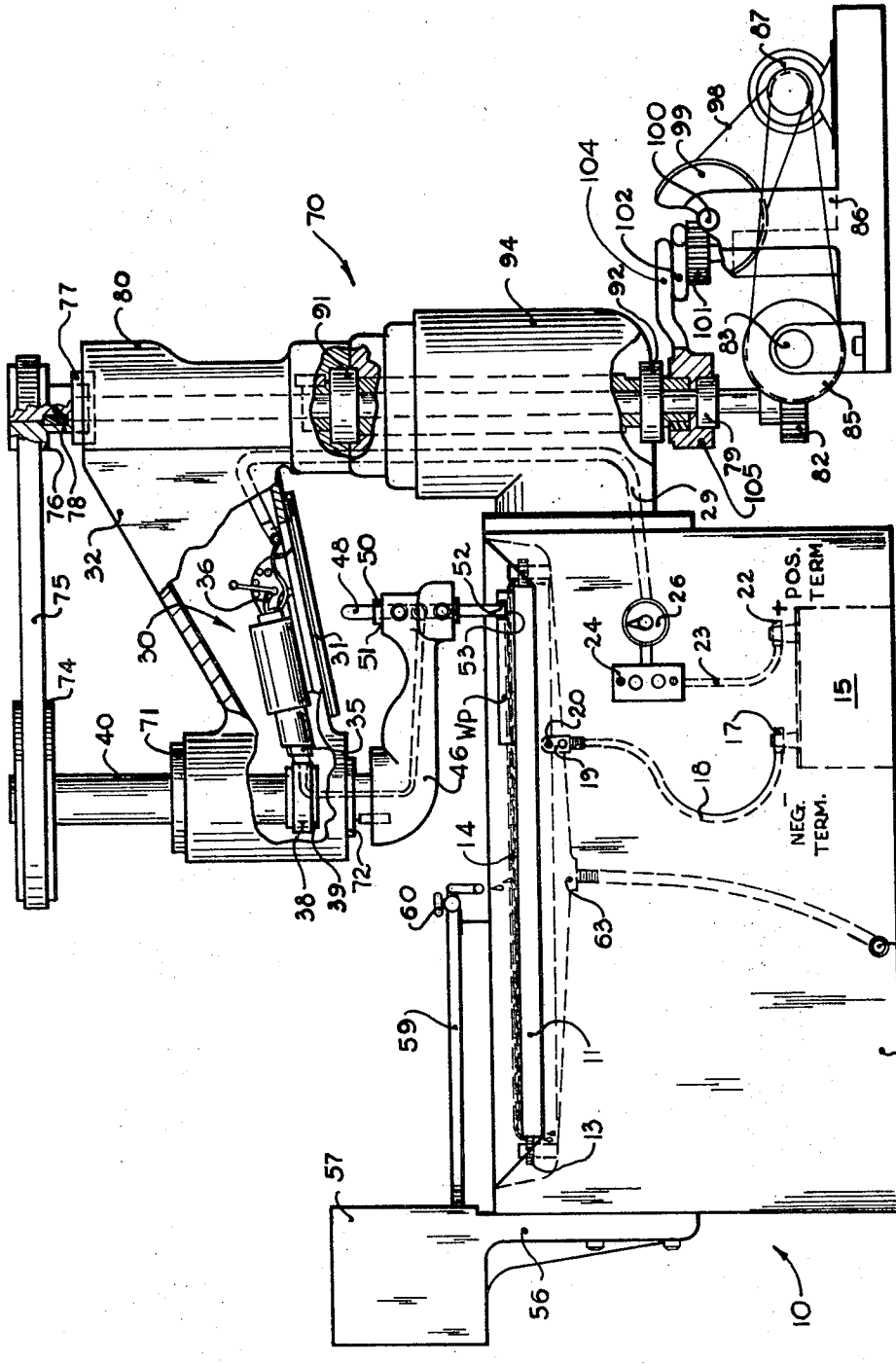


FIG. 1

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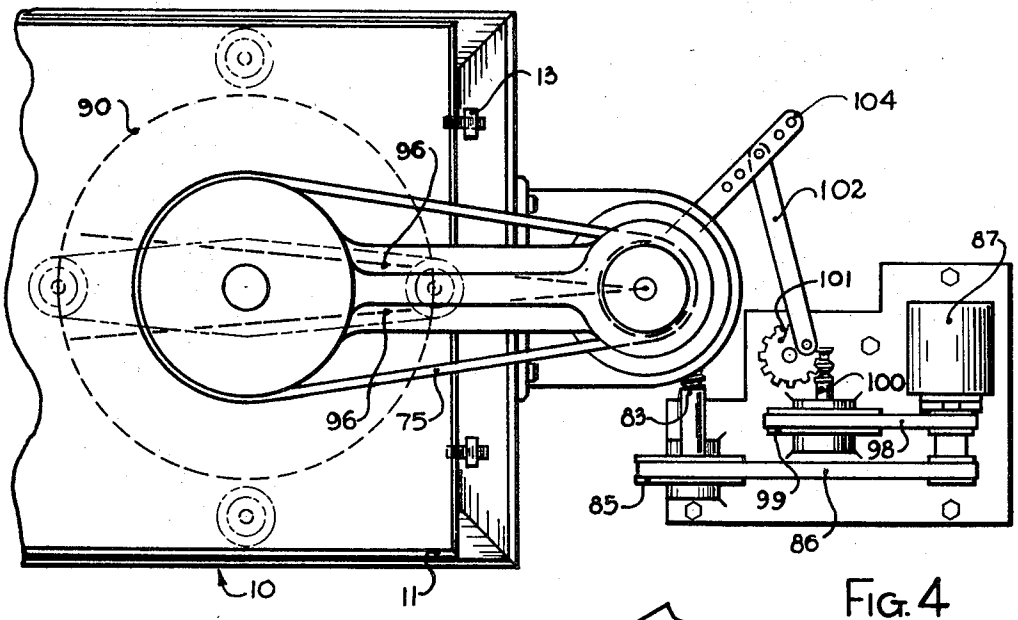


FIG. 4

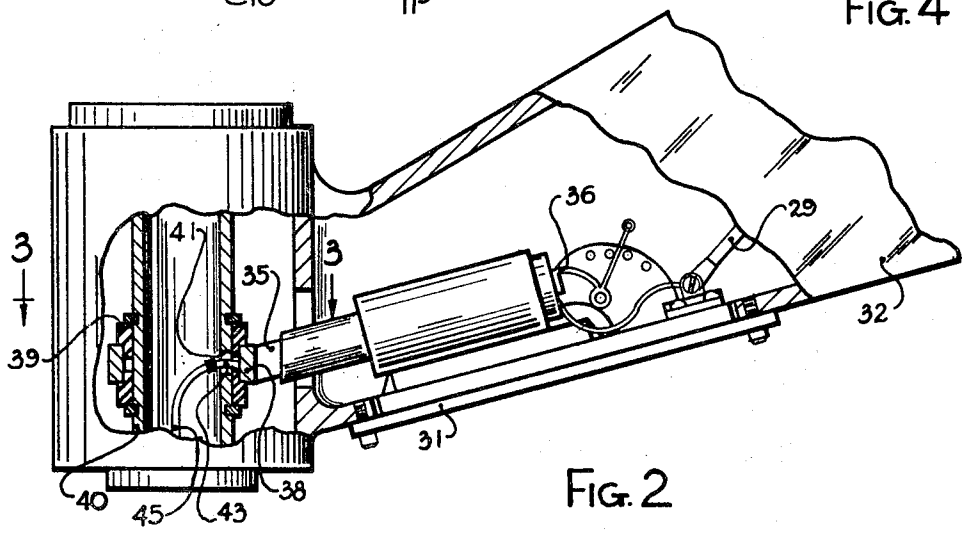


FIG. 2

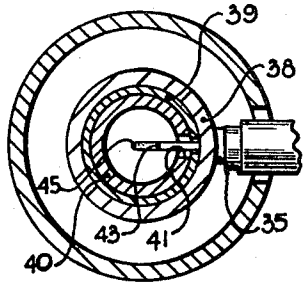


FIG. 3

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APPARATUS FOR MACHINING METALS ELECTROCHEMICALLY

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U.S. Cl. 204—224 3 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus for the electrochemical machining of flat metal surfaces which utilizes a pool of viscous electrolyte of sufficient viscosity to support a workpiece and space the workpiece very slightly from the surface plate, as well as to facilitate movement of the workpiece over the surface plate. Movement of the workpiece in combination with various viscosities of the viscous electrolyte are utilized to obtain the degree of flatness desired.

BACKGROUND OF THE INVENTION

This invention relates to electrochemical machining and more particularly to the electrochemical machining of flat surfaces.

In the making of gibs and ways for machine tools, the customary method of finishing the flat surfaces of the gibs and ways is by the use of grinding procedures. In grinding, there is a tendency for slight warping, requiring the manual scraping of the surface to restore flatness. Manual scraping is a time-consuming operation and requires the services of a skilled craftsman. A method is needed that will reduce the time required for finishing a gib or way and thereby lower the costs involved.

In electrochemical machining, the workpiece is the anode and made positive; the machining tool is the cathode and is made negative. The gap or space between the anode and cathode is filled with an electrolytic solution normally under pressure and operative to carry an electric current from the positive workpiece to the negative machining tool. Due to the electric current, the metal of the workpiece surface will undergo a chemical dissolution wherein a given amount of metal is removed from the workpiece surface.

In previous electrochemical machining apparatus, pumping means were used to circulate large quantities of electrolyte between the surfaces of the workpiece anode and the cathode forming tool, which were urged toward one another under controlled pressure.

SUMMARY OF THE INVENTION

According to this invention, there is provided a new, simplified apparatus and method for machining flat bearing surfaces or enlarged flat metal surfaces, such as machine ways and gibs. A pool of viscous electrolyte is poured on a horizontal flat cathode plate constituting a forming tool. A workpiece is placed on the pool of electrolyte which is of sufficient viscosity to support a moving workpiece and to keep the workpiece separated from the cathode plate by an extremely small distance. The workpiece is then connected to an electrical potential of positive polarity and the cathode surface plate is connected to the negative side of the electrical potential source. The workpiece is then moved by hand or by a machine that will produce a random path of travel over the pool of electrolyte. The random path of travel over the electrolyte will serve to continually position the workpiece over fresh areas of the electrolyte. This will effect the continuous mixing of the electrolyte with the products resulting from the electrochemical dissolution of the flat bearing surface of the workpiece. Very little voltage is required so electric shock is no hazard and all parts of the

apparatus may be freely handled. If desired, the viscosity of the electrolyte can be changed periodically to reach any degree of flatness desired. By using a less viscous electrolyte as the flatness of the workpiece improves, the distance between the workpiece and the cathode surface plate becomes smaller allowing for a finer machining effect.

It is the general object of this invention to provide a method and apparatus for finishing flat surfaces of workpieces that will completely eliminate the requirement for grinding and manual scraping of the flat metal surfaces.

Another object of this invention is to provide a method for electrochemical machining of flat metal surfaces that materially reduces the amount of electrolyte used in the process thereby effecting a substantial reduction in the manufacturing cost.

Still another object of the present invention is to provide a method and apparatus for electrochemical machining of flat metal surfaces that eliminates the necessity of continuously circulating the electrolyte thereby eliminating pumping equipment in the apparatus.

It is a further object of this invention to provide a means whereby gibs, ways and other flat surfaces can be finish machined economically and rapidly under commercial production conditions.

The foregoing and other objects of this invention, which will become more fully apparent from the following detailed description, may be achieved by the exemplifying apparatus depicted and set forth in the specification in connection with the accompanying drawings in which:

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front elevational view of an electrolytic machining apparatus incorporating the features of the present invention with parts broken away to show the brush holder, slip ring, and drive assemblies;

FIG. 2 is an enlarged fragmentary view in elevation of the vertical column, shown in FIG. 1, with parts broken away to show the brush holder and slip ring assemblies;

FIG. 3 is a view in cross section of the shaft taken along a plane represented by the line 3—3, in FIG. 2; and

FIG. 4 is a plan view of the apparatus showing the drive mechanism for effecting the paths of random motion that the workpiece travels on the cathode surface plate.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings and more specifically to FIG. 1 thereof, an electrochemical machining apparatus incorporating the features of the present invention comprises generally a frame **10** which fixedly supports a flat cathode plate **11**. The cathode plate **11** acts as the forming tool in the electrochemical machining process and is secured to the top of the frame **10** by a plurality of insulated bolts **13**. A pool of viscous electrolytic fluid **14**, which is of sufficient viscosity to support a moving workpiece W.P., is poured on the surface of cathode plate **11**. The viscous electrolyte **14** separates the moving workpiece very slightly from the cathode plate **11** as well as facilitating movement of the workpiece thereover.

For electrochemical machining of a workpiece, the workpiece W.P. is positive to consititute an anode and the tool as represented by the cathode plate **11** is negative. As shown in FIG. 1, a direct current source of electricity such as a storage battery **15** has its negative terminal **17** connected by a cable **18** to the cathode plate **11** by a cable lug **19** and bolt **20**. The positive side **22** of the power supply **15** is connected by a cable **23** to an on-off switch **24** and then is continued on to a rheostat **26**, which is used to control the current flow to the workpiece W.P. that is being machined. The on-off switch **24** and rheostat **26**

are mounted on a front panel **27** of the frame **10**. From the rheostat **26** the positive side of the power supply **15** is carried by a cable **29** to a brush holder assembly, which is generally indicated by reference number **30**. The cable **29** and the brush assembly **30** are located within a random motion mechanism **70**, to be subsequently described, which imparts oscillatable and rotatable motion to the workpiece.

As shown in FIG. 2, the brush holder assembly **30** has an insulating bottom plate **31** which is secured to the internal bottom surface of a horizontally extending support arm **32** of the random motion mechanism **70**. A brush **35** is pressed by a spring **36** against a current conducting slip ring **38** which is mounted on a split insulating ring **39** which, in turn, is secured to a hollow vertical shaft **40**. Vertical shaft **40** is provided with an opening **41**, as shown in FIG. 3, to allow a lead wire **43** from the slip ring **38** to be connected to an insulated cable **45** which runs down within the hollow center of shaft **40**. Cable **45** extends downwardly and out of the lower end of the shaft **40** and thence through an arm **46**, and is attached to a vertical metal rod **48**. Rod **48** is freely supported within an insulating bushing **50** which is secured in a vertical bore **51** formed in the arm **46**. The workpieces are provided with a circular recess **52** engaged by the lower end **53** of the rod **48**. The weight of the metal rod **48** will supply sufficient electrical contact between the bottom **53** of the rod and the workpiece. Combined oscillatable and rotatable movement of the arm **46** in a horizontal plane effects like movement of the rod **48**, which is connected to move the workpiece W.P. in a random horizontal path along the cathode plate **11**.

As electric current is passed from the positive workpiece to the negative cathode plate **11** through the electrolytic solution, a material removal action occurs at the workpiece surface.

As shown in FIG. 1, a vertical bracket **56** mounted on the left side of housing **10** supports a tank **57** for electrolytic fluid that is transmitted via a discharge tube **59** to a discharge valve **60**. Valve **60** is operable in known manner to control the output flow of electrolyte from the tube **59** which is movable above the cathode plate **11** for directing an additional supply of electrolyte to the middle of the cathode plate **11**. As this occurs, the original electrolytic fluid will overflow the edges of the cathode plate **11** and run into a sump **63** located beneath the cathode plate **11**. The spent electrolyte will run out an outlet drain **64** located in an external wall of the frame **10**. Instead of running the electrolyte out of a drain, the spent electrolyte could be stored in a tank to be reclaimed at a later date.

Also shown in FIG. 1, to the right and top of the frame **10** is a random motion mechanism indicated by general reference number **70** which supplies the drive for effecting oscillatable and rotatable movement of arm **46**. The random motion mechanism **70** is attached to the frame **10** and is used to move the workpiece in a random path over the whole surface of the pool of electrolyte to continually position the workpiece over fresh areas of the electrolyte **14**. The random motion apparatus **70** can be replaced by an operator who can manually move the workpiece around on the viscous electrolyte solution. The surface of the workpiece could be tilted by the operator applying local pressure on the workpiece which will cause the effect to be concentrated and enables the operator to increase or decrease the taper of the flat surface of the workpiece. Varying amounts of electrochemical material removal action will occur at the workpiece surface depending on the distance between the workpiece and the cathode plate **11**. The distance between the workpiece and the cathode plate **11** is affected by the viscosity of the electrolyte which can be changed by adding more or less thickening agent to the electrolyte tank **57**. Combinations of movement of the workpiece and different degrees of viscous electrolyte are utilized to obtain the degree of flatness desired. Since the operator is working an electrochemical process that operates with an electrical potential

of one to ten volts, there is no hazard from electrical shock. A current density of 3 amperes/sq. inch has been found to work satisfactorily and with the present apparatus a number of workpieces can be electrochemically machined using the same electrolytic fluid.

Irrespective of which electrolytic solution is provided for use in the machine, it has the characteristics hereinbefore described. First, it has sufficient viscosity to support a flat workpiece an extremely slightly spaced distance above the surface of the flat surface presented by the cathode plate **11**. Second, in suporting the flat workpiece slightly, the viscosity of the solution is sufficient to facilitate movement of the workpiece along its random paths of movement. Third, during the random paths of movement of the workpiece, the electrolytic solution coacts with the low amperage current to facilitate a material removal action at the workpiece surface until the requisite degree of flatness is achieved. Fourth, the workpiece material removed by the electrochemical action flows with the spent electrolyte to the sump, and is continually replenished by electrolytic fluid from the metering means.

As viewed in FIG. 1, the random motion mechanism **70** includes the arm **46** which supports the axially movable rod **48**. Arm **46** is keyed to a vertical shaft **40** which is rotatably supported by bearings **71** and **72** carried toward the outer end of the support arm **32** which is secured at its opposite end to a rotatable support column **80**. Shaft **40** is keyed to a driven pulley **74** which is rotated by a belt **75** connected to a drive pulley **76** rotatably supported at the upper end of the column **80** which is supported for limited angular rotation relative to the support frame **10**, as will hereinafter be explained.

Pulley **76** is keyed to vertical shaft **78** which is rotatably supported by an upper bearing **77** and a lower bearing **79** carried by the independently pivotable column **80**. Shaft **78** has keyed to its lower end a gear **82** driven by a worm gear **83** having its shaft secured to a pulley **85** which is driven by a motor **87** by means of a slipping belt **86**, as shown in FIGS. 1 and 4. The rotary motion transmitted by belt **86**, via the vertical shaft **78**, belt **75**, and depending shaft **40** rotates the horizontal arm **46** throughout a 360° circle, as illustrated in FIG. 4 by dotted line **90**, to effect corresponding rotary movement of the drive rod **48** carried thereby.

Column **80** is rotatably supported for limited pivotable movement in bearings **91** and **92** which are carried by a support base **94** attached to the frame **10**. Column **80** is pivotably rotatable through an arc of approximately 30°, as shown by dotted lines **96** in FIG. 4, simultaneously with the rotatable movement of the arm **46**. This approximate 30° movement is obtained from a drive mechanism comprising the motor **87**, belt **98**, pulley **99**, worm gear **100**, gear **101**, pivoting link **102** and arm **104**. These components and their relationships are shown in FIGS. 1 and 4. Motor **87** drives belt **98** which, in turn, rotates pulley **99**. Worm gear **100**, which is connected to pulley **99**, turns as pulley **99** rotates. Rotational drive from the worm gear **100** is transmitted to meshed gear **101**, which is provided with a hub pivotably pinned to one end of the link **102**.

Arm **104** is a lateral extension of hub **105** and is pivotably pinned to the other end of link **102**. Hub **105** is secured to vertical column **80** and consequentially column **80** will turn with hub **105**. The selection of any one of the plurality of holes in arm **104** depend on the angular displacement desired for column **80**. Whatever hole is selected determines the amount of movement arm **104** will make for every revolution gear **101**. By selecting a hole which makes arm **104** longer, there is provided a resulting smaller angular displacement of hub **105** and consequently column **80**.

Slippage of the belts **86** and **98** assures constantly changing angular relationships between arm **46** and column **80**, producing the necessary degree of random movement of the workpiece path.

To summarize, the present invention includes a method and apparatus for electrochemically machining flat surfaces on metal workpieces. A pool of viscous electrolyte is used to space the moving workpiece very slightly from the cathode surface plate, as well as to facilitate movement of the workpiece therealong. An operator or a random motion mechanism is used to move the workpiece over the pool of electrolyte. The workpiece is connected to the positive side of a direct current power supply. The cathode surface plate is connected to the negative side of the direct current power source. A current density of approximately 3 amperes/sq. inch is used with a very small spacing between the workpiece and cathode surface plate. A very low voltage is maintained. The present invention provides a means whereby gibs, ways and other flat surfaces can be machined economically, rapidly and safely under commercial production conditions.

From the above description of a preferred embodiment of my invention it will be apparent that variations in any of the structures may be made without departing from the spirit and scope of the invention and that the scope of the invention is to be determined from the scope of the following claims:

The principles of this invention having now been fully explained in connection with the foregoing description, I hereby claim as my invention:

1. Apparatus for electrolytically removing material from an electrically conductive workpiece to provide thereon a flat bearing surface comprising:

a frame;

a horizontal flat cathode plate constituting a flat work forming tool supported by said frame, said horizontal work forming tool being operatively disposed to maintain on its surface a uniform film of selectively viscous electrolytic fluid comprising a uniform current transmitting film adapted to resiliently support a workpiece for movement;

a reservoir connected to supply a predetermined variable volume of electrolytic fluid to the surface of said work forming tool;

a fluid conductor tube including valving means selectively adjustable and operatively connected to transmit fluid from said reservoir and maintain a predeterminately thick film of viscous electrolytic fluid on the surface of said work forming tool;

a sump positioned to in turn receive excess fluid from the surface of said work forming tool to insure a continuous circulation of a uniformly thick film of fluid over said surface;

an electric power source including conductor means removably connecting the positive side of said power source to a workpiece and separate conductor means connecting the negative side of said power source to said work forming tool in a manner that a material removal is effected on the underside of a workpiece by transmission of positive current through a film of selectively viscous fluid to said negative work forming tool;

a power driven arm movably carried by said frame for horizontal movement along an irregular path parallel to said flat forming tool and being releasably connected to effect irregular horizontal movement of a workpiece along a film of current passing fluid presented by said work forming tool; and,

power drive means connected to effect horizontal bodily movement of said arm along a selectively varied irregular path for effecting corresponding irregular movement of a workpiece in fluid supporting relationship along said forming tool.

2. Apparatus according to claim 1 wherein said means to effect irregular horizontal bodily movement of a workpiece includes a driver opening presented on the upper face of a workpiece to be machined, and comprising:

a workpiece engaging driver rod carried by said power driven arm for vertical movement into gravity urged engagement with a driver opening presented by a workpiece to be machined, said driver rod being operative to transmit both electrical energy and motive power from said irregularly driven arm to move a workpiece in an irregular path of travel along a selectively viscous film of fluid electrolyte circulated over the surface of said work forming tool.

3. Apparatus for electrically removing material from the underside of an electrically conductive workpiece to provide a flat bearing surface and comprising:

a horizontal cathode plate comprising a work forming tool adapted to present on its upper surface a uniformly thick film of selectively recirculating current transmitting electrolytic fluid, said horizontal work forming tool and the film of fluid presented thereby cooperating to provide a selectively resilient bearing support for maintaining a workpiece in fluid supported current transmitting engagement with said work forming tool;

a supply tank including a discharge tube adjustable connected to supply electrolytic fluid of selectively predetermined viscosity and being operatively connected to supply a predeterminately thick film of electrolytic fluid to the surface of said work forming tool;

a sump adapted to receive excess fluid from said work support and cooperating therewith to provide thereon a continuously recirculating film of fluid of selected viscosity and predetermined thickness;

a source of electric energy including a first conductor releasably connected to transmit positive current to a workpiece movably supported for horizontal movement in fluid supported relationship by said tool support, said source of energy connected via a second conductor to transmit negative current to said tool support for transmission via the selectively viscous film of recirculating fluid presented thereby to a workpiece;

a power driven arm means including a work engaging metal driver rod carried in position to releasably engage an electrically conductive workpiece and being selectively operative to move the engaged workpiece along an irregular path in a continuously variable fluid support path on said work forming tool;

said first conductor including a brush assembly and a slip ring assembly connected to be frictionally engaged by said brush assembly during movement of said arm; and,

power drive means for moving said power driven arm means along said irregular path.

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