

March 28, 1967

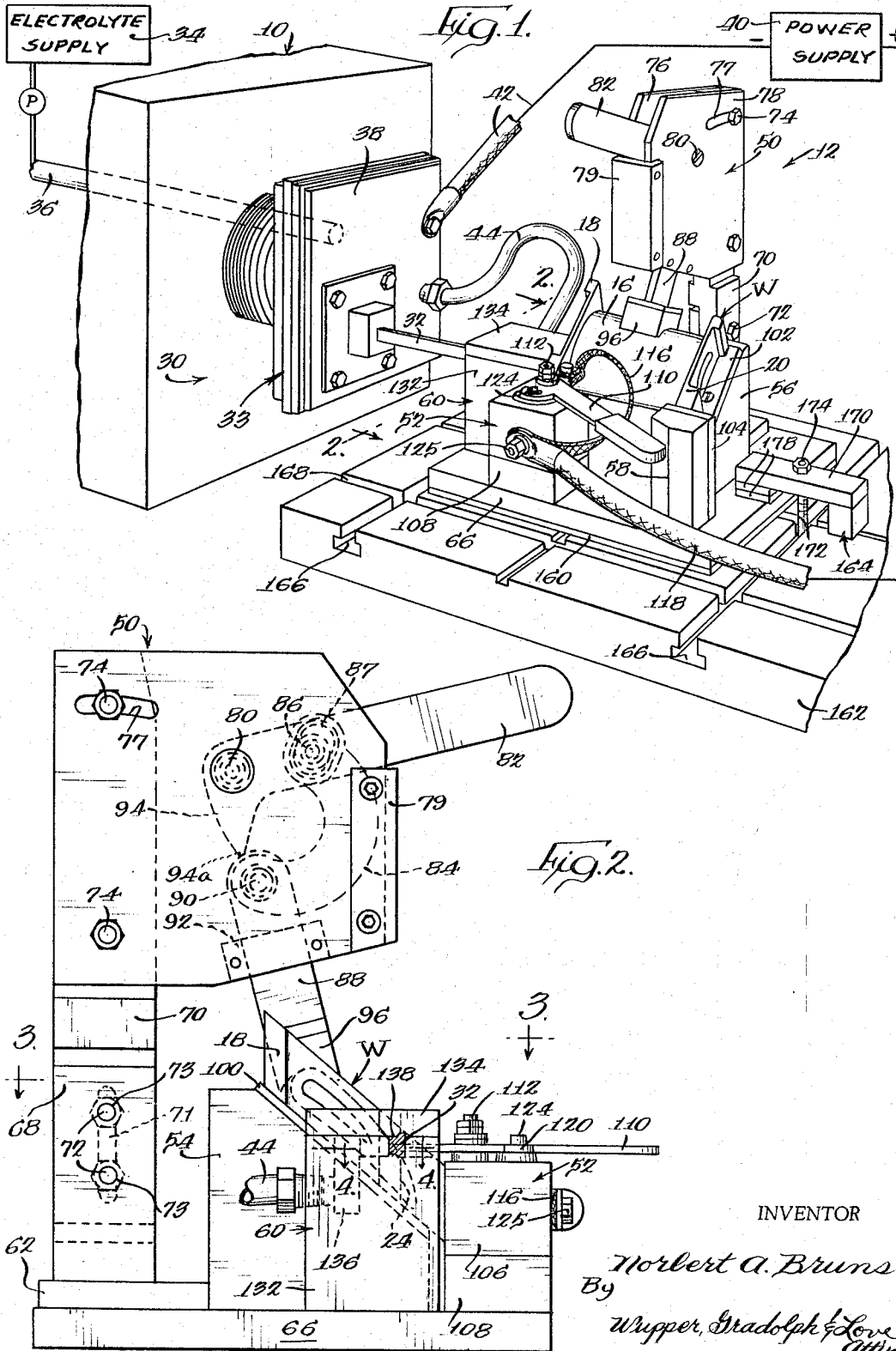
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ELECTROLYTIC SHAPING APPARATUS

Filed Jan. 7, 1963

2 Sheets-Sheet 1



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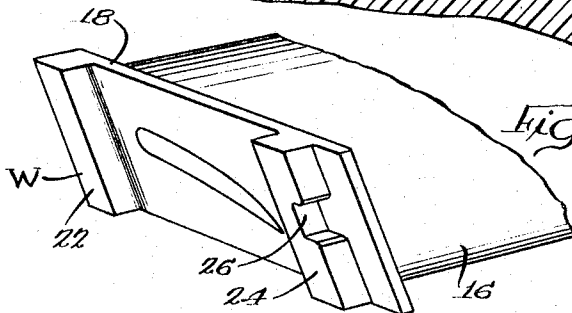
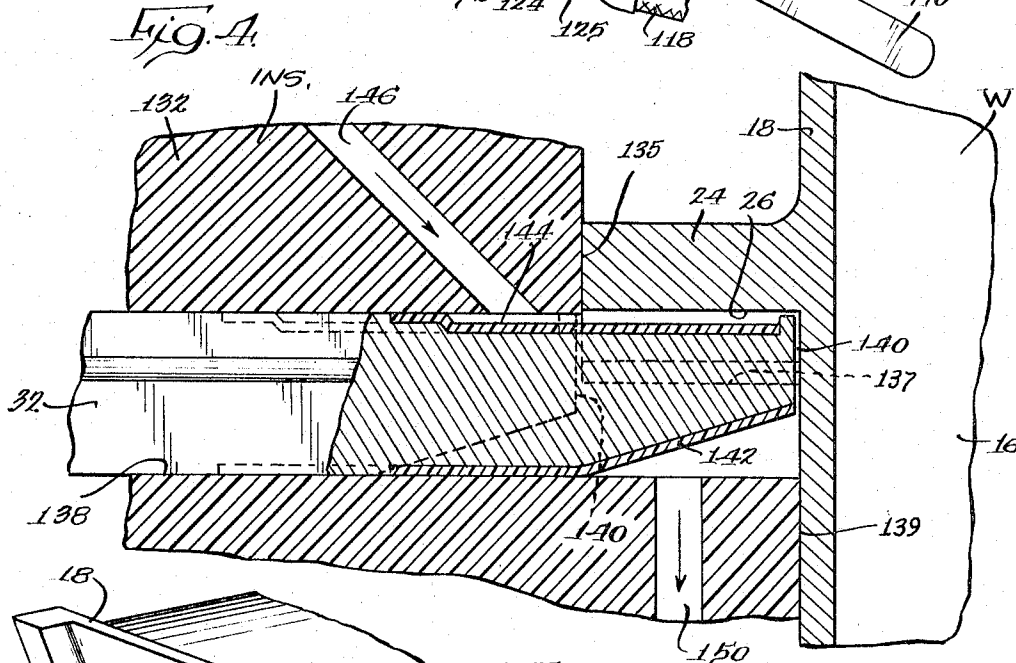
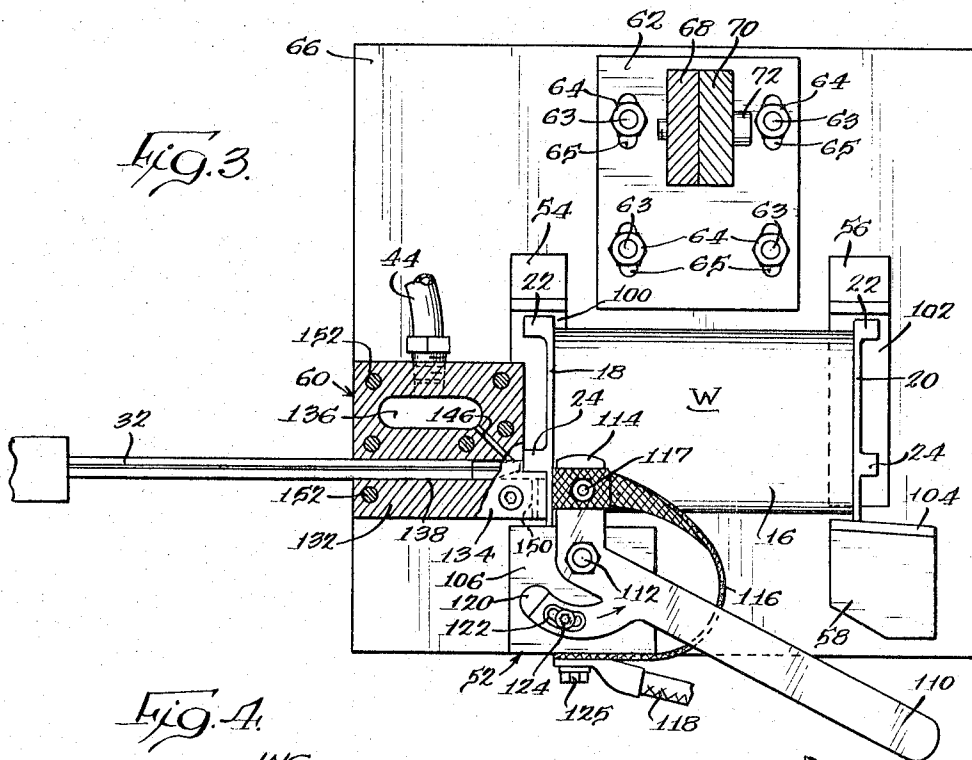
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1

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ELECTROLYTIC SHAPING APPARATUS

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3 Claims. (Cl. 204—224)

This invention relates to improvements in electrolytic shaping apparatus, and in particular to a new and improved fixture for holding a workpiece during electrolytic shaping.

It has been discovered that contours and cavities on and in electrically conductive and electrochemically erodible workpieces can be formed by an electrode wherein electrolyte under appreciable pressure is pumped through a narrow work gap between the electrode and workpiece, and a low potential, high density direct current is passed simultaneously therewith between the electrode and workpiece. This method and the apparatus for practicing it are described in Lynn A. Williams Patent No. 3,058,895, dated Oct. 16, 1962, and in the copending applications of Lynn A. Williams, Ser. No. 73,154, filed Sept. 2, 1960, and Lynn A. Williams and Leonard Malkowski, Ser. No. 201,679, filed June 11, 1962, and with respect to certain details, in other copending applications of Lynn A. Williams.

During such electrolytic shaping operation, it is extremely important that the workpiece is held in proper position and in such manner that it may not move. Furthermore, it is advantageous that the workpiece be held in such manner that it may be easily inserted into and removed from the electrolytic shaping apparatus. In this manner a large number of workpieces may be electrolytically shaped without costly time delay in inserting and removing the workpieces from the electrolytic shaping apparatus.

The present invention provides a fixture for holding workpieces during electrolytic shaping wherein the workpiece may be easily inserted into and removed from the fixture to facilitate electrolytic shaping of a plurality of workpieces. Furthermore, the fixture of the present invention is adapted to prevent stray electrolytic erosion of the electrolytic shaping apparatus, and more particularly, of the work table upon which the fixture is placed.

It is a principal object of the present invention to provide a new and improved fixture for holding a workpiece during an electrolytic shaping operation.

It is a further object to provide a fixture for electrolytic shaping operations wherein the workpiece may be easily inserted into and removed from the fixture.

It is still a further object to provide a work holding fixture for an electrolytic shaping operation wherein stray electrolytic erosion of the electrolytic shaping apparatus is precluded.

Another object is to provide a fixture for holding a workpiece during an electrolytic shaping operation, which is adapted firmly to hold the workpiece in proper position during the electrolytic shaping operation.

Another object is to provide a fixture for holding a workpiece in an electrolytic shaping apparatus which includes an electrode guide and means for conducting the electrolyte to and from the work gap between the electrode and the workpiece.

The invention, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following description taken in conjunction with the accompanying drawings, in which—

FIG. 1 is a perspective view of an electrolytic shaping apparatus employing a fixture embodying the features of the present invention;

2

FIG. 2 is an end elevational view of the fixture illustrated in FIG. 1, taken along the line 2—2 of FIG. 1, and looking at the fixture and workpiece from the electrode entry end;

FIG. 3 is a cross sectional view of the fixture illustrated in FIG. 1, taken along the line 3—3 of FIG. 2, with a portion of the fixture cut away;

FIG. 4 is a fragmentary cross sectional view of the fixture illustrated in FIG. 1, taken along the line 4—4 of FIG. 2; and

FIG. 5 is a fragmentary perspective view of the workpiece held by the fixture illustrated in FIG. 1.

Referring to the drawings, and more particularly to FIG. 1, there is illustrated an electrolytic shaping apparatus, indicated generally by reference numeral 10, associated with a work holder fixture embodying the features of the present invention, and indicated generally by reference numeral 12. The work holder fixture 12 is adapted to hold a workpiece W in proper position during electrolytic shaping. As seen in FIGS. 1 and 5, the workpiece W shown is a turbine blade having a convex center section 16 and end flanges 18 and 20. The latter each have outwardly extending ribs 22 and 24 which are substantially parallel to one another. It is to be understood that this workpiece is by way of example only, and other workpieces are intended to be secured in the fixture 12.

In this particular electrolytic shaping operation described by way of example, it is desired to cut a groove or notch 26 in the rib 24 of the end flange 18. Accordingly, as will be more apparent hereinafter, the work holder fixture 12 is adapted to hold the turbine blade W in proper position during the electrolytic shaping operation wherein the apparatus 10 electrolytically cuts the notch 26 in the rib 24 of the end flange 18.

The electrolytic shaping apparatus 10 is, in this instance, of the type disclosed and claimed in the aforementioned copending application of Lynn A. Williams and Leonard Malkowski, Ser. No. 201,679. The electrolytic shaping apparatus 10 includes a drivehead assembly 30 which controls the axial movement of an electrode 32 as it performs the electrolytic shaping operation on the workpiece W, that is, electrolytically cuts the notch 26 in the rib 24 of the turbine blade W. The electrolytic shaping operation is effected in a work area enclosed by any suitable housing of stainless steel or the like, as more fully described in the copending application of Lynn A. Williams, Ser. No. 73,154, previously mentioned.

As the drivehead assembly 30 is fully described and illustrated in the William and Malkowski application referred to hereinabove, and does not per se constitute a part of the present invention, it need not be described in great detail. The drivehead assembly 30 is mounted on a suitable base (not shown) and includes an axially movable ram assembly 33 which projects into the work area. The ram assembly 33 has an electrolyte supply 34 through a pipe 36, the supply 34 and pipe 36 being indicated schematically in FIG. 1. The electrolyte supply 34 includes a pump and conduits such that the electrolyte is pumped to the entry to the work gap between the workpiece W and the electrode 32 at a pressure in the range of 40 to 350 p.s.i.

The electrode 32 shown is of the solid type and is mounted on a mounting plate 38 of the ram assembly 33. The electrode 32 is connected to the negative terminal of a power supply 40 by an electrical conductor 42 fixedly secured to the mounting plate 38. The power supply may be of the type supplying a low voltage, 4 to 25 volts, high density direct current disclosed in the copending application of Lynn A. Williams and James E. Davis, Ser. No. 863,246, filed Dec. 31, 1959, now abandoned. The electrode 32 projects outwardly from the mounting plate 38 into the work area and is guided by the work holder fix-

ture 12 in a manner more apparent hereinafter. Electrolyte is pumped to the work gap between the electrode 32 and the workpiece W through a nonconducting rubber hose 44 or the like which is connected to the electrolyte manifold in the ram assembly 33.

Basically, the work holder fixture 12 is adapted to support and position the workpiece W with respect to the electrode 32 and also to assure that the workpiece W has a positive potential relative to the electrode 32. To these ends, as seen in FIGS. 1 to 3, the work holder fixture 12 includes a clamping means 50, an electrical contact means 52, supporting blocks 54, 56, and 58, and an electrolyte supply feeder and electrode guide means 60. As will be more apparent hereinafter, the blade portion 16 of the workpiece W rests upon the supporting blocks 54 and 56 while abutting against the supporting block 58, the electrical contact means 52, and the feeder and guide means 60. The clamping means 50 holds the blade W in position on the supporting blocks 54 and 56 and prevents it from moving during the electrolytic shaping operation. The electrical contact means 52 connects the blade W into the electric circuit to be positive with respect to the electrode 32, which is properly guided by the electrolyte supply feeder and electrode guide means 60. The electrolyte supply feeder and electrode guide means 60 conducts the electrolyte, in a manner more apparent hereinafter, to the work gap between the electrode 32 and the workpiece W in order that the desired electrolytic shaping may be effected.

The clamping means 50 includes a base 62 which is fixedly secured to a fixture base 66. In this instance, as seen in FIG. 3, the fixture base 66 has upwardly extending threaded studs 63 secured thereto which extend through slots 65 in the base 62. Nuts 64 engage the studs 63 to secure the base 62 and the clamping means 50 in place. The slots 65 allow the base 62 and therefore the clamping means 50 to be moved and adjusted to proper position before being fixedly secured in place.

Extending upwardly from and rigidly secured to the base 62 by welding or the like is a vertical standard 68 to which is attached an upwardly extending member 70 by bolts 72 which extend through a slot 71 (FIG. 2) in the member 70 and threadedly engage holes 73 in the standard 68. The slot 71 permits the height of the clamping means 50 to be adjusted to correspond with the size of the workpiece to be electrolytically shaped. Attached to the upper end of the support member 70 by nuts and bolts 74 or the like are plates 76 and 78 which are substantially parallel to one another and maintained in proper spaced relationship by a U-shaped bracket member 79. As seen in FIGS. 1 and 2, the plates 76 and 78 have arcuate slots 77 whereby the plates 76 and 78 may be pivoted further to adjust the position of the clamping means 50 to hold workpieces of different sizes and shapes. The plates 76 and 78 support a horizontally extending pin 80 or the like about which a handle 82 is pivoted.

The handle 82 is adapted to pivot on the pin 80 and has an arcuate linkage member 84 pivotally attached thereto between the pin 80 and its outer end. One end of the linkage member 84 has a slot 87 therethrough which cooperates with suitable pin means 86 attached to the handle 82 so that this end of the linkage member 84 may pivot with respect to the handle 82. It will be understood that the pin means 86 may slide within the slot 87 and therefore that this end of the linkage member 84 may move with respect to the handle 82 and the pin means 86. The other end of the linkage member is pivotally attached to an end of a clamping arm 88 by pivotal pin means 90 or the like fixedly secured to the clamping arm 88. Suitable guide means 92 are fixedly secured between the plates 76 and 78 to guide the clamping arm 88 as it moves downwardly to clamp the workpiece W, or moves upwardly to allow the workpiece W to be removed from the clamping means 50, depending upon the movement of the handle 82. The clamping

arm 88 has fixedly secured to its other end a pad 96 of resilient gripping material, such as neoprene or the like, to prevent damage to the workpiece W, while simultaneously providing enhanced gripping of the workpiece by the clamping arm 88.

The handle 82 has a curved camming surface 94 with a V-shaped tip 94a on its inner end adapted to cooperate with the upper end of the clamping arm 88. In FIGS. 1 and 2 the clamping arm 88 is illustrated in its locked or clamping position. This is effected by clockwise rotation of the handle 82 (FIG. 2) which caused the camming surface 94 to force the clamping arm 88 downwardly so that the pad 96 engages the workpiece W. The locked position is achieved when the tip 94a engages the end of the clamping arm 88 as shown in FIG. 2, and any upward movement of the clamping arm 88 is prevented because it cannot rotate the handle 82 in the counterclockwise or unlocking direction. Likewise, it will be understood that upon pivoting the clamping arm 82 in the counterclockwise direction about the pin 80, the linkage member 84 will also pivot in a counterclockwise direction, the V-shaped tip 94a will move off the end of the clamping arm 88, thereby releasing it, and the linkage member 84 will pull the clamping arm 88 upwardly to release the workpiece W. In this manner the clamping means 50 is adapted to hold the workpiece W in proper position on the supporting blocks 54 and 56 and prevent it from moving during the electrolytic shaping operation. Furthermore, by simply lifting the handle 82, the workpiece W is released and may be removed from the fixture 12 to allow another workpiece to be placed in the fixture 12 for electrolytic shaping.

The supporting blocks 54 and 56 are made of stainless steel or the like, but have nonconductive plates 100 and 102, respectively, secured to their top surfaces upon which the workpiece W rests. The nonconductive plates 100 and 102 may be made of a suitable glass laminate, epoxy resin, or the like, and are secured to the supporting blocks 54 and 56 by screws or the like (not shown). If the screws are made of conductive material they are countersunk in the plates 100 and 102 and covered with a nonconductive material to prevent any electric conduction between the blocks 54 and 56 and the workpiece W.

Similarly, the supporting block 58 is made of stainless steel or the like, but has a vertically extending nonconductive plate 104 attached thereto in the same manner the plates 100 and 102 are attached to the blocks 54 and 56. The workpiece W, when it is secured in position by the clamping means 50, abuts the plate 104. Thus, when the workpiece W is placed upon the supporting blocks 54 and 56, it rests upon the nonconducting plates 100 and 102 and abuts the nonconducting plate 104, and in this manner the supporting blocks 54, 56, and 58 do not become anodic during the electrolytic shaping operation.

The electrical contact means 52 comprises a block 106 made of nonconducting material, such as glass laminate, epoxy resin, or the like. The block 106 is mounted upon a stainless steel block 108 and secured to the fixture frame 66 by means of screws or the like (not shown). A handle 110 is pivotally mounted on the block 106 by a bolt 112. The handle 110 has an angularly extending arm 114 to which one end of an exposed copper braid conductor 116 is attached by a screw 117 or the like. The other end of the conductor 116 is attached to a positive line 118 from the power supply 40 by a bolt 125 threaded into the block 106. When the workpiece W has been clamped into position on the supporting blocks 54 and 56, the handle 110 is pivoted in the counterclockwise direction (FIG. 3) to bring the copper braid connector 116 into forced engagement with the flange 18 of the workpiece W. The arm 114 of the handle 110 presses the conductor 116 against the flange 18, a portion of the conductor 116 being positioned between the flange 18 and the arm 114 as seen in FIG. 3. In this manner the workpiece W is con-

5

6

nected to the positive side of the power supply 40 and made anodic with respect to the electrode 32.

Electrical contact between the copper braid conductor 116 and the workpiece W is assured by locking the handle 110 in place. The handle 110 has an integral arcuate finger 120 with an arcuate slot 122 therein. Extending through the slot 122 is a bolt 124 threaded into the block 106. When the handle 110 has been rotated in a counterclockwise direction (FIG. 3) to the point that the copper braid conductor 116 is in firm electrical contact with the workpiece W, the bolt 124 is turned to lock the handle 110 in this position.

Referring to FIGS. 3 to 5, the electrolyte supply feeder and the electrode guide means 60 comprises a base section 132 and a top section 134. Both the base section 132 and the top section 134 are made of nonconducting material, such as glass laminate, epoxy resin, or the like. The top section 134 of the electrolyte supply feeder and electrode guide means 60 is secured to the bottom section 132 by screws or the like 152. The base section 132 has an electrolyte reservoir 136 therein through which electrolyte is pumped from the hose 44 connected to the electrolyte manifold. As seen in FIG. 2, the top section 134 and the bottom section 132 have grooves therein which form a passageway 138 receiving the electrode 32. The passageway 138 has the same cross sectional configuration as the electrode 32, which fits snugly, but slidably, therein. The clearance between the surface of the electrode 32 and the wall of the passageway 138 is in the order of a few thousandths of an inch to prevent electrolyte leakage between the electrode 32 and the wall of the passageway 138.

The passageway 138 extends through the electrolyte supply feeder and electrode guide means 60, and it exits at the faces 135, 137, and 139. The faces 135 and 137 are disposed at right angles to each other and form a pocket into which the rib 24 of the blade W fits. The flange 18 is abutted against the face 139. When the blade W is in position to be shaped, the clamping means 50 will hold the rib 24 securely in this pocket and the exit from the passageway 138 will thus be closed by the workpiece itself, which will be located to have the electrode 32 electrolytically cut the notch 26 in the rib.

With the exception of the working tip 140 (FIG. 5) of the electrode 32, its forward end is covered with a layer 142 of insulating nonconductive material, such as epoxy resin or the like. The layer 142 of nonconductive material prevents excessive side cutting of the workpiece W. The electrode 32 has a groove 144 therein which allows electrolyte to be pumped into the passageway 138 from the reservoir chamber 136 via a passageway 146 communicating with the top of the chamber 136. In this manner electrolyte will be pumped around the working tip 140 of the electrode 32, which effects electrolytic cutting of the workpiece W. After passing between the working tip 140 and the workpiece W, the electrolyte exits from the electrolyte supply feeder and the electrode guide means 60 through a passage 150 into the work area where it is recovered in a pan (not shown) for reuse.

The electrode 32 is shown in FIG. 4 in full lines at the end of the notch cutting operation. Its starting position is indicated by the dot-dash lines. At the start of the operation, electrolyte is pumped through the reservoir or chamber 136, the passageway 146, the groove 144 in the electrode, and around the tip 140 to fill the work gap. The electrolyte will fill the space under the sloped surface of the electrode and between the rib 24 and flange 18 of the workpiece W to exit through the passage 150. When the flow of electrolyte has been established, the electrolyzing current and the power unit to advance the electrode are turned on. The electrode 32 is advanced into the rib 140 at a constant controlled rate, and the work material is electrolytically eroded away ahead of the advancing working tip 140. When the electrode has penetrated the workpiece W to a predetermined depth,

that of the notch 26, the apparatus is shut off, the electrode 32 retracted, the workpiece removed and replaced by another for a subsequent operation. Should it be desired to place a back pressure on the electrolyte in the work gap, the exit passageway 150 may be restricted by a restricting orifice, a valve or the like, as shown in the co-pending application of Lynn A. Williams, Ser. No. 212,916, filed July 27, 1962, now Patent 3,254,013 and entitled "Electrolytic Cavity Sinking Apparatus and Method."

The entire fixture assembly 12 is placed upon an insulating pad 160 supported on a table 162 and fixedly held in place by clamping means indicated generally by reference numeral 164. The table 162 has a pattern of transversely extending inverted T-slots 166 and longitudinally extending inverted T-slots 168 as seen in FIG. 1. The clamping means 164 cooperate with the slots 166 and 168 to secure the fixture 12 in the desired position. The clamping means 164 comprises an arm 170, a bolt 172, and a nut 174. The head of the bolt 172 slidably engages the slot 166 and extends through a hole in the arm 170 and is bolted thereto by the nut 174. Blocks 178 of nonconductive insulating material are provided between the arm 170 and the base 66 of the fixture 12 to preclude electrical conduction from the base 66 to the arm 170 and therefore to the table 162. As the table 66 rests upon a plate 160 of nonconducting material, it will be understood that the table 162 may not become anodic with respect to the electrode 32. In this manner electrolytic erosion of the table 162 is precluded.

It will be understood that other clamping means may be employed to secure the fixture 12 to the work table 162, it being kept in mind that it is necessary to insulate the fixture 12 from the work table 162 to prevent random electrolytic erosion of the work table 162. The table 162 is conventionally adjustable in the vertical and transverse directions to bring the workpiece W into proper position relative to the electrode 32.

While the embodiments described herein are at present considered to be preferred, it will be understood that various modifications and improvements may be made therein, and it is intended to cover in the appended claims all such modifications and improvements as fall within the true spirit and scope of the invention.

What is claimed and desired to be secured by Letters Patent of the United States is:

1. In an electrolytic shaping apparatus for electrolytically shaping an electrically conductive and electrochemically erodible workpiece by a movable electrode, the combination comprising, supporting blocks on which the workpiece is positioned, the workpiece being held in position on said supporting blocks by a clamping means, said clamping means including a clamping arm having a resilient pad on one end thereof adapted to engage the workpiece, said clamping arm being controlled by a handle associated therewith to lock said clamping arm in position and thereby hold the workpiece on said supporting blocks, means for holding a positive lead from an electric power supply against the workpiece, said holding means including a pivotal handle means having a copper braid conductor attached thereto and adapted to be pivoted to contact said conductor with the workpiece, said conductor being connected to a positive terminal of said power supply, and means to lock said handle means in place, whereby the conductor is firmly held in contact with the workpiece, whereby the workpiece is anodic with respect to the electrode during electrolytic shaping, electrode guide means for the electrode, including a passageway through which the electrode slides and is guided during electrolytic shaping, said clamping means holding the workpiece so that the portion to be eroded is secured against said electrode guide means and closes one end of said electrode guide passageway, said electrode guide means including an electrolyte reservoir and means to direct electrolyte from said reservoir to said passageway

7

and to and through a work gap between the electrode and the workpiece during electrolytic shaping, said supporting blocks, said clamping means and said electrode guide means being supported upon a work table, and insulating means to prevent electrical contact between said last mentioned means and said work table.

2. In an electrolytic shaping apparatus for electrolytically shaping an electrically conductive and electrochemically erodible workpiece by a movable electrode, the combination comprising, means to support a workpiece, said support means having nonconducting means upon which the workpiece rests during electrolytic shaping, whereby electrical contact between said support means and the workpiece is precluded, clamping means for holding the workpiece in position during electrolytic shaping, said clamping means including first and second vertically extending support members adjustably attached to one another, a clamping arm having a resilient pad on one end thereof movably supported by the uppermost of said support members, said resilient pad being adapted to engage the workpiece, a handle pivotally supported by said last mentioned support member, an arcuate linkage member pivotally attached to said handle and to said clamping arm, whereby upon pivoting said handle said clamping arm moves toward the workpiece to hold it in position or moves away from the workpiece to allow the workpiece to be removed from said support means, means adjacent the workpiece having a second pivotal handle attached thereto, said second pivotal handle having a free end with a copper braid conductor attached thereto and connected to a positive terminal of an electric power supply, said second handle being adapted to contact said conductor

8

with the workpiece when the workpiece is in position on said support means, and electrode guide means adapted to guide the electrode during electrolytic shaping, said guide means having an electrolyte reservoir and means to direct electrolyte from said reservoir to a work gap between the electrode and the workpiece, and means to allow the electrolyte to exit from the work gap after electrolytic shaping has been effected, said electrolyte guide means being made of nonconducting material.

3. The combination set forth in claim 2, wherein said guide means includes a first passageway into which the electrode slidably extends toward the workpiece, a second passageway communicating with said reservoir and said first passageway, and the electrode having a recess therein adapted to allow electrolyte to pass into said first passageway and to the work gap from said second passageway.

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