June 10, 1969 L. A. WILLIAMS 3,449,226

ELECTROLYTIC DEBURRING APPARATUS AND METHOD

Filed Oct. 3, 1966 Sheet 1 of 3

Fig. 5.

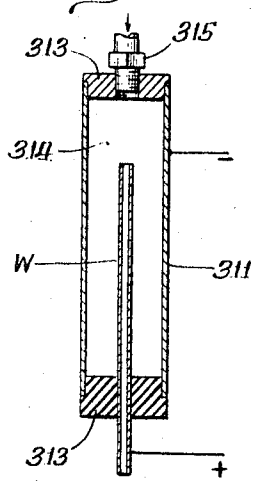


Fig. 1.

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Fig. 2.

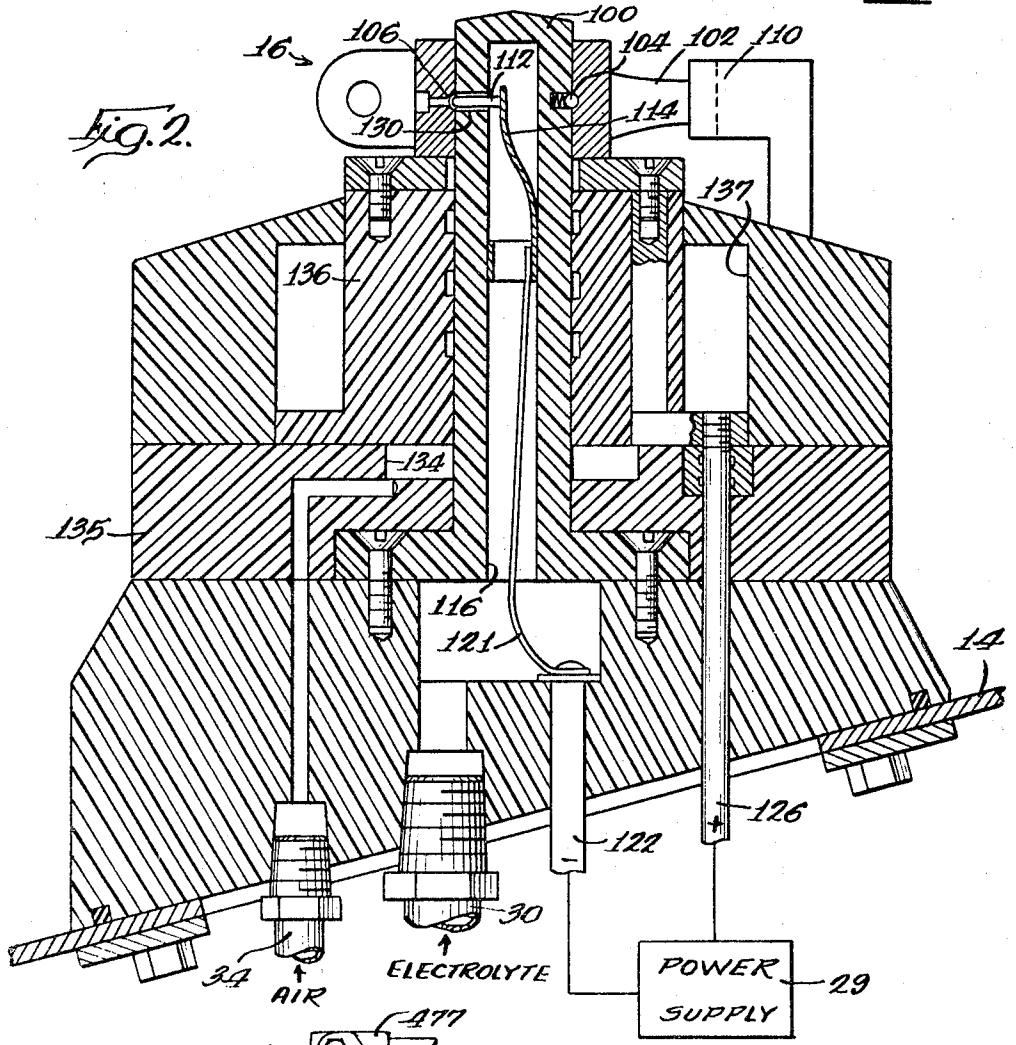
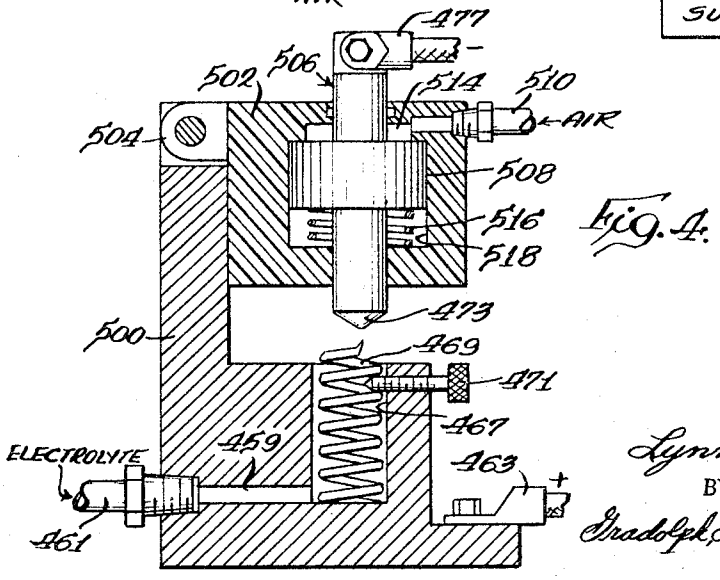


Fig. 4.



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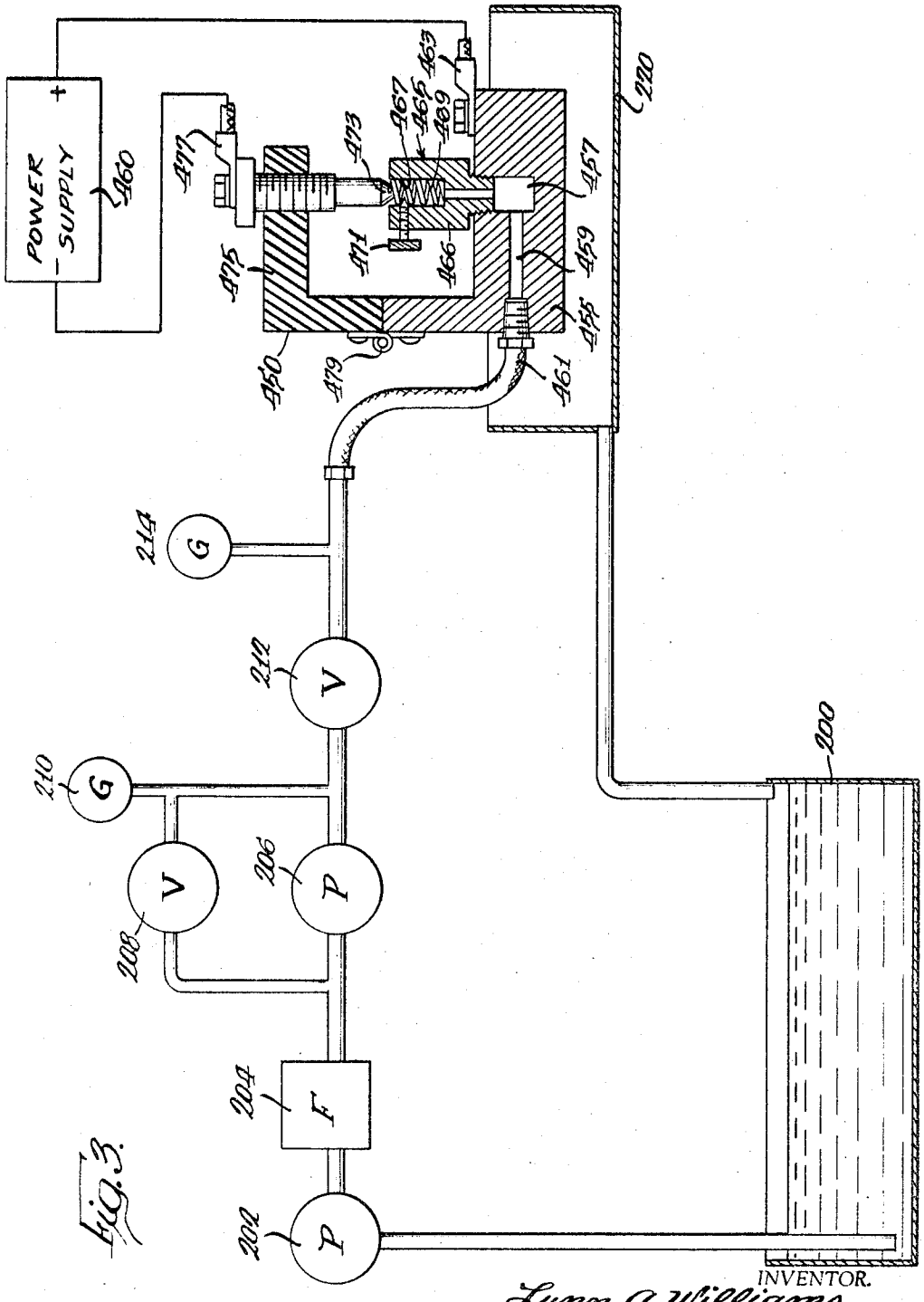


Fig. 3.

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United States Patent Office 3,449,226
Patented June 10, 1969

3,449,226

ELECTROLYTIC DEBURRING APPARATUS AND METHOD

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Continuation-in-part of application Ser. No. 158,042, Dec. 8, 1961. This application Oct. 3, 1966, Ser. No. 583,648

Int. Cl. C23b *3/06, 3/12;* B01k *1/00*

U.S. Cl. 204—143 10 Claims

ABSTRACT OF THE DISCLOSURE

The electrolytic deburring apparatus and method is shown in three basic apparatuses, all of which function in essentially the same fashion.

In the first apparatus an electrode is spring pressed into stationary deburring position at a distance of not appreciably greater than .012" from the burr to be removed, and the workpiece is supported on the end of a piston about a mandrel. The mandrel has a bore therethrough in which the electrode is located and through which the electrolyte is supplied at a pressure of at elast 25 p.s.i. to the entry to the narrow work gap between the electrode and burr. The piston is activated at the conclusion of the deburring operation which is carried on by a low voltage (not more than 15 volts), high density (at least about 100 amperes per square inch) current. The electrolytic action is of very short duration and at the end thereof air pressure is supplied to the head of the piston to drive the workpiece from the mandrel and to permit it to slide down a discharge plate through a wash bath and into a parts basket.

The electrolyte is supplied under pressure which is carefully regulated by valves and gauges to the inlet work gap at a pressure in the range between 25 p.s.i. and 200 p.s.i.

An advantage of this system is the fact that the area of the electrode as contrasted with the area of the burr is substantially great.

Two arrangements for deburring springs are shown wherein an electrode is brought stationarily into electrolytic position with respect to the burr on the end of a spring which is held in the fixture. The electrodes are mounted in hinged holders and the springs are held in cavities in the fixture. The electrolyte is supplied through the body of the spring at a pressure of at least 25 p.s.i. at the entrance to the cavity and the power supply makes the spring anodic and the electrode cathodic in each instance. An improvement in the arrangement provides the electrode with a cylinder piston combination which is moved under air so that the greater area working face of the electrode is brought into close proximity to the spring burr before the current is turned on.

An illustration is presented for the purpose of dramatizing the greater area of the electrode with respect to the workpiece for ECM polishing and burr removing.

This application is a continuation in part of copending application Ser. No. 158,042, filed Dec. 8, 1961, entitled "Electrolytic Shaping Apparatus," now Patent No. 3,276,987, dated Oct. 4, 1966, which was a division of application Ser. No. 772,960, filed Nov. 10, 1958, now Patent No. 3,058,895, dated Oct. 16, 1962, entitled "Electrolytic Shaping."

It has long been known that electrically conductive and electrochemically erodible materials may be removed by electrolytic attack in a configuration where the workpiece is the anode in an electrolytic cell. This principle has been used industrially to some degree for the removal of defective plating and the like, and is sometimes referred to as "stripping." It has also been used to some extent for electrolytic polishing.

The present invention provides a method of removing burrs, ridges, or the like from such electrically conductive and electrochemically erodible workpieces by electrolytic action including the steps of using a tool having a conductive working face brought into closely spaced, fixed relation to the workpiece and with an electrolyte being introduced therebetween, and connecting the tool and the workpiece in an electrolyzing circuit so as to make the working face of the tool cathodic with respect to the workpiece, said method being characterized by the steps of positioning the tool in closely spaced relation to the burr or ridge on the workpiece, pumping the electrolyte through the space between the workpiece and the tool at a high velocity and under a substantial pressure and briefly applying a low voltage-high density current between the workpiece and the tool without any spark or arc to remove the burr or ridge from the workpiece.

Among the objects of the invention are the following:

To provide novel method and apparatus for rapid removal of burrs by electrolytic means;

To provide novel method and apparatus for handling a plurality of workpieces being deburred by electrolytic action;

To provide a novel technique for electrolytic removal of burrs; and

To provide automatic means for advancing electrodes toward the work material.

Other objects and advantages will become apparent from the following description of the present invention which is illustrated in the accompanying drawings.

FIG. 1 is a side view of a work stand, partially broken into section, showing the overall organization of the apparatus incorporating the invention;

FIG. 2 is a vertical sectional view of a working fixture embodying the invention;

FIG. 3 is a vertical sectional view of an alternative working fixture according to the present invention and diagrammatically illustrating the electrolyte supply system;

FIG. 4 is a view similar to FIG. 3 showing an alternative embodiment of a spring deburring fixture; and

FIG. 5 is a sectional view illustrating a principle important to electrolytes deburring and polishing.

FIG. 1 shows the overall organization of the apparatus incorporating the invention. A work stand **10** includes a frame **12** which supports an inclined electrolyte runoff sheet **14** beneath a plurality of working fixtures **16**. Associated with the working fixtures **16** is a Plexiglas window **18**, a front rubber spray arresting flap **20**, a rear rubber spray arresting flap **22**, and an exhaust pipe **24** connected to a suction blower (not shown). An electrolyzing current is supplied to the working fixtures **16** through a negative terminal **26** and positive terminal **28** which are connected to a power supply **29**, shown diagrammatically in FIG. 2.

Electrolyte is supplied to the working fixtures **14** through an electrolyte supply tube **30** the pressure of the electrolyte flowing through the tube being regulated by a bypass valve **32**. Air under pressure is supplied the working fixture **16** through the air supply line **34** from any conventional air compressor (not shown). At the left of FIG. 1 is seen an antirust tank **36**, a part basket **38** and a 150 gallon electrolyte supply tank **40**. Above the tank **40** is a water wash wipe **42**, a fresh water supply **44**, and at the side of the tank is a drain pipe **46**. A motor **48** and a pump **50** supply electrolyte under pressure through the bypass valve **32** to the tube or conduit **30**.

FIG. 2 discloses in section an individual working head or fixture **16**. It includes a placement mandrel **100** about which is placed a workpiece **102** retained in position by a spring ball detent **104** and a pad stop **110**. An electrode **112** is attached to a leaf spring **114** which connects with a conductor and negative lead **122** from negative terminal **26** through the electrolyte supply bore **116** extending into the mandrel **100**. The positive supply from terminal **28** is connected through lead **126** to the pad stop **110** and thence to the part **102**. The electrode **112** is fitted in a passage extending laterally from the bore **116** to the face of the mandrel **100** so that electrolyte flows about the electrode **112** to the burred hole **106** which is to be deburred.

Air under pressure is supplied through line **34** to a piston chamber **134** formed in base **135** which is mounted on the plate **14**. A piston **136** is slidably mounted on the mandrel **100** and adapted to move in cylinder **137** vertically to remove the part **102** when air under pressure is supplied to chamber **134** which is open to the cylinder **137**.

In operation, the part **102** which is to have the hole **106** deburred is placed on the mandrel **100**, electrolyte is pumped to the fixture **16** and through passage **116** to the work gap between the electrode **112** and the workpiece hole **106**. At this time the electrolyzing current supply is turned on and supplied to the electrode **112** and workpiece **102** through negative supply terminal **26** and positive supply terminal **28** and the connecting cables.

When the timed deburring operation has been completed the electrolyzing current is turned off and air under pressure is supplied to the piston chamber **134** causing vertical movement of piston **136** and removal of workpiece **102** from the mandrel **100**.

In FIG. 3 is shown a diagram of a system similar to FIG. 1 of a simple arrangement for adapting the present process to such applications as deburring the ends of coil springs and similar articles. It will be understood that after coil springs—such as internal combustion engine valve springs, for instance—are manufactured and the ends ground flat, there is always a burr or feather edge which results from the grinding operation. This burr or feather edge is comparatively expensive to remove by grinding, particularly from the inside edge. The arrangement and fixture illustrated in FIG. 3, however, accomplishes this expeditiously and inexpensively.

The electrolyte supply is drawn from a reservoir **200** by a low pressure pump **202** and is pumped through a filter **204** to a high pressure pump **206** capable of supplying the requisite amount of electrolyte, depending on electrode area, at a pressure of from 25 to 200 p.s.i. The outlet of the high pressure pump leads to a manually set or spring loaded constant pressure bypass valve **208** and a first gauge **210**, through a needle valve **212**, a gauge **214**, and then through electrolyte feed conduit **461** to fixture **465**.

On the inlet side of the bypass valve **208** a pressure gauge **210** is mounted. It has been found that the system works more smoothly and with complete freedom from hunting when needle valve **212** is connected to the fixture **465** through a length of four to eight feet of neoprene hose **461** which, being slightly expansible, provides a kind of damping or smoothing action. From the fixture **465**, electrolyte falls into pan **220** and is returned to the reservoir **200**.

Bed or base **455** of the fixture **465** has a threaded socket **457** therein, connected by a passage **459** to the hose **461** which supplies the electrolyte. The base **455** is also connected by a terminal **463** to the positive side of an electrolyzing current supply **460**. The fixture **465** includes a work holder **466** threaded into the socket **457**, and has a recess **467** therein to receive a spring **469** to be deburred. This spring is retained in position in the present example by a cone-pointed thumb screw **471** carried by the work holder **466**. This screw secures the spring **469** in position with its lower end against the bottom of the recess **467**, while its upper end is slightly below the top of the recess **467**. A generally conical electrode **473** is positioned with its pointed end within the upper end of the spring **469**, but not quite touching the spring. This electrode is threaded into a support member **475** made of an electrically nonconductive material and is connected to the negative side of the power supply **460** through the terminal **477**. The electrode **473** must, of course, be insulated from the side of the power line represented by the work holder **465**, and as shown, this is accomplished by forming the member **475** of insulating material, and for convenience in loading the work holder **466**, this member is hinged as at **479** to the base portion **455**.

In operation, a group of fixtures **455** having individual electrodes **473**, and their electrode support members **475**, are tilted backward about the hinge **479** so as to provide access to the sockets **467** so that a set of springs **469** to be finished may be placed in the sockets. Thereafter, the electrodes **473** are tilted to the position shown in close adjacency to the upper ends of the springs **469**, after which the electrolyte flow is established and the electrolyzing current from the power supply **460** is turned on. The electrolyte is pumped through the space between the workpiece **469** and the electrode **473** at a high velocity and under substantial pressure as measured on the gauge **214** which indicates the pressure at the entry to the workgap. The action is to deplate the upper ends of the spring **469**, and, of course, this action is carried forward only for a short period of time, this deplating action will have the effect of removing the burr at the ends of the springs so as to give a smooth finished contour to the article without removing material from the main portion of the springs.

FIG. 4 shows an alternative working fixture similar to that of FIG. 3 and adapted to be used in a working stand containing plural fixtures as in FIG. 1 and as described with respect to FIG. 3. A bed or base **500** and an electrode support member **502** are connected by a hinge **504**. In the insulating support member **502** is an electrode mount **506** which includes a piston **508** and the electrode **473** which may be similar to that of FIG. 3. A conduit **510** for air under pressure is connected to an upper chamber **514**. Within a lower chamber or cylinder **518** in which the piston **508** reciprocates is a spring **516** which biases the electrode mount **506** in upwardly to hold the electrode **473** out of deburring position.

This device functions in a manner similar to that of FIG. 3. The support member **502** is tilted backward in order that a spring **469** may be inserted in the socket **467** to be retained therein by the thumb screw **471**. Thereafter, the top member **502** is tilted to position the electrode **473** over the end of the spring **469** in the socket **467**.

As the electrolyte flow is established through electrolyte supply hose **461** through the horizontal bore **459** to the socket **467** and the electrolyzing current supply **460** is energized, air pressure is supplied through conduit **510** to the upper chamber **514** in the support member **502**. This moves the electrode mount **506** downwardly against the spring **516** to bring the electrode **473** into close proximity to the end of the spring **469** to be deburred. The burr at the end of the spring **469** will be removed so as to give a smooth and finished contour to the end of this spring without moving material from the main body of the spring. The air pressure need be held on only for an instant as the deburring operation in time is very short and when released the spring **516** will return the electrode mount **502** and the electrode **473** to inoperative portion.

As described in detail in the application, of which this is a division and continuation-in-part, Ser. No. 158,042, a low voltage, high current density current is supplied to the electrode and workpiece that are maintained in closely spaced relation to one another with an electrolyte being pumped through the electrode and into the gap.

FIG. 5 shows a tube **311** of copper plugged at both ends with insulating bushings **313**. Into the upper one of these

is threaded a tube fitting **315** to which the electrolyte conduit **461** leading from the pressure pump (FIG. 3) is connected. Into the other bushing is pressed a workpiece W, here shown to be tubular. Electrolyte then enters through the fitting **315** into the pressure chamber **314** formed by the copper tube **311**, and its end bushings and exits through the bore of the tubular workpiece. There is no requirement that the electrolyte be exhausted through a tubular workpiece. For other shapes of workpieces, an exhaust orifice or valve may be useed, and this is connected into the insulating bushing opposite the inlet connection or, if convenient for spacing, in the same end as the inlet connection; but the inlet and exit, and the size of the chamber **314**, should be such as to cause great agitation, high velocity, and constant electrolyte flow over the workpiece.

The copper tube **311** is connected to the negative pole and the workpiece W to the positive pole of the direct current power source. At a potential of 15 volts, a preliminary polish may be obtained on a hypodermic needle .067" in outside diameter, of stainless steel, in six seconds, and a good polish in ten seconds. In the former case, the diameter of the tube was reduced about .001". In twelve seconds the diameter was reduced by more than .002".

It is believed that the electropolishing action may be caused by relatively high electrolyte velocities and pressure over the work surface The high velocities may tend to reduce the polarizing or passive film which is always tending to form on the anode at high current densities. But this reduction in thickness of the anodic film is much more marked on any protuberance or minute point of the surface, and much less marked at any depressed portion, thus tending to attack the high points more rapidly. This is an important consideration in deburring, and by electrolytic action burrs may be removed in a few seconds, leaving the deburred surface smooth and in some instances polished.

FIG. 5 illustrates another principle valuable in deburring. It should be noted that the cathode tube **311** has a very substantially greater area than the anodic workpiece. This means that the current density on the cathode is much less than on the anodic workpiece, and the interface losses due to resistance through the electrolyte is lessened. It is the current density on the workpiece that does the work of electrolytic erosion to remove the burrs and produce a smooth, and where desired polished, surface. FIG. 5 illustrates what also may be obtained by other forms and shapes of cathodic electrodes which would have working faces substantially greater in area than the surface to be deburred and smoothed.

It has been found that reasonably good results can be obtained by furnishing the electrolyzing direct current within the range of approximately 4 to 15 volts. Within this approximate range, and depending upon resistance in the work gap, the current intensity will usually be in the range of 100 to 3,000 or more amperes per square inch. The resistance in the work gap is determined by the width of the gap and the character of the electrolyte therein. Work gaps of less than .001", for example .005" and as great as .012" are acceptable. The pressure of several atmospheres must be used to insure the proper flow of electrolyte and to carry away the eroded material. Therefore, the electrolyte is pumped to the gap at pressures within the range of 25 p.s.i. to at least 200 p.s.i.

A wide variety of electrolytes may be used in the apparatus and processes heretofore described. These may include highly concentrated solution of sodium and/or potassium chloride, sometimes with small additions of sodium or potassium nitrate. Other solutions and formulations are described in the above mentioned Patent No. 3,058,895.

From the above description of the invention it will be appreciated that many changes may be made both in the apparatus and in the method, without departing from the scope or spirit of the invention, and that the scope of the invention is to be determined from the scope of the accompanying claims.

What is claimed as new and desired to be secured by United States Letters Patent is:

1. A method of removing burrs or ridges from a conductive, electrochemically erodable workpiece by electrolytic action including the steps of bringing an electrode having a conductive working face and workpiece into a spaced, fixed relation so that the electrode working face is in closely spaced relation to the burr or ridge on the workpiece by a spacing distance not exceeding about .012", pumping an electrolyte through the space between the workpiece and the electrode working face at a high velocity and under a pressure of at least 25 p.s.i. at the entry to said space, and briefly applying a direct current of not more than about 15 volts and of at least 100 amperes per square inch between the workpiece and the electrode working face without any spark or arc to remove the burr or ridge from the workpiece.

2. The method of claim **1**, wherein the voltage of the electrolyzing current is in the range between 4 and 15 volts.

3. In the method of claim **1**, wherein the current density is between 100 and 3,000 amperes per square inch.

4. In the method of claim **1**, wherein the electrolyte is supplied under a pressure within the range between 25 and 200 p.s.i.

5. In the method of claim **1**, including the steps of removing said workpiece from said position in closely spaced relation to said electrode by supplying air under pressure to a piston physically contacted with the workpiece at the termination of the application of low voltage, high-density current.

6. An electrolytic apparatus for removing burrs and ridges from an electrically conductive and electrochemically erodible workpiece, the combination including, a fixture having a workpiece holder, a workpiece supporting cavity in said holder, means carried by said holder for locking a workpiece in said cavity, an electrically conductive electrode, means movably mounting said electrode on said fixture for movement into and out of a stationary electrolytic erosion relationship with respect to the workpiece, electrolyte conducting passages in said fixture and said workpiece holder communicating with the area of electrolytic relationship between said electrode and the workpiece, means connected to said passages for pumping an electrolyte therethrough at superatmospheric pressure and high velocity, and electric circuit means connected between the workpiece and said electrode for passing a low voltage direct current therebetween.

7. In an electrolytic apparatus, the combination recited in claim **6** wherein means are provided to vary the pressure of the electrolyte in the area of electrolytic relationship of the electrode and workpiece.

8. In an electrolytic apparatus, the combination recited in claim **6** wherein said means for electrode movement includes an air operated piston.

9. An electrolytic apparatus for removing material from an electrically conductive and electrochemically erodible workpiece, the combination including, a mandrel to hold said workpiece, an electrically conductive electrode within said mandrel and maintained stationarily in proximity within a distance of not more than about .012" to an area of said workpiece, electrolyte conducting passages in said mandrel communicating with the area of electrolytic relationship between said electrode and workpiece, means connected to said passages for pumping an electrolyte therethrough at superatmospheric pressure and high velocity, electric circuit means connected between the workpiece and said electrode for passing a low voltage direct current therebetween, and means to remove said workpiece from said mandrel at the termination of the eelctrolytic material removal operation.

10. In an electrolytic apparatus, the combination recited in claim **9** wherein said workpiece removal means is

an air operated piston caused to function at the termination of the electrolytical removal operation.

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U.S. Cl. X.R.

204—224, 225, 237, 285, 297

Dedication

3,449,226.—*Lynn A. Williams*, Winnetka, Ill. ELECTROLYTIC DEBURRING APPARATUS AND METHOD. Patent dated June 10, 1969. Dedication filed Dec. 23, 1971, by the assignee, *Anocut Engineering Company*.

Hereby dedicates to the Public the portion of the term of the patent subsequent to Dec. 24, 1971.

[*Official Gazette April 25, 1972.*]