May 21, 1968 J. TAYLOR 3,384,563

METHOD OF RADIUSING THE EDGE OF AN APERTURE ELECTROLYTICALLY

Filed July 21, 1965 2 Sheets-Sheet 1

Fig. 1.

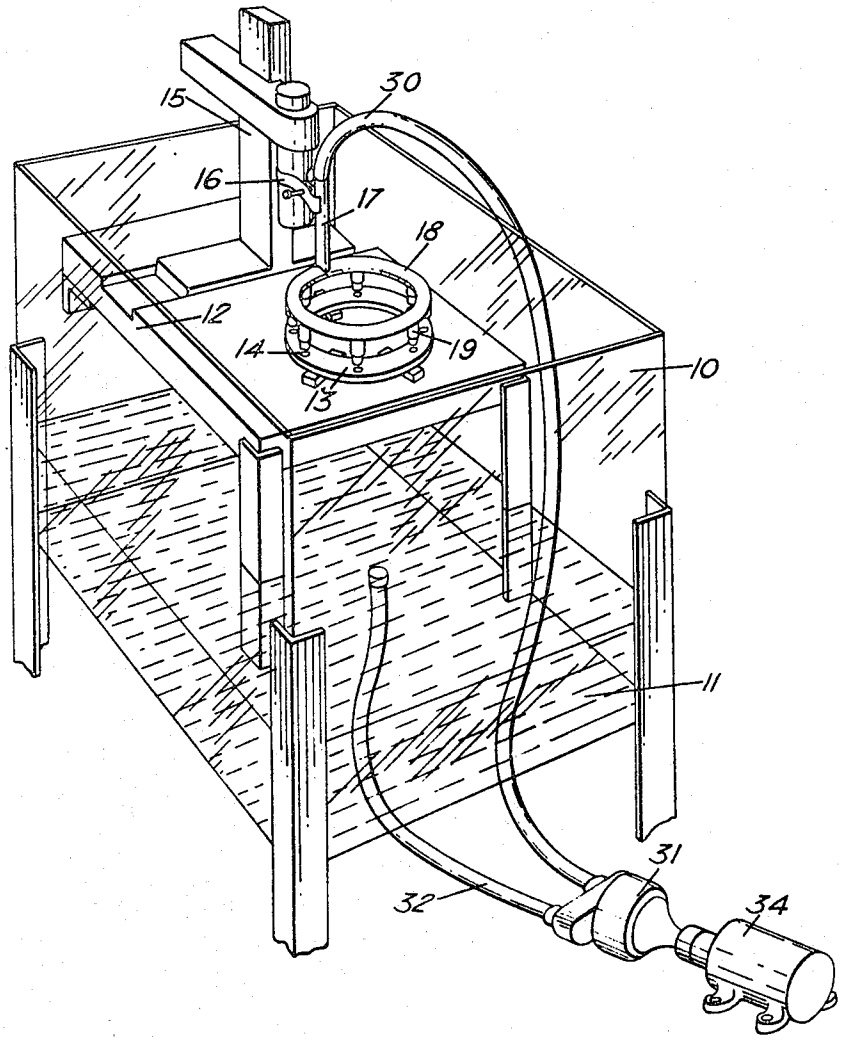

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Fig. 2.

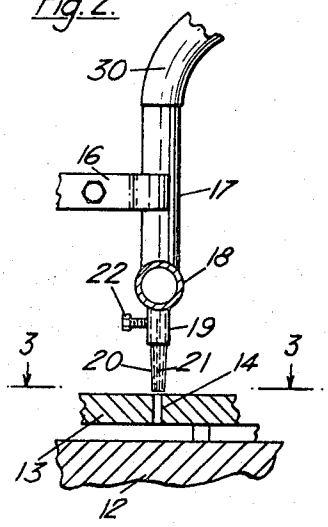


Fig. 3.

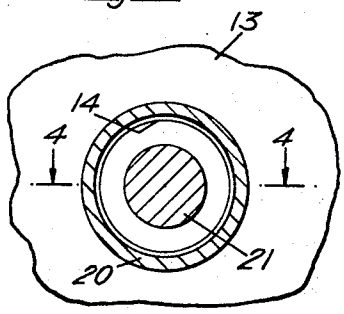


Fig. 4.

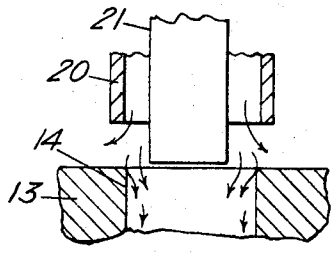
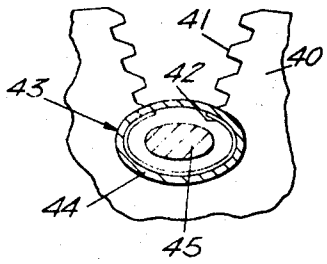


Fig. 5.



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METHOD OF RADIUSING THE EDGE OF AN APERTURE ELECTROLYTICALLY

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6 Claims. (Cl. 204—143)

This invention concerns electrolytic machining and in particular a method of smoothing the sharp edge(s) of an aperture within a metal workpiece.

The invention is particularly applicable to the smoothing or radiusing of the sharp edge(s) which are left after machining blade roots on turbine or compressor rotor discs for gas turbine engines. If these edges are left sharp on such components they are liable to initiate cracks and thus cause breakdown of the engine. It has previously been proposed to radius these edges by means of an abrasive string used manually but such a method is expensive, time consuming and not particularly satisfactory.

According therefore to the present invention there is provided a method of smoothing the sharp edge(s) of an aperture within a metal workpiece comprising providing a nozzle-electrode assembly, the nozzle of which is the same shape as, but of somewhat larger internal dimensions than, said aperture, disposing said assembly adjacent said aperture, causing electrolyte to flow continuously through said nozzle-electrode assembly and into said aperture such that it passes over the sharp edge(s) of said aperture, and making said workpiece electrically positive relative to said assembly whereby the sharp edge(s) of said aperture is or are removed by electrolytic action.

Thus it is possible to smooth or radius the sharp edges which are left after machining the blade roots on turbine or compressor rotor discs electrolytically and it has been found that this method is most suitable for this application.

Preferably the nozzle-electrode assembly comprises an outer tubular structure of electrically non-conductive material within which there is disposed an electrically conductive rod or plate which is made electrically negative with respect to said workpiece.

In a preferred method the electrolyte is caused to flow continuously whilst the workpiece and electrode are electrically biased relative to one another. This is most important if accurate results are to be obtained since, should the electrolyte flow stagnate deep etching may occur at the points of stagnation and a smooth edge will not be obtained.

Preferred electrolytes are those containing sodium ions and thus solutions of sodium chloride, sodium sulphate or sodium nitrate may be used.

The invention is illustrated merely by way of example in the accompanying drawings, in which:

FIGURE 1 is a general view of apparatus which may be used in employing the method according to the present invention,

FIGURE 2 is a detailed side elevation of part of the apparatus shown in FIGURE 1,

FIGURE 3 is a sectional view on line 3—3 of FIGURE 2,

FIGURE 4 is a sectional view on line 4—4 of FIGURE 3, and

FIGURE 5 is a view similar to FIGURE 3 of an alternative form of nozzle-electrode assembly used in machining a gas turbine engine turbine rotor disc.

Referring to the drawings and particularly to FIGURES 1 to 4 thereof there is shown a tank **10** containing electrolyte **11**. A work table **12** is disposed within

tank **10** and clamped thereon is an annular metal workpiece **13** having formed therein eight circular holes **14** having sharp edges which it is desired to smooth or radius.

Slidably mounted on the table **12** is a support **15** having a clamp **16** fixed thereto. Clamp **16** rigidly holds a tube **17** therein, the tube **17** communicating with and being fixed to an annular manifold **18**. Projecting from and communicating with annular manifold **18** are eight tubular extensions **19** to the lower ends of which are attached electrically non-conductive tubular nozzles **20**. Fixed within and connected to the tubular extensions **19** are metal electrodes **21**. Set screws **22** threaded within apertures in the tubular extensions **19** make electrical contact with the electrodes **21**. The electrically non-conductive nozzles **20**, together with the metal electrodes **21**, constitute nozzle-electrode assemblies.

As seen in FIGURES 1 and 2 the upper end of tube **17** has fixed thereto a flexible pipe **30** which communicates with the outlet side of a pump **31**. The inlet side of pump **31** communicates by a further flexible pipe **32** with the outlet from tank **10** from which it receives electrolyte. Pump **31** is driven by an electric motor **34** and, when in operation, pumps electrolyte continuously from the tank **10** through tube **17** and thus through tubular nozzles **20**. Electrolyte which has flowed through nozzles **20** passes over table **12** and into the electrolyte **11** within tank **10** to be used again by recirculation.

To radius the sharp edges of holes **14**, the nozzle-electrode assemblies constituted by tubular nozzles **20** and electrodes **21** are disposed closely adjacent the upper ends of holes **14**, as clearly seen in the figures. It will be noted, particularly from FIGURES 3 and 4, that the internal dimension of each tubular nozzle **20** is somewhat larger than that of the hole **14** which it is desired to machine and it will also be noted that the shape of each tubular nozzle **20** is identical with that of each hole **14**. The pump **31** is actuated by electric motor **34** and a continuous flow of electrolyte therefore flows through tubular nozzles **20** and into apertures **14**, the electrolyte being forced over the sharp edges of holes **14** due to the relative sizes and shapes of tubular nozzles **20** and holes **14**. The workpiece **13** is made electrically positive with respect to electrodes **21**, the electrodes **21** being made electrically negative by connecting electrical leads to the set screws **22**. Electrolytic action takes place and the sharp edges of the apertures **14** over which the electrolyte flows are machined away by this electrolytic action, the sharp edges thereby being smoothed or radiused.

The method is particularly suitable for use in machining apertures within turbine rotor and compressor rotor discs of gas turbine engines and a modified electrode for use in such an arrangement is shown in FIGURE 5. In FIGURE 5 there is shown a turbine disc **40** which has been machined to provide a "fir tree" blade root **41** having an enlarged radially inner end **42**. The aperture formed at the radially inner end **42** has sharp corners as a result of the machining process and these are liable to initiate cracks if left sharp. A generally elliptical tubular nozzle-electrode assembly **43** is provided as shown in FIGURE 5, the nozzle being of the same shape as but somewhat larger than the aperture formed at the radially inner end **42**. As in the embodiment of FIGURES 1 to 4, the nozzle-electrode assembly comprises an electrically non-conductive outer tubular portion **44** and an inner electrode **45** which is made electrically negative with respect to the turbine rotor disc **40**. The sharp edges of the aperture at the radially inner end **42** are now removed by electrolytic action in the manner described above with reference to FIGURES 1 to 4.

It will be appreciated that the arrangement described above may be employed in any location in which it is

desired to remove the sharp edges of an aperture provided in a workpiece. Any well known electrolyte may be used in the method described but solutions containing sodium ions are preferred e.g. sodium chloride, sodium sulphate or sodium nitrate solution.

For holes having a circumference of the order of ½" to 1", a 15 volt supply of 5 amps has been found to provide satisfactory smoothing or radiusing of the holes after 5 to 10 minutes machining.

During all machining processes in accordance with the present invention it is imperative that the electrolyte flow should not be allowed to stagnate since if this happens deep etching is liable to take place at the point of stagnation and the smoothing or radiusing operation is thereby hindered.

I claim:

1. A method of smoothing the sharp edge of an aperture within a metal workpiece comprising providing a nozzle-electrode assembly, the nozzle of which is the same shape as, but of somewhat larger internal dimensions than, said aperture, disposing said assembly adjacent said aperture, causing electrolyte to flow continuously through said nozzle-electrode assembly and into said aperture such that it passes over the sharp edge of said aperture, and making said workpiece electrically positive relative to said electrode whereby the sharp edge of said aperture is removed by electrolytic action.

2. A method of smoothing the sharp edge of an aperture within a metal workpiece comprising providing a nozzle-electrode assembly comprising an outer tubular nozzle structure of electrically non-conductive material and an electrically conductive electrode member disposed within said outer tubular nozzle structure, said nozzle being the same shape as, but of somewhat larger internal dimensions than, said aperture, disposing said assembly adjacent said aperture, causing electrolyte to flow continuously through said nozzle and into said aperture such that it passes over the sharp edge of said aperture, and making said workpiece electrically positive relative to said electrode whereby the sharp edge of said aperture is removed by electrolytic action.

3. A method of smoothing the sharp edge of an aperture within a metal workpiece comprising providing a nozzle-electrode assembly, the nozzle of which is the same shape as, but of somewhat larger internal dimensions than, said aperture, disposing said assembly adjacent said aperture, causing electrolyte to flow continuously through said nozzle-electrode assembly and into said aperture such that it passes over the sharp edge of said aperture, and making said workpiece electrically positive relative to said electrode whereby the sharp edge of said aperture is removed by electrolytic action, said electrolyte flowing continuously whilst the workpiece and nozzle-electrode assembly are electrically biased relative to one another.

4. A method of smoothing the sharp edge of an aperture within a metal workpiece comprising providing a nozzle-electrode assembly, the nozzle of which is the same shape as, but of somewhat larger internal dimensions than, said aperture, disposing said assembly adjacent said aperture, causing electrolyte containing sodium ions to flow continuously through said nozzle-electrode assembly and into said aperture such that it passes over the sharp edge of said aperture, and making said workpiece electrically positive relative to said electrode whereby the sharp edge of said aperture is removed by electrolytic action.

5. A method of smoothing the sharp edge of an aperture within a metal workpiece comprising providing a nozzle-electrode assembly, the nozzle of which is the same shape as, but of somewhat larger internal dimensions than, said aperture, disposing said assembly adjacent said aperture, selecting electrolyte from the class including sodium chloride, sodium sulphate and sodium nitrate solutions, causing the electrolyte to flow continuously through said nozzle-electrode assembly and into said aperture such that it passes over the sharp edge of said aperture, and making said workpiece electrically positive relative to said electrode whereby the sharp edge of said aperture is removed by electrolytic action.

6. A method of smoothing the sharp edge of an aperture within a gas turbine rotor disc comprising providing a nozzle-electrode assembly, the nozzle of which is the same shape as, but of somewhat larger internal dimensions than, said aperture, disposing said assembly adjacent said aperture, causing electrolyte to flow continuously through said nozzle-electrode assembly and into said aperture such that it passes over the sharp edge of said aperture, and making said workpiece electrically positive relative to said electrode whereby the sharp edge of said aperture is removed by electrolytic action.

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