July 10, 1962 L. A. WILLIAMS 3,043,766

ELECTROLYTIC GRINDING APPARATUS

Filed Sept. 14, 1959

Fig.1.

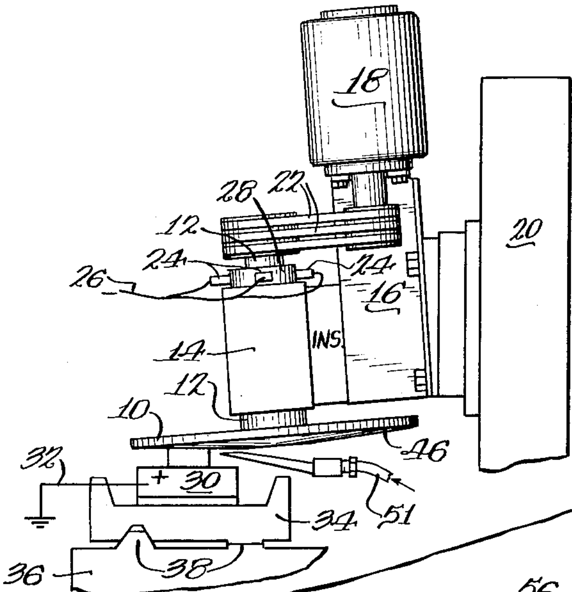
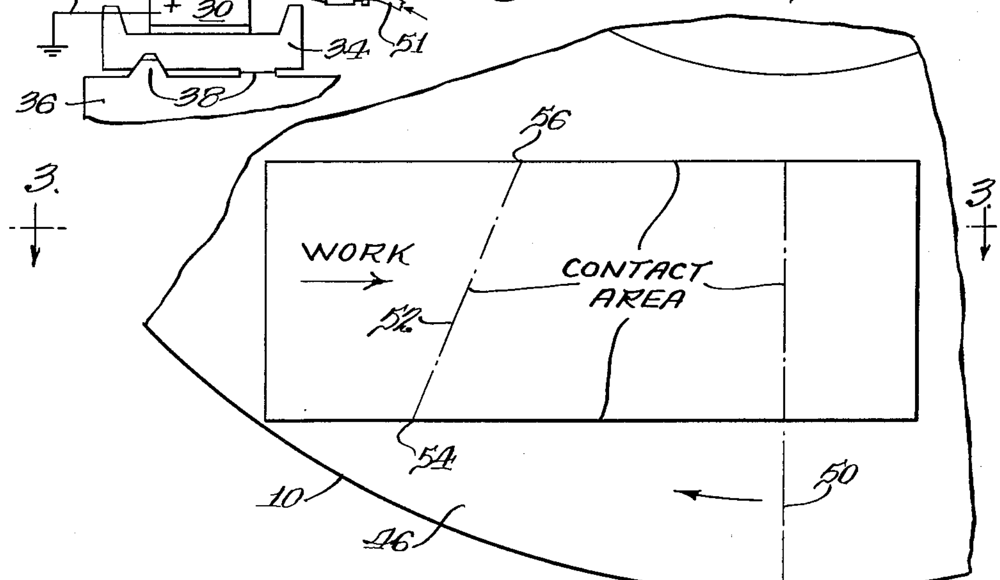


Fig.2.



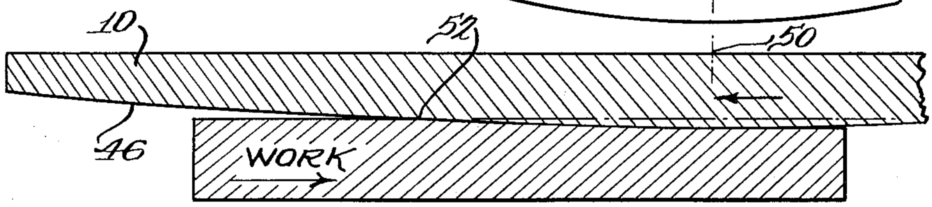


Fig.3.

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ELECTROLYTIC GRINDING APPARATUS

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The present invention relates to electrolytic grinding and more particularly to grinding apparatus and a method of grinding which are particularly applicable to the situation where a surface of a workpiece is to be ground flat by being traversed across the surface of the grinding wheel in an electrolytic configuration.

Electrolytic grinding briefly consists in bringing a workpiece against the face of a rotating metal bonded grinding wheel under conditions where a low voltage direct current passes through an electrolyte between the workpiece and the wheel during the operation so as to remove material from the workpiece by electrolytic action. An arrangement and process for carrying out this basic process is well described in George F. Keeleric Patent No. 2,826,540 for "Method and Apparatus for Electrolytic Cutting, Shaping and Grinding." See also my earlier patent application Serial No. 569,107, filed March 2, 1956, now Patent No. 2,950,239 for "Control System for Electrolytic Grinding."

One of the objects of this invention is to provide a novel mechanism and method for speeding the removal of material from a workpiece having a flat surface formed thereon by electrolytic grinding.

An additional object is to provide an arrangement and a method by the use of which a workpiece is traversed across the face of the grinding wheel in such fashion that the area of contact between the workpiece and the grinding wheel is at a substantial maximum.

Yet another object is to provide a novel apparatus and method for electrolytic grinding in which a workpiece is traversed across the face of a grinding wheel so as to form a flat surface upon the workpiece, and in which high current densities together with a high work removal rate are accomplished at minimum voltages.

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

In the drawings, in which similar characters of reference refer to similar parts throughout the several views,

FIG. 1 is a diagrammatic end elevation of apparatus incorporating the features of the present invention;

FIG. 2 is a diagrammatic illustration of a fraction of the grinding wheel face showing the workpiece moving thereacross principally for the purpose of illustrating the portion thereof in contact with the grinding wheel in a typical application of the invention; and

FIG. 3 may be considered as a vertical sectional view taken in the direction indicated by the arrows substantially along the line 3—3 of FIG. 2.

During an ordinary grinding operation where a flat surface is to be finished upon a workpiece solely by abrasive action it is customary to traverse the workpiece back and forth across the peripheral edge of a rotating grinding wheel in such direction that the workpiece approaches the grinding wheel tangentially. The strip of workpiece metal in contact with the face of the grinding wheel therefore has a length which is equivalent to the thickness of the grinding wheel and a width of no more than a very few thousandths of an inch at most. Thus, the instantaneous wheel and workpiece engagement area is ex-

tremely limited unless impractically excessive grinding wheel diameters are used.

When this conventional grinding approach is used in an electrolytic grinding apparatus, the electrolytic action between the workpiece and the wheel electrode is almost entirely confined to this extremely small zone. The work removal rate, therefore, is relatively low since for any particular voltage in the electrolyzing circuit the current flow, and hence the work removal rate, are directly proportional to the effective area of the anode and cathode, and this area is in turn limited essentially to the zone within which the spacing between the grinding wheel conductive face and the workpiece is uniform and a matter of no more than a few thousandths of an inch.

Attempts to increase the work removal rate in an electrolytic grinding operation by increasing the voltage so as to increase the current density is of limited utility, both because excessive voltages may result in arcing between the electrode elements and because increased current flow at the expense of increased voltage excessively increases the electric power cost. As an example, doubling the current in the circuit by doubling the voltage increases the wattage, which is a measure of the cost, four times, whereas any expedient that can result in increasing the current in the circuit without an increase in voltage simply increases the cost for electric power as a direct function of the current increase. Since the work removal rate is also a direct function of the current, increasing the current does not increase the electric power cost per unit of work removed so long as the voltage remains the same. The overall cost with higher current is, however, reduced because the machine time per job is less.

With these fundamentals understood, it will be appreciated that large area contact between the grinding wheel and the work is highly desirable in electrolytic grinding, and it is to this problem when associated with flat grinding, as opposed to plunge grinding, that this invention is directed. More specifically, the use of this invention permits far greater area engagement between the wheel and the workpiece than is possible with conventional pass grinding, without appreciably increasing the wheel size and without increasing the amount wheel bites into the workpiece at each pass.

Referring now to FIG. 1, I have diagrammatically indicated a metal bonded grinding wheel at **10** mounted upon a spindle **12** which is journaled within a housing **14**. The housing is attached to a bracket **16** which supports an electric motor **18** and in turn is attached to the frame **20** of the grinding machine. An insulating pad **21** between the housing **14** and bracket **16** permits these elements to be at different electrical potential. The spindle **12** and wheel **10** are driven from the motor **18** through one or more belts **22**. The negative low potential direct current electrolyzing lead **24** is connected to brushes **26** which engage a slip ring **28** mounted upon the spindle **12**. The grinding wheel is therefore at the negative electrolyzing potential, whereas, the motor **18** and machine frame may be at ground potential.

The work W is held in the present instance upon a magnetic chuck **30** which is connected to ground and to the positive electrolyzing lead **32**. The chuck **30** is in turn secured to a table **34** which moves longitudinally of the machine bed **36** upon ways **38**.

Although it is not shown, since such arrangements are common, it will be understood that suitable mechanism, usually hydraulic, traverses the table **34** back and forth at a selected speed and through a stroke of desired length. Furthermore, mechanism is also provided to index the bed **36** upwardly toward the wheel an appropriate amount between strokes of the table **34**.

The grinding wheel 10 performs its work upon its outward face 46 which, reference to FIGS. 1 and 3 will show, is not an annular flat surface, but rather is a frustum of a very obtuse cone. For the purpose of illustration the angularity of this surface has been shown considerably exaggerated. Preferably the working face is a surface of revolution which is at an angle of about two degrees with respect to a plane surface normal to the axis of the spindle 12. This surface is convex in that the portion toward the center of the wheel is slightly farther outward than the periphery.

This wheel will normally be mounted in a slightly inclined position so that its axis is tilted with respect to the vertical by an amount equal to the angularity of the wheel face. In the present example, the amount of tilt is thus about two degrees. There is, therefore, a radial line across the wheel face at one position which is horizontal, and it is at this position that the spacing between the wheel face and the top of the chuck is at a minimum. This position is indicated in FIGS. 2 and 3 by the line 50. The set-up is so organized that this line 50 lies above the chuck and extends at right angles to its direction of movement along the ways 38. The position of this line, it will be appreciated, determines the plane of the ground face upon the workpiece at the conclusion of each pass of the table 34.

At each side of the center line 50, however, the face of the wheel recedes from this plane very gradually so that even with a small wheel, when the work is advanced by the table 34 in such a position of the bed 36 as to remove an appropriately thin layer of metal, the work will engage the wheel face very gradually, and ultimately—when the work leading edge reaches the radial center line 50—over an extremely large surface area. The electrolytic action (the electrolyte is shown as being supplied through a line 51 so as to flow over the wheel face) therefore takes place over a large area of the workpiece surface which, as previously explained, is highly desirable.

FIGS. 2 and 3 illustrate the engagement between the wheel and the workpiece under what may be considered as typical conditions, although, in the interest of clarity of illustration, the angularity of the wheel face, and hence the thickness of the metal removed, have been exaggerated. The area of contact between the work and the wheel where electrolytic action takes place is indicated as lying between the broken lines 50 and 52 and having a width equivalent to the width of the workpiece. As the work approaches the wheel from the left, it is clear of contact until it reaches the point 54. There is, therefore, no danger of jamming. With slight additional advancement (to the point 56), full contact across the workpiece is established and this engagement remains in effect until the work passes off the wheel face at the center line 50.

By the use of this invention it will be appreciated that large area contact between the work and the wheel, and hence efficient and rapid electrolytic action, can be accomplished in pass grinding even with small wheels, and furthermore, that this can be done while insuring very gradual engagement between the work and the wheel and without danger of the advancing work jamming against the wheel edge.

The particular embodiment of the invention illustrated and described above assumes the grinding wheel axis as being inclined only slightly from the vertical. It will be appreciated, however, that the axis of the wheel mounting will be determined largely by the type of grinding

machine upon which the operation is to be conducted. For instance, the FIG. 1 arrangement is convenient since it permits the work face being ground to be horizontal with respect to the table, but it will be appreciated that the work face to wheel relationship would not be changed if both the wheel axis and the work face were tilted from this position by an equal amount and in some operations this might conceivably be more convenient. The important considerations in this respect is of course the wheel contour and the positioning and orientation of the wheel face with respect to the work face and the direction of movement of the work with reference to the wheel face.

From the above description of a preferred embodiment of my invention, it will be apparent that variations and substitutions may be made without departing from the scope or spirit of the invention, and therefore that the scope of this invention is to be determined from the scope of the following claims.

Having described my invention, what I claim as new and useful and desire to secure by Letters Patent of the United States is:

1. An electrolytic grinding device comprising an electrically conductive wheel body having abrasive particles forming a grinding face upon an annular surface thereof, said annular surface being slightly convex and having the form of a frustum of an obtuse cone with the frustoconical surface having an angularity of substantially two degrees with respect to the surface which is normal to the axis of the wheel, means for rotating said wheel about its axis, a work holder, a slide for carrying said work holder, means for guiding said slide for movement in a direction normal to the axis of rotation of said wheel so as to carry work held in said work holder across the grinding face in a direction substantially normal to the radius of said face which is most deeply advanced into the work as said work passes said wheel, means for supplying electrolyte to the interface between the wheel and the work, and means connecting the wheel and the work in an electrolyzing circuit such that the wheel is a cathode.

2. An electrolytic grinding device comprising an electrically conductive wheel body having abrasive particles forming a grinding face upon an annular surface thereof, said annular surface being slightly convex and having the form of a frustum of an obtuse cone with the frustoconical surface having a slight angularity with respect to a surface which is normal to the axis of the wheel, means for rotating said wheel about its axis, a work holder, a slide for carrying said work holder, means for guiding said slide for movement in a direction normal to the axis of rotation of said wheel so as to carry work held in said work holder across the grinding face in a direction substantially normal to the radius of said face which is most deeply advanced into the work as said work passes said wheel, the slight angularity of said wheel face being sufficiently great to permit the work safely to clear the periphery of the wheel as the work is advanced toward the wheel but not substantially greater, means for supplying electrolyte to the interface between the wheel and the work, and means connecting the wheel and the work in an electrolyzing circuit such that the wheel is a cathode.

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Dedication

3,043,766.—*Lynn A. Williams*, Winnetka, Ill. ELECTROLYTIC GRINDING APPARATUS. Patent dated July 10, 1962. 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 March 14, 1972.*]