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G. F. KEELERIC

3,433,727

DYNAMIC ELECTRODE FOR ELECTROLYTIC MACHINING APPARATUS

Filed Dec. 17, 1965

Sheet 1 of 2

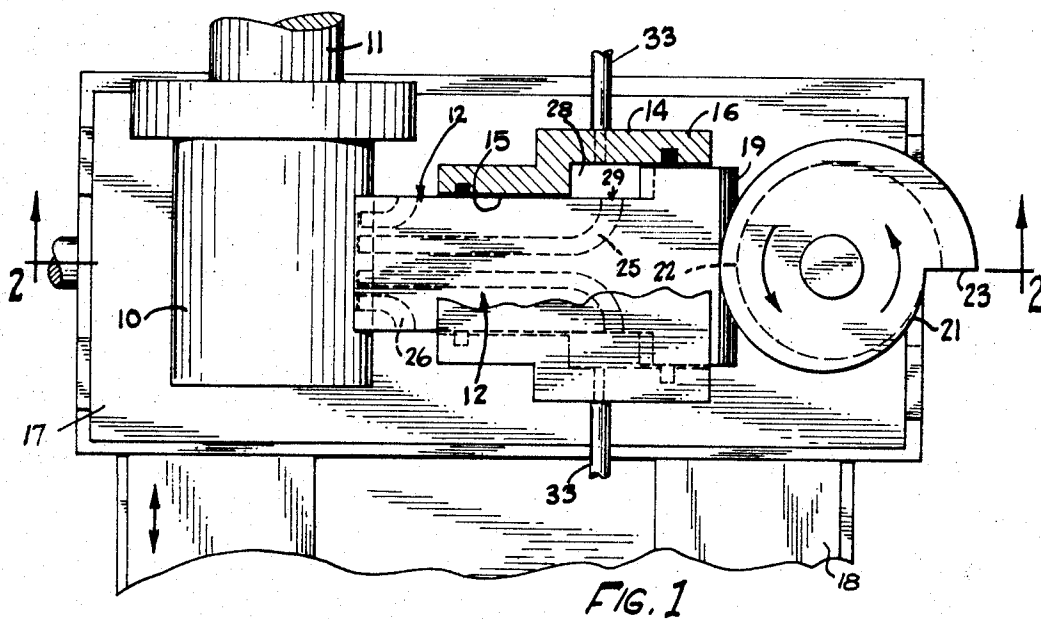
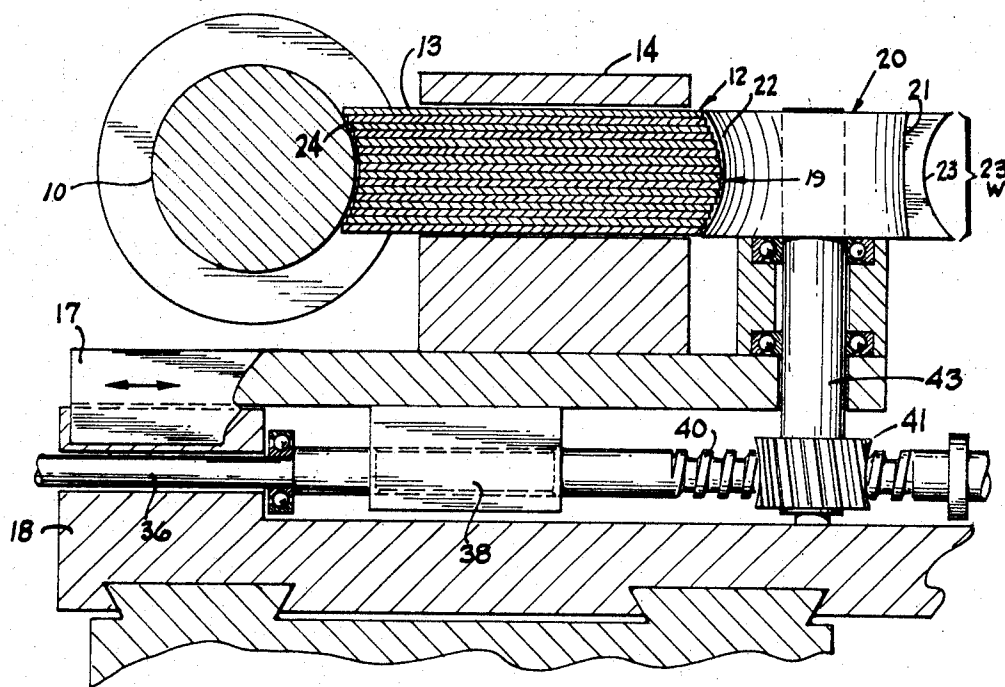


FIG. 2

INVENTOR.
GEORGE F. KEELERIC
BY *Kay S. Kyle*

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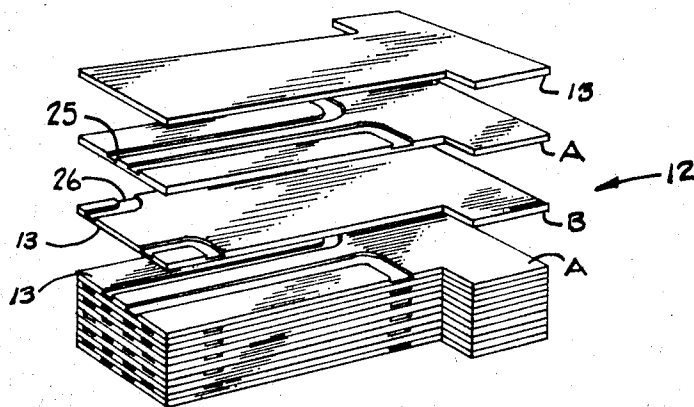


FIG. 3

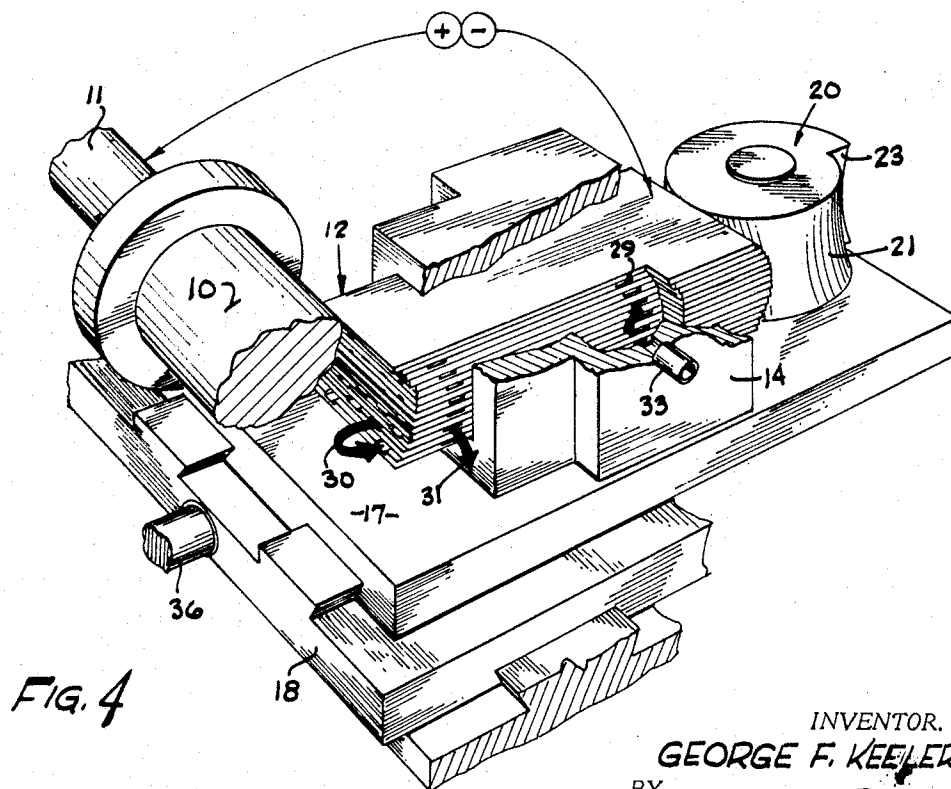


FIG. 4

INVENTOR.
GEORGE F. KEELERIC
BY *Ray S Pyle*

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DYNAMIC ELECTRODE FOR ELECTROLYTIC MACHINING APPARATUS

George F. Keeleric, Big Sur, Calif.

(Shannon Airport P.O., County Clare, Ireland)

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4 Claims

ABSTRACT OF THE DISCLOSURE

An electrode for electrolytic machining. The electrode changes contour by increments to follow shape of changing workpiece. Flat plates in a stack are advanced by a spiral cam form which changes the profile of the stack as the stack is advanced toward the workpiece.

This invention relates in general to forming of metal by electrolytic erosion, and more specifically to an electrode which advances and changes in shape by infinitely small increments as a workpiece is formed.

This invention is directed to mechanical aspects of an electrolytic die for use in electro-machining of the type taught generally by Keeleric Patents 2,826,540 and 3,004,910.

The electrolytic transfer of a metal from an anode into a solution requires an anode and a cathode, an electrolyte occupying the space between, and a flow of current between them.

In the Keeleric Patent 2,826,540, electrically-insulating particles are provided in an electrically-conducting cathode, serving two purposes: preventing short circuiting of the anode and cathode, and secondly, providing a light abrasive action.

Both the control and the use of particles, such as diamond grit, will be useful in the electrode of this invention, but those features are not set forth in this specification and drawing because applicant's prior work has made this knowledge well known. Hence, the drawings illustrate, and this specification discusses only the mechanical features of a dynamic electrode, omitting all electrical connections and specific details of pumping of electrolyte and other related disciplines, including the use of diamond particles.

Hard metals are now being employed in many forms, including sprayed metal admixed with abrasive particles. One use of such metal is in coating a roll surface, such for example as a steel mill roll. It is necessary for maximum usefulness to smooth the hard metal after it is deposited. Being very difficult to abrade or machine by ordinary methods, the electrolytic approach becomes practical; however, the provision of a suitable electrode has presented a barrier to the successful use of this method due to the uncertain diameter of the workpiece at the beginning of the operation and the fact that as the work progresses, the surface no longer is mated to the electrode in a proper relationship for efficient electrolytic machining.

Accordingly, it is an object of this invention to provide a dynamic electrode in that the electrode is capable of changing its contour by increments, and advancing toward the rotating center of a workpiece, as the surface of the workpiece is electrolytically eroded.

In accordance with these and other objects which will become apparent hereinafter, the best mode contemplated

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for the present invention is disclosed in the accompanying drawings wherein:

FIGURE 1 is a top view of a schematic arrangement of a workpiece and dynamic electrode according to this invention with the electrode holder top broken away;

FIGURE 2 is a section taken along line 2—2 of FIGURE 1;

FIGURE 3 is a schematic illustration, partially exploded, of a plate electrode stack used in the holder of FIGURES 1 and 2; and

FIGURE 4 is a perspective schematic illustration with parts broken away, to illustrate the electrode and associated apparatus.

The drawings are schematic because the electrode of this invention may be employed in rebuilt standard machines, or in equipment specifically designed for electrolytic machining.

A workpiece 10 is mounted on a mount 11 for rotation about its longitudinal axis. An electrode 12 is positioned as close as possible to the face of the workpiece, but not electrically shorted.

Electrode 12, if it were formed to come close to the surface of the raw workpiece at the beginning of the operation, would not match the surface after a very short period of operation, and all of the electrolytic action would gradually be restricted to the center portion of the electrode, thus losing the benefit of the full electrode face. Accordingly, the electrode 12, made according to the principles of this invention, is composed of a plurality of plates 13. A holder 14 provides a guide to hold the stack of plates 13 in cross-sectional alignment, but free for independent longitudinal shifting.

The plate members 13 have a T configuration and the holder 14 is formed to provide a close-fitting passageway 15 which holds the stems of the T plates of the stack in rectangular relationship, but in no way restrains the longitudinal movement of the individual plate. An enlarged box portion 16 accepts the cross-member of the T for guidance in the same manner.

The holder 14 is mounted on a table 17, and table 17 is in turn mounted upon a cross slide 18. The table 17 is mounted for longitudinal movement to carry the electrode 12 to the workpiece 10, and the cross slide 18 is provided to move the table 17 and electrode along the longitudinal axis of the workpiece.

The stack of plates 13 project from the box portion 16 of holder 14 and present a butt end 19 composed of a composite of the plates. A cam wheel 20 has a width W substantially equal to the composite dimension of the plurality of plates 13, and abuts against the butt end 19 in order to provide a backing against which the plates may rest. Thus, the surface of the cam 20 determines the character of the profile of the electrode 12.

The cam 20 has a peripheral surface configuration which begins at a first station 21 wherein the curvature of the cam is approaching or substantially equal to a flat wall. Thus, the area in the vicinity of reference character 21 may be considered to be of very large or infinite curvature.

The peripheral edge of the cam changes by increments as the surface progresses around a convolute curve. Thus, a portion 22 is shown to be in contact with the stack of plates 13 in FIGURE 2 and, therefore, produces the particular curvature of that portion of the cam. The terminal station area of the cam 20 is indicated by the reference character 23, and in FIGURE 2, the curved area 23 is seen to be considerably greater than the intermediate

station 22 or the beginning station 21. Thus, as the cam wheel 20 turns, the electrode butt end in abutment with the cam 20 becomes progressively rounded on a smaller radius of curvature. This radius of curvature is reflected in a face end 24 of the electrode. By this means, the cam 20 is in control of the radius of curvature of the face 24 of the electrode.

As indicated, the individual plates are free to move longitudinally and accordingly the desired curvature as dictated by the cam 20 will be achieved only if each of the individual plates is in tight contact with the surface of the cam 20. The fluid force of a coolant supply is used to fulfill this need.

Accordingly, to accomplish both the supply of fresh electrolyte and to keep the individual plates in contact with the cam 20, a flow of fluid under pressure is introduced into the surface between the workpiece and the plurality of individual plates.

In order to accomplish this flow action, alternate ones of the plates 13 are provided with longitudinal supply conduit grooves 25, as best seen in FIGURE 3. These are marked as A plates. Between the A plates are B plates provided with short radius exhaust grooves 26. Hence, when the plurality of plates 13 are stacked together to form the complete electrode, there will be created a plurality of closed supply channels leading from an area near the T bar of the plates to the composite forward end face 24, and there will be created a plurality of exhaust channels from the forward end 24 to a side position just adjacent the end.

Refer to FIGURE 1 for a fuller understanding of the supply and exhaust system. Here it will be seen that a supply header cavity 28 is created in the holder 14 by the provision of the box portion 16, to accommodate the cross bar sections of the individual plates. Because the box portion must be long enough to provide for travel of the individual plates, this space necessarily results. Space 28 is then used to advantage as a supply header. Fluid introduced under pressure into the header 28 finds inlet ends 29 of the supply grooves 25 and follows along the grooves 25 to the face end 24 of the electrode. Hence, there is a supply of fresh coolant coming through the face end over the entire area of the electrode.

In order to prevent the trapping of spent electrolyte between the workpiece and the electrode, the exhaust grooves 26 allow the fluid to move just a short distance to find the entrance end of an exhaust groove. Such a short route to exhaust is suggested by the curved arrow 30, shown in FIGURE 4. The exhaust grooves have an outlet end 31, also suggested by an arrow in FIGURE 4, which allows the coolant to vent to atmosphere and be caught up in a sump provided in the machine.

Pipes 33 are used to deliver fluid electrolyte from a source under pressure to the supply header 28 for this purpose. The electrolyte is gathered from the sump and recirculated. The pressure of the fluid circulating between the face of the electrode and the workpiece provides a force sufficient to hold each plate tight against cam 20.

In order to produce effective machining electrolytically, the advancement of the electrode and its face configuration is controlled by a programmed advancement system. Such an advancement system may take many forms and is suggested in the illustrated preferred embodiment as a lead screw 36 which may be programmed by computer or control tape, or by other suitable control techniques. Furthermore, the drive may be caused to stop or reverse under excessive sparking conditions to prevent a physical contact and dead short of electrode 12 with the workpiece.

A drive header 38, carried by the table 17, is interconnected with the lead screw 36 by an interchange system of threads, ball and groove, or other desired advancement techniques known to the art.

As a further example, a threaded area 40 and gear 41

are employed to drive a shaft 43 in order to rotate the cam 20.

By coordination of the speed of drive of lead screw 36, and the feed speeds through the drive header 38 and gear 41, the table 17 is caused to advance at the desired rate to match the rapidity of metal removal and the curvature, the latter being a function of the distance from the workpiece to the cam is programmed into the control system in order to cause the butt end and face end of the electrode to take on the exact shape of the workpiece at that stage of machining advancement. Each workpiece will require handling calculations which will differ from others, because the particular materials which require this type of electrolytic finishing will vary in the rapidity with which they succumb to this treatment of finishing. The programming of the advancement and rotation of the cam, however, is within the skill of the mathematician and machinist.

Whereas the present invention has been shown and described herein in what is conceived to be the best mode contemplated, it is recognized that departures may be made therefrom within the scope of the invention which is, therefore, not to be limited to the details disclosed herein, but is to be afforded the full scope of the invention as hereinafter claimed.

What is claimed is:

1. A dynamic electrode comprising:

a plurality of plate electrode members, a stack of said plate members in laminar relationship;

means for holding said stack of plate members in cross-section alignment and free for independent longitudinal shifting, said plate and said stack having a face end and a butt end;

cam means acting on said butt end of said stack for contouring the face end profile thereof, said cam having a surface profile evolving from a large to a small radius; and

means to simultaneously advance said electrode longitudinally in the direction of said face end and move said cam along said butt end for progressively decreasing the radius of curvature of the stack face end profile.

2. In the electrode as defined in claim 1;

said plate electrode members having opposed, broad, flat side surfaces and narrow edge surfaces;

some of said plate members having side surface supply grooves running from the face end thereof to a manifold area and some having side surface exhaust grooves running from the face end thereof to an edge, said grooves being capped by an adjacent plate member to provide closed conduits; and

means for injecting electrolyte coolant into the conduits resulting from closing said side grooves;

whereby, electrolyte pressure between a workpiece and said stack face end provides a force, urging said stack into engagement with said cam.

3. In the electrode stack as defined in claim 2:

said plates having said exhaust grooves alternately spaced with plates having supply grooves to provide multiple escape routes in order that a greater volume of electrolyte may be passed between said stack face and a workpiece without excessive interface fluid pressure.

4. An electrolytic machine tool, comprising:

a power-driven rotary workpiece support means for turning a workpiece in space;

a table, and means for advancing said table toward said workpiece space position;

an electrode holder carried by said table, a plurality of plate electrode members, a stack of said plate electrode members in laminar relationship in said holder and free to shift only along the longitudinal axis thereof with respect to one another, said stack having a face end and a butt end;

a cam having a surface contoured from a first station

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curvature having a radius at least as great as the curvature of a raw workpiece and changing by increments to a curvature corresponding to the desired workpiece curvature, and means to move said cam along said butt end of said stack for causing said laminations to follow said cam and change the stack face end to correspond to said cam;
 said plates having surface configurations providing coolant conduits opening in said stack face end for supply and exhaust of electrolyte coolant; and
 means to place an electrical potential between said electrode and workpiece support means.

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JOHN H. MACK, *Primary Examiner.*DONALD R. VALENTINE, *Assistant Examiner.*

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