

Description

The present invention relates to electroerosion machines.

Travelling-wire electroerosion machines, frequency abbreviated TW-EDM machines (in the case of electric discharge machining), are machine tools in which an elongated electrode is displaced substantially continuously along a generally rectilinear path along the length of the machining stretch of the electrode between a pair of wire guides from an electrode supply system to an electrode takeup system.

The term "electroerosion" is used generically to describe electrical machining using such an electrode and a machining liquid which is introduced into the region at which the electrode is juxtaposed with the workpiece, *inter alia* to sweep the machining zone free from machining detritus, i.e. material removed from the conductive workpiece.

In EDM, the machine liquid is generally a dielectric e.g. water of low conductivity and the machining is effected by impressing discharge electrical pulses across the electrode and the workpiece so that discharges develop in the gap between the workpiece and the electrode to remove material at least preferentially from the workpiece.

There are other types of electroerosion which utilise, for example, electrochemical solubilization of workpiece charge machining (ECM) or a combination of electrochemical and discharge machining (ECDM) in which the liquid can have a more conductive character.

In practically all cases, the electrical energy utilised in the machining process is supplied to the machining zone in the form of discrete electrical pulses.

The term "wire" is used herein to describe the machining electrode and should also be understood to encompass elongated members generally and thus wires of various cross-sectional configurations as well as tapes, ribbons or the like. The electrode, of course, should be conductive and the thickness of the electrode should be between 0.05 mm and 0.5 mm.

In the published Europatent application EP-A 0 142 034, there is described a travelling-wire electroerosion machine with double-floating nozzle assemblies.

The floating-nozzle assembly can serve to deliver the machining liquid to the machining zone and can be traversed by the machining electrode or wire and in that system, the flow of the machining liquid is axial, i.e. parallel to the axial travel of the tool electrode.

The floating fluid-delivery nozzles of that system are axially movable so that, for example, they may be urged toward engagement with the workpiece to constrict the zone at which the liquid may flow away from the face with which this nozzle is juxtaposed.

In a travelling-wire electroerosion machine, the path of the cut in the workpiece in a direction substantially perpendicular to the direction of movement of the electrode along its travel path, is customarily determined by a program controlled by a numerical controller or other computer which can be

connected to an X-Y table upon which the workpiece is mounted. Of course, the head through which the electrode passes may be provided with an X-Y controller to determine this path, if desired, as an alternative or in addition. The later X-Y controller may be used to controlledly incline the electrode with a predetermined or varying angles relative to the workpiece surfaces so that a tapered or three-dimensional cut contour may be formed in the workpiece.

In the more common construction, the workpiece is fed into this electrode path and, as a result, a cut is formed in the workpiece so that it can be said that a cutting path is formed through the workpiece which is the path of the wire in the workpiece. Thus, there is a relative displacement of the workpiece and the electrode in a direction perpendicular or transverse to the travel direction of the wire.

A portion of the travelling wire will confront workpiece material over the thickness of the workpiece in the region at which this material is to be eroded. This zone of the workpiece at the leading end of the kerf or machining slot formed by the wire is the machining front and, depending upon the direction in which the machining front is oriented with respect to the axis of the wire, the travelling-wire electrode will be considered to have a machining face juxtaposed with the machining front and, in most electroerosion operations, the apparatus will be provided with control means for maintaining the gap between the machining face and the machining front substantially constant.

It has now been discovered that, when a nozzle through which a travelling-wire electroerosion electrode passes is biased floatingly against a surface of the workpiece and is formed with a discharge passage for the machining liquid which is inclined in the direction in which the electrode is fed into or out of the workpiece during the machining operation, there is a significantly enhanced stability of the machining operation, with improved precision and less tendency toward destabilization of the machining operation even where relatively large workpiece thicknesses are subject to be encountered.

Specifically, means is provided in conjunction with such a nozzle for continuously reorienting the nozzle to maintain the aforementioned passage so that it is directed in the electrode-feed direction and specifically against the surfaces of the electrode which are turned away from the machining front of the workpiece.

According to an embodiment of the present invention there is provided an electroerosion machine comprising an elongate electrode supported in a substantially linear machining stretch between a pair of guides located on opposite sides of a workpiece site, a movable nozzle member through which said electrode extends, said nozzle member being coupled to a source of machining liquid to provide a stream of machining liquid to a workpiece at a position where it is being eroded by the electrode, and means for urging the nozzle member towards the workpiece, characterised in that said nozzle member includes a flow discharge passage having an ax-

is inclined to the axis of the electrode, and a formation which is arranged to ride on the surface of the workpiece in a caster-like manner to rotate the nozzle member in accordance with any change in direction of the displacement of the electrode relative to the workpiece whereby to direct the stream so that a component thereof is maintained directed generally in the direction of movement of the electrode, relative to the workpiece.

According to an alternative embodiment the present invention there is further provided an electroerosion machine comprising: a travelling-wire electrode, a pair of fluid delivery assemblies mounted on opposite sides of a conductive workpiece to guide the electrode along a straight line thereacross and for discharging a machining fluid medium along said electrode and into a cutting zone in the workpiece; and drive means for effecting relative displacement between said assemblies and the workpiece along a predetermined feed path to form a corresponding contour in the workpiece, at least one of said assemblies comprising: a hollow base member defining an inner fluid passage about the electrode for receiving the machining fluid through fluid inlet means; and a nozzle member movably supported by said base member and having a fluid discharge passage surrounding the electrode characterised in that the fluid discharge passage has its axis inclined to the axis of the electrode and in that the nozzle member includes projection means cooperating with said workpiece to orientate the axis of the outlet passage in response to changes in the cutting direction of said electrode so as to have a component in the direction of a cutting front of the electrode.

Swivel means, preferably in the form of at least one ball, acting like a caster, and which is offset from this axis, can engage the workpiece and preferably can ride in the kerf or slot to ensure that the passage will always be trained against the machining front and into the machining zone.

To allow free rotation of the nozzle so that it can swivel in the manner described, the nozzle is preferably mounted by bearings in its support and where it is resiliently mounted in a floating manner, any mounting springs can act upon the nozzle via thrust bearings or the like.

According to a feature of the invention, the nozzle structure formed with this passage is rotatably mounted on a tubular structure through which the liquid is guided around a central sleeve traversed by the wire so that this directing member, formed with the inclined passage, can ensure the inclined flow of the machining liquid rather than an axial flow as is the case, for example, in the aforementioned Europatent application.

Preferably, the angle inclined between the axis of the passage and the axis of the wire in the direction of flow of the liquid can be between 5° and 45° and most preferably between 10° and 40°.

The caster ball which is preferably used can be spring-loaded against the workpiece or can be composed of an elastomeric or elastic, or otherwise frictional material and the nozzles above and below the workpiece can both be provided as swivelling members although at least the nozzle from which the

wire emerges should be provided with such a swivelling member having an inclined discharge passage.

According to the invention, therefore, the electroerosion machine can comprise a pair of fluid-delivery assemblies disposed at opposite sides of a conductive workpiece and adapted to define a straight-line travel path thereacross for a continuous machining electrode, also referred to as a travelling wire or wire-like electrode, and to discharge a machining fluid medium along the electrode into a cutting zone in the workpiece.

The machine also will include drive means for effecting relative displacement between the assemblies and the workpiece along a predetermined feed-path to form a corresponding contour in the workpiece.

At least one of these assemblies can comprise a hollow base member formed with an inner fluid passage around the electrode for receiving the machining fluid through fluid-inlet means, and a fluid-outlet member supported by the base member and rotatable about the electrode travel path. This outlet member is formed with a fluid discharge orifice traversed by the electrode and communicating with the fluid passage of the base member.

The axis of the discharge orifice is inclined at the aforementioned angle to the wire travel path and means are provided to rotate the fluid outlet member to position the discharge orifice adjacent the cutting zone so that it directs its outflow against the aforementioned cutting front or behind the electrode with respect to the direction in which the electrode advances through the workpiece to form the contour. Means can also be provided to urge the outlet member against the corresponding face or the workpiece with which the respective assembly is juxtaposed.

Electroerosion machines embodying the invention, will now be described, by way of example with reference to the accompanying diagrammatic drawings in which:

Fig. 1 is a diagrammatic side elevational view of an electroerosion machine illustrating principles of the present invention;

Fig. 2 is a detailed cross-section of one of the nozzle assemblies in accordance with one embodiment of the invention;

Fig. 3 is an axial section illustrating another nozzle assembly in accordance with the principles of this invention; and

Fig. 4 is still another axial section showing an assembly for discharging machine fluid for a machine as shown in Fig. 1.

In Fig. 1 of the drawing there is shown an electroerosion machine, for example a TW-EDM machine, for machining a cantilevered workpiece 8 which is connected by a bolt clamp 11 and a support post 10 to a worktable 9 capable of being driven incrementally in two mutually perpendicular directions by motors 9a and 9b and respective lead screws, one of which has been shown at 9c in Fig. 1, the motors being controlled by an NC (numerical control) unit representing any computer or programmable unit capable

of generating the desired cut contour in the workpiece.

The tool post is represented at 2 and rises from a base 1 upon which the table 9 is movably mounted in the manner described and carries, as has been shown highly diagrammatically, a supply spool 13 of the travelling-wire electrode 3 which passes a tensioning roller 14 and between a pair of driven pinch rollers 15, 16 whose drive can be coupled to the drive of a pair of pinch rollers 25, 26 at the takeup side to maintain a predetermined tension in the wire.

A linear stretch of the traveling wire is established between a pair of guide rollers 23, 23' and a wire is deflected into this linear stretch by a deflection roller 17.

Over its linear stretch, the wire passes through a pair of nozzle assemblies straddling the workpiece and represented at 7 and 22, respectively, at least one of these nozzle assemblies being provided with the swivel means illustrated in FIG. 2 although preferably both nozzle assemblies are provided with such swivel means (the upper nozzle assembly corresponding to FIG. 2 while the lower nozzle assembly corresponds to the structure of FIGS. 3 or 4).

The principles described in the aforementioned Europatent application, for urging at least the outlet member of each nozzle assembly in the direction of the workpiece surfaces 8g and 8h will, of course, also be used. A roller 24 can serve to measure the utilization of the wire electrode and can be used as a control for the rate of feed thereof in the wire travel direction which is downwardly in FIG. 1.

Referring now to FIG. 2, it can be seen that the wire 3 passes through the workpiece 8 and forms a cut therein which is in the form of a slot 8g lying behind the wire. The workpiece is fed in the direction 46 which is perpendicular to the wire travel direction as previously described and, because of the kinetic energy of the machining operation released in the gap G between the machining front F and the machining surface S of the wire, there is tendency for the wire to bend away from the machining front as shown in dot-dash lines and hence for the gap width to be changed.

At least part of the increased accuracy of the machining operation is obtained, in accordance with the invention, by counteracting the forces acting upon the wire away from the machining front F with hydrodynamic and hydrostatic forces in this direction by training the flow of the liquid medium against the wire in the direction of the machining front, i.e. opposite to the arrow 46, at least with a component of the velocity of flow of this liquid medium.

In the construction shown in FIG. 2, the upper nozzle assembly 7 comprises a hollow base member which is formed with a passage 7b through which the wire 3 passes into a chamber 7c supplied, if desired with compressed air or some other fluid preventing backflow of the machining liquid into this chamber through the wire guide opening 19 of the tube 19a traversed by the wire 3.

The chamber 7c receives a pair of rollers 18 and 18a which position the wire, the roller 18 being engaged by a brush 28 in an electrically insulating sleeve 29 fitted into the base member 7. A coil 32

clamps a lug 31 of a supply conductor 30 from the EDM power supply to the brush 28. The other conductor from this power supply is affixed to the clamp 11 and hence completes the electrical circuit through the workpiece 8.

The fluid outlet member in this nozzle is represented at 35 and is formed with an inclined outlet passage 41 communicating via a chamber 21 with an inlet 45 in the hollow base member and constituting fluid inlet means for the latter.

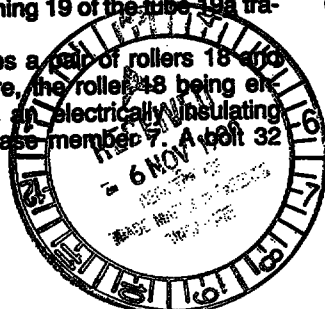
A coil spring 36 is braced against the base 7 and bears upon a washer 38 engaging a thrust bearing 40 lying on one side of an annular flange of the outlet member 35. Another thrust bearing 40 on the lower side of this flange is supported on another spring 37 so that in effect the outlet member 35 floats vertically while being biased by the dielectric fluid medium downwardly against the workpiece and being free to rotate within the base member 7.

To ensure that the passage 41 will always be trained against the machining front F and thus direct its stream of liquid against the traveling wire at an inclination with a force component in this direction, a caster ball 42 is provided eccentrically with respect to the axis of rotation of the member 35, bears upon the upper surface of the workpiece and preferably rides in the slot machined therein and is resiliently supported by a coil spring 43 in the axial direction. Naturally the diameter of the ball 42 should be greater than the width of the slot or kerf machined in the workpiece.

As can be seen from FIG. 2, therefore, during the machined operation which requires no specific description, the machining liquid does not flow directly axially along the wire but rather is always directed from behind against the wire and braces the wire hydraulically in the direction of the machining front F to prevent oscillation of the wire during machining operations even for large thickness workpieces and thereby improve the machining accuracy.

In FIG. 3, the lower nozzle assembly 22 is shown and can be seen to comprise a base member 47 into which the liquid medium is fed through an inlet which has not been illustrated. A thrust bearing 50 rotatably supports the outlet member against the base member 47 and, of course, a spring suspension can be provided here as well, or some other floating arrangement can be utilized. The member 48 surrounds the tube 19b through which the wire is fed as does the outlet member 35 of FIG. 2 and is formed with an inclined passage 49 training the liquid not strictly axially along the wire but always in the direction of the machining front as is clearly apparent from FIG. 3. The upper nozzle assembly has not been illustrated here but only the obstruction 19 against reverse flow of the liquid has been indicated by reference numeral. A diaphragm can be used for this purposes although compressed air is preferred as the reverse flow blocking medium. A similar blockage of reverse flow through the tube 19b can be ensured as well.

The caster roller is here formed by the ball 51 which is biased by a spring 53 against the lower surface of the workpiece within the recess 52 in the



outlet member 48. The axial passage of tube 19B has been represented at 19' in FIG. 3.

FIG. 4 shows another lower nozzle assembly 122 in which the outlet member 56 has the inclined passage 57 and a caster ball 59 in the manner previously described, and is free to rotate via a thrust bearing 58 on the liquid supply member 55 through which the tube 19B extends.

In this embodiment, the outlet from member 55 narrows before opening into the chamber 57' which is upstream of the inclined passage 57. Here again the outlet member swivels to follow the progress of the cut, keeping the liquid outflow always directed against the side of the wire turned away from the machining front F.

Claims

1. An electroerosion machine comprising an elongate electrode (3) supported in a substantially linear machining stretch between a pair of guides located on opposite sides of a workpiece site, a movable nozzle member (35) through which said electrode (3) extends, said nozzle member (35) being coupled to a source of machining liquid to provide a stream of machining liquid to a workpiece (8) at a position where it is being eroded by the electrode (3), and means for urging the nozzle member (35) towards the workpiece, characterised in that said nozzle member (35) includes a flow discharge passage (41) having an axis inclined to the axis of the electrode (3), and a formation (42) which is arranged to ride on the surface of the workpiece (8) in a caster-like manner to rotate the nozzle member (35) in accordance with any change in direction of the displacement of the electrode (3) relative to the workpiece (8) whereby to direct the stream so that a component thereof is maintained directed generally in the direction of movement of the electrode (3) relative to the workpiece (8).

2. A machine according to claim 1 characterised in that said nozzle (35) is rotatably mounted for rotation about an axis coinciding with the axis of said electrode (3).

3. A machine according to claim 1 or to claim 2 characterised in that said formation (42) comprises a roller located in a position offset from the axis of said electrode.

4. A machine according to claim 3 characterised in that said roller (42) is positioned and dimensioned to engage partly in the cut in the workpiece produced by the electrode (3).

5. A machine according to claim 3 or to claim 4, characterised by means resiliently mounting the roller on the nozzle (35) to urge the roller (42) towards the workpiece.

6. A machine according to any preceding claim characterised by a thrust bearing supporting said nozzle (35).

7. The machine according to claim 1 or to claim 2, characterised in that said formation is a ball (44).

8. A machine according to any preceding claim characterised in that one said guide comprises a tube (19) traversed by said electrode (3) and extending into the nozzle member (35) but lying spaced

from the entrance to said flow discharge passage (41).

9. A machine according to any preceding claim characterised in that said passage (41) has an axis inclined at an angle in the range of from 5 to 45° to the axis of said electrode (3).

10. A machine according to any preceding claim characterised by a second nozzle assembly (48) located on an opposite side of the workpiece (8) to the first-mentioned nozzle member (35), and being traversed by said electrode (3), said second nozzle member (48) being coupled to a source of machining liquid to supply said machining liquid to the workpiece (8).

11. A machine according to Claim 10 characterised in that said second nozzle member (48) defines a flow discharge passage (49) having an axis inclined to the electrode (3), and a formation (51) which is arranged to ride on the surface of the workpiece (8) in a caster-like manner to turn the nozzle member as the electrode progresses into the workpiece (8) so that the stream of liquid emerging from the passage (49) has a component directed generally in the direction of displacement of the electrode relative to the workpiece (8).

12. A machine according to Claim 11, characterised in that the or each said nozzle member (35, 48) is floatingly supported but is urged by the pressure of said machining liquid towards said workpiece (8).

13. An electroerosion machine comprising: a travelling-wire electrode (3), a pair of fluid delivery assemblies (7, 22) mounted on opposite sides of a conductive workpiece (8) to guide the electrode along a straight line thereacross and for discharging a machining fluid medium along said electrode (3) and into a cutting zone in the workpiece (8); and drive means for effecting relative displacement between said assemblies (7, 22) and the workpiece (8) along a predetermined feed path to form a corresponding contour in the workpiece (8), at least one of said assemblies (7) comprising: a hollow base member (34) defining an inner fluid passage about the electrode (3) for receiving the machining fluid through fluid inlet means, and a nozzle member (35) movably supported by said base member (34) and having a fluid discharge passage (41) surrounding the electrode (3) characterised in that the fluid discharge passage (41) has its axis inclined to the axis of the electrode (3) and in that the nozzle member (35) includes projecting means (44) cooperating with said workpiece (8) to orientate the axis of the outlet passage (41) in response to changes in the cutting direction of said electrode so as to have a component in the direction of a cutting front of the electrode (3).

14. An electroerosion machine according to Claim 13 characterised in that said projecting means (44) includes a caster ball (44) adapted to ride along a surface of said workpiece (8).

15. An electroerosion machine according to claim 14, characterised by spring means (43) in said nozzle member (35) for resiliently biasing said ball (44) against said surface.

16. An electroerosion machine according to claim 15 characterised in that both of said assemblies (7, 22) have a respective base member (34, 47) and

outlet member 48. The axial passage of tube 19B has been represented at 19' in FIG. 3.

FIG. 4 shows another lower nozzle assembly 122 in which the outlet member 56 has the inclined passage 57 and a caster ball 59 in the manner previously described, and is free to rotate via a thrust bearing 58 on the liquid supply member 55 through which the tube 19B extends.

In this embodiment, the outlet from member 55 narrows before opening into the chamber 57' which is upstream of the inclined passage 57. Here again the outlet member swivels to follow the progress of the cut, keeping the liquid outflow always directed against the side of the wire turned away from the machining front F.

Claims

1. An electroerosion machine comprising an elongate electrode (3) supported in a substantially linear machining stretch between a pair of guides located on opposite sides of a workpiece site, a movable nozzle member (35) through which said electrode (3) extends, said nozzle member (35) being coupled to a source of machining liquid to provide a stream of machining liquid to a workpiece (8) at a position where it is being eroded by the electrode (3), and means for urging the nozzle member (35) towards the workpiece, characterised in that said nozzle member (35) includes a flow discharge passage (41) having an axis inclined to the axis of the electrode (3), and a formation (42) which is arranged to ride on the surface of the workpiece (8) in a caster-like manner to rotate the nozzle member (35) in accordance with any change in direction of the displacement of the electrode (3) relative to the workpiece (8) whereby to direct the stream so that a component thereof is maintained directed generally in the direction of movement of the electrode (3) relative to the workpiece (8).

2. A machine according to claim 1 characterised in that said nozzle (35) is rotatably mounted for rotation about an axis coinciding with the axis of said electrode (3).

3. A machine according to claim 1 or to claim 2 characterised in that said formation (42) comprises a roller located in a position offset from the axis of said electrode.

4. A machine according to claim 3 characterised in that said roller (42) is positioned and dimensioned to engage partly in the cut in the workpiece produced by the electrode (3).

5. A machine according to claim 3 or to claim 4, characterised by means resiliently mounting the roller on the nozzle (35) to urge the roller (42) towards the workpiece.

6. A machine according to any preceding claim characterised by a thrust bearing supporting said nozzle (35).

7. The machine according to claim 1 or to claim 2, characterised in that said formation is a ball (44).

8. A machine according to any preceding claim characterised in that one said guide comprises a tube (19) traversed by said electrode (3) and extending into the nozzle member (35) but lying spaced

from the entrance to said flow discharge passage (41).

9. A machine according to any preceding claim characterised in that said passage (41) has an axis inclined at an angle in the range of from 5° to 45° to the axis of said electrode (3).

10. A machine according to any preceding claim characterised by a second nozzle assembly (48) located on an opposite side of the workpiece (8) to the first-mentioned nozzle member (35), and being traversed by said electrode (3), said second nozzle member (48) being coupled to a source of machining liquid to supply said machining liquid to the workpiece (8).

11. A machine according to Claim 10 characterised in that said second nozzle member (48) defines a flow discharge passage (49) having an axis inclined to the electrode (3), and a formation (51) which is arranged to ride on the surface of the workpiece (8) in a caster-like manner to turn the nozzle member as the electrode progresses into the workpiece (8) so that the stream of liquid emerging from the passage (49) has a component directed generally in the direction of displacement of the electrode relative to the workpiece (8).

12. A machine according to Claim 11, characterised in that the or each said nozzle member (35, 48) is floatingly supported but is urged by the pressure of said machining liquid towards said workpiece (8).

13. An electroerosion machine comprising: a travelling-wire electrode (3), a pair of fluid delivery assemblies (7, 22) mounted on opposite sides of a conductive workpiece (8) to guide the electrode along a straight line thereacross and for discharging a machining fluid medium along said electrode (3) and into a cutting zone in the workpiece (8); and drive means for effecting relative displacement between said assemblies (7, 22) and the workpiece (8) along a predetermined feed path to form a corresponding contour in the workpiece (8), at least one of said assemblies (7) comprising: a hollow base member (34) defining an inner fluid passage about the electrode (3) for receiving the machining fluid through fluid inlet means, and a nozzle member (35) movably supported by said base member (34) and having a fluid discharge passage (41) surrounding the electrode (3) characterised in that the fluid discharge passage (41) has its axis inclined to the axis of the electrode (3) and in that the nozzle member (35) includes projecting means (44) cooperating with said workpiece (8) to orientate the axis of the outlet passage (41) in response to changes in the cutting direction of said electrode so as to have a component in the direction of a cutting front of the electrode (3).

14. An electroerosion machine according to Claim 13 characterised in that said projecting means (44) includes a caster ball (44) adapted to ride along a surface of said workpiece (8).

15. An electroerosion machine according to claim 14, characterised by spring means (43) in said nozzle member (35) for resiliently biasing said ball (44) against said surface.

16. An electroerosion machine according to claim 15 characterised in that both of said assemblies (7, 22) have a respective base member (34, 47) and



nozzle member (35, 48) surrounding said electrode (3).

17. An electroerosion machine according to any one of claims 13 to 16 characterised by a thrust bearing (50) rotatably supporting said nozzle member (48) on said base member (47).

18. An electroerosion machine according to claim 17 characterised by spring means (36, 37) for floatingly supporting said nozzle member (35) on said base member (34) in an axial direction.

19. An electroerosion machine according to any one of claims 13 to 18 characterised in that the inclination of the axis of the fluid passage (41) relative to the axis of the electrode (3) lies in the range of from 5° to 45°.

Patentansprüche

1. Funkenerosionsmaschine, umfassend eine lange Elektrode (3), die in einem im wesentlichen linearen Bearbeitungsabschnitt zwischen einem Paar Führungen gelagert ist, die auf entgegengesetzten Seiten einer Werkstücksposition angeordnet sind, eine bewegliche Düse (35), durch die die Elektrode (3) verläuft, wobei die Düse (35) mit einem Arbeitsflüssigkeitsvorrat verbunden ist und einen Arbeitsflüssigkeitsstrom zu einem Werkstück (8) an einer Stelle liefert, an der dieses von der Elektrode (3) abgetragen wird, und Mittel zum Beaufschlagen der Düse (35) in Richtung zum Werkstück, dadurch gekennzeichnet, daß die Düse (35) einen Strömungsaustrittskanal (41), dessen Achse zur Achse der Elektrode (3) geneigt ist, sowie eine Formation (42) aufweist, die auf der Oberfläche des Werkstücks (8) gleitrollenartig abläuft und die Düse (35) entsprechend jeder Änderung der Verlagerungsrichtung der Elektrode (3) relativ zum Werkstück (8) verdreht, um dadurch den Strom so zu richten, daß eine Komponente desselben im wesentlichen in der Bewegungsrichtung der Elektrode (3) relativ zum Werkstück (8) gehalten wird.

2. Maschine nach Anspruch 1, dadurch gekennzeichnet, daß die Düse (35) um eine mit der Achse der Elektrode (3) zusammenfallende Achse drehbar angeordnet ist.

3. Maschine nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Formation (42) eine Rolle umfaßt, die in einer zur Achse der Elektrode versetzten Position angeordnet ist.

4. Maschine nach Anspruch 3, dadurch gekennzeichnet, daß die Rolle (42) so positioniert und bemessen ist, daß sie teilweise in den von der Elektrode (3) erzeugten Schnitt im Werkstück eintritt.

5. Maschine nach Anspruch 3 oder 4, gekennzeichnet durch Mittel, die die Rolle federnd an der Düse (35) halten, um die Rolle (42) in Richtung zum Werkstück zu beaufschlagen.

6. Maschine nach einem der vorhergehenden Ansprüche, gekennzeichnet durch ein die Düse (35) abstützendes Axiallager.

7. Maschine nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Formation eine Kugel (44) ist.

8. Maschine nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß eine der

Führungen ein von der Elektrode (3) durchsetztes Rohr (19) ist, das sich in die Düse (35) erstreckt, aber vom Eintritt des Strömungsaustrittskanals (41) beabstandet ist.

9. Maschine nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß der Kanal (41) eine Achse hat, die zur Achse der Elektrode (3) unter einem Winkel von 5-45° geneigt ist.

10. Maschine nach einem der vorhergehenden Ansprüche, gekennzeichnet durch eine zweite Düsenanordnung (48), die an einer zur erstgenannten Düse (35) entgegengesetzten Seite des Werkstücks (8) liegt und von der Elektrode (3) durchsetzt ist, wobei die zweite Düse (48) mit einem Arbeitsflüssigkeitsvorrat verbunden ist, um dem Werkstück (8) die Arbeitsflüssigkeit zuzuführen.

11. Maschine nach Anspruch 10, dadurch gekennzeichnet, daß die zweite Düse (48) einen Strömungsaustrittskanal (49) mit einer zur Elektrode (3) geneigten Achse definiert und eine Formation (51) aufweist, die auf der Oberfläche des Werkstücks (8) gleitrollenartig ablaufen kann, um die Düse zu drehen, während die Elektrode in das Werkstück (8) eindringt, so daß der aus dem Kanal (49) austretende Flüssigkeitsstrahl eine Komponente hat, die im wesentlichen in Richtung der Verlagerung der Elektrode relativ zum Werkstück (8) gerichtet ist.

12. Maschine nach Anspruch 11, dadurch gekennzeichnet, daß die oder jede Düse (35, 48) schwimmend gelagert, jedoch vom Druck der Arbeitsflüssigkeit in Richtung zum Werkstück (8) beaufschlagt ist.

13. Funkenerosionsmaschine, umfassend: eine Laufdrahtelektrode (3), zwei auf entgegengesetzten Seiten eines leitfähigen Werkstücks (8) angeordnete Arbeitsflüssigkeitszuführeinheiten (7, 22), die die Elektrode auf einer Geraden über das Werkstück führen und eine Arbeitsflüssigkeit entlang der Elektrode (3) und in eine Zerspanzone im Werkstück (8) liefern; und einen Antrieb zur Durchführung einer relativen Verlagerung zwischen den Einheiten (7, 22) und dem Werkstück (8) längs einer vorbestimmten Vorschubbahn unter Bildung einer entsprechenden Kontur im Werkstück (8), wobei wenigstens eine der Einheiten (7) umfaßt: ein hohles Basisteil (34), das einen inneren Flüssigkeitskanal um die Elektrode (3) zur Aufnahme der Arbeitsflüssigkeit durch Flüssigkeitseinlaßmittel bildet, und eine von dem Basisteil (34) beweglich gehaltene Düse (35) mit einem Flüssigkeitsaustrittskanal (41), der die Elektrode (3) umgibt, dadurch gekennzeichnet, daß der Flüssigkeitsaustrittskanal (41) eine Achse hat, die zur Achse der Elektrode (3) geneigt ist, und daß die Düse (35) ein mit dem Werkstück (8) zusammenwirkendes vorspringendes Teil (44) aufweist, um die Achse des Austrittskanals (41) aufgrund von Änderungen der Zerspanrichtung der Elektrode so zu orientieren, daß sie eine Komponente in Richtung einer Zerspanfront der Elektrode (3) hat.

14. Funkenerosionsmaschine nach Anspruch 13, dadurch gekennzeichnet, daß das vorspringende Teil (44) eine Gleitrolle (44) aufweist, die längs einer Oberfläche des Werkstücks (8) abrollt.

15. Funkenerosionsmaschine nach Anspruch 14, gekennzeichnet durch eine in der Düse (35) vorge-



sehene Feder (43), die die Kugel (44) federnd gegen die Oberfläche beaufschlagt.

16. Funkenerosionsmaschine nach Anspruch 15, dadurch gekennzeichnet, daß beide Einheiten (7, 22) jeweils ein die Elektrode (3) umgebendes Basisteil (34, 47) und eine Düse (35, 48) aufweisen.

17. Funkenerosionsmaschine nach einem der Ansprüche 13-16, gekennzeichnet durch ein Axiallager (50), das die Düse (48) drehbar an dem Basisteil (47) aufnimmt.

18. Funkenerosionsmaschine nach Anspruch 17, gekennzeichnet durch Federn (36, 37), die die Düse (35) an dem Basisteil (34) in Axialrichtung schwimmend abstützen.

19. Funkenerosionsmaschine nach einem der Ansprüche 13-18, dadurch gekennzeichnet, daß die Neigung der Achse des Flüssigkeitskanals (41) relativ zur Achse der Elektrode (3) 5-45° beträgt.

Revendications

1 - Machine à électro-érosion comprenant une électrode allongée (3) supportée dans une étendue d'usinage substantiellement linéaire entre une paire de guides placés sur des côtés opposés d'un emplacement de pièce travaillée, un organe mobile à buse (35) à travers lequel s'étend cette électrode (3), cet organe à buse (35) étant raccordé à une source de liquide d'usinage pour fournir un courant de liquide d'usinage à une pièce travaillée (8) à un endroit où elle est en cours d'érosion par l'électrode (3), et des moyens pour pousser l'organe à buse (35) en direction de la pièce travaillée, caractérisée en ce que cet organe à buse (35) comprend un passage (41) de sortie du courant ayant un axe incliné sur l'axe de l'électrode (3), et un dispositif (42) qui est agencé pour circuler sur la surface de la pièce travaillée (8) à la manière d'une roue orientable pour faire tourner l'organe à buse (35) en correspondance avec tout changement de direction du déplacement de l'électrode (3) par rapport à la pièce travaillée (8), dirigeant par ce moyen le courant de telle sorte qu'une composante de ce dernier est tenue dirigée, dans l'ensemble, dans le sens du mouvement de l'électrode (3) par rapport à la pièce à travailler (8).

2 - Machine selon la revendication 1, caractérisée en ce que la buse (35) est montée tournante pour tourner autour d'un axe coïncidant avec l'axe de ladite électrode (3).

3 - Machine selon la revendication 1 ou la revendication 2, caractérisée en ce que le dispositif (42) comprend un galet situé à un endroit déporté par rapport à l'axe de ladite électrode.

4 - Machine selon la revendication 3, caractérisée en ce que le galet (42) est disposé et dimensionné pour s'engager partiellement dans la coupe produite dans la pièce travaillée par l'électrode (3).

5 - Machine selon la revendication 3 ou la revendication 4, caractérisée par des moyens de montage élastiques du galet sur la buse (35) pour pousser ce galet (42) en direction de la pièce travaillée.

6 - Machine selon l'une quelconque des revendications précédentes, caractérisée par un palier de butée qui supporte ladite buse (35).

7 - Machine selon la revendication 1 ou la revendication 2, caractérisée en ce que le dispositif est une bille (44).

8 - Machine selon l'une quelconque des revendications précédentes, caractérisée en ce que le guide comprend un tube (19) traversé par l'électrode (3) et s'étendant à l'intérieur de l'organe à buse (35) mais étant espacé de l'entrée du passage (41) de sortie du courant.

9 - Machine selon l'une quelconque des revendications précédentes, caractérisée en ce que le passage (41) a un axe incliné d'un angle se trouvant dans la gamme de 5° à 45° par rapport à l'axe de l'électrode (3).

10 - Machine selon l'une quelconque des revendications précédentes, caractérisée par un second ensemble à buse (48) situé sur un côté opposé de la pièce travaillée (8) par rapport à l'organe à buse (35) mentionné en premier, et étant traversé par l'électrode (3), ce second organe à buse (48) étant raccordé à une source de liquide d'usinage pour fournir ce liquide à la pièce travaillée (8).

11 - Machine selon la revendication 10, caractérisée en ce que le second organe à buse (48) définit un passage (49) de sortie du courant ayant un axe incliné par rapport à l'électrode (3) et un dispositif (51) qui est agencé pour circuler sur la surface de la pièce travaillée (8) à la manière d'une roue orientable pour faire tourner l'organe à buse à mesure que l'électrode progresse dans la pièce travaillée (8) de telle sorte que le courant du liquide sortant du passage (49) a une composante dirigée dans l'ensemble dans le sens du déplacement de l'électrode par rapport à la pièce travaillée (8).

12 - Machine selon la revendication 11, caractérisée en ce que l'organe ou chaque organe à buse (35, 48) est supporté de manière flottante mais il est poussé en direction de la pièce travaillée (8) par la pression du liquide d'usinage.

13 - Machine à électro-érosion comprenant: une électrode (3) en fil en déplacement, une paire d'ensembles de fourniture de fluide (7, 22) montés sur des côtés opposés d'une pièce travaillée (8) conductrice pour guider l'électrode le long d'une ligne droite à travers cette dernière et pour fournir un milieu liquide d'usinage le long de ladite électrode (3) et dans une zone de coupe de la pièce travaillée (8), et des moyens d'entraînement pour produire un déplacement relatif entre lesdits ensembles (7, 22) et la pièce travaillée (8) le long d'un chemin d'alimentation prédéterminé pour former un contour correspondant dans la pièce travaillée (8), au moins l'un desdits ensembles (7) comprenant: un organe de base creux (34) définissant un passage intérieur de fluide autour de l'électrode (3) pour la réception du fluide d'usinage par l'intermédiaire d'un moyen d'arrivée de fluide et un organe à buse (35) supporté de manière mobile par ledit organe de base (34) et ayant un passage de sortie de fluide (41) entourant l'électrode (3), caractérisée en ce que le passage de sortie de fluide (41) a son axe incliné sur l'axe de l'électrode (3) et en ce que l'organe à buse (35) comprend un moyen saillant (44) coopérant avec la pièce travaillée (8) pour orienter l'axe du passage de sortie (41) en réponse aux changements de la direc-



tion de coupe de l'électrode afin de produire une composante dans la direction d'un front de coupe de l'électrode (3).

14 - Machine à électro-érosion selon la revendication 13, caractérisée en ce que le moyen saillant (44) comprend une bille orientable (44) adaptée pour circuler sur une surface de la pièce travaillée (8).

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15 - Machine à électro-érosion selon la revendication 14, caractérisée par un moyen élastique (43) de l'organe à buse (35) pour rappeler élastiquement ladite bille (44) contre ladite surface.

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16 - Machine à électro-érosion selon la revendication 15, caractérisée en ce que les deux ensembles (7, 22) ont un organe de base respectif (34, 47) et un organe à buse (35, 48) entourant ladite électrode (3).

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17 - Machine à électro-érosion selon l'une quelconque des revendications 13 à 16, caractérisée par un palier de butée (50) supportant de manière tournante ledit organe à buse (48) sur ledit organe de base (47).

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18 - Machine à électro-érosion selon la revendication 17, caractérisée par des moyens élastiques (36, 37) pour supporter de manière flottante en sens axial ledit organe à buse (35) sur ledit organe de base (34).

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19 - Machine à électro-érosion selon l'une quelconque des revendications 13 à 18, caractérisée en ce que l'inclinaison de l'axe du passage (41) du fluide par rapport à l'axe de l'électrode (3) se trouve dans la gamme de 5° à 45°.

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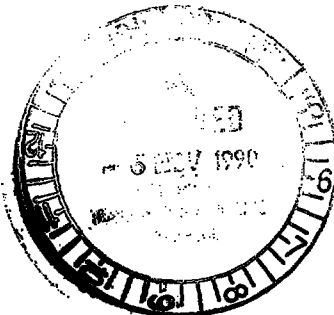
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