ARG FURNACE ELECTRODE ASSEMBLY
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ABSTRACT OF THE DISCLOSURE
An electrode comprises three separate assemblies including a tip assembly, an electrode column assembly, and an electrical connection and water manifolding assembly. The tip assembly is held to the electrode column assembly by a single ring nut which when removed permits the entire tip assembly to be pulled from the electrode column assembly. The tip assembly includes a plurality of fluid flow passageways and passageway defining means which, when the tip is inserted in the column assembly, make sealing engagement therewith. In addition, conduits or hollow lead extensions in the tip assembly for bringing cooling fluid to the field coil make electrical contact with contact fingers mounted in the column assembly, so that the conduits or lead extensions to the field coil, when a tip assembly is inserted, make good electrical connection, provide for thermal expansion, and make fluid-tight seals.

CROSS REFERENCES TO RELATED APPLICATIONS
The quick change magnetic field coil and some associated structure are described and claimed in a pending application of George A. Kemeny et al. for "Quick Change Magnetic Field Coil and Assembly for Use in an Electrode," Ser. No. 777,366, filed Nov. 20, 1968, and assigned to the assignee of the instant invention.


BACKGROUND OF THE INVENTION
Field of the invention
The invention relates to nonconsumable electrodes for use in electric arc furnaces including vacuum furnaces in which a fluid cooled arcing surface is provided and a magnetic field is set up to substantially continuously move the arc over the arcing surface to thereby reduce sublimation and evaporation of material from the arcing surface or a burn-through of the material forming the arcing surface by the intensely hot arc spot.

Description of the prior art
Prior art electrodes have employed materials with high melting points to provide long electrode life, or have been fluid cooled, and some have utilized a magnetic field to move the arc, but, generally, there have been many interrelationships which have to be taken account of to provide a workable electrode having a satisfactory life. Closely related prior art includes Patents Nos. 3,368,018; 3,368,019; and 3,369,067.

SUMMARY OF THE INVENTION
An electrode of the type employing a fluid cooled electrode tip forming an arcing surface with a field coil disposed in the tip to generate a magnetic field to move the arc, comprises three separate assemblies including an electrode tip assembly, an electrode column assembly, and an electrical connection and water manifolding assembly. The electrode tip assembly is easily removable as a unit simply by unscrewing one ring nut which secures the electrode tip assembly to the electrode column assembly. When an electrode tip assembly is inserted onto the electrode column assembly, the means in the electrode tip assembly for assembling fluid flow passageways register with fluid flow passageway forming means in the electrode column assembly and form fluid-tight sealing engagement therewith; in addition, conduits or lead extensions forming part of the electrode tip assembly for bringing cooling fluid and electrical current to and from the field coil are engaged by spring loaded contact fingers in the column assembly, forming good electrical connection while allowing for thermal expansion. Additional spring loaded contact fingers in the electrical and water manifolding assembly, which is removable from the column assembly, make good electrical connection with portions of conduit therein, forming fluid and electrical leads, and further provide good electrical contact while allowing for thermal expansion. A number of unique and novel configurations within all of the assemblies of the electrode result in an electrode which is easily assembled and disassembled, which includes means for protecting the electrode from damage while it is lowered into operating position and raised from operating position in a furnace, and in addition the electrode tip assembly includes new and novel means for positioning the cup enclosing the field coil to provide a fluid flow passageway of the desired cross section around the interior surface of the electrode tip and provide other passageways for the flow of cooling fluid into and out of the electrode tip.

BRIEF DESCRIPTION OF THE DRAWINGS
FIGURES 1A, 1B and 1C taken together are a cross-sectional view of the electrode according to the preferred embodiment; and FIG. 2 is a plan view of the electrode.

DESCRIPTION OF THE PREFERRED EMBODIMENT
In FIGS. 1A and 1B the electrical and water manifolding assembly includes that portion of the electrode designated EW; in FIGS. 1B and 1C the electrode column assembly includes that portion of the electrode designated EC; in FIG. 1C the electrode tip assembly includes that portion designated ET.

The structure may best be described with reference to the functions which it must perform. As previously stated, fluid is brought to a passageway in the column assembly for conducting heat flux from the arcing surface, and whereas the electrode will be described with reference to fluid entering the electrode column assembly in a manner whereby the cooling fluid first flows around the annular wall of larger diameter of the tip, thence flows around the bottom of the tip and thereafter flows around the inner wall of smaller diameter of the tip and thence exits from the electrode, it will be understood that the direction of fluid flow could be reversed if desired. In FIG. 1A the manifolding assembly is seen to include an end plate 10 composed of metal and having an eye nut 11 secured thereto for lifting the electrode into place and the furnace and removing it from the furnace. Abutting against the end plate 10 is a field coil manifold block 12 composed of insulating material adjacent the other side of which is an insulating plate 13. Bolts 14, FIGS. 1A and 2, pass through bores 15 in plate 10 and bores 16 in block 12 and thence make threaded engagement at 17.
with the aforementioned insulating plate 13, securing the plate 10, the block 12 and the plate 13 firmly together.

As previously explained the field coil within the electrode tip is composed of hollow conduit, and conduit means and lead extension means hereinafter to be described in greater detail extend from the field coil manifold block 12 to the field coil. Only one of the conduits by means 27 is shown in the plane selected for illustration, and is seen connected to a fluid inlet or outlet 18, the other fluid inlet or outlet for the field coil being shown at 19. As seen in FIG. 2, the inlets and outlets 18 and 19 extend transversely through the block 12. In addition to conducting fluid to and from the conduit, the conduits also carry electrical current for energizing the field coil. The leads to the field coil are shown at 24 and 25, FIG. 1A, are seen to be bent and are seen to extend part way through the structure with a gap 26 therebetween to insulate them from each other. The aforementioned conduit 27 is seen, preferably composed of copper or other material having high electrical conductivity, with the upper end thereof opening into the fluid inlet or outlet 18, having O-rings 28 and 29 in shallow grooves therein to provide a fluid-tight seal, and electrical contact between conduit 27 and lead 25 is made by a plurality of spring contact fingers, two of the contact fingers being shown at 31 and 32, the contact fingers being secured to or formed integrally with a contact member 33 threaded at 34 into lead 25. It will be understood that a similar electrical contact arrangement is provided for the other conduit to the field coil, making contact with lead 24, the other contact fingers not appearing in the plane selected for illustration. Conduit 27 is seen to extend almost to the lower end of the column assembly shown in FIG. 1C, and to have threaded at the other or lower end thereof by threads 36 an electrical contact member 37 having peripherally spaced spring contact fingers, two of these fingers being shown at 38 and 39, making electrical contact and forming an electrical quick disconnect finger assembly, the fingers making electrical contact with lead extension 41 from the field coil. The lead extension 41 is composed of electrical conductive material and as shown is hollow so that fluid may flow to the field coil. In FIG. 1B, it is seen that there are two shallow annular grooves 44 and 45 cut in the outside surface of conduit 27, but not cut so deep that they reach the interior passageway of the conduit, and that O-rings 46 and 47 are disposed in the annular grooves respectively. In passing through the electrical connection and within the field coil manifold block 12 passes through an insulating sleeve 48 having at the lower end thereof, FIG. 1B, a portion of increased inner diameter 49 in which fits an additional insulating sleeve 50, the sleeve 50 extending to the aforementioned electrical contact member 37, FIG. 1C, which has the spring contact fingers thereon.

Adjacent and underneath the aforementioned transverse portion of leads 24 and 25 to the field coil is an insulating plate 52, FIG. 1B, having adjacent thereto and underneath a bus 54 for bringing to the electrode the current which will form the arc from the tip. An electrical connection to a source of potential is symbolized by lead 55, connected to one terminal of a source of potential, not shown for convenience of illustration, it being understood that the arc takes place to a surface of opposite polarity, which may be another electrode or may be the mouth of the furnace, where the metal is composed at least in part of electrically conductive material. A bus 56, shown in FIG. 1A, disposed in a recess 57 in the aforementioned field coil manifolding block 12 passes through an insulating sleeve 58 extending through the insulating plate 13, the lead 24, the insulating plate 52 and the bus 54 of the bus 54 and making threaded engagement at 59 with a fluid manifold block 60, thereby securing the electrical connection and water manifolding assembly to the fluid manifold block. The fluid manifold block 60 has a number of axially extending bores there-through including drilled holes for the passage of an inlet and outlet to the field coil, such as bored 62 for the passage of the aforementioned insulating sleeve 48, sleeve 48 having two annular grooves 63 and 64 therein in which are disposed O-rings 65 and 66, respectively, insulating sleeve 48 having an annular rim portion 69 of increased diameter with the shoulder 70 of fluid manifold block 60, maintaining the insulating sleeve 48 in axial position. Fluid manifold block 60 has a gas inlet passageway 71 entering laterally and extending into an axial bore 73 in which is disposed the upper end of a centrally disposed tube 74 for conducting gas to the electrode tip and discharging the gas through the external circumference of the annular electrode tip. It will be understood that this gas may be used at will, or that this passageway may be unused where desired and closed if desired.

Disposed in a shallow groove 75 in tube 74 is an O-ring 76 for providing a fluid-tight seal. It is seen that the block 60 has a large opening 77 therein communicating with a fluid outlet passageway 78 and also communicating with an annular passageway 79 formed by an additional tube 80 disposed coaxially with the aforementioned tube 74. The aforementioned tube 80 engages the wall of bore 82 in block 60 and has fingers 83 therein contacting the aforementioned member 86, there being O-ring seal 85 between members 88 and 89. Near the lower end of the aforementioned block 60 on the outer wall surface thereof there is a radially extending annular rib 90 which abuts against the end of a metallic cylinder or sleeve 91 forming the outer wall of the aforementioned assembly of the electrode. The outer surface of the cylinder 91 is threaded at 92 and a circular nut 93 is threaded to the cylinder and has an upper portion clamping against the aforementioned rib 90 to secure the block 60 firmly to the thick walled metallic cylinder 91 forming the aforementioned outside wall of the column assembly. A fluid-tight seal is provided by O-ring 95, this being disposed in a shallow annular groove as shown. Key 184 extending into keyway 185 holds members 60 and 91 against rotary movement with respect to each other. Fluid entering the insulated assembly generally designated 96 passes into a large opening 97 within the fluid manifold block 60, this opening 97 providing ample space between the exterior wall of the aforementioned member 92 and the aforementioned tube 80 for the flow of fluid and also providing a passageway for the aforementioned conduit 27 and insulating sleeve 50. It will be understood that another conduit and another insulating sleeve, not shown in the plane selected for illustration, also pass through block 60 to the field coil.

Within the aforementioned cylinder 91 disposed between the inner wall of the cylinder 91 and the outer wall of the aforementioned tube 80 is a generally cylindrical member 99 composed of insulating material, the outer wall of member 99 being of smaller diameter than the inner wall of cylinder 91, providing a space 100 which is annular or cylindrical in shape and which extends around the entire periphery of the column assembly. The inner cylindrical wall of the aforementioned member 99 closely fits the outer wall of the aforementioned tube 80 which has a generally cylindrical member 102 therein with an O-ring seal 103 for providing a fluid-tight seal. The aforementioned member 99 has an axially extending bore or passageway 104 therethrough for the passage of the aforementioned conduit 27, the insulating sleeve 101 and the insulating sleeve 50, the retaining member 105 abutting against the upper end thereof. It is seen, FIG. 1C, that the annular passageway 106 communicates with the lower end thereof with a number of peripherally spaced axial grooves such as the axial groove 107 through which
fluid flows through an annular gap into passageway 109 within the outer cylinder 110 which forms a part of the electrode tip assembly, and which is held to the aforementioned cylinder 91 by ring nut 112 in threaded engagement at 113 which threads on the internal surface of the cylinder 91. Member 99 between gaps 107 has peripherally spaced portions of increased outer diameter such as portion 106 which fit into an adjacent portion of increased inner diameter 108 of tube 91, also near retaining ring 119. Cylinder 110 has a shoulder portion 114 which abuts against the upper end of member 112 and also has an annular groove 115 with an O-ring 116 therein for providing a sealing engagement. It is seen that the inside wall of cylinder 91 has an annular groove 118 therein in which is disposed retaining ring 119.

The aforementioned cylindrical member 99 has a shoulder 121 formed by a change in the inside diameter of the central opening therethrough, against which abuts the lower end of the aforementioned tube 80, FIG. 1C. As aforementioned, the electrode tip assembly is removable as a unit. At the lower extremity of the aforementioned cylindrical member 99 there is also a portion of increased inner diameter 123 of the central opening, so that the inside wall portion 123 snugly fits the adjacent outside wall of a sleeve or tube member 125 extending toward the tip. The aforementioned tube 74 is seen to have at the lower end thereof a portion of increased inner diameter 127 which snugly receives the upper end of an additional member of the lead extension 41, and forming an annular passageway 130 between tube 129 and tube 125, passageway 130 conducting fluid from the tip and forming a continuation of the aforementioned annular passageway 79 in the electrical and water manifold assembly, FIG. 1B. As previously stated, the tip may be inserted as a unit and a new tip assembly may be quickly inserted in the electrode column assembly, the new tip assembly carrying with it all of the necessary O-rings to provide fluid-tight seals, where fluid-tight seals are necessary, and the field coil lead extensions of the tip assembly sliding into good electrical contact with the aforementioned contact finger assemblies, such for example as that having contact fingers 38 and 39.

It is seen that the aforementioned cylindrical member 99 composed of insulating material has an additional bore or aperture 132 extending axially therethrough, which is inserted in the aforementioned lead extension 41. It is seen that the lead extension 41 is surrounded over a portion of its length by an insulating sleeve 133, and to accommodate the additional width or diameter of the insulating sleeve 133 the aforementioned bore 132 in cylindrical member 99 has a portion of increased inner diameter 134. O-ring 135 disposed in a suitable shallow groove in the outside wall of member 133 provides a fluid-tight seal.

The aforementioned lead extension 41 at the bottom thereof is brazed at 136 to field coil lead 137 forming a permanent attachment, the field coil being generally designated 139, composed of hollow conduit shown as square in cross-section. Lead 137 may also be of square cross-section, the change to round cross-section taking place where lead 137 joins lead extension 41. Coil 139 is shown in an insulating housing 142 having an extension 144 extending to and abutting against the lower end of the lead extension 41.

Whereas an annular space 136 is shown between the outside wall of insulating housing 142 and the inner wall of cup or shell 158, the amount of space, if any, may be varied at will. The aforementioned lead extension 41 has an annular groove 140 therein in which is disposed a retaining ring 141 which prevents the aforementioned insulating sleeve 133 from sliding upward on the lead extension 41, and prevents stress on the lead when plugging in.

It is seen then, that all of the various tubes and sleeves of the tip assembly are anchored or secured at the lower ends thereof so that when the aforementioned ring nut 112 is removed or loosened the tip may be grasped and the entire tip assembly removed. To this end the aforementioned cylinder 110 is threaded at 143 to the electrode tip generally designated 145; aforementioned lead extension 41 is brazed to field coil lead 137 at 138 and secured thereto, and the aforementioned retaining ring 141 insures that the insulating sleeve 133 will be removed from the column assembly when the lead extension is removed; aforementioned sleeve or tube 125 is threaded at 146 to a support member 116, with O-ring seal 149 to provide a fluid-tight seal, which member 147 is in turn threaded at 148 to the electrode tip 145, with O-ring 160 to provide a fluid-tight seal; the aforementioned inner tube of smallest diameter 129 is threaded at 150 to the aforementioned member 147, with O-ring 165 to provide a fluid-tight seal. As a result, the tubes 129, 125, 116, the lead extension 41 and the sleeve 133 are all in effect secured to the electrode tip 145 and are removed therewith and a new tip assembly including all of the aforementioned members may be quickly inserted in the column assembly and secured thereto by tightening nut 112 in a matter of a few seconds. The numerous O-rings including O-ring 116, O-ring 135, O-ring 152, O-ring 153 and O-rings 154 and 155 all seated in shallow grooves provide the necessary fluid-tight seals. Contact fingers 38 and 39 make the firm necessary good electrical connection, and it is understood that another contact finger arrangement is provided for in the inner lead extension, this last-named contact finger arrangement not being shown in the plane selected for illustration.

It is old in the art as exemplified by the aforementioned issued patents and copending applications to have an annular tip composed of inner and outer annular shells each generally U-shaped in cross-section with a fluid flow passageway therebetween. The inner and outer shells (the inner shell also being referred to as the coil cup) of the tip of our invention are shown at 158 and 159, the fluid flow passageway for the sheet flow of water on other cooling fluid being shown at 162.

An additional path for the passage of arc producing current from the column assembly to the tip is through ring nut 112. A novel feature of the instant invention is an annular shoulder 164 formed in the outer shell, and there is a ring or should 166, threaded on the outer surface of the inner shell 158, which also serves as a field coil cup, which abuts against the aforementioned shoulder 164. This ring or shoulder 166 is not solid or continuous, since fluid must pass therethrough, but has a series of peripherally spaced gaps around the entire perimeter thereof, so that fluid may pass into the passageway extending around the tip near the arcing surface. Fluid leaving the passageway in the tip passes through a plurality of peripherally spaced bores including bore 168 into the aforementioned annular passageway 130.

Annular shell or coil cup 158 has the upper ends of smaller and larger diameter respectively 171 and 172 of the extended wall portions extending into portions of increased inner diameter and reduced outer diameter of an annular member 174 disposed in the lower portion of the electrode tip assembly, annular member 174 having passageway 175 therethrough for aforementioned extended portion 144 of coil housing 142. O-rings 177 and 178 provide sealing engagement.

Whereas one passageway 162 is shown in the tip for the flow of cooling fluid, a number of discrete generally U-shaped peripherally spaced passageways could be provided if desired.

Whereas the invention has been described with reference to a separate fluid inlet source and fluid outlet for the field coil, our invention includes radially extending bores in block 60 extending from tip fluid inlet 97 and tip fluid outlet 79 (or 78) to the outside of the electrode, the bores being threaded to receive hose connections which hoses connect to 18 and 19, FIG. 2.
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By way of further summary of advantages, all tubes in the column except the outer tube are allowed to move relative to each other to allow for thermal expansion.

Gas entering at 71 and passing out passageway 188 through the tip may be used to improve visibility in the vacuum furnace by acting as a vehicle to carry out condensing vapors. The use of a certain selected gas may help in increasing or decreasing arc voltage. The position of the arc on the electrode may be regulated and to some extent controlled by gas admission.

The passageway 71 and passageway 188 in member 147 are used as a pressure tap for monitoring pressure at the tip in vacuum furnaces.

The drawings and the foregoing written description are illustrative and exemplary only and are not to be interpreted in a limiting sense.

We claim as our invention:

1. An electrode comprising, an electrode column assembly and a detachable electrode tip assembly, the tip assembly including an annular electrode tip comprising inner and outer annular shells each generally U-shaped in cross-section disposed at least partially within the other with at least one fluid flow passageway therebetween for conducting heat flux from the tip, a field coil composed of hollow conduit disposed in the tip for setting up a magnetic field to substantially continuously move the arc, the electrode tip assembly including a plurality of coaxially mounted tubes for bringing cooling fluid to the tip and conducting fluid therefrom, the electrode tip assembly including lead extensions being hollow and composed of electrically conductive material for bringing cooling fluid and energizing current to and from the field coil, all of said tubes and said lead extensions being secured to said tip, a nut fastening the tip assembly to the column assembly which when loosened frees the electrode tip assembly, the electrode tip and all of the tubes and field coil leads of the tip assembly being removable as a unit when the nut is loosened, the electrode column assembly including a plurality of generally cylindrical members forming fluid flow passageways which communicate with passageways in the tip assembly, the electrode column assembly including first and second electrical spring contact finger assemblies which engage the first and second lead extensions of the field coil while the tip assembly is mounted on the column assembly, the members of the tip assembly carrying fluid sealing means whereby when the tip assembly is inserted in the column assembly all fluid flow passageways are made fluid-tight, the spring contact fingers providing that all electrical connections to the field coil are good, at least a portion of the electrode column assembly and at least a portion of the electrode tip assembly being composed of conductive material and providing a path for current to the tip to produce an arc therefrom.

2. An electrode according to claim 1 in which the nut fastening the tip assembly to the column assembly forms part of the path for current to the tip to produce the arc.

3. An electrode according to claim 1 in which the tip assembly includes in addition a ring member mounted on the outside wall of the inner shell at a predetermined position thereon, and in which the outer shell is characterized as having a contour forming a shoulder against which the ring member abuts, thereby precisely positioning the inner shell within the outer shell, said ring member having a plurality of peripherally spaced gaps around the outside edge thereof through which cooling fluid may flow from a passageway in the electrode tip assembly into the passageway in the electrode tip between the inner and outer shells.

4. An electrode according to claim 1 including in addition tube means for bringing a gas to the tip and exhaust said gas through the central aperture of the annular electrode tip.

5. An electrode according to claim 1 in which said lead extensions of the tip assembly are brazed to the leads of the field coil to be secured thereto.

6. An electrode according to claim 1 in which the tip assembly includes a sleeve composed of insulating material surrounding each of the lead extensions and supporting the field coil, and a retaining ring in each of the lead extensions which prevents the insulating sleeve from sliding on the lead extension, thereby insuring that the insulating sleeve will be removed with the remainder of the electrode tip assembly when the electrode tip assembly is detached from the electrode column assembly.

7. An electrode according to claim 1 in which the plurality of generally cylindrical members of the electrode column assembly includes a tubular member composed of electrically conductive material and forming the outer wall of the electrode column assembly, the outer wall of the electrode tip assembly is an additional tubular member composed of electrically conductive material having a portion of enlarged outer diameter at the end thereof adjacent the electrode column assembly and forming a shoulder, the internal surface of the end of said tubular member adjacent the electrode tip assembly being threaded, and said additional tubular member making threaded engagement with said threaded ends on said tubular member of the electrode column assembly and abutting against the shoulder at the end of said additional tubular member of the tip assembly, said ring nut forming part of the electrical current path between column assembly and tip assembly.

8. An electrode according to claim 1 adapted for use in a vacuum furnace including in addition a member mounted in the electrode tip having a passageway therethrough communicating with atmosphere at a point within the central space defined by the annular electrode tip, in which the electrode tip assembly has an additional cylindrical block of the electrode column assembly has an additional tube communicating at one end thereof with said last-named passageway, and the electrode column assembly has an additional tube communicating with the last-named tube of the electrode tip assembly and with the outside of the electrode, the passageway and the tubes being adapted to be used as a pressure tap for monitoring the pressure in the vacuum furnace.

9. An electrode according to claim 1 in which one of the generally cylindrical members forming fluid passageways is a cylindrical block of insulating material with the outside surface thereof spaced from the inside wall of a cylindrical member of the column assembly and forming the outside wall of the electrode column assembly, fluid flowing to the tip for cooling the same passing through the annular passageway between said cylindrical member and said inside wall.

10. An electrode according to claim 9 wherein the end of the cylindrical blocks of insulating material near the electrode tip assembly is characterized as having a plurality of peripherally spaced axially extending grooves therein through which the fluid flows and including in addition a retaining ring on the inside surface of said last-named cylindrical member of the electrode column assembly abutting against the adjacent end of the cylindrical block of insulating material thereby trapping the insulating block into the column assembly and preventing movement of the insulating block when the tip assembly is removed.

11. An electrode according to claim 10 in which the cylindrical block of insulating material is additionally described as having a portion of the length thereof of increased outer diameter at the end thereof adjacent the electrode tip assembly, and said cylindrical member forming the outside wall of the electrode column assembly is additionally characterized as having an annular axially extending wall portion of increased outer diameter in which said portion of increased outer diameter fits.

12. An electrode according to claim 11 in which the cylindrical block of the electrode column assembly is ad-
Additionally described as having two axially extending passageways therethrough for the passage of the field coil lead extensions, the last-named two passageways having therein portions of two conduits communicating with the passageways in the lead extensions.

13. An electrode according to claim 1 including in addition an electrical connection and water manifold assembly operatively connected to that end of the electrode column assembly distant from the electrode tip assembly.

14. An electrode according to claim 13 in which the electrical connection and water manifold assembly includes fluid inlet means and fluid outlet means communicating with the fluid flow passageways of the electrode column assembly.

15. An electrode according to claim 13 in which the electrical connection and water manifold assembly additionally includes gas inlet means, the electrode column assembly additionally includes tubular means communicating with the gas inlet means for conducting the gas toward the electrode tip, and the electrode tip assembly additionally includes means including tubular means communicating with the last-named tubular means of the electrode column assembly for conducting gas toward the electrode tip and exhausting said gas in the central space of the annular electrode tip.

16. An electrode according to claim 13 in which the electrical connection and water manifold assembly additionally includes two conduits composed of electrically conductive material and insulated from the remainder of the assembly and the electrode column assembly and electrode tip assembly include insulated means connecting said two conduits to the field coil in the electrode tip.

17. An electrode according to claim 16 in which the electrical connection and water manifold assembly includes two spring contact finger assemblies making electrical contact with the two conduits and providing for thermal expansion of the conduits while maintaining good electrical connection therewith, said two spring contact finger assemblies forming part of an electrical circuit for bringing energizing current to and from the field coil.

18. An electrode according to claim 13 in which the electrical and water manifold assembly includes three bent plates of conductive material all electrically insulated from each other, said plates protecting the electrode from damage when it is lowered into a furnace or raised therefrom, one of said plates making electrical contact by way of contact fingers with one of the conduits, another of said plates making electrical contact by way of additional contact fingers with the other of said conduits, the third of said plates providing means for bringing current to the electrode to produce the arc, said electrical connection and water manifold assembly including conductive material in electrical contact with the third-mentioned of said plates, said column assembly including electrically conductive material in contact with the electrically conductive material of the electrical connection and water manifold assembly, said electrode tip assembly including electrically conductive means in contact with the electrically conductive means of the electrode column assembly and with said electrode tip whereby a complete current path is provided from said last-named plate to the electrode tip to produce an arc therefrom.

19. An electrode according to claim 13 including in addition a ring nut for maintaining the end of the electrical connection and water manifold assembly secured to the adjacent end of the electrode column assembly.

20. An electrode according to claim 18 including in addition a key and keyway for maintaining a selected point on the periphery of the electrical connection and water manifold assembly in predetermined radial alignment with respect to a selected point on the periphery of the electrode column assembly.

21. An electrode according to claim 18 including a first plate of metallic material at the upper end of the electrical connection and water manifold assembly, an eye nut in said plate secured thereto, a plate of insulating material adjacent said first-named plate and having a fluid inlet and a fluid outlet therein communicating with the conduits to the field coil, a third plate of insulating material adjacent the first plate of insulating material, a bolt extending from the end of the assembly into the third plate, and an additional bolt passing through the third plate and the three lead-ins which form electrical connections to the two conduits and the electrical connection for the arc current, said last-named bolt being electrically insulated and securing the end portion of the electrical connection and water manifold assembly to the remainder of the electrical connection and water manifold assembly.

22. An electrode having a supporting column and an electrode tip forming an arcing surface mounted thereon, the column including means for bringing current to the tip to produce an arc therefrom and fluid channeling means for bringing cooling fluid to and from the tip, an annular tip including an inner shell and an outer shell, the outer shell being hollow and substantially U-shaped in cross-section with a generally cylindrical inside wall portion of larger diameter and a generally cylindrical inside wall portion of smaller diameter, at least one of the wall portions having an abrupt change in the diameter thereof in the portion thereof near the supporting column and forming an annular shoulder, the inner shell fitting at least partially into the outer shell, the inner shell having means forming a ring secured to at least one of the outside walls thereof, said ring abutting against said shoulder and spacing the inner shell from the outer shell to provide a fluid flow passageway between the shells, said ring having a plurality of peripherally spaced apertures therein for the even radial distribution of fluid flow, the passageway between shells communicating with the fluid channeling means in the supporting column.

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