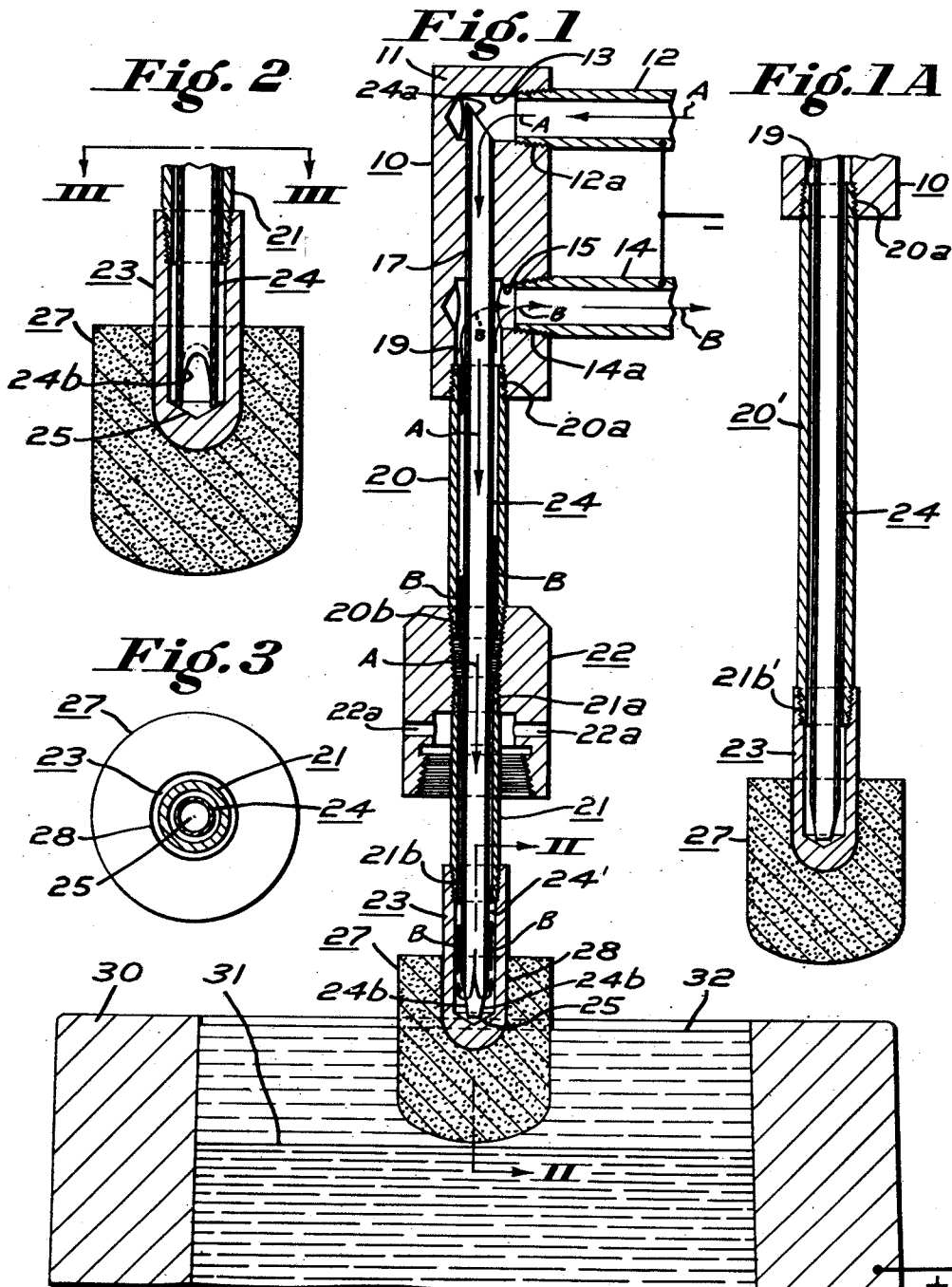


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HOT TOP ELECTRODE TIP

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HOT TOP ELECTRODE TIP

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This invention relates to electric hot topping of ingots and the like, and particularly to an improved type of electrode therefor.

Ordinarily, the progressive freezing action of the metal that is within the shell of the ingot, tends to form or develop pipes which result from volume change or shrinkage taking place upon solidification of the metal within the mold. Heat has thus been supplied to the top of metal teemed in an ingot mold while the teemed metal is covered by a blanket of protecting flux, in order to promote solidification with a minimum formation of defects due to shrinkage. The flux blanket applied to the teemed metal may be in a liquid or solid state, and preferably has such physical and chemical characteristics that it protects the teemed metal from the atmosphere and retards heat losses at the top of the ingot.

The heat is best supplied by an electrode introduced through such flux blanket. The electrical discharge from the electrode facilitates the absorption of segregates and impurities liberated in the metal during solidification and the proper distribution of the teemed metal to the top of the ingot. That is, electrically-supplied heat is applied to the top of the metal in such a manner as to provide a reservoir of gradually diminishing size of highly heated molten metal that feeds to the solidifying metal as volume changes due to the solidification take place and which is continued until the solidification of the teemed metal is substantially completed.

A present day type of heat generating mechanism employs an electrode assembly made from a highly conductive metal. Such assembly includes a head portion to which a pair of highly conductive tubes are connected for supplying cooling fluid thereto and for removing heated fluid therefrom. A suitable generator or source of electrical current is connected on its negative side to the tubes and by the tubes to the head. The positive side of the generator is ordinarily connected to the ingot shell. The head carries a tube-like, primary shank which at its lower end, carries a nipple holder that supports a secondary tube-like shank. A hollow, copper tip having a closed lower end is secured to the lower end of the secondary shank, and a black iron pipe nipple is screwed into the nipple holder and extends downwardly in a spaced relationship over the copper tip and for about three inches therebelow.

In employing this assembly, the cooling fluid or coolant is introduced through one of the connector tubes, through the head, to the bore of the

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head portion. A vertical tube extends from the bore of the head portion through the lower end of the head portion in a spaced relationship along the primary shank, the secondary shank, and into a bore of the electrode tip. When the assembly is placed in position at the start of a hot topping operation, the pipe nipple extends approximately three inches into the molten metal, and as the assembly is raised under a suitable automatic control, the lower portion of the pipe nipple melts away and exposes the end of the electrode tip. Enough flux is liquified by the heat generated (if the flux is supplied in the form of solid particles) to form a pool through which the electrode tip descends. Such tip then supports the current discharge and completes the hot topping operation. The coolant is continuously circulated through the tip to protect it under the high temperature conditions involved, for example, the average temperature may be around 3000° to 3200° F.

In utilizing such a mechanism, or in employing a procedure such as above outlined, I have determined that the copper tip, although relatively stable under such conditions, tends, over a period of time, to nick or burn. Its extreme lower, closed end wall must be maintained at a maximum thickness under such conditions, and when its thickness decreases as much as $\frac{1}{8}$ of an inch, the tip must be replaced. Another difficulty is that particularly, during the starting operation, there are wide variations or surges in power consumption, and the voltage may vary for example, from 20 to 80 volts during the first minute of operation.

Even if $\frac{1}{1000}$ of a per cent of copper is melted off the tip during a given operation, it will be apparent that each small portion will accumulate or build-up where scrap metal is used in making up an ingot. Although the cooling of the tip minimizes such pick-up as to each separate ingot, it may be sufficient to badly contaminate a higher grade ingot metal, such as a high grade alloy steel. Since the current for the heating operation is carried through the entire assembly, it is essential that a highly conductive metal, such as copper, be employed and regardless of the relatively low melting temperature of such metal.

I have also determined that the life of the copper electrode tip is shortened and its scoring and gradual sluffing-away is enhanced due to the utilization of the iron nipple or sleeve for initiating the arcing operation. That is, a secondary discharge between inner portions of the iron nipple, and side wall portions of the copper tip,

not only cause surging and an excessive heating of the tip, but also tends to burn and diminish the life of the copper tip. The desired current flow is between the copper tip and the teemed metal. The melted-off portions of the nipple also serve to contaminate the ingot metal.

In such a utilization, it is preferable to employ a flux which, itself, is conductive; the copper tip at its extreme lower end can be slightly covered with the slag, but cannot be exposed therebeneath. Such adjacency to the ingot metal however contributes to the deterioration of the tip. Although a copper tip may last for 50 to 100 heats, it must be replaced when its lower end wall reaches a thickness of about $\frac{1}{8}$ of an inch, otherwise the coolant fluid may break through and spoil the casting.

I have determined that a straight carbon tip is, itself, impracticable. Due to its porosity and lack of strength, a cooling medium cannot be directly circulated therethrough. Also, due to the relatively high temperature of a non-internally cooled tip, the carbon will tend to contaminate the teeming metal of the ingot. In a high grade steel casting having, for example, .07 to .10 per cent carbon, a very small carbon pick-up is critical and may change the entire characteristics of the metal.

In view of the above factors, the copper tip has been more or less generally adopted in spite of its disadvantageous features. Those skilled in the art have tended to shy away from carbon electrodes, due to their relative short period of life and to their tendency to contaminate the molten metal.

It has thus been an object of my invention to provide a practical solution to the problem above outlined;

Another object has been to discover critical factors involved in the procedure and to develop an improved form of electrode tip which will meet such factors;

A further object of my invention has been to devise a new and improved form of electrode tip;

A still further object of my invention has been to provide a highly conductive and improved form of tip which will make possible the utilization of the favorable features of the present form of electrode tip and which will eliminate the disadvantageous features thereof;

These and many other objects of my invention will appear to those skilled in the art from the hereinafter illustrated embodiments thereof.

In the drawings, Figure 1 is a sectional view in elevation showing an electrode tip constructed in accordance with my invention, as utilized in connection with a somewhat conventional electrode head assembly, and illustrates how it may be employed in a hot topping operation;

Figure 1A is a sectional detail showing a modified and simplified form of shank arrangement that may be used in connection with an electrode tip constructed in accordance with my invention;

Figure 2 is an enlarged sectional detail showing an electrode tip constructed in accordance with my invention and is taken along the line II—II of Figure 1.

Figure 3 is a horizontal section taken along the line III—III of Figure 2.

Keeping in mind that an electrode tip should have a reasonable period of useful life and a high conductivity, should be able to withstand the temperatures involved in a hot topping operation, and to do so without adversely contaminating the metal of the ingot, I have been able to devise a

new and improved form which utilizes a highly conductive, non-ferrous metal primary (inner) part, e. g., of a relatively low melting point metal such as copper, in such a manner that it has no opportunity to contaminate the ingot metal, nor to become damaged during the hot topping operation. That is, such a primary part now has an unlimited period of life. To initiate the arcing operation and to continue such operation, I have provided a protective coating or secondary (outer) part which fits over a lower end portion of the primary part and is thus cooled on its inside by the cooling medium which is circulated through the latter. The secondary or coating part is fitted on the primary part in such a manner as to provide a highly efficient electrical connection therewith, and in such a manner to avoid secondary arcing therebetween. The secondary tip part need not have a long period of life, since it can be readily replaced and is relatively inexpensive as to its manufacture and as to the materials contained therein. I prefer to employ an essentially carbon-containing material for the secondary part of closely compacted, relatively pure carbon in graphitic or allotropic form having relatively good electrical conductivity and a high temperature resistance. Graphites of this type are available on the present day market. Impurities, such as binding clay or metal, etc., are vaporized away during the forming of the part, leaving a highly-conductive, carbon, or graphitic product.

The graphite of the secondary part is an excellent conductor of electricity and is a relatively poor conductor of heat. This part is internally cooled through the highly thermally conductive primary part. The graphite part may be employed to start the arc without dipping beneath the level of the ingot metal to start the operation and may be raised to a suitable operating position, as shown in Figure 1, without any loss of carbon to the metal. In fact, I have determined that the vaporized ingot metal forms a slight coating on the arcing tip end of the graphite part to further protect it during the operation. A tip of this type is so efficient that the arcing operation may be continued, where it is entirely enclosed by the flux and is out of direct contact with the teemed or ingot metal. On the other hand, its outer part may, if desired, extend slightly below the flux layer.

The secondary part can be readily replaced by breaking it off and removing it from the end portion of the primary part, and a new secondary part may be added by sliding it over the lower end portion of the primary part and, if desired, by cementing it with a suitable conductive cement, such as a water glass containing carbon or metal particles. A tight friction fit may, itself, be employed to support the secondary or outer tip part. The outer part has a useful life sufficient to withstand sixteen or more heats and is inexpensive compared to the primary part.

Referring to the drawings, and particularly to Figure 1, 11 represents a head of a hot topping assembly 10. An inlet or supply tube 12 is securely threaded into an upper transverse or horizontal bore 13 of the head portion 11 at 12a to supply a cooled fluid to the head 11, see the arrows A. A second or exhaust tube 14 for the cooling medium is in like manner secured as by threads 14a within a lower transverse or horizontal bore 15 of the head 11 to exhaust warmed fluid, as indicated by arrows B. A fluid circulating tube 24 extends vertically-upwardly through a vertical bore 17 of

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the head 11 and has a slit-off open end 24a facing the direction of fluid flow from the tube 12. The bore 17 extends longitudinally between and connects the upper and lower transverse bores 13 and 15.

An enlarged vertical bore 19 in the head 11 is connected to the vertical bore 17 and is spaced from outer wall portions of the circulating tube 24. A primary or upper hollow shank 20 is securely threaded in the bore 17 at 20a. A lower end of the upper shank 20 is securely threaded at 20b into an upper end portion of a vertical bore through a holder 22 which in turn carries a secondary hollow shank 21 that is threaded at 21a into its lower end portion. The secondary shank 21 is threaded at 21b to receive a primary electrode part 23 thereon. The part 23 is hollow, has a closed off bottom wall, and an open upper end that is secured on the shank 21 and has a bore 24', as defined by the wall portions thereof, which terminates in a tapered end portion 25.

The longitudinal tube 24 extends downwardly, with its outer wall portions in a spaced-apart relationship with the vertical bore 19 of the head 11, and with inner wall portions of the primary shank 20, the bore of the holder 22, the secondary shank 21, and the primary tip part 23. The lower end of the tube 24 may extend, as shown in Figure 2, to a position adjacent and slightly into the space defined by tapered or off-set bottom wall portions of the bore 25 and has opposite sheared-off, and downwardly-converging, bifurcated or open side portions 24b to permit the cooling fluid to flow therethrough and return upwardly, as indicated by the arrows, between its outer wall portions and the inner wall portions of the bore 24' of the part 23, shanks 20 and 21, the holder 22, the bore 19 of the head 11, and then out through the bore 15 and the exhaust tube 14.

A secondary or outer electrode tip part or coating 27 is mounted, as shown, over a lower end portion (including the closed-off, rounded end wall) of the inner part 23 and has an inner bore 28 shaped to correspond to the contour of the outer wall portions of the part 23. As previously indicated, a suitable cement may be used in further securing the part 27 on the part 23.

In Figure 1, an ingot shell is indicated as 30, the teemed or ingot metal as 31, and the protective slag as 32.

Heretofore, the holder 22 which has suitable air circulating holes 22a, was provided to removably secure a pipe nipple to extend downwardly therefrom and beyond the electrode tip and to provide for an easy replacement of the electrode tip. Now, such a holder can be eliminated in view of my invention, and a single shank 20', threaded at its ends 20a and 21b', see Figure 1A, may be utilized. Since it is customary to supply current to the electrode tip through the pipes 12 and 14, the head 11, the shanks 20, 20', and 21, and the nipple holder 22, such parts are preferably made of a highly conductive metal, such as copper.

In utilizing a tip constructed in accordance with my invention, the operation can be conducted in somewhat the same manner as outlined in connection with a pipe nipple, with the difference that the part 27 does not melt off during the operation, current or voltage surges will be eliminated, the part 27 may, but does not have to dip into the teemed metal to start

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the arc, and no secondary arcs will be formed between the electrode parts 23 and 27.

The graphitic material or part 27 forming the protective coating is of a length, type, and thickness such that it may be submerged within the slag during the arcing operation, will have a proper strength, and will be stable under the high temperatures involved in the arcing operation, when internally cooled as indicated. For example, the inner or primary part 23 of the electrode may, for an ordinary operation, have a length of approximately two inches, an outside diameter of about $\frac{1}{4}$ of an inch, a side wall thickness of about $\frac{1}{8}$ of an inch, and a bottom end wall thickness of about $\frac{1}{4}$ of an inch. The outer part 27 may have an overall length of about 2 inches, fitting over the inner part about 1 inch, and extending beneath the latter about 1 inch. The thickness of the wall of the outer part 27 may be about $\frac{1}{2}$ of an inch and its outside diameter about 1 and $\frac{1}{4}$ inches. This example is for the purpose of illustration and gives an idea as to suitable proportions for the two parts of the electrode tip.

As shown in Figure 1, the inner part 23 is protected from direct contact with heat generated by the operation at its upper portion by the surrounding atmosphere and at its lower portion by the relatively poor heat conductor or graphitic part 27. It thus has a much lower operating temperature than that of previous constructions. Another feature of my invention, is that the preliminary inserting and partial withdrawing action of prior constructions need not be employed. That is, the electrode tip may be initially positioned in its final operating position and need not be first deep-inserted to initiate the forming of an arc. In such event, I prefer to use an electrically-conductive slag 32.

What I claim is:

1. In an arc-forming electrode of the character described for melting ingot metal, wherein current of one potential is to be applied to the electrode, wherein the electrode has a head part provided with a cooling fluid inlet and outlet and that carries a pair of longitudinally-extending substantially concentric inner and outer tubes of a highly conductive metal, wherein the inner tube defines an inlet chamber therealong connected to the cooling fluid inlet and the inner and outer tubes define an outlet chamber therebetween along the inlet chamber which outlet chamber is connected to the fluid outlet, and wherein a forwardly-extending end portion of the outer tube terminates substantially behind a forwardly-extending end portion of the inner tube, the combination which comprises, a primary nose part of a highly conductive metal having a bore wall of larger diameter than an outer diameter of the inner tube which bore wall is closed at its forward end and open at its inner end, the inner end of said bore wall being threadably mounted on the forwardly-extending end portion of the outer tube and enclosing the forwardly-extending end portion of the inner tube to define a continuation of the outlet chamber with the outer tube, a bifurcated and outwardly-converging end on the extending end portion of the inner tube to provide an unrestricted flow of cooling fluid from the inner tube to the continuation of the outlet chamber defined by said bore wall, said primary nose part being of cylindrical shape and having a rounded tip at its forward end, a secondary nose part of allotropic

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carbon having a rounded forward tip end to provide an arc for melting the ingot metal, said secondary nose part having a central bore wall therein open to its inner end and closed to its tip end which bore wall conforms in shape to the forward end of said primary nose part and is mounted in tight frictional engagement with and over the forward end of said nose part, and said secondary nose part extending backwardly along a portion of the length of said primary nose part and the outlet chamber defined thereby and backwardly beyond said bifurcated end of the inner tube.

2. In an arc-forming electrode of the character described for melting ingot metal, wherein current of one potential is to be applied to the electrode, wherein the electrode has a head part provided with a cooling fluid inlet and outlet and that carries a pair of longitudinally-extending substantially concentric inner and outer tubes of a highly conductive metal, wherein the inner tube defines an inlet chamber therealong connected to the cooling fluid inlet and the inner and outer tubes define an outlet chamber therebetween along the inlet chamber which outlet chamber is connected to the fluid outlet, and wherein a forwardly-extending end portion of the outer tube terminates in a longitudinally-spaced relation behind a forwardly-extending end portion of the inner tube, the combination which comprises, a primary nose part of a highly conductive metal having a longitudinal bore wall of larger diameter than an outer diameter of an inner tube which bore wall is closed at its forward end and is open at its inner end, the inner end of said bore wall terminating in a longitudinally-spaced relationship behind a forwardly-extending end portion of the inner tube, a detachable joint between the inner end of said bore wall and the forwardly-extending end portion of the outer tube and enclosing the forwardly-extending end portion of the outer tube and the forwardly-extending end portion of the inner tube to define a continuation of the outlet

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chamber with the outer tube, the forwardly-extending end portion of the inner tube having an open end in a spaced relationship with the forward end of said bore wall and defining unrestricted cooling passageways with said bore wall to provide an unrestricted flow of cooling fluid from the inner tube to the continuation of the outlet chamber defined by said bore wall, said primary nose part being of cylindrical shape and having a rounded tip at its forward end, a secondary nose part of allotropic carbon having a rounded forward tip end to provide an arc for melting the ingot metal, said secondary nose part having a central longitudinal bore wall therein open to its inner end and closed to its tip end which bore wall conforms in shape to the forward end of said primary nose part and is mounted in tight frictional engagement with and over the forward end of said nose part, and said secondary nose part extending longitudinally backwardly along a portion of the length of said primary nose part and the outlet chamber defined thereby and backwardly beyond the open end of the inner tube to a position intermediate the detachable joint and the forward end of said primary nose part.

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