March 28, 1939. R. K. HOPKINS 2,151,914

WELDING APPARATUS

Filed Sept. 16, 1936 2 Sheets-Sheet 1

FIG. 1

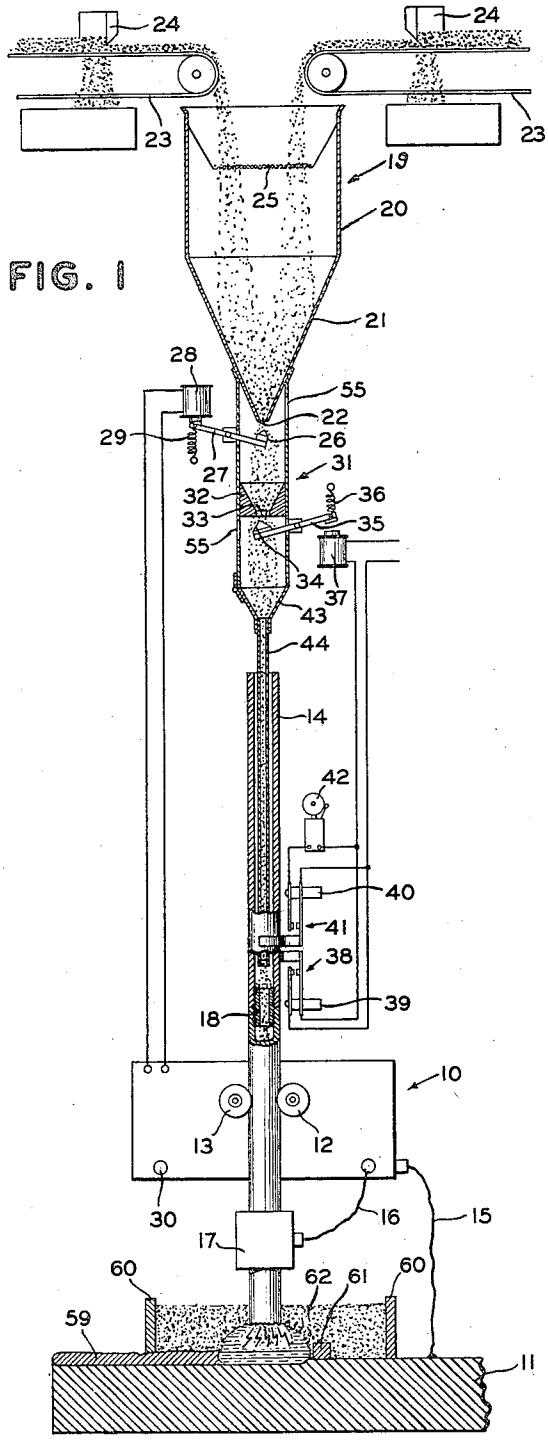
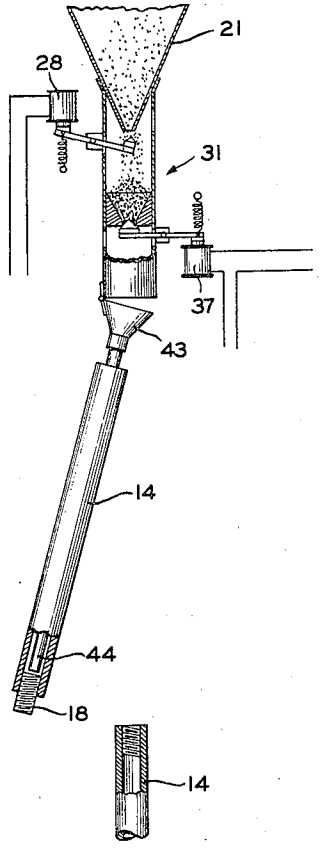


FIG. 2



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WELDING APPARATUS

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FIG. 4

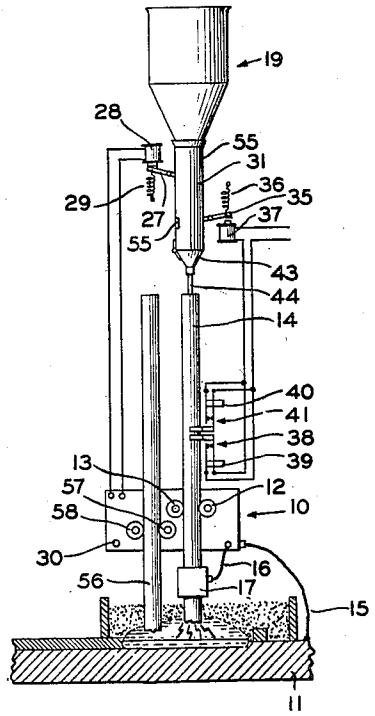
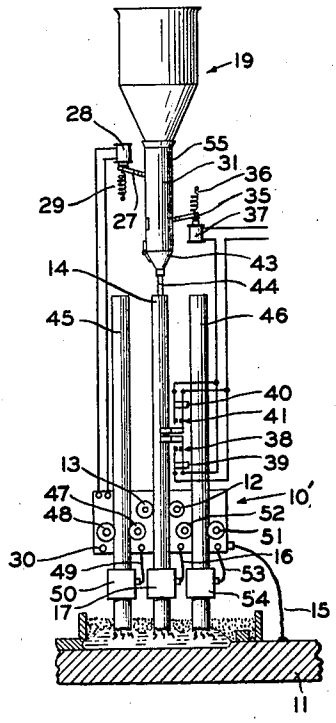


FIG. 3



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2,151,914

WELDING APPARATUS

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Application September 16, 1936, Serial No. 101,103

14 Claims. (Cl. 219—8)

This invention relates in general to electric fusion of metals and in particular to the electric fusion of metals for welding, veneering, and similar purposes.

This application is a continuation in part of my application filed February 18, 1936, Serial No. 64,496.

In arc welding, as at present carried out, and in the veneering, or coating, of metallic surfaces by electric arc deposition of metal as disclosed in my application above identified, it is generally necessary to employ as an electrode a body having a special composition so that the weld metal, or the veneering metal, may have the required composition. The electrode is made of special composition primarily in order to obtain a weld metal or a veneering metal of desired composition while compensating for losses of the constituents of the electrode in the arc and the dilution of the metal deposited from the electrode due to its penetration into the metal being welded or veneered.

In the present commercial practice, electrodes, whether bare or covered, generally include all of the constituents that they are to supply to the final deposited metal in the core or metallic portion of the electrodes even though it has long been proposed, in patents and in the literature, to include some of these constituents in the coatings of the electrodes. The proposals have not been commercially successful because of the difficulties involved in obtaining from the proposed electrodes a deposited metal in which the constituents included in the covering are found in proper proportions throughout.

Electrode metal is usually much more costly than other metal of generally similar analysis. The high cost of electrode metal is due in part to the small quantities that are made up at one time and the difficulties encountered in compounding some of the special analyses. The cost of electrode metal is always many times more than the total cost of its constituents in their readily available commercial forms. Furthermore, while electrode metal of a wide variety of analyses may be obtained all desirable analyses are not available. This is particularly true of chromium alloys of high chromium content and of chromium alloys of low carbon content.

I have found that it is not necessary in order to obtain the results of the prior art to incorporate all of the constituents of the finally deposited metal into a metallic electrode, but that all of the results of the prior art and results not obtainable by the prior art, may be obtained in a simple and much more inexpensive manner.

In accordance with my invention I employ as an electrode a metallic member, in the form of a solid or a hollow body, that is made up of the major portion of one or more of the constituents of the metal it is desired to deposit, and separately feed to the gap between the end of the electrode and the work, or in the vicinity of said gap, in the form of granules, pellets, wire, and the like, preferably through the electrode when it is a hollow body, the remainder of the constituents required to produce the desired deposited metal. The electrode and the granules, pellets, wire and the like, are fed to the gap between the end of the electrode and the work, at such rates that at substantially each instant the proper proportion of constituents is deposited to produce the desired deposited metal. Thus, with any set of constituents it is possible simply by varying the melting rate and/or the rate of travel of the electrode and/or the rate or rates of feed of the granules, pellets, wire, etc., to obtain deposited metals of widely different analysis.

The constituents of the desired deposited metal are supplied to the gap between the end of the electrode and the work, in their most economical forms. Thus, for instance, when the desired deposited metal is an iron alloy the electrode is made of mild steel or other equally cheap and readily available material. If the desired deposited metal includes chromium, the chromium constituent may be supplied as granular ferrochrome or similar chromium compound or alloy; maganese may be supplied as ferro-manganese; nickel as a metallic nickel wire, ribbon or pellets, etc.

It is an object of this invention to provide simple and inexpensive apparatus for depositing, under the influence of the flow of electric current through a gap between the end of an electrode and the work, metals of different composition, or metal of substantially constant composition but under different conditions of deposition, from a set of constituents whereby by varying the feed of any or all of the constituents the required proportions of the constituents to produce the desired deposited metal is substantially constantly deposited.

It is also an object of this invention to provide simple and inexpensive apparatus for depositing metal under the influence of the flow of electric current through a gap between the end of an electrode and the work, in which the constituents are fed to the gap in their most economical forms at controlled rates to substantially constantly

deposit the required proportions of the constituents to produce the desired metal.

It is a further object of this invention to provide simple and inexpensive apparatus for depositing metal under the influence of the flow of electric current through a gap between the end of an electrode and the work, in which a hollow electrode of comparatively cheap and readily available material that includes a constituent, or constituents, of the desired deposited metal is used and the remainder of the constituents required to produce the desired deposited metal are supplied to the gap separately, but through or partly through the hollow electrode at such rate or rates that there is substantially constantly deposited the desired metal; the said remainder of the constituents are also preferably materials in their most economical forms.

The further objects and advantages of the invention will be better appreciated from a consideration of the following description of preferred modes and apparatus for carrying it out in practice together with the accompanying drawings, in which,

Fig. 1 is a part sectional front view of one form of the apparatus of my invention,

Fig. 2 is a fragmentary view of the apparatus of Fig. 1, illustrating the manner of adding electrode sections during the metal depositing operation,

Fig. 3 is a view similar to Fig. 1, of a modified form of apparatus, illustrating the use of a plurality of electrodes, and

Fig. 4 is a view similar to Fig. 3, illustrating the use of a dead electrode.

The apparatus disclosed, as shown particularly in Fig. 1, includes a welding head 10 of the usual construction and arrangement mounted on a suitable support, not shown, so that it can be moved through a desired path relative to work 11. Work 11 may be mounted on an immovable support, also not shown, or it may be mounted on a support capable of movement in a predetermined path relative to welding head 10. Welding head 10 includes a current supply means, such as a welding current generator or a connection to a source of welding current, devices and arrangements for controlling the voltage and the amperage of the welding current, and an electrode feed motor that drives electrode feed wheel 12, together with the usual devices and arrangements for controlling the drive of the electrode feed motor. It is to be understood that welding head 10 includes all of the usual arrangements and devices which are required for satisfactory operation.

Electrode feed wheel 12 is backed by an idler wheel 13 which serves to maintain electrode 14 in contact with feed wheel 12. One side of the current generator, or current supply means, is connected through cable 15 to the work 11, the other side being connected through cable 16 to a contact device 17 that passes the electric current to welding electrode 14.

While as explained hereinafter, other than hollow electrodes may be used, the apparatus of Fig. 1 is particularly adapted to the use of hollow electrodes. Electrode 14, as shown, is made up of a plurality of sections of convenient length which are easily connected together during the operation to form an electrode 14 of indefinite length. In this manner, there is no need to discontinue the operation in order to replace consumed electrodes. Each length of electrode 14 is internally threaded at each end so that it may be connected to the last section in the apparatus by screwing onto threaded nipple 18. The sections of electrode 14 as shown, are of circular cross-section but any preferred cross-section such as, square, elliptical, and the like may be used as preferred. Also, while the sections of electrode 14 are shown as seamless, it is to be understood, that they need not have seamless walls but can be made of plate or sheet of proper thickness, shaped as desired, with the edges joined, or not as preferred. Electrode 14 is preferably bare but, if desired it may be coated externally or internally. When electrode 14 is externally coated, it is preferably provided with bare contact areas spaced along its length, and a contact device 17 is provided that is arranged to pass the welding current through the bare contact areas.

Above welding head 10 and in line with the path of electrode 14, is supported hopper 19, from which material is passed through the hollow electrode 14 to the gap between electrode 14 and work 11. Hopper 19 includes a cylindrical body 20 and a conical bottom 21 that is provided with an orifice 22. Orifice 22 may be used to meter the material on its way to electrode 14. In such case, orifice 22 is preferably adjustable to provide for variation in the rate of feed of the material. The material, which may be made up of one or more component materials, is passed to hopper 19 by means of one or more conveyor belts 23.

Conveyor belts 23 may be used as the metering means instead of or in conjunction with orifice 22. In such case, while conveyor belts 23 may be of any usual construction, they should be provided with means for moving them at a range of predetermined rates and also with means, such as knives 24, for maintaining a definite depth of material upon them. When the material is metered by belts 23, orifice 22 may be dispensed with, or made of such size that it will not impede the flow of material out of hopper 19. To prevent large-sized particles of the material from stopping the flow through hopper 19, a screen 25 of suitable mesh is provided adjacent the top of hopper 19.

In order to shut off the flow of material out of hopper 19, as for instance at the end of the operation or during an interruption thereof, a valve 26 is provided which is adapted to seat on orifice 22. Valve 26 is mounted at one end of an articulatable bar 27. The other end of bar 27 is connected to the armature of an electro-magnet 28 and to a spring 29. The arrangement is such, that the pull of spring 29 tends to seat valve 26 and electro-magnet 28, when its circuit is closed, unseats valve 26. The circuit of the electro-magnet 28 is opened and closed by manipulation of a button switch 30 located on the front of welding head 10. The arrangement may also be such that the circuit of magnet 28 is automatically opened and closed with the opening and closing of the welding circuit.

The material passes from orifice 22 into a cylindrical communicating member 31. Member 31 has its top united to the conical portion 21 of hopper 19 and surrounds the lower end thereof. Between the ends of member 31 is a diaphragm plate 32 that is provided with a central orifice 33. Windows or openings 55 are provided in the walls of member 31 above plate 32 to prevent changes in pressure in the space between the top of member 31 and plate 32 which pressure changes would effect the flow of the material. The top of plate 32 is provided with a conical recess to facilitate the passage of material to and through orifice 33.

Orifice 33 is larger than orifice 22 and is, of course, also larger than an orifice equivalent to belts 23, when belts 23 are used as the metering means, so that it will have no effect on the metering of the material. Orifice 33 may be closed to shut off the flow of material to the lower end of member 31 by a valve 34 provided for this purpose.

Valve 34 is mounted at one end of an articulatable bar 35. The other end of bar 35 is connected to a spring 36 and to the armature of an electro-magnet 37. Spring 36 exerts a pull tending to remove valve 34 from contact with orifice 33 and electro-magnet 37, when its circuit is closed, exerts a pull that overcomes the pull of spring 36 and seats valve 34 on orifice 33. The circuit of electro-magnet 37 includes a switch 38 that is mounted on a support member 39 adjacent the path of the electrode at a predetermined distance from feed wheel 12. Switch 38 may be of any preferred construction but should be such that it includes a spring pressed member that is adapted to bear against electrode 14 to open and maintain the circuit open when the end of electrode 14 is above it and to close the circuit and maintain it closed when electrode 14 is out of contact with said spring pressed member. A support member 40 is fixed a short distance above support member 39 and has mounted on it a switch 41 similar to switch 38. Switch 41 opens and closes the circuit of an alarm means such as bell 42 that is intended to warn the operator of the machine, of the approaching necessity of adding a section to electrode 14.

To the bottom of cylindrical communicating member 31 is hinged a funnel like member 43 whose spout 44 is adapted to extend into the upper end of electrode 14 to pass the material from communicating member 31 to the hollow center of electrode 14. Spout 44 is made of such a length that it will extend to a point approximately level with or preferably a short distance below the spring pressed member of switch 38.

During the operation of the apparatus, whenever the end of a section of electrode 14 passes switch 41, bell 42 will sound to warn the operator and call his attention to the fact that a new section must be added to electrode 14.

When electrode 14 passes switch 38, electromagnet 37 will pull valve 34 onto orifice 33 and thus shut off the flow of material to funnel member 43. When the end of electrode 14 passes the end of spout 44, the operator will grasp spout 44 and swing it out of position as shown in Fig. 2 and pass a new section of electrode 14 over spout 44. Spout 44 is then brought back to the normal position and the new section connected to the last section of electrode 14 by screwing the sections together on the threaded nipple 18. When the new section is swung back to the normal position and into contact with switches 38 and 41, the circuits controlled by switches 38 and 41 will again be opened, bell 42 will stop sounding and valve 34 will be pulled off orifice 33 to reestablish the flow of the material. It is to be noted that orifice 33 is large enough so that it will quickly allow the material accumulated during the shut-off period of valve 34 to pass the funnel member 43. Since the operation just described is an extremely simple one, it can be performed so quickly that there is in fact no substantial interruption in the flow of the material to the bottom of electrode 14. And thus the overall quantity of the material will be supplied to the deposited metal thereby maintaining the analysis uniform.

The apparatus shown in Fig. 3 includes the elements of the apparatus of Fig. 1, above described, and also electrodes 45 and 46, together with their feed means and current supply means. It is to be understood that while two electrodes 45 and 46 are mentioned, only one or more than two may be used. Electrode 45 is driven toward work 11 by electrode feed wheel 47 that is backed up by idler wheel 48. The motor for driving feed wheel 47, as well as the control arrangements therefore, not shown, are located in back of the panel of welding head 10'. The current supply means for electrode 45, not shown, which may be a welding current generator or a connection to an outside source of welding current, together with the usual control arrangements, are located in back of the panel of welding head 10'. A cable 49 connects the current supply means to contact means 50 that is adapted to pass the welding current to electrode 45. The other side of the current supply means for electrode 45 may be connected to the work by a separate cable, not shown, or it may be connected by cable 15. Electrode 46 is driven towards the work 11 by electrode feed wheel 51 that is backed up by idler wheel 52. The motor for driving feed wheel 51 as well as the control arrangements therefore, not shown, are located in back of the panel of welding head 10'. The current supply means for electrode 46, not shown, which may be a welding current generator or a connection to an outside source of welding current, together with the usual control arrangements are also located in back of the panel of welding head 10'. A cable 53 connects the current supply means to contact means 54 that is adapted to pass welding current to electrode 46. The other side of the current supply means for electrode 45 may be connected to the work by a separate cable, not shown, or it may be connected by cable 15.

As above stated, electrodes 14, 45, and 46 may be separately supplied with welding current or they may all be supplied from a single source. It is also within the scope of my invention to feed all of these electrodes from a single feed motor, by connecting all three of feed wheels 12, 47, and 51 through a suitable train of shafts and gears to the drive shaft of a single feed motor. The single feed motor may be controlled in accordance to the average characteristics of all three arcs or any one or the arcs may be used to effect the control. Also, the current and voltage control may also be effected in accordance with the average characteristics of all three arcs or any one of them.

Welding electrodes 14, 45, and 46 may be arranged on a line as shown or they may be arranged in any preferred manner, however, it is important that they be so closely spaced that all three of them deposit their metal in a single pool. Electrodes 45 and 46 may be of any preferred cross-section, they may be solid or hollow and they may be coated or bare. Electrodes 45 and 46 may be of the same analysis or of different analysis as required to produce the desired results.

The apparatus shown in Fig. 4 includes the elements of the apparatus in Fig. 1, above described, and also, provides means for feeding, what may best be called a dead electrode 56, to work 11. Dead electrode 56 is fed to work 11 by a feed wheel 57 that is backed up by an idler wheel 58. Dead electrode 56 is driven by a motor,

not shown, located in back of the panel of welding head 10''. The motor just mentioned may be controlled in any preferred manner to feed dead electrode 56 to work 11 at any desired rate. Dead electrode 56 may be solid or hollow and of any preferred cross-section and may be located in any position relative to electrode 14, however, it is important that it be located sufficiently close to electrode 14 that it will be fused by the heat generated by the flow of welding current through the gap between electrode 14 and work 11. Dead electrode 56 may be of any preferred analysis and while only one is shown any number desired may be used.

The feed motor for dead electrode 56 may be dispensed with if desired and feed wheel 57 driven from the motor that drives feed wheel 12. If this is done dead electrode 56 may be fed at the same rate as electrode 14 or by the use of any of the well known variable speed drive arrangements it may be fed at any preferred rate. The apparatus of Fig. 4 illustrates the use of a dead electrode, however, it is within the scope of this invention to combine the apparatus of Figs. 3 and 4 so that live electrodes, 45 and 46, as well as dead electrodes 56 may be used with the hollow electrode of Fig. 1.

The novel method of this invention is of general application and can be applied with success to the coating or veneering of metallic articles, as described in detail in my copending application above identified, as well as to the joining or seam welding of metallic articles by the usual arc welding methods as well as by the method disclosed in the patent to B. S. Robinoff et al., No. 1,782,316. The novel method is not limited to any particular metal or alloy but in view of the wide use of steel and corrosion resistant alloys in the fabrication of metallic articles, it will be disclosed in connection with the coating or veneering of steel with corrosion resistant alloys.

The article to be coated or veneered, work 11, is substantially horizontally positioned beneath welding head 10 with the point, where it is desired to start the first band of veneer 59, beneath the path of electrode 14. Electrode 14 is then fed to work 11 and a "gap starter" such as a ball of steel wool, a sliver of graphite, an iron nail, etc., interposed between and in contact with electrode 14 and work 11. A light frame 60 is placed around the area of work 11 to be covered by the first band of veneer 59. Frame 60 is then filled with flux 62 to form a blanket of substantial thickness on work 11 over and adjacent the situs of band 59.

Flux 62 may be any fusible compound, or mixture of fusible compounds, that do not produce an objectionable amount of gas under the influence of the discharge of the welding current through the gap between the end of electrode 14 and work 11 and do not substantially add any undesirable constituents to or remove any desirable constituents from the deposited molten metal. Silicates or the components of silicates in general are suitable particularly if they are dried or calcined or sintered prior to use. However, prefused silicates either neutral, basic or acid are sometimes preferred because of their pronounced non-gassing character. Manganese silicate, iron silicate, calcium silicate, aluminum silicate, glass and the like, both alone and in mixture have been found satisfactory. While flux 62 should be easily fusible its melting point should be high enough to assure that when molten it does not flow too readily but remains on, and in the immediate vicinity of, the molten metal to form a heat retaining and gas excluding blanket for the molten metal.

Flux 62 is preferably used in the granular form and while great variation is possible in the size of the flux particles, it is at present preferred to employ a flux the particles of which vary from powder size to ¼ of an inch and more. The blanket of flux 62 is preferably of a depth sufficient to "submerge the arc", i. e. prevent the visual and audible manifestations of an arc from being apparent, and present a substantially quiet top layer of flux. It is my present belief that when an arc is submerged it is not extinguished and that the welding heat is generated by the arc discharge rather than by the passage of the welding current through a pool of molten flux. However, as this application is a disclosure of fact, it is to be understood that I am not to be bound by any theory or hypothesis as to what takes place beneath the surface of the flux blanket 62. Flux blankets 62 varying in depth from one inch or less to six inches and more have been found satisfactory. To obtain band 59 with substantially straight edges strips 61 may be used. Strips 61 are located near the desired position of the edges of band 59 and enough space is allowed so that the molten metal does not contact strips 61. Strips 61 restrain the flow of the flux and thus restrain the molten metal.

After the blanket of flux 62 is positioned the various control arrangements are adjusted and set to maintain the predetermined voltage and amperage, which in turn maintains a predetermined melting rate of electrode 14 and rate of travel along work 11, as well as the predetermined rate of feed of the material from hopper 19 to and through hollow electrode 14. The welding current circuit is then closed. With the "submerged arc" extremely high energy values may be used, thus 75 k. w. and more may satisfactorily be used with electrodes of about ¼'' diameter. The initial flow of current takes place through the arc starter which upon being consumed leaves a gap between the end of electrode 14 and work 11. The current flow through the gap melts the surface of work 11, the end of electrode 14 and some of flux 62. Since the fluxes mentioned specifically above, and practically all known useful fluxes, are second degree conductors and hence have a substantial conductivity when molten, it may be that the molten flux forms all or a part of the current path between the end of electrode 14 and work 11. If such is the case, the gap will be filled with molten flux and the welding heat will result from the passage of the welding current through the molten flux. However, if such is not the case, and the probabilities are that it is not, the molten flux will form a bubble in which an arc is present that plays between the end of electrode 14 and work 11. As the passage of current continues the metal fused from electrode 14 and from work 11, as well as the metal that results from the material passing to the gap between the end of the electrode 14 and work 11 coalesces into a unitary molten pool.

After the initial passage of current work 11 or welding head 10, or both, are moved to cause the molten metal to deposit on work 11 in the form of a wide band 59. When the work 11 and electrode 14 move relative to each other the flux melted by the welding heat remains on and covers the molten metal. Because of the heat retaining capacity of flux 62 as well as the welding heat generated at the gap, the molten metal spreads

out into a wide band and thoroughly fuses with work 11. The operation is then allowed to continue until the full length or width, of work 11 is covered by band 59. It is of course to be understood that during the band depositing operation sections of electrode 14 are added as required in the manner previously described. The remainder of the bands 59 required to completely cover the surface of work 11 are then deposited. The procedure is the same except that only one strip 61 is used, on the side opposite to the already deposited band or bands 59, and the new bands 59 are so located that their contiguous edges overlap so as to assure a continuous and properly fused surface as well as proper fusion into work 11.

The band forming operation with the apparatus of Figs. 3 and 4 is substantially identical with that just described and a detailed description of the operation with each of these apparatus is not thought necessary.

The penetration of the veneer 59 into work 11, or as may be otherwise stated, the amount of metal of work 11 that finds its way into veneer 59, is an important factor in obtaining a veneer 59 of desired analysis. Penetration is affected by many factors among which may be mentioned, (1) rate of travel of the electrode relative to the work, (2) the current density and total energy dissipation at the gap between the electrode and the work, (3) the temperature of the work and (4) the position of the work with respect to the horizontal. In general a high rate of travel results in a higher penetration than a low rate. High current densities give higher penetration than lower current densities; the same effect is noticed if the current density per unit of metal area is maintained constant and the area of the electrode is changed, an electrode of small area will give a greater penetration than an electrode of larger area. For a given set of conditions the higher the temperature of the work, the greater the penetration obtained, thus the penetration may be increased by preheating the work. Also, for a given set of conditions the penetration may be varied by tilting the work relative to the horizontal. If the work is tilted so that the molten metal tends to flow down hill in back of the electrode the penetration is increased; if the work is tilted so that the molten metal tends to flow down hill ahead of the electrode the penetration is decreased. By controlling these factors almost any penetration desired may be obtained. In practice, penetrations ranging from 5 to 95% have been obtained, i. e. veneers have been deposited that extended from 95 to 5% below the original surface of the work.

Because of the number of factors involved and the variations of each factor possible, no attempt will be made to set forth the specific manner for obtaining any particular penetration. It is believed that the above explanation will enable any skilled worker in the art to attain any desirable penetration in the range set forth.

In veneering steel with corrosion resistant alloys ordinary mild steel pipe with a carbon content in the neighborhood of 0.03% or less is a preferred material for electrode 14. The chromium required is preferably supplied by using ferro-chrome as the material passed to the gap between electrode 14 and work 11 through electrode 14. Ferro-chrome of commerce usually contains, in round numbers 70% chromium and 30% iron and can be obtained with carbon contents ranging from 0.06% to 6.0%. When nickel in comparatively small quantities is required in the alloy it may also be supplied as material passed through hollow electrode 14. The nickel may be metallic nickel in granular or powder form or it may be some suitable nickel compound or alloy in the granular or powder form.

It should be evident to anyone skilled in the art that a wide range of chromium-iron and chromium-iron-nickel alloy veneers are possible with the materials above mentioned simply by varying the penetration, the electrode feed, and the feed of the material passed through the electrode. In depositing any particular veneer, as for instance a 16% chrome veneer with a maximum of 0.12 carbon a penetration which allows the desired results to be obtained is first determined. With the work 11 of 0.25 carbon steel a 40% penetration is satisfactory. This penetration will cause work 11 to supply 40 parts, based on 100 as the total parts, of the iron to the final alloy and .10 part of carbon. If a ferro-chrome of 0.06 carbon is chosen the 16 parts of chromium required will be supplied by 22.8 parts of ferro-chrome. This amount of ferro-chrome will supply 6.8 parts of iron to the final alloy and 0.013 part of carbon. If a mild steel of .02 carbon is used as electrode 14, the remaining 37.2 parts of iron required will be supplied by an equal number of parts of electrode 14. The electrode 14 will in this case add .006 part of carbon to the alloy. Thus, the final veneer will contain the 16% chromium required and will have a carbon content of 0.119%. This analysis will be obtained by so adjusting and controlling the operation that 37.2 lbs. of electrode 14, and 22.8 lbs. of ferro-chrome are alloyed with 40 lbs. of the metal of work 11 fused by the current discharge. It is to be noted here that there is a loss of constituents during the operation due to the absorption by the flux and other causes so that in order to obtain the results indicated it will be necessary to increase the quantities above the values given to take care of the losses. It is sometimes desirable to add some of the alloying constituents through flux 62 by incorporating them in flux 62. In such cases the quantity of the materials fed to the gap will be modified accordingly.

With the materials specifically disclosed above a wide change in analysis of alloy is possible. Thus, the carbon content of the alloy may be reduced materially by using lower penetrations. The chromium content may be varied by changing the relative rate of feed of the ferro-chrome and melting rate of the electrode. By choosing the proper rates of feed and the proper penetration, chromium alloys may be deposited with .06 carbon and less and also with 26% chromium and more.

In carrying out the novel method of this application, hollow electrode 14 may in general, be made up preponderantly of the metal that forms the base of the alloy of the veneer and the material fed through the hollow electrode 14 will be made up of materials that predominate in the alloying constituents of the veneer. However, cases will arise when this will be departed from, thus in depositing a high nickel, nickel-chrome-iron alloy, the penetration chosen may be such that the base metal will supply the major proportion of the iron required. In such case it would be preferable to make the hollow electrode of pure nickel or some suitable nickel alloy. Thus, in interpreting this disclosure it is to be remembered that it contemplates the use of the materials for electrodes and feed material through

the electrode 14 best suited to give the desired results.

In using the apparatus of Figs. 3 and 4 the method above described is also carried out, however with these apparatus further variations of the method are possible. Thus, if it is desired to deposit an alloy having alloying constituents in minor proportions as, for instance, a 4–6 chrome steel, a portion of the steel required may be supplied through electrodes 45 and/or 46 and/or dead electrode 56. These apparatus are also suited to the cases where cheap metal is available having a composition not very much different from the desired alloy. In the latter cases all or some of the electrodes may be made of the available material and the rest of the constituents required for the desired alloy fed through the hollow electrode.

I claim:

1. In apparatus for depositing metal under the influence of the flow of electric current through a gap between the end of an electrode and the work, in combination, a hollow electrode, means for feeding said hollow electrode at a controllable predetermined rate to the work, electric current supply means connected to the electrode and to the work, a hollow member adapted to extend into said hollow electrode, material metering means in communication with said hollow member adapted to pass material to said hollow member at a predetermined rate, and means for shutting off at will communication between said metering means and said hollow member, said shutting off means being arranged to accommodate the material metered during the period that said hollow member and said metering means are out of communication and to release said accumulated material to said hollow member at a rapid rate when communication is again established.

2. In apparatus for depositing metal under the influence of the flow of electric current through a gap between the end of an electrode and the work, in combination, a hollow electrode including a plurality of connectable sections, means for feeding said hollow electrode at a controllable rate to the work, electric current supply means connected to the electrode and to the work, a hollow member adapted to extend into the top end of said electrode on its way to the work, a material metering device, and a hollow communicating member attached to said metering device, said communicating member having said hollow member hingedly connected thereto whereby said hollow member may be swung out of the path of the electrode for the addition of new sections to the electrode as needed, said communicating member including an operatable shutoff device adapted to cut off the flow of material from said metering device to said hollow member during the addition of electrode sections and to pass the material accumulated during the shutoff period at a rapid rate to said hollow member when communication is again established between said hollow member and said metering device.

3. In apparatus for depositing metal under the influence of the flow of electric current through a gap between the end of an electrode and the work, in combination, a hollow electrode, including a plurality of connectable sections, means for feeding said hollow electrode at a controllable rate to the work, electric current supply means connected to the electrode and to the work, a hollow member adapted to extend into the top end of said electrode on its way to the work, a material metering device, and a hollow communicating member attached to said metering device, said communicating member having said hollow member hingedly connected thereto whereby said hollow member may be swung out of the path of the electrode for the addition of new sections to the electrode as needed, said communicating member including an operatable shutoff device adapted to cut off the flow of material from said metering device to said hollow member during the addition of electrode sections and to pass the material accumulated during the shutoff period at a rapid rate to said hollow member when communication is again established between said hollow member and said metering device, said communicating member having pressure equalizing apertures therein to prevent changes in the metering and the flow of said material due to changes of pressure in said communicating member and in said hollow member.

4. In apparatus for depositing metal under the influence of the flow of electric current through a gap between the end of an electrode and the work in combination, a hollow electrode, means for feeding said hollow electrode to the work at a controllable predetermined rate, current supply means connected to said electrode and to the work, a communicating member, metering means controlling the passage of material to said member, operatable means for stopping the passage of the material to said communicating member, a hollow member adapted to extend into the end of said electrode on its way to the work, said member being in communication with said communicating member and being adapted to pass material from said communicating member to said gap through said hollow electrode, operatable means in said communicating member for stopping passage of material to said hollow member, said second mentioned operatable means being arranged to accumulate the material passing to it during the stoppage of communication between the communicating member and the hollow member and to pass said material to the hollow member upon reestablishment of communication, said hollow member being connected to said communicating member the connection being such that said hollow member may be swung out of and into the path of the electrode for the addition of electrode sections.

5. In apparatus for depositing metal under the influence of the flow of electric current through a gap between the end of an electrode and the work in combination, a hollow electrode, means for feeding said hollow electrode to the work at a controllable predetermined rate, current supply means connected to said electrode and to the work, a communicating member, metering means controlling the passage of material to said member, operatable means for interrupting at will the passage of material to said communicating member, a hollow member having one end in communication with said communicating member and the other end extending into said hollow electrode on its way to the work, said hollow member being arranged to be swung out of and into the path of the electrode to allow addition of electrode sections as required, a second operatable means for interrupting the passage of material to said hollow member, and means including means positioned at a point a predetermined distance from said other end of said hollow member adapted to operate said second operatable means to close communication when the end of the electrode passes said point and to operate said

econd operatable means to open communication hen the end of the electrode again extends pos-eriorly of said point.

6. In apparatus for depositing metal under the ıfluence of the flow of electric current through gap between the end of an electrode and the ork, in combination a hollow electrode made up f connectable sections, an electrode feed means, lectric current supply means connected to the lectrode and to the work for passing electric urrent through said gap, material supply means, movable hollow member in communication with ıid supply means and adapted to extend into ıid hollow electrode to feed material thereto for assage to said gap, said hollow member being ıovable away from said electrode for placing of lectrode sections thereon and being movable into ne with said electrode for connection of sections ıereto.

7. In an apparatus for depositing metal under ıe influence of electric current discharge ırough a gap between an electrode and the work, ıe combination with an electrode having a pas-ıgeway, means for continuously feeding said lectrode to the gap, electric current supply ıeans connected to the electrode and the work, separate metal supply means, means for feed-ıg metal from the metal supply means to the assageway in the electrode, means for inter-ıpting the supply of metal to the electrode with-ıt varying the ultimate metal supplied to the ap.

8. In an apparatus for depositing metal under ıe influence of electric current discharge ırough a gap between an electrode and the work, ıe combination with an electrode having a pas-ıgeway, means for continuously feeding said ectrode to the gap, electric current supply means ınnected to the electrode and the work, a sepa-ıte metal supply means, means for feeding metal om the metal supply means to the passageway in ıe electrode, means for interrupting the supply metal to the electrode, including a reservoir r accumulating metal supplied during the inter-ıption period, said interrupting means adapted supply metal from the supply means and ac-ımulated metal without varying the ultimate etal supplied to the gap.

9. In an apparatus for depositing metal under ıe influence of electric current discharge ırough a gap between an electrode and the work, ıe combination with an electrode having a pas-ıgeway, means for continuously feeding said ectrode to the gap, electric current supply means ınnected to the electrode and the work, a sepa-ıte metal supply means, and means for inter-ittently feeding metal from the separate metal ıpply means to the gap.

10. In an apparatus for depositing metal under e influence of electric current discharged rough gaps between a plurality of electrodes ıd the work, including in combination a plural-ity of electrodes positioned substantially transversely to the direction of relative movement of the electrodes and the work, one of said electrodes providing a passageway, a separate metal supply means, and means for controlling the feed of metal from the separate metal supply to the electrode having said passageway.

11. In an apparatus for depositing metal under the influence of electric current discharge through gaps between a plurality of electrodes and the work, including in combination a plurality of solid electrodes and one electrode having a passageway, a separate metal supply means, and means for separately controlling the feed of said solid electrodes and the metal feed from said separate metal supply, and means for supplying current to said electrode.

12. In an apparatus for depositing metal under the influence of an electric current discharge through a gap between an electrode and a workpiece, including in combination, a conduit having a substantially unbroken periphery, said conduit being in the form of a consumable metal electrode, means for feeding said electrode to the gap, current supply means contacting said electrode and the workpiece for passing current through said gap to fuse the electrode, metal supply means, and separate means for feeding metal in said supply to said conduit to be directed thereby to the gap to be fused with the metal of the electrode.

13. In an apparatus for depositing metal under the influence of an electric current discharge through a gap, submerged beneath a blanket of protective flux, between an electrode and a workpiece, including in combination, a fusible metal pipe electrode of substantially unbroken periphery, means for feeding said electrode to the gap, current supply means contacting said electrode and the workpiece for passing current through said gap to fuse the electrode, a supply of metal in particle form, controllable means for feeding said metal in said supply to said electrode for conveyance therethrough without substantial loss to the gap beneath said flux to be fused thereat with the metal of the electrode.

14. In an apparatus for depositing metal under the influence of an electric current discharge through a gap between an electrode and a workpiece, including in combination, a conduit having a substantially unbroken periphery in the form of a consumable metal electrode, means for feeding said electrode to the gap at a controllable rate, current supply means contacting said electrode and the workpiece for passing current through said gap to fuse the electrode, metal supply means, and separate means for feeding metal in said supply to said conduit to be directed thereby to the gap to be fused with the metal of the electrode, said separate means for feeding said metal being controllable to effect a rate of feed of the metal independent of the rate of feed of the electrode.

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