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METAL COATING DEVICE

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My invention relates to improved methods of coating surfaces with metal and particularly to the coating of elongated metal objects having extensive metal surfaces such as those of tubes, bars, strips or sheets for the purpose of imparting desirable surface characteristics thereto.

The method of applying metal coatings by spraying the coating metal in a molten or semi-molten condition has long been known. However, the present methods are costly, the rate at which the coating can be applied is extremely low and the metals that can be employed are quite limited. Furthermore, the coatings are merely mechanically bonded to the base, are porous, and the metal or alloy deposited is always oxidized to a greater or less degree.

Thus, one of the most widely used methods requires that the metal or alloy to be sprayed be in the form of wire which is fed into an oxy-acetylene flame or an electric arc where it is melted and thereafter projected on to the base in the form of molten or semi-molten particles by means of an air blast. Many metals and alloys which can be melted easily, cannot be used in a spray gun of this type because they cannot be drawn into wire. The cost of melting metal in this way is very high, and any metal or alloy in the form of wire is comparatively expensive due to the costs of drawing. High costs are also encountered where the metal must be reduced to powder form before it can be sprayed.

It has been proposed to premelt a small volume of the metal to be sprayed and then to disperse it from such a molten mass, but, so far as I am aware, this last mentioned method is limited for many reasons to the dispersion of metals and alloys having melting points of less than about 600° F. While there are many difficulties encountered in dispersing high melting point metals and alloys from a premelted mass, one of the principal difficulties is the impossibility, by present methods, of pouring the metal from a comparatively large molten mass at a rate slow enough to permit dispersion without having the metal freeze in the nozzle. Thus, by present methods it is quite impossible to withdraw high melting point metals from a molten mass thereof at a rate which is fast enough to prevent its freezing and at the same time to maintain the rate of flow so low that the molten metal can be dispersed.

One of the objects of my invention is to provide an improved means and method for substantially, continuously applying a metal coating to a sheet, strip, bar, tube or the like.

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Another object is to provide a means and method whereby the metal forming the coating to be applied can be utilized in the form of scrap, grindings, chips or in any other form conveniently available. Another object is to provide a means and method whereby a substantially continuous stream of molten metal of a comparatively small cross-sectional area can be provided for dispersion purposes without danger of freezing. Another object is to provide a means and method of procedure whereby a coating of one metal may be applied to the surface of another metal and a substantially welded bond obtained between the coating and the base metal to which it is applied. With these objects in view my invention includes the steps described below and the novel elements and arrangements thereof described in connection with the accompanying drawing in which—

Fig. 1 is a diagrammatic side elevation view with certain parts shown in section of an arrangement of apparatus which may be used to perform my process;

Fig. 2 is a vertical cross-section view of a heater through which the molten metal is passed to the dispersion chamber;

Fig. 3 is a transverse cross-section through a modified form of dispersion chamber;

Fig. 4 is a section of Fig. 3 in the plane 4—4;

Fig. 5 is a fragmentary elevation view of a pair of rolls adjacent the dispersion chamber; and

Fig. 6 is a plan view of a heating element.

In general it may be said that I accomplish the objects of my invention by forming a pool or reservoir containing a substantial volume of molten metal which is maintained molten so long as the process is continued and to which additional metal is added from time to time to maintain the necessary volume of molten metal at hand. Molten metal may be poured from such a pool at a substantial rate but it cannot be poured therefrom, without freezing, at a rate which would be sufficiently slow to permit dispersal thereof in a thin coating on a strip of base metal because of the comparatively small area to be covered and the excessively high rate at which the strip would have to be moved through the dispersion area. On the other hand, the metal can be maintained molten for an indefinite period in the pool.

I propose to withdraw molten metal from such a pool in comparatively small volumes but at a comparatively high rate, such as by pouring directly into a ladle, and then to transfer these small volumes to a smaller, funnel-like heater

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having a discharge orifice of small cross-sectional area in the bottom thereof so that the flow of metal therethrough will be at a comparatively low rate and yet will not freeze because it is possible to maintain the small volume of metal in this second heater at some degree of superheat, if necessary, and to maintain the discharge orifice open by the application of heat to the walls forming said orifice or, by induction, to the metal passing therethrough. In this way, I am enabled to discharge the molten metal from the secondary heater at such a comparatively low and substantially controlled rate of flow that it can be dispersed by a gas blast at a rate which is practicable. Such rate, is substantially higher than the rate at which the metal is dispersed from the present type of spray guns but, on the other hand, is sufficiently low to make it practicable to apply a comparatively thin layer or coating of metal to an object passing through the dispersion area at a reasonable rate of travel.

In the drawings 1 is an electric furnace preferably of the tilting type mounted on rollers 2 and having a spout 3 through which the molten metal is discharged. 4 is a door through which additional metal may be introduced into the furnace for melting. If necessary two or more of these furnaces may be employed to maintain a pool of molten metal of the required aggregate volume. 5 is a secondary heater preferably of the high frequency induction type but which may be of the electrical resistance heating type. It comprises an inner crucible 6 of highly refractory material surrounded by layers 7 and 8 of insulating material and around which is the water cooled helical tube 9 forming the primary coil of the heater. The bottom of the crucible 6 is provided with a central opening which is closed by removable refractory plug 10 having a vertical passage 11. The size of the passage determines the rate at which the molten metal flows from the heater to the dispersion chamber. Ordinarily this passage will be circular and from about $\frac{1}{8}$ to $\frac{1}{4}$ of an inch in diameter, or of other geometrical configuration of equivalent cross-sectional area, which will permit a minimum discharge of molten metal at the rate of about five to seven pounds per minute, but may, of course, be increased to any size required; the minimum size being influenced by the surface tension and fluidity of the particular metal being dispersed. A rate of five pounds per minute is considerably higher than the rate of dispersion from an ordinary spray gun which is only about twenty pounds per hour. The crucible 6 is mounted upon a suitable refractory support 12 which surrounds and is spaced from the plug 10. Within this space and surrounding the plug 10 is a sintered silicon carbide or graphite electrical heating element 13 which functions as an electric valve. When the heating element 13 is in operation any metal in the passage 11 will be maintained in molten condition thus providing free flow through the passage. On the other hand, if for any reason it becomes necessary to stop operations, electrical energy in the heating element 13 and coil 9 may be shut off and the metal permitted to freeze. When operations are to be started, coil 9 may be first energized, and after the metal in the crucible has melted, the heating element 13 may be energized to melt the metal in the passage through plug 10.

The secondary heater 5 is mounted on the roof or top 14 of the dispersion chamber over opening 15. Preferably somewhat below the bottom of

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the plug 10 is an annular casting 16 provided with a central passage 17 coaxial with the passage 11 through which the molten metal falls. The casting 16 is cored out as shown at 18 to form an annular space into which gas under pressure is introduced through the opening 19. At the bottom, the casting is provided with an annular passage 20 which is inclined inwardly and downwardly toward the axis of the casting and through which gas at high temperature and under substantial pressure is discharged against the descending stream of metal to effect a dispersal thereof into the dispersion chamber. The dispersion chamber is merely an elongated box formed of refractory material having horizontally elongated slots 21 and 22 in the opposite ends thereof through which the strip of metal 23 to be coated is moved. The metal strip 23 moves in the direction of arrow 24 from a suitable source, not shown, into the pinch rolls 25, the upper one of which may be knurled to effect a roughening of the top surface of the strip. After leaving the pinch rolls the strip passes through the high frequency induction heater 26 where it is preferably heated to a temperature of the order of 400° to 2000° F., depending on the kind of metal or alloy in the strip, which favorably effects the bonding of the dispersed metal thereto.

The surface of the strip or other object to be coated should be free of scale and may be pretreated in a variety of ways before entering the dispersion chamber. Thus, it may be cleaned by any of the methods well known to manufacturers, such as pickling by means of an acid or salt, or by purely mechanical operations such as by grit blasting, and it may be roughened by knurling, as pointed out above. Another pretreatment which has been found suitable is to form a light film of oxide on the strip before it enters the furnace. I do not mean an oxide scale of the ordinary type but a film of such thinness that the metallic sheen of the metal beneath will be visible therethrough. Such an oxide film is easily produced and may be produced on ordinary steel strip by merely heating it for a very brief interval to 1400° F., in a slightly oxidizing atmosphere as in passing through the induction heater 26, or by heating the chemically cleaned strip in an atmosphere of natural gas at about the same temperature. When the dispersed metal falls on a surface having such an oxide coating a bond is formed between the dispersed and base metal, which, if examined under a microscope, has the appearance of a fully welded union. As long as the bond obtained gives good adherence for deep drawing and forming purposes, it is immaterial whether the surface line of bonding is 100% metal to metal or less.

Within the dispersion chamber the strip may be supported on a series of rolls 27 within the zone where it is subjected to the blast of molten metal. Upon leaving the chamber the strip passes between the pinch rolls 28 and may be coiled as shown at 29. The strip may be afterwards hot or cold rolled, or it may be rolled immediately after leaving the dispersion chamber by passing through the rolls 30, as shown in Fig. 5. In the latter case, if hot rolling is desired, the dispersion chamber may be provided with an induction heater 31 near the outlet end thereof. This to insure that the bonding by dispersion will be accomplished as well as heating the strip to the desired temperature for hot rolling when it encounters the rolls 30.

Where strips wider than the area covered by

one dispersion nozzle are to be coated, two or more nozzles may be employed as shown in Figs. 3 and 4. Here the crucible 6 is preferably mounted above and at one side of the path of the strip 32 which is supported on rollers 33 within the zone of metal deposition. Molten metal flowing from crucible 6 is first deposited in the refractory basin 35 and flows therefrom by gravity in an open channel 36 to the dispersing nozzles, three of which are shown at 37, 38 and 39. In order to maintain the metal molten in the channel 36 electrical resistance heating elements 40 may be connected in series and supported in spaced relation just above the channel 36 as shown in Figs. 3 and 4. To drain the basin 35 when operations are stopped I provide an opening in the bottom which can be plugged with clay or other refractory material 42.

The dispersion chamber in all cases should be heated before starting and during operations by one or more burners (not shown), and the atmosphere therein preferably maintained as a reducing atmosphere.

In order to disperse the metal some gas under rather substantial pressure must be employed. Air, for example, may be used with no greater oxidation of the metal than occurs in any of the present types of sprayers. However, I prefer to use a reducing gas or, otherwise, superheated steam which can be readily produced in substantial quantities at almost any pressure and temperature desired. I am well aware of the effect of ordinary steam on molten iron but I find that superheated steam produces very little oxidation of the metal and is a very desirable medium. I may also use oxygen under high pressure to disperse the molten metal where the effect of the oxygen on the stream of hot metal is not detrimental to its subsequent properties. With alloys of certain composition the oxygen may in fact increase the temperature of the metal being dispersed, and in some cases even change its chemical composition so that higher carbon scrap may be utilized for the initial melting operation. This, in certain cases, is not only an advantage but results in a definite saving in cost.

From the foregoing it will be apparent that my process is very economical. Instead of using metal in any specially fabricated form, such as wire or powder, I can utilize scrap of any metal or alloy and in any form. By maintaining the molten metal in the furnace 1 at a suitable degree of superheat, additions of scrap thereto from time to time will be rapidly and cheaply melted and a supply of metal in a fluent molten condition is always available.

If necessary, or desirable, a battery of furnaces similar to furnace 1 may be employed to maintain at all times a pool of molten metal of sufficient volume to keep heater 5 supplied; the metal from the furnaces being poured into ladle 43, and from ladle 43 into heater 5, as shown in Fig. 1.

No melting is done in the secondary heater except under circumstances already mentioned. Here, the metal is merely maintained in a highly fluent molten condition by the application of heat thereto through means which is easily controlled. The plug 10 can be readily replaced when worn to the extent that the discharge therethrough is in excess of that which can be properly dispersed, and, by heating the comparatively short plug, high melting point metals and alloys which are prone to freeze quickly, especially when poured at a slow rate, can be maintained highly

fluent in the comparatively attenuated passage through the plug. Thus, while the strip or other object to be coated must be moved quite rapidly through the zone of metal deposition, the rate of travel, which depends on the thickness of the coating to be deposited, is not so excessively high as to be impracticable even where only two to three thousandths of an inch are to be applied.

The molten metal leaves the plug as a substantially free-falling stream until it is struck by the dispersing blast of gas and hence there is no rapid abrasive wear on the end of the nozzle due to contact with the high temperature molten metal moving at high velocity.

By the term "ferrous metal" as used herein I mean to include only iron, and the alloys thereof in which the iron content is substantially in excess of 50%, by weight.

What I claim is:

1. In a device for depositing molten metal at a controlled and comparatively slow rate, the combination with refractory container adapted to contain said molten metal, of means for heating the metal in said container and maintaining it therein in a fluent, molten condition, a refractory element defining an attenuated passage communicating with the lower interior portion of said container and through which molten metal from said container may flow by gravity, and means for controlling the outflow of metal from said container through said passage comprising means for heating the metal in said passage by the action of electric current.

2. In a device for depositing molten metal at a controlled and comparatively slow rate, the combination with refractory container adapted to contain said molten metal, of means for heating the metal in said container and maintaining it therein in a fluent, molten condition comprising means for inducing high frequency electric currents in said metal, a refractory element defining an attenuated passage communicating with the lower interior portion of said container and through which molten metal from said container may flow by gravity, and an electrical resistance heating element disposed in heat transfer relation to said passage for preventing the metal in said passage from freezing.

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