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VERTICAL INTERFACE MOLTEN ALUMINIZING BATH COATING PROCESS

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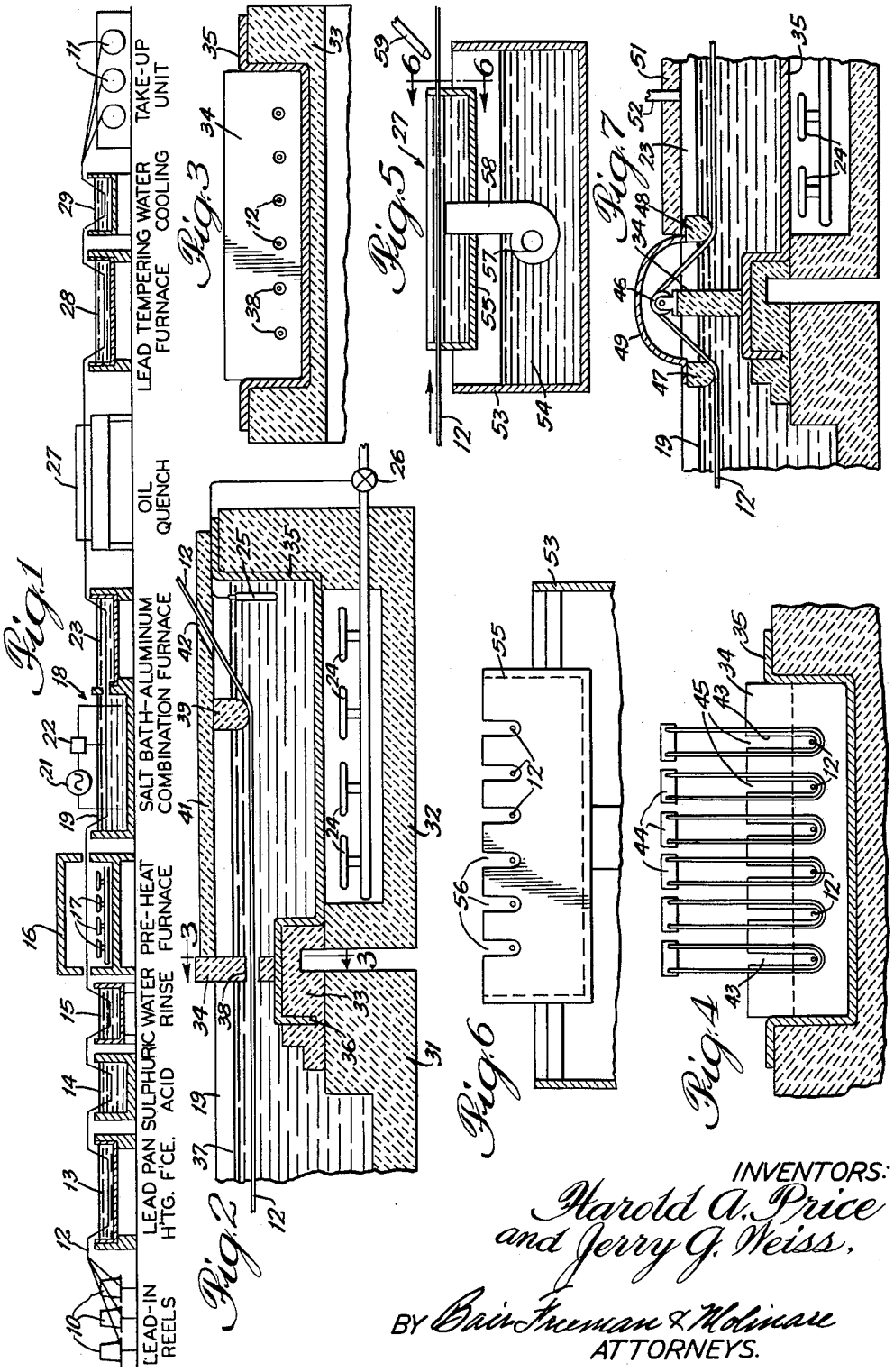


Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig. 7

INVENTORS:
Harold A. Price
and Jerry G. Weiss,

BY Brin Freeman & Molinare
ATTORNEYS.

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VERTICAL INTERFACE MOLTEN ALUMINIZING BATH COATING PROCESS

Harold A. Price, Lafayette, Calif., and Jerry G. Weiss, Peoria, Ill., assignors, by mesne assignments, to American Mollerizing Corporation, Los Angeles County, Calif., a corporation of Nevada

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This invention relates to apparatus for aluminizing metal strips and more particularly to apparatus for continuously coating elongated metal strips or wires with aluminum.

In aluminizing metal and particularly ferrous metal parts, it has been customary either to float a body of molten salt on a body of molten aluminum or by utilizing a heavy salt to float the molten aluminum on the molten salt and to pass the strips or articles to be aluminized first through the salt and then directly into and through the aluminum. In such products the article is heated and fluxed in the salt and enters the alumium in a heated and cleaned condition so that it will be coated rapidly and effectively.

One serious difficulty encountered in such processes is that dross such as oxides and reaction products of the base metal or of carbon particles thereon with the salt or aluminum, tend to collect at the interface between the salt and aluminum As the article passes from the salt into the aluminum through this interface, it tends to pick up particles of the dross which adhere to the surface thereof and prevent complete coating of the article by the aluminum. Additionally, many of the dross particles are extremely hard and when the article is treated after coating as, for example, by further drawing or rolling wire or strip such particles are pressed into the body of the article and damage or weaken it.

It is accordingly one of the objects of the present invention to provide apparatus for aluminizing metal strips in which movement of the strip through an interface between baths of salt and aluminum is entirely eliminated.

According to a feature of the invention, separate salt and aluminum baths are arranged end-to-end and a strip to be coated passes first through the salt bath and is then immersed through the aluminum bath above the bottom thereof without an opportunity for intermediate cooling or oxidation. In a preferred construction the baths are separated by a partition formed with openings therein below the levels of the baths through which the strip passes.

A further object is to provide apparatus for aluminizing metal strips in which the pressure head above the openings is higher on the aluminum bath side than on the salt bath side to counteract the tendency of the traveling strip to drag salt through the opening.

A still further object is to provide apparatus for aluminizing metal strips in which the strip is liquid quenched promptly after emerging from the aluminum bath by being passed horizontally through a horizontally elongated trough formed with openings at its ends to receive the strip and through which a quenching liquid is continuously circulated to overflow through the openings and submerge the strip.

The above and other objects and features of the invention will be more readily apparent from the following description when read in connection with the accompanying drawing, in which:

FIGURE 1 is a diagrammatic view with parts illustrated in section of a complete apparatus for aluminizing a continuous metal strip, such as a wire;

FIGURE 2 is an enlarged partial section of the salt bath aluminum combination furnace;

FIGURE 3 is a partial section on the line 3—3 of FIGURE 2;

FIGURE 4 is a view similar to FIGURE 3 showing an alternative construction;

FIGURE 5 is an enlarged sectional view of the oil quench bath;

FIGURE 6 is a partial transverse section on the line 6—6 of FIGURE 5; and

FIGURE 7 is a partial section similar to FIGURE 2 of an alternative construction.

The process of our invention for coating metal material comprises passing the metal through a molten heating medium, in horizontal fashion, to heat the metal, then passing the metal through a substantially vertical interface formed by the molten heating medium, and a molten coating metal, and after passing through the coating metal, quenching the metal. The coating metal is preferably aluminum, and the molten heating medium is preferably salt.

Apparatus for effecting this process is described below.

In the completed apparatus, as shown in FIGURE 1, one or more strips of wire or the like to be aluminized are led off supply reels **10** continuously through the apparatus to take-up reels **11** on which the aluminized wire or strip is stored. The term "strip" as used herein, and in the claims, includes wire and sheet, as well as other continuous forms of material. As shown, the wire or strip indicated at **12** is led first through a molten lead bath **13** in which the wire is heated to relieve strains therein imposed by the drawing, rolling or other cold working operations. From the lead bath the heated wire is guided through a cleaning bath **14** containing an acid or a cleaning salt which will clean the surface of the wire, removing lubricant and exposed carbon particles therefrom. The wire is then guided through a water rinse **15** which rinses the acid therefrom leaving the surface of the wire in a clean condition.

From the water rinse the wire is conducted through a preheating furnace **16**. As shown, the preheating furnace may comprise a relatively enclosed chamber in which gas burners **17** are mounted and through which the wire or strip is continuously conducted. The use of fuel burners in the preheat furnace maintains a non-oxidizing atmosphere in the furnace so that oxidation of the wire will be minimized. It will be understood, however, that the furnace could be heated electrically or in any other indirect manner and a separate non-oxidizing atmosphere could be supplied thereto. The furnace brings the wire or strip up to a temperature in the range of 600° F. to 900° F. to eliminate the thermal shock which would otherwise result when the wire or strip enters the salt bath and also to eliminate encrustment of the salt which tends to form on a cold part entering the bath.

From the preheat furnace the wire or strip is led directly with minimum opportunity for intermediate cooling into a combination salt bath and aluminum furnace, indicated generally at **18**. This unit is diagrammatically shown in FIGURE 1 and includes a first bath section **19** containing molten salt which is preferably composed of metal chlorides, such as barium chloride, sodium chloride, and the like, as conventionally employed in salt baths used in various metal processing. The mixture of salt may be such that it is heavier than the aluminum or lighter than the aluminum or of approximately the same density, as desired. As shown, the salt is heated by immersing electrodes therein which are connected to a current source **21** and the temperature of the salt is controlled by a conventional temperature controller **22** to maintain the salt at a temperature in the range of 1400° F. to 1600° F.

At the other end of the combination unit in side-by-side relationship with the salt bath is an aluminum bath **23** containing a body of molten aluminum. The alumi-

num is separately heated in any desired manner as, for example, by gas burners 24 shown in FIGURE 2 and the temperature thereof may be controlled by a bulb 25 immersed in the aluminum and controlling a valve 26 for the fuel supply.

After leaving the aluminum bath, the wire or strip is liquid quenched to cool it below the melting point of the aluminum so that alloying action of the aluminum with the metal of the wire or strip will be stopped and a continuous bright coating will be left. For this purpose, as shown, the wire or strip is led horizontally through an oil quench 27 through which the strip passes in a straight horizontal line in a manner more particularly described hereinafter. It is desirable that the strip be led through the quench without bending it since it is relatively brittle at this point and would break relatively easily if subjected to sharp bending.

From the oil quench the strip is led through a lead tempering furnace 28 in which it is heated to a temperature of about 800° F. to 900° F. to temper the wire and to relieve brittleness therein. It will be noted that this temperature is below the melting point of the aluminum so that the coating will not be affected by the tempering step. For low carbon wire as used, for example, in fencing and for other decorative uses, the tempering step may be omitted since wire of this type does not tend to become brittle when quenched. From the tempering furnace the wire or strip is led through a water cooling tank 29 to cool it to approximately room temperature and is then wound on the take-up reels 11.

The combination salt bath aluminum furnace is constructed as more particularly shown in FIGURES 2 and 3. As illustrated in these figures, the salt bath 19 is formed of a ceramic body 31 and is preferably in the form of an elongated relatively narrow tank which is lower at one end than at its opposite end and at its sides, as shown in FIGURE 2. The aluminum bath is formed similarly by a ceramic body 32 which is lower at the end adjacent the salt bath than its opposite end and at its sides. Where the aluminum and salt baths join they are connected by a ceramic block 33 below the normal level in the baths and which supports a separating wall or partition 34 formed of ceramic or refractory material, such as tile, to maintain the salt and aluminum separated.

The aluminum in the aluminum bath is held in a metal pot or container 35 which may be formed of iron or steel since the temperature of the aluminum is maintained below the temperature at which it will alloy with the iron or steel. Preferably the temperature of the aluminum is maintained at about 1200° F., but in any event below the temperature at which the aluminum will alloy with the material to be coated or with the material of the pot 35. The pot 35 is supported by projecting flanges at its upper edges resting on top of the walls of the ceramic furnace body 32 and at the end adjacent to the salt furnace extends to the ceramic block 33 and may be secured thereto by a downwardly projecting flange 36 entering a slot in the ceramic block. The partition wall 34 rests on top of the projecting lower level flange of the pot 35 and spans it completely to prevent intermixing of the salt and aluminum.

The wire 12, as shown in FIGURE 2, is led through the salt bath at an elevation below the level of the salt therein, as indicated at 37. To conduct the wire or strip into the aluminum bath the partition wall 34 is formed with one or more openings 38 therein at a level below the levels of both the salt and aluminum baths and of a size loosely to receive the wire or strip passing therethrough. In this way, the wire or strip is conducted immediately from the salt bath into the molten aluminum without passing through a horizontal interface between the salt and the aluminum and without any opportunity for cooling of the wire or strip or for oxidation thereof. The wire or strip passes horizontally through the aluminum below the top level thereof and beneath the guide bar 39 and then angles upward over the end of the aluminum furnace.

In the operation of the unit as so far described movement of the wire or strip through the salt and through the opening 18 into the aluminum has a tendency to drag or carry a certain amount of salt from the salt bath into the aluminum bath. Unless this quantity becomes excessive, it is not serious since the salt will either sink to the bottom of the aluminum bath from which it may be removed periodically or will rise to the top of the aluminum bath and can be removed periodically. Also any dross carried by the wire or strip into the aluminum bath will either sink to the bottom or rise to the top and may be removed. It is desirable, however, to minimize the drag-through of salt and for this purpose the aluminum is maintained at a level such that it will provide a higher liquid head above the openings 38 than will the molten salt. In case the salt utilized is heavier than aluminum the aluminum level will be maintained higher than the salt level, as shown in FIGURE 2. When a lighter salt is used, the aluminum level may be the same as or even lower than the salt level but will, in any case, create a higher liquid head on the openings than does the salt. The exact difference in the level required to balance the drag-through effect will vary with the size and nature of the wire or strip but can easily be determined by experimentation so that the drag-through will be minimized.

Preferably also the aluminum bath is covered to minimize oxidation of the aluminum. As shown in FIGURE 2, this may be accomplished by providing a flat refractory cover 41 which fits over the aluminum bath and which is formed with openings 42 therethrough through which the wire or strip may pass. The level in the aluminum bath is preferably maintained at the top thereof so that the cover 41 is in contact with the aluminum and will prevent direct access of air to form the aluminum oxides. Where this is not practical, an inert gas may be pumped in under the cover to maintain an inert atmosphere in contact with the aluminum surface.

In the alternative construction shown in FIGURE 4, wherein corresponding parts are designated by the same reference numerals, the partition wall 34 instead of being formed with openings, such as 38, is formed with vertically elongated slots 43 extending downward from the top thereof to a point below the levels of the baths. The slots 43 are preferably made relatively narrow, but are of a width such that the wires or strips can pass freely therethrough to the bottom portions thereof, as shown in FIGURE 4. In normal operation, the wires or strips will pass through the bottom portions of the slots 43 so that the apparatus functions in exactly the same manner as where the holes 38 are provided.

The apparatus of FIGURE 4 provides an additional advantage in that any one or more of the wires or strips can easily be removed from the slots when the apparatus is shut down so far as that particular wire or strip is concerned due to breakage, stopping of a wire or strip to connect an additional length thereto, or for other reasons. To facilitate removal of the wires or strips from the slots, lifting devices, as indicated generally at 44, are provided. Each of these devices may comprise a wire formed into a loop which is slightly wider than the slots 43 and which extends downwardly adjacent to the partition wall 34 in registration with a slot 43. When it is desired to lift any one of the wires or strips out of a slot, the lifting device for that particular wire or strip may be elevated so that the portion of the loop underlying the wire or strip will engage it and raise it out of the baths. If a wire or strip is to be held out of its slot for any appreciable interval of time, the slot is preferably closed by a plug of metal or ceramic material, as shown at 45, which is temporarily fitted into the open slot.

Alternatively to passing the wire or strip through the partition from the salt bath into the aluminum bath a construction may be employed, as shown in FIGURE 7, in which parts corresponding to like parts in FIGURES

2, 3 and 4 are indicated by the same reference numerals. As shown in this figure, the partition wall **34** is imperforate and may carry on its top one or more guide pulleys or rollers **46**. The wire **12** in passing from the salt bath into the aluminum bath passes beneath a guide bar **47** in the salt bath and then up over the pulley or roller **46** and beneath a guide bar **48** in the aluminum bath. In this way, the wire or strip enters the top of the aluminum bath and avoids pick-up of dross which is heavier than the aluminum and tends to sink into it.

To avoid oxidation or cooling of the wire as it travels up out of the salt bath and before it re-enters the aluminum bath, a hood **49** is provided which may be supported on the guide bars **47** and **48** and which fully encloses the space above the partition wall **34**. The hood may be supplied with an inert atmosphere to prevent oxidation of the wire and the space within the hood will be heated by the baths so that wire will not cool in the brief interval when it is out of both baths. The aluminum bath is preferably covered by a ceramic cover **51** which is spaced above the level of the molten aluminum. The space beneath the cover may be supplied with an inert atmosphere through a pipe **52** so that oxidation of the aluminum will be minimized.

The oil quench **27** is constructed, as shown in FIGURES 5 and 6, to enable the wire or strip to pass horizontally therethrough in a straight line with no abrupt bends. As shown, the oil quench comprises a tank or sump **53** adapted to contain a body of oil **54**. A trough **55** which is shorter than the tank **53** is supported above the tank with its ends spaced inward from the ends of the tank. The ends of the trough **55**, as shown in FIGURE 6, are formed with downwardly extending slots **56** through which the wires or strips pass.

In order to maintain a level of oil in the trough above the wires or strips a pump **57** is provided in the tank **53** which pumps oil upwardly from the tank **53** through a vertical conduit **58** into the trough **55**. The oil will overflow through the slots **56** at the ends of the trough but the rate of supply is such with respect to the overflow rate that the oil will be maintained in the trough at a level above the wires or strips passing therethrough. In this way, the wires or strips can be liquid quenched without being bent and furthermore the circulation of the oil serves to maintain its temperature substantially uniform. The oil is preferably maintained at a temperature on the order of 120° F. to 200° F. to quench the wire or strip quickly without excessive thermal shock and may be heated or cooled as required to maintain this temperature range. The wire or strip leaving the oil quench has excess oil removed therefrom by an air nozzle **59** directed downwardly and counter to the direction of travel of the wire or strip at the exit end of the oil quench to blow excess oil therefrom back into the tank.

While several embodiments of the invention have been shown and described herein, it will be understood that they are illustrative only and not to be taken as a definition of the scope of the invention reference being had for this purpose to the appended claims.

What is claimed is:

1. In a process for coating a metal strip by passing the strip through a molten heating media into a molten coating metal and thereafter quenching the strip; the improvement which comprises passing the said strip substantially horizontally through a substantially vertical interface formed by the said molten heating media and the said molten coating metal.

2. The process according to claim 1 wherein the said molten coating metal is aluminum and the molten heating media is a salt.

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