March 15, 1938. T. SENDZIMIR 2,110,893

PROCESS FOR COATING METALLIC OBJECTS WITH LAYERS OF OTHER METALS

Filed July 16, 1935 5 Sheets-Sheet 1

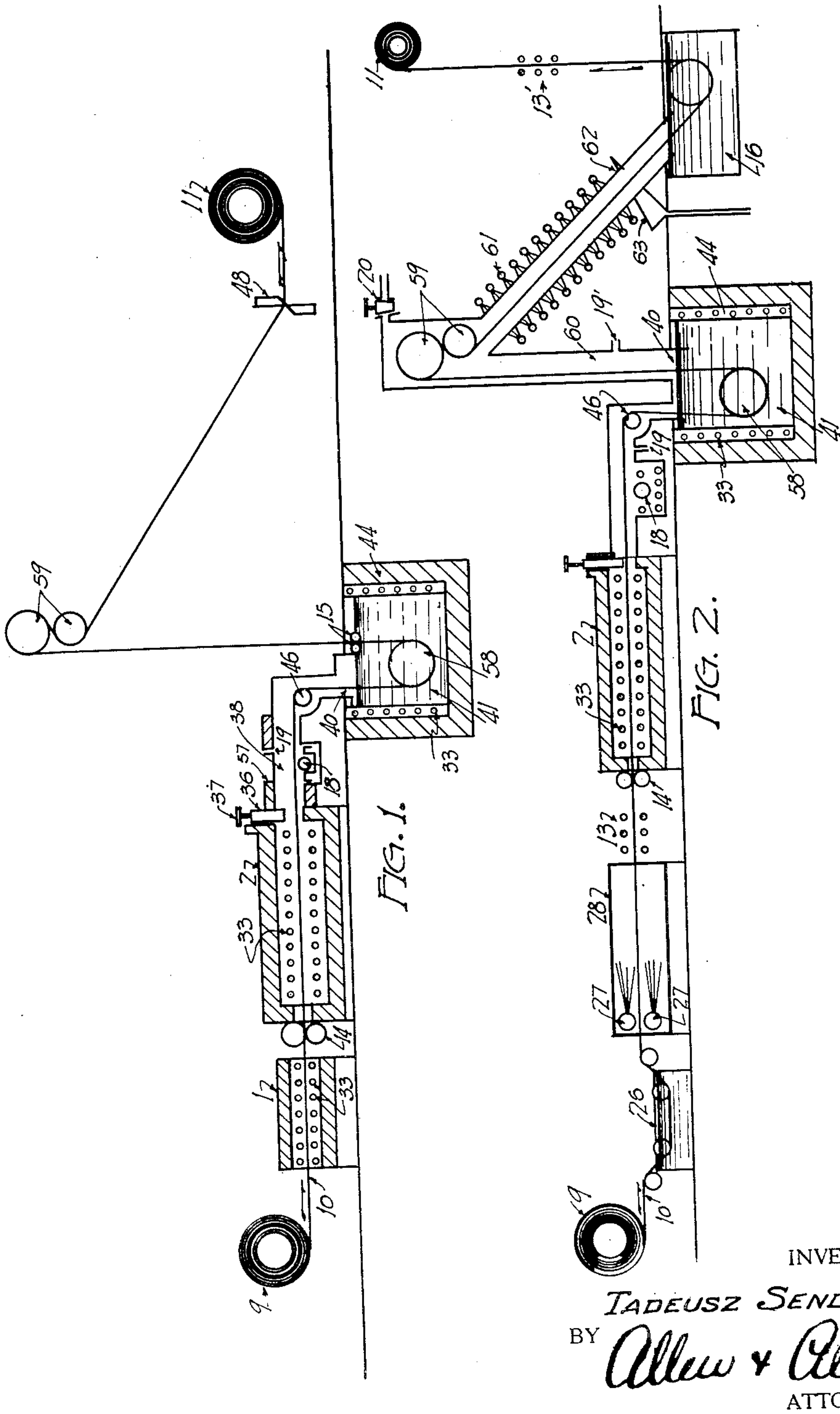

FIG. 1.

FIG. 2.

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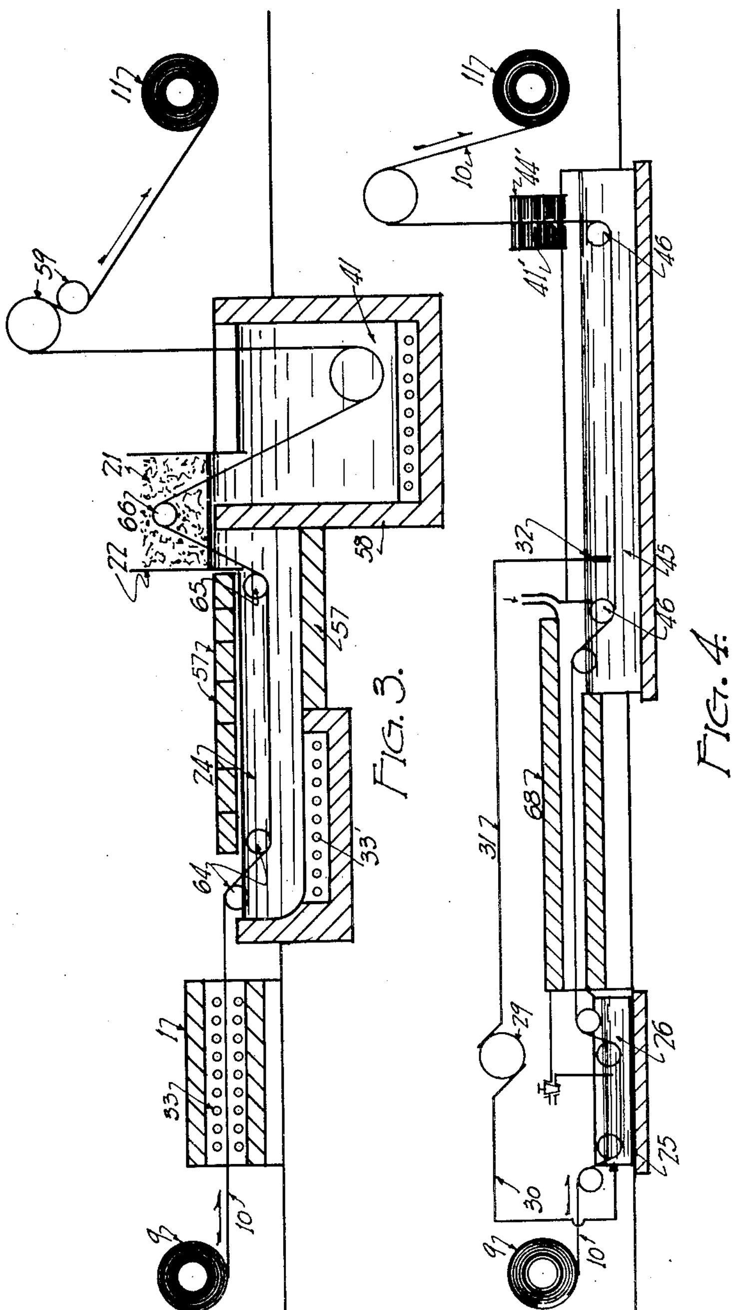

FIG. 3. FIG. 4.

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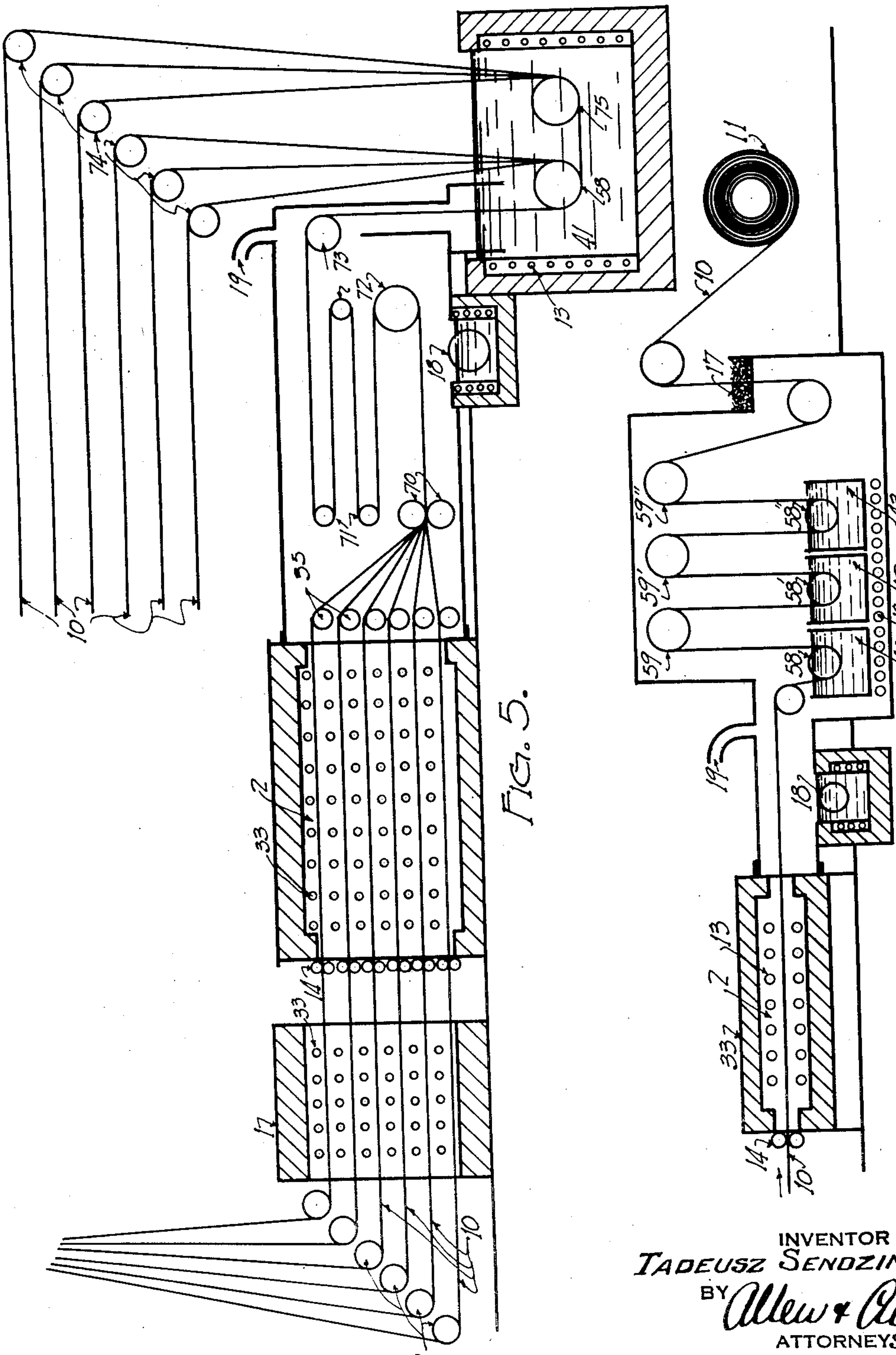

FIG. 5.

FIG. 6.

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Filed July 16, 1935 5 Sheets-Sheet 4

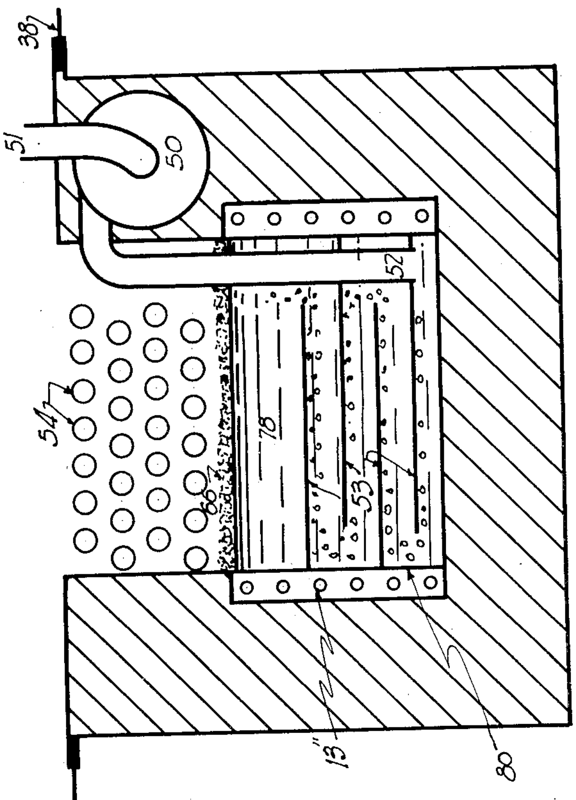

FIG. 8.

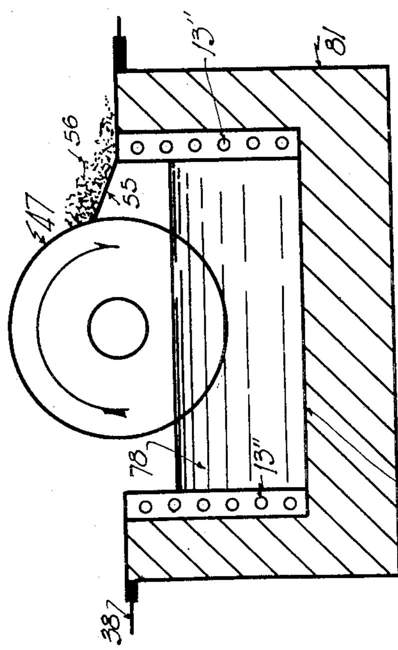

FIG. 7.

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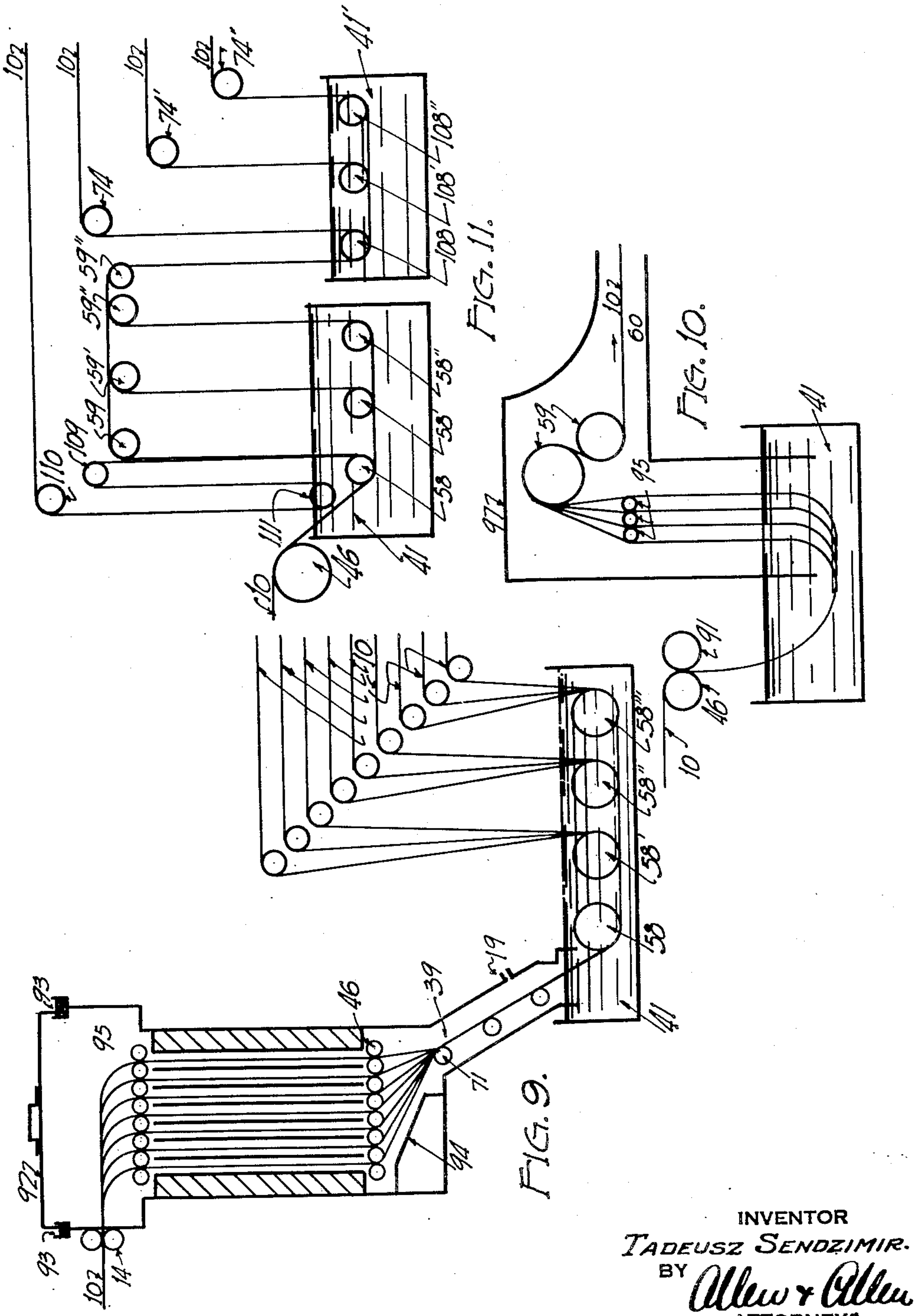

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Patented Mar. 15, 1938 2,110,893

UNITED STATES PATENT OFFICE

2,110,893

PROCESS FOR COATING METALLIC OBJECTS WITH LAYERS OF OTHER METALS

Tadeusz Sendzimir, Katowice, Poland, assignor to The American Rolling Mill Company, Middletown, Ohio, a corporation of Ohio

Application July 16, 1935, Serial No. 31,699

12 Claims. (Cl. 91—70.3)

My invention relates to the coating of metallic objects with a layer of another metal or with multiple layers of different metals by a hot coating process.

Hitherto the metallic objects such as sheets have been coated by pickling them and dipping them into a bath of the coating metal. Difficulties have been had with unsatisfactory and irregular surfaces of the coating and insufficient adhesion of the coating to the parent metal so that the coating has a tendency to chip off or flake, particularly during bending or working. It is a fundamental object of my invention to avoid these difficulties, and to provide a method and apparatus which renders possible the production of much better products than those made by the conventional commercial processes.

It has been suggested hitherto to heat substantially continuous bands or strips of metal to a temperature closely approaching the annealing temperature followed by a dipping of the strip into the metal bath with precautions to prevent oxidation between the heat treatment and the coating treatment. While such a process has the advantage of high economy, theoretically, the products thereof have not been entirely satisfactory. It is an object of my invention to attain the economies of such proposed procedure without the disadvantage thereof.

These and other objects of my invention which will be set forth hereinafter or will be apparent to one skilled in the art upon reading these specifications, I accomplish by that certain process and by that certain construction and arrangement of parts and apparatus of which I shall hereinafter describe several exemplary embodiments. For the sake of clearness, reference is made to the drawings wherein:—

Figure 1 shows a simple arrangement of apparatus adapted to the practice of my invention.

Fig. 2 shows an apparatus in which the metal may be sprayed prior to the heat treatment.

Fig. 3 shows an apparatus embodying an annealing bath following an oxidizing treatment.

Fig. 4 shows a different assembly of apparatus hereinafter to be described.

Fig. 5 shows an arrangement for the simultaneous treatment of a plurality of metal strips.

Fig. 6 shows a multi-bath arrangement.

Figs. 7 and 8 show different forms of oxygen removing equipment.

Figs. 9, 10 and 11 show various forms of a device for handling a plurality of metal strips.

Briefly in the practice of my invention I heat the metallic object to a definite temperature in a heating furnace or its equivalent followed by a cooling to a temperature which is nevertheless preferably higher than the melting temperature of the coating metal, following this by dipping the metal into the bath at this latter temperature. My specific improvement in this art includes the treatment of the surface of the metallic object so as to bring about a chemical reaction producing a thin layer of a compound of the metal thereof, and the subsequent production of a different chemical reaction whereby the metallic compound is changed to a thin layer of the original metal closely adherent to the metallic object, of slightly different metallographical character, and in a condition actively to combine with the coating metal. One way of accomplishing this is by heating the metal in an oxidizing atmosphere to form thereon an extremely thin coating of a metallic oxide. The thickness of this coating will be very slight and the coating may vary in appearance from light yellow to purple or even as far as grey where the parent metal is iron or steel. This coating may be produced by heating objects made of iron to a temperature of approximately 170° to 500° C.

After this treatment the metallic object is passed to an annealing furnace in which the atmosphere is controlled so as to have a reducing effect. It is advantageous to pass the object through the oxidizing furnace and into the reducing furnace at even higher temperatures than those given above where there is relatively a very short interval during which the oxidizing atmosphere is in contact with the heated base metal.

The treatment in the reducing furnace substantially completely reduces the microscopic thinness of the outside coating. Thus there is produced on the surface of the metallic object a thin layer of freshly reduced metal of different metallographical characteristics having the property of uniformly and actively amalgamating with the coating metal and strongly adherent to the base metal. The oxidizing treatment has the advantage of cleaning the surface of the metal object of grease and organic impurities and ordinarily no pickling pre-treatment is necessary unless the metallic object is covered with a heavy scale which it is necessary to remove.

Instead, however, of treating the metal object as above described, I may secure like results by moistening the surface of the metal object with water as by dipping it in a bath or spraying it, following this by drying the object before it reaches the reducing furnace. I may likewise employ moisture or water vapor or baths or sprays or vapors containing acid or alkaline substances. Also these treatments can be applied in combination with a pre-heating or oxidizing treatment. Before or during the drying process a very thin homogeneous coating of oxides, hydroxides and/or salts is formed on the surface of the base metal. These substances can be changed or reduced in the reducing furnace to a coating of the nascent metal, probably passing through oxide or hydroxide stages.

It will be understood that after the thin coating of nascent metal has been formed upon the surface of the metallic object, the object should be protected from the effects of oxidation, until it has passed beneath the surface of the bath of the coating metal. This is ordinarily accomplished by passing the metal object through a cooling chamber in which the atmosphere is controlled. Another object of my invention is to provide a convenient and practicable means for removing from the atmosphere of the cooling chamber effective concentrations of oxidizing ingredients in the atmosphere. As is well known the further the cooling progresses the less partial pressure of oxygen will cause scaling of an iron surface. The oxygen may either be free or in such combinations as make a reaction with the base metal possible. For example, water vapor, carbon dioxide and the like have oxidizing actions. The presence of such reagents in the cooling chamber have made it impossible heretofore to cool the surface of the object which is to be coated without at the same time getting it covered with a layer of oxides. To avoid these difficulties it is necessary to practice a control of the atmosphere in the cooling chamber as well as a control of the atmosphere in the reducing chamber (where reducing baths or the like are not employed). To this end I employ a heated surface of a metal which easily combines with oxygen, such as hot copper wool, iron shavings or the like. I may also employ a molten metal which easily combines with oxygen. One way of doing this is by providing a horizontally mounted drum dipping into the metal bath and rotating slowly so as to provide a continuous contact of the gases in the cooling chamber with clean surfaces of the molten metal. The drum will preferably be brushed as it rotates so as to remove the metal oxides which are formed. Other ways of exposing active metal surfaces to the gases may likewise be employed.

In many cases precaution against oxidation has to be taken so far as the surface of the metal coating bath is concerned, and for this purpose the cooling chamber may be built in such a way as to enclose the container holding the coating metal as well as such heating and cooling apparatus as may be necessary and the apparatus for removing the coated metal.

Inasmuch as the reducing and annealing furnace raises the temperature of the metal to a high degree, while it is advantageous thereafter to cool the metal before dipping it into a coating bath, yet it is not necessary to cool the metal to such an extent that it has no appreciable effect on the temperature of the coating bath. Thus it is entirely possible to transfer some of the heat from the annealing furnace to the coating bath whereby a saving may be made in the direct application of heat to the coating bath for the purpose of maintaining it molten.

Successively arranged coating baths can also be used whereby multiple coatings can be formed. These coatings can either be of the same or of different metals. Where the coatings are of different metals, it is advantageous to select the metals and arrange them in the order of their solidification temperatures, each successive bath in the direction of movement of the objects to be coated containing a metal or an alloy having a lower melting point. For example, in accordance with my invention an iron object can be successively coated with copper, brass, aluminum, zinc, etc.

In the place of an annealing and reducing furnace of ordinary type an annealing bath of high melting point substance may be employed. The bath may have a neutral or a reducing effect. Where baths are used the forward end of the bath may be heated higher than the other end so that some or all of the necessary cooling of the metal object takes place therein. As has been indicated, the partial cooling, down to a temperature say of 50 to 150° C. above the temperature of the coating bath may also take place partly or wholly in the space between the annealing device and the coating bath. Again the metallic objects may be covered with a layer of pulverized or granular gas insulating medium to prevent oxidation. Such a medium should be lighter than either the annealing bath or the coating. Lime, clay, coke-breeze or the like may be employed. Such substances may likewise consist of or contain materials having a reducing effect or which are adapted to generate reducing gases. Charcoal powder is an example of such substances.

In the practice of my process it is likewise possible to treat a plurality of strips of metal at one time in a given mechanism. This not only speeds up production but also in certain instances has a useful effect in diminishing the rate of cooling after the annealing treatment. Particularly is this effective where very soft materials are desired.

I shall describe various forms of my apparatus more particularly in connection with the treatment of a continuous supply of strip metal. It will be understood that such a supply may be made by attaching strips, coils or sheets end to end by welding, stitching or in other ways. In Fig. 1, I have shown a strip of metal 10 being uncoiled from a coil at 9 and passing through a pre-heating or oxidizing furnace 1, where heat is applied thereto by means of electrical heating elements 33 other heating methods may be employed. It is in this first furnace that the oxidation of the metal takes place. The metal strip 10 then proceeds to the annealing and reducing furnace 2 wherein I have again shown electrical heating means 33. Inasmuch as the atmosphere in this furnace is to be controlled so as to render it non-oxidizing or reducing, I have indicated at 14 a gas seal for the furnace. Any known type of gas seal may be employed therein. Instead of being electrically heated this furnace may also be heated in any way desired. The control of atmosphere therein may be practiced in accordance with any of the well known methods employed in what is commonly called "bright annealing". At the exit end of this furnace there is preferably a slide 36 the height of which can be adjusted by means of screws 37 so as to leave very little space for gases to pass through.

The strip 10 is thence passed through the cooling chamber 38 which may be provided with adjustable insulators 57 to control the rate of cooling. The strip passes over a roll 46 and down into a coating bath 41, under a sheave 58 located therein, up through wiping rolls 15 and thence out of the bath. It may be cooled by passing over rolls 59 or other means for causing it to travel for a fairly long distance in contact with the atmosphere. It then may be sheared by shears 48 or wound up into a coil indicated at 11.

The cooling chamber 38 the great portion of which is horizontal is shown as having a vertical portion 39 which widens at its bottom to form a bell 40, the edges of which are partly submerged in the coating bath 41. Thus the metal strip 10 passing through the annealing and reducing furnace is carried into the bath without being exposed to the atmosphere. The metal in the coating bath may be considerably heated by the passage of the hot strip into it and the widening of the bell 40 keeps the edges thereof away from the warmer zone of the metal and serves in part to isolate this zone.

Non-oxidizing or reducing gas may be admitted into the cooling chamber 38 through a pipe indicated at 19. Since the bottom of the cooling chamber is sealed by the bell 40 this gas can escape only into the furnace 2. Where the furnace is an electrical furnace it may be allowed to escape at the seal 14 and to burn with a free flame in the outer air.

In view of the fact that it is not always possible to obtain a gas sufficiently free of native or combined oxygen, and also in view of the fact that there may be some diffusion of gas from the furnace 2 into the cooling chamber, means for the further removal of oxygen from the gases in the cooling chamber may be employed therein. Especially is such means useful when starting a run of the apparatus, particularly to minimize the danger of an explosion when the heated metal strip first passes from the furnace 2 into the cooling chamber 38, where its heat would ignite any explosive mixture of gases that might be found in this space. I have indicated at 18 an oxygen removal device. This device may be of any kind desired. As I have indicated above, it may comprise a roll turning in a bath of molten metal which has a high affinity for oxygen together with means such as asbestos brushes or the like to clean the oxide from the surface of the cylinder as it rotates.

The coating metal 41 fills a container 44 which may be either of metal or refractory. Heating elements 33 may be provided initially to melt the coating metal; but as soon as the operation is properly started the supply of heat may be cut down and in many instances entirely eliminated, inasmuch as the heat of the strip 10 is usually sufficient to maintain the bath in a liquid condition. Ordinarily the partly cooled strip 10 is sufficiently heated not only to overcome radiation from the bath but also to melt new coating metal as the addition thereof is required to maintain the level of the coating bath.

I have not indicated the use of flux or a flux box in my apparatus since ordinarily this is not required. Fluxes may be used, however, if desired.

In Figure 2 the strip 10 is first passed through a bath of water 26. The water may contain reagent substances or cleaning and detergent substances or materials. After this if desired the strip may be passed through a chamber 28 in which sprays 27 maintain the atmosphere charged with water vapor. The strip passes subsequently through a dryer which may comprise a series of heating elements 13 arranged on either side of the path of travel of the strip.

Most of the other elements shown in Figure 2 are the same as those previously described in connection with Figure 1, excepting that I have shown the metal, as it leaves the coating bath, protected from oxidation by a hood device. This device is indicated at 60 and the forward end of it is shown as sealed by the molten metal 41 at one end and by a sealing bath 16 at the other. Non-oxidizing gas may be admitted to the hood 60 by means of a pipe 19′. Once the hood is properly filled no further additions of gas should be necessary. For the purpose of scavenging or renewing the gas atmosphere, an outlet valve 20 is provided. The hood may be cooled so as to promote the cooling of the metal strip not only to bring the temperature to one which is safe for the removal of the strip to the atmosphere, but also to cool it to such an extent as to prevent the boiling of the sealing bath 16, which may be a bath of oil or water. To this end I have provided jets of water 61 playing on the surfaces of the hood. The cooling water is delivered by a flange 62 into a funnel 63 by which it is removed. After the metal has left the sealing bath 16, the surface thereof may be dried as by means of a drying heater 13′. In the organization of Figure 3 the metal strip 10 is first passed through the oxidizing furnace 1 and thence through an annealing bath 24 in lieu of an annealing furnace. The metal is conducted through this bath by being passed over and under such idler rolls 64 and 65 as may be found necessary. The bath 24 will be held in a suitable container and the forward portion of it may be heated as by means of the heating elements 33′ to effect the necessary heat treatment of the strip. The other end of the bath is not heated and serves as a cooling space. Adjustable insulating means 57 may be positioned above the bath. In order to prevent oxidation of the strip as it is being carried from the annealing bath to the coating bath 41, it may be conducted through a body 21 of air excluding pulverized material contained in a suitable hopper 22, the strip being carried over an idler 66 located in this body.

In Figure 4 I have shown a way in which the strip may be annealed by the direct application thereto of electrical current. The strip 10 is first passed through a moistening bath 26 held in a container 25 to which one lead 30 of a generator or power source 29 is bolted or otherwise connected electrically. The strip thence passes over suitable idler pulleys through an enclosed annealing space 68 and to a pre-cooling bath 45. The other lead 31 of the power source is connected to this bath as by means of an electrode 32. The annealing space 68 is closed off at its ends by gas sealing means as will be understood. The coating bath 41′ is maintained in floating condition upon the pre-cooling bath 45 in a suitable container 44′. The strip is led through the pre-cooling bath and up through the coating bath over suitable idlers 46. Care should be taken to prevent a short circuit of the electric current through other parts of the apparatus in order to insure that the current in passing between baths 26 and 45 must pass through the strip extending therebetween. In this way, by adjustment of the power source, the degree of heat generated in the strip may be quite accurately controlled. A reducing atmosphere maintained in the reducing space 68 will bring about the desired conversion of metal oxide or hydroxide films to the nascent layer of substantially pure metal. The power source will, of course, be a low voltage, high amperage source.

Figure 5 shows an apparatus for handling a plurality of the metal strips 10 at one time. The general organization of parts is substantially the same as that of Figure 1 and like numerals have been used to indicated like parts. In this figure the several strips are carried separately through the oxidizing furnace and through the reducing furnace. After passing over idler rolls 35 they are combined on a pair of rolls 70 in the cooling space and are looped back and forth therein over idlers 71 and 72. Thus, the cooling rate is diminished. Finally the combined strip is led over an idler 73 into the bath 41. Although the metal is led into the bath as a combined strip, the several strips are, of course, separated before they emerge from the bath. This may be accomplished, as shown, by carrying them over idlers 58 and 75 and separating the strips, exteriorly of the bath by means of idlers 74. Thus, the metal of the coating bath is permitted to get at all sides of each strip before the strips emerge from the bath.

Figure 6 shows a type of apparatus for performing a multiplicity of coatings. The oxidizing furnace is not shown, but will be understood to be present. In the cooling space I locate a plurality of coating tanks indicated, respectively, at 41, 42 and 43. The strip is passed over a plurality of idlers 59, 59′, 59″ and 47. As the strip emerges from the cooling chamber it is shown passing through a gas seal comprising a pulverized material indicated at 17.

In Figure 7 I have shown in detail one way of arranging the oxygen withdrawing apparatus. Here the roll 47 is caused to turn with a portion of its surface dipping into a bath of molten metal 78 contained in a container 80 insulated as at 81 and heated by the elements 13″. A scraper 55 engages the surface of the roll so as to remove therefrom continuously the metal oxide formed on the surface thereof. As the roll 47 turns it carries up with it a thin film of the metal of the bath 78, which metal has a high affinity for oxygen.

A glass may be fitted in a suitable place in the cooling chamber 33 both to gauge the operation of the apparatus and to see whether or not all free oxygen has been absorbed. If the surface of the drum even when revolving very slowly always remains clean and free of oxides, an oxygen-free condition of the atmosphere will be indicated.

Figure 8 shows another construction of an oxygen removing device. The container is heated as before and contains a molten metal having a high affinity for oxygen. Gas from the cooling chamber is withdrawn by a pump 50 through an inlet 51 and is delivered by a conduit 52 beneath the surface of the molten metal. In order to facilitate intimate contact of the gas with the metal, I may employ a series of baffles 53 in the tank. Any oxides that are formed float upon the top of the molten metal 78, at 66. The emerging gases are preferably not emitted directly to the cooling chamber 38 but first pass through a condenser comprising the tubes 54 through which some cooling medium such as steam is passed. This condenser serves to rid the gases of any metal vapors they may carry, which might interfere with the process of coating.

Figure 9 again shows a device for coating simultaneously a plurality of strips. It is analogous to the arrangement of Figure 5 excepting that here an annealing furnace is vertically disposed. Such a vertical arrangement of the annealing furnace offers a marked advantage so far as volume of output is concerned. The metal strips 10, which will be understood to have passed through an oxidizing chamber are conducted together through a pair of tight fitting rolls 14 into the chamber 95, the purpose of which is to facilitate the gas sealing of the upper part of the annealing furnace without at the same time interfering with its accessibility for treating or repair. The inside of the chamber 95 is rendered accessible by the removal of a cover member 92. This cover will be understood to have a gas tight type connection with the chamber 95. One way of doing this is by providing the upper edges of the chamber with a channel 93 to accept the edges of the cover 92 and placing a sealing medium in this channel about the said edges. During any time when the cover is opened, and when the apparatus is in operation, the flow of gas through the annealing device must, of course, be increased to prevent diffusion therewith of the outer air.

The strips as shown, pass down through the annealing furnace and enter a cooling chamber 39. The strips, preferably entering the chamber 95 together, are separated therein by suitable guide means and carried individually through the annealing furnace. They leave the furnace through guides 46 having a fairly tight fitting; and they may be passed over an inclined guide 94. They are drawn or pressed together by a roll 71 and are conducted over suitable idlers if necessary through the cooling chamber 39. Afterward they pass through the coating bath and are separated over suitable idlers 58, etc.

In Figure 10 the superposed strips 10 are fed between rolls 46 and 91 into the coating bath 41 wherein they hang as more or less free loops. They are separated by being pulled out by rolls 59 over separating means 95. The apparatus of Figure 10 will be considered as located either within the pre-cooling space or within some chamber having a controlled atmosphere. If necessary the solidification chamber 60 may be separated from the cooling chamber by suitable walls 97 and a different atmosphere maintained therein. This arrangement possesses marked advantages, especially in connection with a coating of the strip with a high melting point metal where it is impracticable to maintain idler rolls or guide means beneath the bath of coating metal.

Figure 11 shows an arrangement for coating one side only of a plurality of metal strips. Superposed strips 10 are led over a roller 46 into the coating bath 41. They are separated therein in pairs over rolls 58, etc. This provides for the coating of but one side of the two strips in each pair as will be clear. The strips may be recombined above the bath on rolls 59, etc. and led beneath the surface of a second coating bath 41′ by means of rolls 108, etc. Again they may be separated in pairs over these rolls and carried out of the bath by being led over rolls 74, etc. One or more of the strips may be coated on both sides by being diverted over a roll 109 led again beneath the surface of the bath over a roll 111 and finally carried therefrom over a roll 110.

Various modifications of my invention may be made without departing from the spirit thereof.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent, is:—

1. A process of coating metallic bodies with molten metal which comprises the steps of producing upon the surfaces thereof a thin and uniform reducible film, by treating the metal bodies with an oxidizing medium under conditions to produce said reducible film having a thickness comparable to the thickness of an oxide film which, when formed upon iron or steel, would vary in appearance from light yellow to purple and as far as gray, then under conditions of heat and a reducing atmosphere completely reducing the said film so as to form a reduced metal layer in intimate contact with the body metal, and while the metallic bodies are continuously protected by a non-oxidizing atmosphere leading them beneath the surface of a bath of the said molten coating metal.

2. The process as claimed in claim 1, in which the treatment of said metal bodies with an oxidizing medium is carried on in the presence of water or water vapor, and the said reducible film comprises in part at least a hydroxide of the body metal.

3. A process as set forth in claim 1 wherein the metallic bodies, after the reducing treatment, are cooled to a temperature only slightly above the temperature of the said bath of molten coating metal before being led beneath the surface thereof.

4. A process as set forth in claim 1 involving carrying the metal bodies out of the bath of molten coating metal while protecting them by a non-oxidizing atmosphere.

5. A process of coating iron or steel bodies with molten metal, which comprises the steps of producing upon the surfaces thereof a thin and uniform film of oxides of the body metal, having a thickness characterized by a color ranging from light yellow to purple and as far as gray, by treating said iron or steel bodies with heat in an oxidizing atmosphere, then under conditions of heat and a reducing atmosphere completely reducing the said film so as to form a reduced metal layer in intimate contact with and closely adhering to the body metal, and while the iron or steel bodies are continuously protected by a non-oxidizing atmosphere, leading them beneath the surface of a bath of the said molten coating metal.

6. A process as set forth in claim 5 wherein the iron or steel bodies after the reducing treatment are cooled to a temperature only slightly above the temperature of the said bath of molten coating metal before being led beneath the surface thereof.

7. A process as set forth in claim 5 wherein the primary component of said molten coating metal is zinc.

8. A process of coating metallic bodies with molten metal, which comprises the steps of producing upon the surfaces thereof a thin and uniform reducible film by treating the metal bodies with an oxidizing medium under conditions to produce a reducible film having a thickness comparable to the thickness of an oxide film which, when formed upon iron or steel, would vary in appearance from light yellow to purple and as far as gray, then under conditions of heat and a reducing atmosphere completely reducing the said film so as to form a reduced metal layer in intimate contact with the body metal, and while the metallic bodies are still protected by said reducing atmosphere, leading them beneath the surface of said bath of molten coating metal, and during the passage of said metal bodies through said reducing atmosphere, treating said reducing atmosphere to reduce its oxygen content.

9. A process of coating iron or steel strip with molten zinc which comprises passing said strip material continuously through a heated zone containing an oxidizing atmosphere and raising the temperature of said material therein to a range of approximately from 170° to 500° C. so as to form upon the surfaces thereof a uniform coating of oxide appearing as a light yellow to purple and ranging as far as gray, thereupon passing said material through a heated zone having a reducing atmosphere in which zone said material is heated to normalizing temperature and in which zone said film of oxide is reduced to form a purified and strongly adhering film of the body metal, then cooling said material down to a temperature above, but not substantially more than 150° C. above the temperature of a coating bath into which the material is to be conducted, while maintaining said material in a reducing atmosphere, and finally passing said material while still protected by said atmosphere through a bath of coating metal the primary component of which is zinc at a temperature sufficient to maintain said metal molten, while protecting at least the entrance portion of said bath by said reducing atmosphere.

10. A process of coating metallic bodies with molten metal which comprises the steps of producing upon the surfaces thereof a thin and uniform reducible film by treating the metal bodies with an oxidizing medium under conditions to produce said reducible film having a thickness comparable to the thickness of an oxide film which, when formed upon iron or steel, would vary in appearance from light yellow to purple and so far as gray, then under conditions of annealing heat and a reducing atmosphere completely reducing the said film so as to form a reduced metal layer in intimate contact with the body metal, and so as to anneal the said metallic bodies, and while the metallic bodies are continuously protected by a non-oxidizing atmosphere leading them beneath the surface of a bath of the said molten coating metal.

11. A process of coating iron or steel bodies with molten metal, which comprises the steps of producing upon the surfaces thereof a thin and uniform film of oxides of the body metal, having a thickness characterized by a color ranging from light yellow to purple and as far as gray, by treating said iron or steel bodies with heat in an oxidizing atmosphere, then under conditions of annealing heat and a reducing atmosphere completely reducing the said film so as to form a reduced metal layer in intimate contact with and closely adhering to the body metal, and so as to anneal said iron or steel bodies, and while the iron or steel bodies are continuously protected by a non-oxidizing atmosphere, leading them beneath the surface of a bath of the said molten coating metal.

12. A process as set forth in claim 11 wherein the primary component of said molten coating metal is zinc.

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