July 18, 1939. J. L. HERMAN 2,166,250

METHOD OF COATING METALLIC MATERIALS

Filed April 2, 1936 2 Sheets-Sheet 1

Fig. 3.

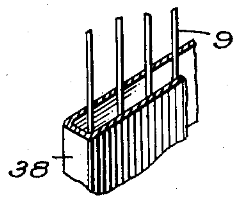


Fig. 1.

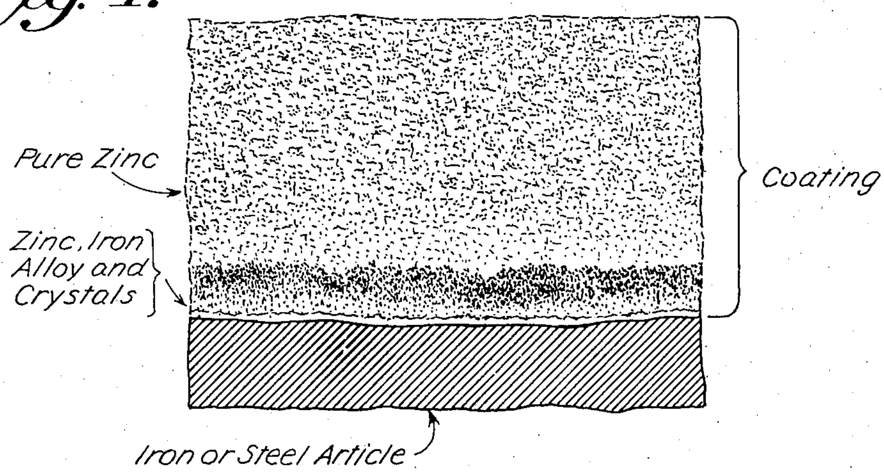


Fig. 4.

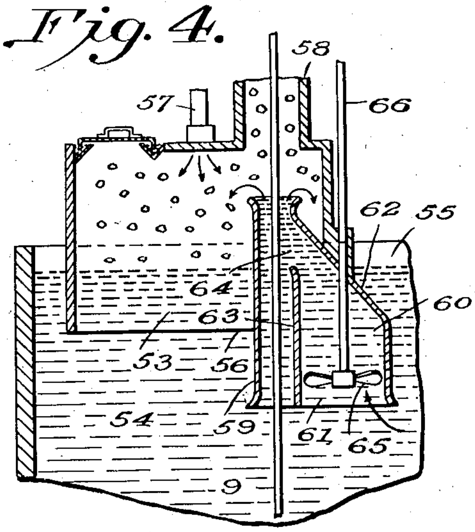
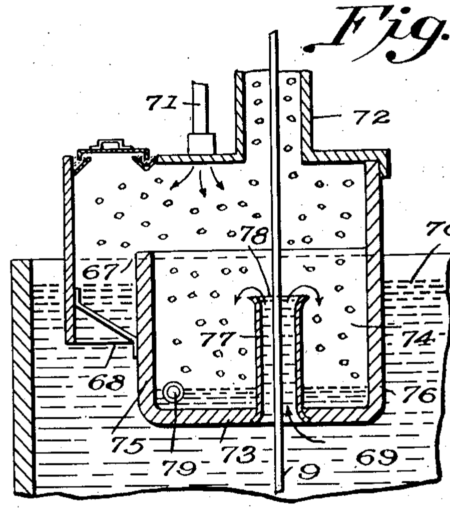


Fig. 5.



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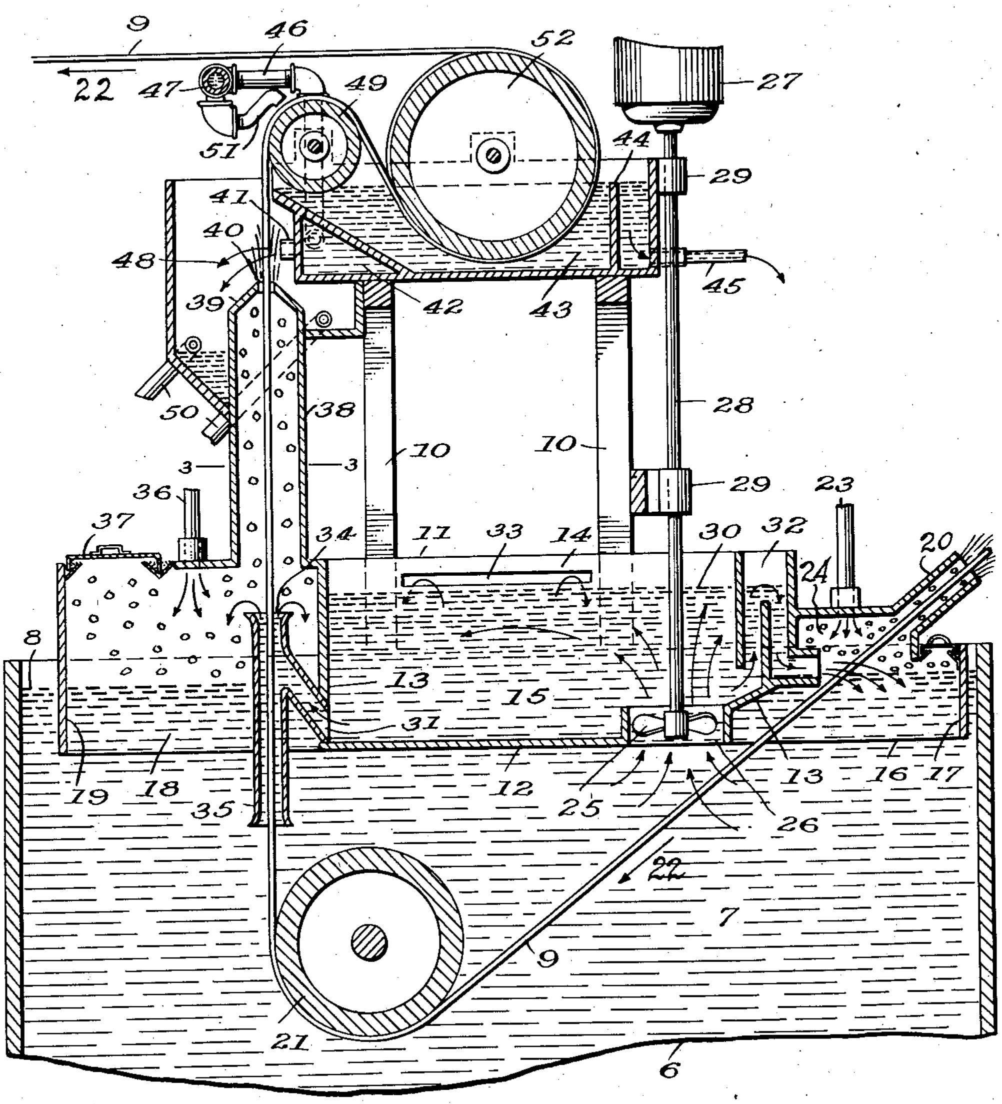
Filed April 2, 1936 2 Sheets-Sheet 2

Fig. 2.



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2,166,250

METHOD OF COATING METALLIC MATERIALS

Joseph L. Herman, Peoria, Ill.

Application April 2, 1936, Serial No. 72,425

4 Claims. (Cl. 91—70.2)

This invention relates to an improved method of coating a metallic article of iron or steel, and while capable of other application is primarily intended for effecting galvanization of such article; it being the primary object of the invention to produce such article, greatly improved over comparative articles heretofore made, as well as to reduce the cost of the manufacture of articles of like weight of coating.

Galvanized articles or materials are desirable in so many fields of service and the demands of particular uses, that it is practicably impossible to provide a galvanized coating that will attain the best possible results over the entire field. With this in mind, an object of the present invention is to provide a galvanized article or a coating for articles or materials capable of wide and practical uses.

These characteristics have greater or less bearing on the particular application or use of the material or device that may be in mind, and inasmuch as their force and effect will be readily understood and appreciated by workers in the art, the present disclosure of the characteristics of the galvanized article, generally, of my invention, may be confined to a consideration of a specific article, for example, a galvanized wire.

Now, a galvanized wire—and, as stated, this discussion will apply to many other galvanized products—is of quite universal application and, dependent on the special make-up of the galvanized coating, will operate to greater or less advantage under special conditions attending use. For example, in services where the galvanized wire may encounter salt atmosphere, spray, or immersion, or where the same may be subjected to intense heat, the most successful results are attained where there is a substantial iron content in the coating; but in many other instances the presence of such a substantial content is disadvantageous and, in fact, the practical elimination of iron is desirable, as in telephone, telegraph wire, etc. In still other instances, as in connection with bucket bales, utensil handles or, in fact, domestic uses where bright appearance is aesthetically desirable, a substantial iron content will be in part objectionable because of its effect in dulling the appearance. Again, the dulling effect is frequently the result of oxides taken up by the wire from the bath or created after removing the wire from the bath, so that for this reason, among others, it is desirable to eliminate to the greatest possible extent the presence of oxides in the coating; other reasons being that oxides in the coating create difficulties attending bending, twisting, or shaping of the wire, when the coating will crack or flake off where the oxides have changed the thickness of the coating, etc.; and also in pressing and forming operations it is desirable to eliminate the iron content in the outer exposed body of the coating so that the coating will be relatively soft and ductile, and to eliminate the oxides so that in the stamping or pressing operations particles of the coating will not dust or break off and accumulate on the operating dies or other mechanical instrumentalities. Therefore, to meet the larger range of service for galvanized wire, while my improved wire is practicable and useful in the more limited work, such as under salt conditions, as in ice cream factories or under heat conditions, as in stoves or furnaces, it is nevertheless more perfect in its operation than in other fields where there is not the demand or consideration of substantial iron content in the coating: so that the outstanding characteristics of my improved galvanized wire may be said to be—

A higher degree of ductility, because of a low iron content and the practical elimination of oxides and other deleterious constituents;

The capability of bending or twisting, as upon itself, wthout cracking, flaking, or loosening the coating from the wire;

A higher degree of electric conductivity, because of the absence of any substantial amount of iron in the outer portion of the zinc coating;

An unusual brightness and pleasing color (blue-white) closely resembling the lustre of natural zinc;

A much heavier coating of the zinc than has ever before been attained, resulting in part from the practical elimination of oxides from the substantial outer portion of the body of zinc constituting the coating, and in part from the method of applying the coating, as hereinafter to be revealed;

A smooth, continuous coating, non-porous and free of voids, checks, or cavities or discontinuous areas, resulting from the practical elimination of oxides and other deleterious substances, and which voids or spaces or surface interruptions in or on the coating lend themselves to enlarging the area exposed to atmospheric corrosion and the like;

A greater density, as well as smoothness and ductility of the coating, resulting from the comparatively pure nature of the main body of the coating, lending itself to the fabrication of fence fabrics and analogous articles where bending, coiling, and twisting of the wires play a prominent part in the manufacture of such articles and in the manufacture of barbed wire where like conditions exist, and also in the production of door springs, bed springs, garment hangers and other various products requiring wire which has not only a brilliant surface appearance but also where the zinc coating, itself, must be soft and pliable to lend itself to machine operations without clogging the dies and instrumentalities of the machine and where in its use there will be no cracking or flaking of the coating, and which will withstand severe atmospheric conditions when the coated article is used out of doors; and

Uniformity in the thickness of the heavy coating applied to the wire, resulting from the absence of oxides, etc., since oxides mixed with the coating cause a change in the viscosity or fluidity of the zinc, which causes an uneven spread of the zinc, resulting in thick and thin spots in localized areas, these spots being brittle and cracking and peeling when bent or deformed.

A galvanized article will be illustrated in the accompanying drawings forming a part hereof and properly designated to show the base product, as a wire, strip, plate, or fragmentary part of an article or device, and the coating and constituents thereof as applied to the base product.

Such illustration (Fig. 1) is a true representation of a cross-sectional view, transverse or longitudinal (they being substantially the same in appearance), magnified approximately 1000 times with respect to the normal construction of which the section is taken. This sectional view portrays a galvanized article created by my improved method, and which possesses all of the structural characteristics hereinabove enumerated in connection with the example of galvanized wire. It will be seen that the base product denominated "Iron or steel article" is representative of an article that has been coated, irrespective of its shape, contour, or purpose; the illustration, while having been taken from a wire, being equally appropriate to the other materials and articles to which reference has been made. The coating as an entirety is denominated "Coating" and comprises the entire mass which adherently attaches to the base. The coating, while integral throughout, is divided into relatively localized areas of substantially pure and relatively impure zinc zones, and as combined the coating is of substantial depth or what may be styled a heavy coating of dense character with a smooth exterior surface, the surface and body of the coating being free from voids. The different zones of the coating are respectively denominated "Pure zinc", and "Zinc-iron alloy and crystals". A comparison of these areas shows that the zone of zinc-iron alloy and crystals is very small as compared to the relatively large or predominating area of pure zinc.

From the physical structure of the article thus depicted and possessing the various characteristics previously outlined, resulting from such physical structure, including the brilliant blue-white or natural zinc external appearance, I now pass to special consideration of the method followed in the creation of my new galvanized article.

While it has been recognized that it is desirable to avoid oxides and deleterious substances that would naturally be created or accumulated on galvanized products of the nature with which I am dealing herein, it has also been realized that it is most difficult, if not impossible, to eliminate the same; because it seems to have been the practice, prior to my present conception (based apparently on the belief that such was necessary) that the article remain submerged in the molten zinc bath for a substantial period of time to enable the accumulation of the thickness of coating desired. Accordingly, especially where it is intended that the article should have a heavy coating, this practice of permitting the article to remain submerged for a relatively long period, necessarily adds the concomitant disadvantage of prolonging the period in which the iron content will increase.

As distinguished from the foregoing, I have discovered that where so-called heavy coating is desired on the article, the period of time of submersion of the article in the bath should be minimized and the article withdrawn, after dipping relatively quickly, as compared to the usual practices, wherein the run or movement of the coated article, after leaving the molten bath, tends in an upward direction, and consequently the slower the movement the more the opportunity for the coating to flow back towards or into the bath, thereby lessening the thickness of the coating. In keeping with my invention, quick lifting or upward movement of the coated article as it leaves the bath will carry the same and substantially all of its coating to the point of subsequent treatment for fixing or setting said coating before it has had substantial opportunity to flow from the article or down the same, or, in fact, materially alter the relationship of the coating and the article. In this way it has become an easy matter to predetermine the thickness of the coating desired in any given instance, and to insure uniformity of the coating. In passing the article quickly through the bath, the opportunity for the formation of zinc-iron alloys and crystals is reduced to so great an extent that the iron content becomes negligible. Iron content in the zinc coating, especially the outer area or areas thereof, as compared to localizing the zinc-iron alloy and crystals adjacent the article to which the zinc coating is applied, constitutes a factor of objection.

Thus, the first step in my method is suitably termed the step of immersion of the article in the molten zinc bath, by moving the article into and out of said bath rapidly, as compared to the prior art; or, defining the same in approximate figures, I have found that in satisfactory instances the immersion may be of a duration of about five seconds, although favorable results may be accomplished in even less time, say around three seconds, or in instances perhaps a little longer than five seconds, all as contrasted with the best commercial method of hot galvanizing of which I am aware and in which, for example, attempts to obtain a coating of eight-tenths of an ounce on a No. 14 gauge wire require approximately from twenty to thirty seconds; whereas, in the practice of my invention, I obtain by the brief immersion stated a coating on said wire of from six-tenths of an ounce to one and one-half ounces, the present comparison being per square foot of surface in each instance. Of course, also as an incident to this immersion for the relatively short duration, the resultant iron content of the coating is reduced to the absolute minimum and localized; that is, specifically stated, concentrated in an area remotely related to the outer or relatively pure zinc portions of the coating. To further illustrate, and looking to economy in operation, I have found that in the practice of my improved method a zinc pot of approximately six feet in length will answer all requirements as against pots operating under like conditions and for the same class of work, 20 to 30 feet in length. This results in the saving of fuel costs and the reduction of zinc oxides and dross, as well as the saving of space in factory area and equipment and insulation, all vital factors in the costs of production.

Another advantage incident to this first step of my method resides in the permissibility of operating under a bath temperature substantially lower than the temperature of the previous common practice referred to. In the latter instance the temperatures commonly employed run in the neighborhood of 850–900° F., which has never been substantially lowered, because it has been believed that to get the desired weight or thickness of coating, slow speed or time and heat both enter into the equation of bringing successful results; but I have found that the building up under this old process and the slow withdrawal of the coated article or prolongation of the time of immersion was more largely because of the development of the iron-zinc alloys under the heat that was employed. Because of this discovery and the incident fact that in my process I aim to avoid this builidng up of zinc-iron alloy, so far as possible, I can dispense with a substantial degree of heat and have found that the zinc bath for practical purposes may be of a temperature from approximately 800–830° F. In other words, my coating of substantial depth or heavy character obtained and maintained by the short duration of bath and the relatively quick withdrawing movement of the coated article is enabled by the utilization of a degree of heat very close to the melting point of the bath. Excessive heat therebeyond, or the increase of heat as used in the old practices, of about 70° F., was unnecessary, resulted in the loss of heat, and because of its influence in the formation of the zinc-iron alloy, was harmful to the ultimate product for my intended substantially universal usage. This difference in the maximum temperatures followed in old practices and discovered by me as suffiicent, alone resulted in comparatively early impairment or deterioration and, in fact, ultimate destruction of the pots and equipment.

The second step of my method comprises the freeing or avoiding of the coated article from contamination by oxides or deleterious substances in the bath or floating on the bath in the region of the exit of the coated article therefrom, as herein previously indicated, to avoid brittleness, cracking, dusting-off, unevenness of coating and discoloration thereof, commonly resulting from oxide accumulations variously disposed on or in the coating. It is desirable that the coated article at the point of its exit from the bath shall be protected from any mass or accumulation of oxides tending to arise to or forming on the surface of the bath, whether created by exposure of the bath at some point to oxygen or by elements attending the introduction of the article into the bath and either conveyed by the article itself or picked up by the article at the surface of the bath and where the oxides will be liable to form because of the contact of air with said surface. It is my purpose to avoid the picking up of oxides or other deleterious substances that from any source or cause may have a tendency to become compactly associated or matted in the region of the exit of the coated article, as in all galvanizing processes within my knowledge. In reaching this result, and to all practical intents and purposes, I positively prevent the formation of such a flotation mat or the like; so that in the second step of my process or method, I pass the coated article through and out of the bath material from well within the interior of the body of the bath or, stated otherwise, from far below the surface area upon which oxides usually accumulate and to which widely or loosely dispersed oxides from within the bath commonly arise, after the fashion of an inverted snow storm. Thus, there can be substantially no deleterious effect on the discharging coated article.

I have discovered that if the bath material through which the coated article is lifted or passes is kept in motion, the oxides have no opportunity to assemble and mat at the surface of the bath, whether the oxides come up through the bath or are formed on the surface thereof by possible access of air to said surface. This step, involving the idea of motion, or circulation of bath material in the avoidance of oxide mat formation at the point of exit of the coated article from the bath, will be instantly appreciated when it is stated that where the portion of the bath from which the coated article is escaping is quiescent or like still water, all of the oxides arising thereto or formed thereon will practically instantly accumulate and form a film or mat area defined by the discharge portion of the apparatus and through which film or mat the coated article must pass when leaving the bath. This simply means that, dependent upon the density or other characteristic of the film or mat, first of all, concentrated or condensed portions of the oxides will be carried up or away by the coated article with the resultant impairment of the coating in the many particulars previously brought out in this specification; or the normally expected depth of the coating on the article being withdrawn from the bath will be rubbed or wiped by the oxide film or mat, and, as affected by such rubbing or wiping contact, with no attending degree of certainty or uniformity, said expected depth of coating on the article is reduced and made irregular, thus frustrating the obtaining of an article or produce in keeping with predetermined plans with that nicety in uniform depth and density, evenness, non-brittleness, etc., throughout, as well as discoloration.

Thus, the second step of my method embraces the withdrawing of the coated article from the molten zinc bath in a fashion to avoid serious contact and contamination of the coated article by oxides or other deleterious substances, especially with reference to accumulations on the surface of the bath in the region of the exit of the coated article from the bath, accomplished by the immersion and passage of the article coated and still being coated through the moving bath material, the result of which is to promote and obtain a heavy, dense, commercially pure zinc coating free of oxides and voids.

But the foregoing is not the only important characteristic involved in the second step of my method, which step may be properly defined as involving a compound or two-fold action or effect. I refer to the movement of the bath material as one phase of the action, possessing the desirable function attributed thereto. The other phase, and an important one, resides in the specific nature of the movement of the bath material at the point of discharge of the coated article from the bath. This movement is in the same direction as the withdrawing movement of the coated article. The speed of this movement may be varied, of course, to suit the desired or possibly the needs of given operations. It will be clear that this feature of my method will facilitate the maintenance of the desired depth of coating on the article, as distinguished from the detrimental or opposing tendency of any washing, spraying, or wiping action of streams flowing in a direction opposed to the movement of the coated article, which latter would result in a tendency to wash, wipe, or brush away a part of the coating from the article, or present a constant tendency to interfere with the coated article by opposing the movement of travel of the latter. All of this is overcome in having the movement of the final coating bath material under my invention, travel along with or in the same direction as the movement of the article, because up to the final departure of the coated article from the bath the article is still being coated and substantially augmented by these movements in the same direction. Incidentally, it is to be observed that this movement of the bath in the direction of movement of the coated article is also measurably helpful in overcoming the tendency of the coating on the article to flow or drop back toward the bath as it leaves the same, in any such degree as prevails in those instances where the coated article immediately upon leaving the bath is passed in an ascending direction of movement through or past a stream or streams of prevailing bath material discharging or flowing towards the bath; in other words, in the same direction that gravity is operating to influence the movement of the coating on the article. A downward sweep of zinc leaving a grooved surface in the zinc makes an effect on the surface similar to the bark of an oak tree. These grooves forming within the surface of the coating will effect a variation of the thickness of the coating, which will cause cracking when the article is bent or deformed, due to the unevenness of the coating.

I come now to the third step of my method, which consists in utilizing oxygen-free atmosphere above and contacting the surface or surfaces of the bath in proximity to the point of discharge of the coated article therefrom, so as to prevent, so far as possible, the contact of air with the surface of the bath, and the formation of oxides that might become matted and picked up by the coated article as it is withdrawn from the bath, as well as surrounding the coated article as it leaves the bath, to protect the same from air, and thereby to preserve the coating in its intended condition for setting or fixing, as will be referred to in the recitation of the fourth and final step of my method.

Incidental to this overlying of the bath surface and the surrounding of the coated article with the oxygen-free atmosphere referred to when, as preferable, such atmosphere is created by the introduction and confinement of relatively cool gas, the same instantly, as the coated article emerges from the coating bath, commences to exert a cooling action on the coating, which action will be continued coincidently with the complete envelopment of the article in the oxygen-free atmosphere within the very short space of travel (usually a matter of inches, in the case of a wire somewhere in the neighborhood of twelve inches) intervening the complete escape of the coated article from the bath and the presentation of the same to the final setting or fixing step of my method. Owing to the shortness of this interval of travel, the coated wire or the like will be susceptible or subjected to very little, if any, vibration, which might tend to disturb the coating thereon.

In the performance of the third step of my method, just under discussion, and as an auxiliary feature thereof, I practically seal the coated article, in its passage through the oxygen-free atmosphere, by moving the coated article in the same general direction as the gas of said oxygen-free atmosphere is traveling towards its discharge, and contemporaneously pass both the gas and the coated article through a common discharge opening whereby the gas introduced into the chamber for the oxygen-free atmosphere under pressure and under its natural ascending tendency will fill and pass through the exit opening in surrounding relationship to the coated article passing along therewith through said exit opening. Thus, admission of air into said treating in surrounding relationship to the coated article after it leaves the treating chamber is ready for presentation to the fixing or setting medium in identically the intended condition derived from the treatment of the article in the molten zinc bath and the non-interference therewith in any particular, whatsoever, from the point of its discharge from the bath to the point of its presentation to the setting or fixing medium referred to.

This fixing or setting medium and the application thereof to the coated article, constituting the fourth and final step in the essential characteristics of my method, comprises a subjection of the coated article, as preserved in its passage through the oxygen-free atmosphere, and as still protected on its emergence from the gas chamber by the enveloping gases escaping therefrom, to the cooling water treatment projected onto the coated surface of the article or onto and around the treated exterior of articles such as wires or strips, as distinguished from plates—the projection of the cooling water being through the confronting body of escaping gases in the path of the projected streams or jets of said water.

The immediate result of this the fourth step of my method is that the coating will be hardened and set or, as technically known in the art, "quenched", with practically no opportunity for the coating to be contacted, contaminated, or impaired by oxygen, or by abrasive or other action of extraneous objects in the course of the travel of the coated article.

In addition to the article obtained by the practice of my method, facilitated by the use of a suitable machine designed by me for these purposes, I have further illustrated in the drawings not only my preferred embodiment of coating mechanism, but also several other practical embodiments of the invention, common in important characteristics to each and all of said embodiments.

In these drawings—

Fig. 2 shows a vertical section of the preferred apparatus for practicing my method of galvanizing in producing the article of Fig. 1;

Fig. 3 is a detail taken on the line 3—3 of Fig. 2;

Fig. 4 is a vertical sectional view of a modified outlet portion for the article leaving the zinc pot, provided with means immediately associated therewith for creating flow of the zinc, as distinguished from the relatively remote means of that embodiment of the invention illustrated in Fig. 2; and

Fig. 5 is a vertical section through another embodiment of the invention, wherein the means for forcing the flow of the bath as employed in those embodiments illustrated in Figs. 2 and 4 are dispensed with and instead a natural flow of the material is relied on in connection with suitable means for facilitating the desired operation.

Referring more specifically to the drawings, and first with reference to the preferred form of the apparatus illustrated in Fig. 2, the numeral 6 represents a zinc pot of any conventional or preferred type, usually made of iron, the essential difference between the pot utilized by me, more particularly in the heavy coating of wire, as compared to those of the prior art, being in the greatly reduced length of the pot; for, as previously noted herein, the convenient length of pot in the present instance may be in the neighborhood of six feet, as compared to the common practice of using pots, for like purposes, in the neighborhood of twenty to thirty feet in length.

The dash-line illustration is, of course, the bath 7 of molten zinc, the normal level of which is represented at 8.

9 represents, for convenient example, the wire entering and leaving the bath to obtain the coating thereon. The means and manner of treatment of the wire will be now described.

Supported upon the wall of the pot in any manner found expedient, such as by standards or uprights 10, which may be either bolted to or separably rest on the walls of the pot (not necessary to be illustrated in detail) is a pan 11 partially submerged in the molten zinc bath 7. This pan 11 having a bottom portion 12 intermediate of the ends thereof forming, with the partitions 13 and sides 14, a centrally disposed compartment or chamber 15. The pan member or structure 11 has its side walls extending outwardly in an opposite direction from the intermediate portion just referred to, to provide in the instance of the extension designated 16, an inlet compartment for the wire to be treated, said compartment being open at its bottom and closed at the end by the wall 17 bridging the extended portions of the side walls 14; and to provide in the instance of the extension designated 18 an open bottom outlet compartment for the coated wire, this compartment being closed at its end by a wall 19 bridging the extensions of the side walls 14, the same as in the case of the wall 17 at the opposite end of the pan. The extension 16 has a tubular inlet 20 (of cylindrical or rectangular cross-section, as obviously may depend on the wire or wires to be treated) arranged at an inclination in line tangentially with the periphery of a guiding roller or drum 21 mounted at a substantial depth in the zinc pot and around which the wire 9 passes and extends upwardly in an approximately vertical direction to pass out of the zinc pot when coated, it being understood that this roller is free to rotate in conventional manner, the feeding of the wire during its coating travel being by mechanism ordinarily employed in the art to pull the wire through the machine, in the directions represented by the arrows 22.

It is necessary to prevent, so far as possible, the formation of accumulations of oxides on the surface of a molten zinc bath, because of the evil effects thereof on the wire or other article introduced into and withdrawn from the bath and incidental contact with matted oxides, etc. This is especially true of the exit end of the bath; but to avail myself of such advantages as may flow from the same at the inlet end of the bath, I have arranged to deliver into the compartment within the extension 16—20 an oxygen-free gas or atmosphere which will protect the surface of the molten zinc to a considerable extent from contact by air and also tend to prevent the drawing in of moisture or air incident to the incoming movement of the wire being drawn into the bath. Such gas-delivering means is diagrammatically illustrated at 23, and the gases contained within the compartment diagrammatically at 24.

While the arrangement just described is, as stated, helpful in avoiding to some extent the formation of oxides at the surface of the bath and the conveying of the same downwardly into the body of the bath, I have found it necessary to give more consideration to the prevention of the formation or accumulation of oxides or other deleterious substances at the discharge end of the bath; and by discharge end I mean that point or region of the bath through which the coated article is withdrawn from the bath. One means or arrangement to this end conceived by me, and found in actual demonstration to be successful in attaining the ends in view, is that consisting of a pump 25, here in the nature of a propeller located in a small casing or cylinder 26 at the bottom of the pan 11 and establishing open communication between the interior of the pan and the molten zinc at a point located substantially below the level 8 of the zinc bath. The pump or fan may operate in any suitable manner, as by a motor, driven pulley, gearing, or the like, 27 for driving the propeller shaft 28 revolvably mounted in any practicable manner, as by bearings 29 secured to the standards or uprights 10. It is intended that this pump 25, in the operation of the apparatus shall raise the zinc from the low or relatively pure portion of the body thereof, meaning that portion protected against the accumulation of surface flotation, including oxides, etc., up to approximately the level 30 in the pan 11, to afford a substantial head or pressure assisting in forcing a part of the pan contents outwardly and upwardly through the correspondingly inclined passage 31 leading from the end wall 13 intermediate the compartment of the pan at that end thereof remotely related to the opposite wall in immediate adjacence to the pump 25. The operation of the pump, while intended to primarily force a part of the molten zinc upwardly and outwardly through the passage 31 to secure the results intended in the use of the devices and arrangement thus far related, said pump will or may, as desired, supply the intermediate compartment of the pan 11 with sufficient molten zinc to cause some of the latter to pass into and out of a trap 32 at the inlet end of the bath; the purpose thereof being two-fold, one purpose being to cause a movement or agitation of the zinc at the inlet surface of the pot, thereby helping to prevent accumulation of matted oxides that might cling to and be conveyed into the bath by the incoming wire, and the other purpose being to prevent any oxides that might form on the upper exposed face of the zinc in the intermediate compartment or pan 11, itself, from passing through the trap and back to the bath, which latter function, that is the preventing of the escape of oxides from the surface of the zinc in the pan, is similarly accomplished by taking the zinc therefrom into the upwardly and outwardly inclined passage 31 from substantially the bottom thereof. While the escape of the zinc from the intermediate compartment of the pan 11 through the trap and through the passage 31 (to be more fully disclosed as to the latter) will effect, in many instances, sufficient overflow to maintain the desired level in the pan, auxiliary overflow passages 33 are provided in the side walls 14, from which excess molten zinc in the pan may escape and be delivered back to the main bath or body of molten material outside the limits of the pan and its extensions.

The outwardly and upwardly inclined passage 31 into which the zinc flows from the intermediate compartment 15 of the pan 11 is effected by the pressure resulting from the difference in level between the normal level 14 of the molten zinc in the compartment 15 of the pan and the overflow 34 at the upper end of the outwardly and upwardly inclined passage 31. This overflow 34 is a common point of discharge not only of the zinc that is forced upwardly through the passage 31 but also of any zinc that is entrained or induced to pass upwardly through an elongated vertical shield 35 (conveniently of rectangular or box-like cross-section to accommodate a series of wires) open at its lower end and closed by side and end walls, or by tube-like formation, whereby relatively pure zinc from a low point in the pot may pass upwardly thereinto and be drawn by the zinc forced upwardly and outwardly through the passage 31 to a common elevation whence the combined or merged body of zinc will flow over the upper end or overflow 34 of the united structure. The opposite ends of the shield 35 are shown as flaring outwardly (though this is not necessary). The lower portion of the shield is much longer than the upper portion thereof and dips correspondingly to a greater depth into the zinc bath than said upper portion projects upwardly above the normal level of the bath, so that the resistance of the bath material in the lower portion of the shield to being displaced downwardly relatively to the main body of the bath, will cooperate in insuring the movement of bath material upwardly and out of the upper end of the shield. It is my purpose that this shield 35 shall be of a shape and size to generally conform to the coated article or articles (wires) passing therethrough, but that the same shall be of a size to have no contact with said coated article, in order that the latter may pass therethrough freely in its travel from the coating bath to the next stage of the operation on the coated article. The normal level of the molten zinc in the extension 18 being, as stated, approximately at the line designated 8, it will be appreciated that as the coated article passes upwardly through the shield 35 the latter will be perfectly protected against any contact or intimate association with whatever accumulations—oxides or the like—that may accumulate on the surface of the zinc bath; so that in this respect the coated article will not be contaminated.

It is, of course, my purpose to prevent the contact of air with the zinc in this discharge extension, and for that purpose I make provision for delivering under pressure thereinto what I have styled an oxygen-free atmosphere or gas, or non-oxidizing gas, discharged into the chamber as indicated by the arrows, and thoroughly encompassing and overlying the exposed portions of the passage 31 and shield 35 and zinc overflowing at the discharge mouth 34 thereof. This oxygen-free atmosphere, while exerting its sealing function will prevent access of air to the surface of the zinc bath, but cannot, of course, prevent oxides that may reach or be formed in the bath in other respects from arising to the surface of the bath within this discharge extension 18; but as previously noted the upper projecting portion of the shield 35 affords abundant safeguard for the discharging coated article from having any engagement with the oxides that may reach the surface of the bath in the extension in the manner just stated.

It is hardly necessary to mention it, but it will be understood that marked advantages are inherent in the movement of the molten zinc upwardly through the passage 31 and shield 35 in the same direction of movement as the discharge of the coated article upwardly through said shield. At times, the overflow of the zinc material from the shield may be augmented and at other times decreased, as may be fit to conditions appertaining to the particular work being done; but I have found that satisfactory results may be accomplished by a very slight overflowing or continued movement of the liquid out of the shield 35. This will be sufficient to prevent accumulations or mass-formation of oxides on the zinc within the shield and will correspondingly prevent deleterious action thereof with respect to the coated article passing through and out of the said shield; and the trend of the movement of the zinc in the shield being the same as that of the movement of the discharging coated article also avoids the interposing of any action, whatever, on the coated article, as by washing, brushing, or rubbing, in opposition to the direction of movement of the article at a stage of such movement when the coating is, of course, in its softest condition. I have found that even by subjecting a freshly coated wire, for example, to a washing jet or spray, the same has a disadvantageous effect on the coating on the wire, in grooving or rendering the same uneven by displacement, etc.; and this is peculiarly so where the ejection of the stream or jet against the coating is in a direction contrary to or the reverse of that of the direction of the movement of the article bearing the coating. Naturally, the coating on the article, in an apparatus such as illustrated in Fig. 2, wherein the coated article is moving in a vertical direction, the force of gravity alone tending to affect the soft coating, is a factor, and this is rendered decidedly more so where any washing, brushing, or rubbing action takes place in the direction of and supplementing such force of gravity. All of this is overcome or prevented in my present apparatus and method. It has probably been noticed from an inspection of the drawing (Fig. 2) that in order to seal the compartment within the extension 18, the same is provided with a lid 37 formed with a sealing flange adapted to seat within a sand-filled groove.

In describing my process or method, in an earlier part of this specification, I emphasize the desirability of producing a coated article, such as wire, in a way to provide a predetermined uniform result, including not only the smoothness and brightness of the surface of the coating, but also the given depth or thickness of the coating; because where heavy coatings are desired it is quite important that such coatings shall not be varied in their depth as, for example, where the surface has been wiped, in keeping with prevailing prior art practices, or washed, or brushed, or, in fact, treated, after dipping, to any element or device that would disturb or abrade the coating, as by scratching or rendering the surface undulatory, that is thick in some places and thin in other places. With these factors in mind, it will be further understood that in the use of the apparatus herein disclosed I have eliminated any possibility of a jet or stream—even of the zinc bath material, itself—being delivered against or over the coated article in a movement contrary to the travel thereof, and which by its stripping or reducing action on the coating frustrates the uniform or regular depth of coating constituting one goal of the present invention.

Also, in the disclosing of my method I emphasized the phase of my discovery involving the quick passage of the article through the coating zinc bath, and gave a fair illustration of the comparison of time availed of by me and that of the trade practices in similar coating operations; in other words, the approximate difference between the three-to-five-seconds period that I use as against the twenty-to-thirty-seconds period employed in general practice: and also in connection with which discussion reference was made to my findings concerning the building up of the zinc-iron alloy under the old practice and the avoidance thereof under my new practice. My theory is, as stated, that where (as in the apparatus of Fig. 2) the coated article is conveyed in a vertical direction or in a direction tending toward the vertical, a slow movement permits the coating to drip or recede over the treated article; whereas, in proportion to the increase of movement, the coated article will carry just that much more of the coating along with it, and, provided the coating is appropriately fixed or set with promptness, much better results than heretofore are accomplished or attained. During the passage of the coated article from the zinc pot into and through the shield 35, and therebeyond, everything is favorable to the rapid movement of the article, because, at the final discharge of the coated article from the shield the movement of the coating material is in the direction of the movement of the coated article. This means that up to this exit from the shield no conflicting influences have been encountered to impair the results of the coating operation. Now, immediately upon the discharge of the coated article, as thus appropriately formed, the same is surrounded by the oxygen-free atmosphere heretofore referred to; and this, as stated, being preferably relatively cool gas, it will commence to instantly chill the coating on the article and play its part in preventing flow or displacement of the coating, as well as the more important part of enveloping and sealing the coated article against contact with air or extraneous substances or devices. This is attained by the provision of the vertical dome, chamber, or extension 38 in open communication with and extending upwardly a relatively short distance—say from 18 inches or thereabout—from the top wall of the compartment of the extension 18, so that substantially throughout the entire course of travel of the coated article from its point of exit from the shield 35 to the principal cooling or setting means, now to be described, the coated article moves freely through an unobstructed, uncontaminated zone protected from air or harmful substances or devices, the same constituting the third step in my method, as pointed out. The dome or extension 38 is closed at the top, as represented at 39, save for a slot or aperture, as the case may be, through which the wire or wires or other product escapes to the operating zone of the fourth step of my method immediately above the closed top 39. Here, it is to be observed that the non-oxidizing gas introduced through the pipe 36 is preferably under pressure and the same will pass upwardly through the dome or extension 38 entirely surrounding the coated article passing therethrough, and out at the top 39 through the aperture or slot referred to and now designated 40, the discharging gas through the relatively small opening at the top constituting an effective seal against the ingress of air into the dome or extension 38 and, of course, coincidently barring the admission of air to the compartment in the extension 18 therebelow. The discharging gas from the dome or extension 38, although afforded ample opportunity for expansion as it leaves the opening in the top 39 is, however, of sufficient volume to extend upwardly in immediate adjacence to the coated article leaving the dome or extension 38, to continue its protecting effect on the coating; that is, so far as exposing the coated article to any substantial deleterious effect of air is concerned. This continued utilization of the protecting influence of the gas is rendered possible because of the very close proximity of my cooling or setting instrumentalities to the exit at the top of the dome or extension 38. This cooling and setting means comprises essentially jets or sheets of water delivered through a nozzle or nozzles 41 from a pressure chamber 42 in a water box 43 supported at the upper ends of the uprights or extensions 10, the water box having an overflow at the dam 44, and a final outlet pipe 45. The pressure chamber 42 receives its water in continuous flow, through a supply pipe 46 leading from any feeder or source 47. The water jetted onto or against or around the coated article, as indicated by the arrows 48, is generally transversely of the coated article and the arrangement is such that the water will penetrate the gaseous film arising with and surrounding the article as they both leave the extension or dome 38, the water eventually reaching the coating and having direct contact and influence thereon in setting and fixing the coating in such manner that the same is substantially perfect and insured against any damaging effect, whatsoever, as the coated article is drawn upwardly and around the guiding roller 49.

In lieu of having the gas liberated as it escapes through the opening 40 in the top 39 of the dome or extension 38 and passes upwardly along the sides of the coated article in front of the cooling jets, I also contemplate burning this gas by igniting the same at the opening or nozzle of the closed top so that the flame will pass upwardly and envelop the coated article and be interposed between the latter and the jets of cooling water. This flame will utilize the oxygen in its neighborhood and therefore prevent any tendency of air to enter the dome or seriously contact the coated article.

It will be noted that, if desired, the water pressure chamber 42 may have compartments on both sides of the wire or coated article, so that the water jets may be thrown in opposite directions towards each other; but particularly in the instance of wire I have found that the single set of nozzles delivering the water in the one direction is sufficient. The top of the dome or extension 38 is inclined upwardly and inwardly from opposite sides towards the exit opening 40, to shed the cooling water that may fall onto the same and direct the former in opposite directions for escape into either one or the other of water-discharge pipes or drains 50. As the completed article passes around the guide roller 49, the same is subjected to additional cooling water to obtain the final setting, through the medium of a nozzle or nozzles 51 also receiving their water supply from the main or source 47 and directing the same onto the top of the roller 49 and over the wire or wires passing therearound, this water flowing downwardly over the vertical runs of the wires outside the water box 43 and eventually finding its way to either one or the other of the drains 50 and also passing with the completed wire over and around the guide roller 49 into the interior of the water box 43 in which a revolving drum 52 is mounted to dip into and consequently force the coated wire into the water in the box 43, from whence the finally cold and set coated article (wire) is drawn off to the usual take-up block or reels.

It is feasible to dispense with the intermediate pan 11, and extension 16 through which latter the article to be treated is passed in its travel into the zinc bath, of course including also the elimination of the immediately associated elements, and functioning thereof including the locating of pump 25 in the pan, the communicating of the passage 31 with the pan, the trap 32, the gas supply 23, etc., whereby the resultant apparatus, in instances, may be materially reduced in size and otherwise simplified. One such example is illustrated in Fig. 4, and another in Fig. 5, it being suggested that all other portions of the apparatus, not redrawn in these particular views of the drawing are intended to remain the same as in substance disclosed in Fig. 2, or the equivalents thereof substituted therefor. This last statement relates more particularly to the retention of the gas dome, as 38 (Fig. 2), the closing of the top thereof, as at 39, to provide the exit opening, as at 40, for free passage or burning of the gases thereat, the cooling or setting apparatus in immediate adjacence to the zone of exit of the coated article and gases or flame from the zone, etc., or as has been previously gleaned from the consideration of the form of apparatus illustrated in Fig. 2.

In the light of the explanation just made, and first with particular reference to Fig. 4, it will be seen that 53 represents a compartment dipping into the metal bath 54 whose normal bath level is indicated at 55, and having an open bottom 56 the same as the extensions 16 and 18 of Fig. 2, to permit the normal bath material to rise into the compartment. The compartment has a supply 57 for non-oxidizing gas adapted to fill the unoccupied area within the compartment and above the normal level of the bath, said area opening into and correspondingly enlarging the oxygen-free atmosphere within the dome portion 58, broken away in the figure, and, as stated, intended to have the form and function of the dome portion 38 of Fig. 2.

Corresponding to the shield 35 of Fig. 2, I provide in the embodiment of my invention under discussion (Fig. 4), a similar shield 59, it being understood that all of these shields are tubular or elongated transversely, or of other hollow cross-section, in keeping with the shape and arrangement of the articles being coated and intended to be passed through and be protected by the shield. The shield 59 also projects downwardly through the compartment 53, and for the greater portion of its length into and below the normal bath line 55, and at its upper end extends into the oxygen-free atmospheric area of the compartment. To one side of the shield 59 is a casing in part preferably tubular, constituting a pump chamber 60 open at its lower end 61 conveniently on a line common to the lower open end of the shield 59, whereby both the shield 59 and casing 60 will receive part of the material of the bath in relatively pure condition from the relatively low point within the bath. The wall 62 of of the casing 60 inclines upwardly and merges into the discharge or outlet mouth of the shield 59, the intervening partition or wall 63 between the shield and the casing 62 terminating short of the upper end of the shield to provide a passage 64 between the interior of the shield and casing. 65 is a propeller or pump located at the inlet into the casing 60, adapted to be driven by the propeller shaft 66 operatively connected to a source of power such as a belt and pulley, gearing, motor, etc. (not shown).

Normally, the bath material will extend upwardly into the shield 59 to approximately the normal bath level 55 or upper edge of the partition 63, and the pump 65, when in operation, will force the material of the bath that has similarly arisen in the casing and which will be drawn into the casing by the pump and driven upwardly into the casing, out through the passage 64 into the shield, and through the upper discharge end thereof, whence the same will flow over and back to the main body of the bath, the movement of the bath material entraining and moving upwardly the bath material in the shield to maintain a greater or less flow of the combining bath material within the shield and casing in a direction upwardly and out of the same so as to prevent an opportunity for arising oxides to accumulate on the surface of the bath material at the discharge mouth of the shield, where it would be liable to be carried away by the coated material passing upwardly through the shield. In this instance, the movement of the part of the bath material out of the shield being, as heretofore, in the general direction of withdrawal movement of the coated article, presents all of the advantages attributable to such operation and relationship herein, before explained.

Referring now to Fig. 5, the compartment is represented at 67, immersed and opening at 68 in the molten bath 69 at a point substantially below the bath level 70. The compartment has means 71 for supplying the non-oxidizing gas to the vacant area within the compartment 67 in part over the normal surface of the molten bath therein, 72 representing the dome or extension of the oxygen-free atmosphere, as suggested in connection with the earlier disclosures herein. In the present instance, the larger portion of the bottom of the compartment is closed as at 73, the end walls 74 and inner side walls 75, together with the outer side walls 76 comprising a receptacle located at substantial depth in the molten bath, permitted by the abnormal length of the outer wall 72, as compared to the depth of the compartment extensions 16 and 18 of Fig. 2, or the compartment 53 of Fig. 4. The relatively lower location of the receptacle just defined in the molten bath is for a purpose now to be pointed out. The shield in this instance is denominated 77 and opens through the bottom 73 of the receptacle for the admission and passage upwardly therethrough of a part of the relatively pure zinc obtained at this depth in the bath. The upper end of the shield, that is the discharging portion thereof, terminates at a point substantially below the normal bath line 70 so that there is always present sufficient force on the bath material to move the same upwardly through the shield and over into the receptacle, thereby obtaining a continuous flow and avoiding any quiet or unmoving status of the bath material in the shield which would permit ascending oxides to accumulate and form such a matted condition as would enable oxides thus aggregated to act as a wiper to seriously reduce the amount of coating on the article passing therethrough, or to cling to and be carried along with the coated article in its passage through the mat, thereby giving rise to the objections noted in the discussion of the general objects of the invention. To prevent undue accumulation of the bath material in the receptacle, and so that any level of such material in the receptacle is always maintained well below the overflow 78 from the shield, I provide an outlet 79 from a point near the base of the receptacle in open communication with a pump (not shown), which will, at an appropriate rate, either continuously or at intervals, draw the excess material from the receptacle and return it to the bath.

Due to the smoothness and uniformity of the coating, many articles can be manufactured without the use of lubricants, as the coating is so smooth and uniform that it does not need to be lubricated, the result being that the necessity of cleaning the coated articles after fabrication is eliminated.

A great advantage in producing a coated article free of oxides and surrounded and protected by an oxygen-free atmosphere until the presentation of the coated article to the cooling medium to set or fix the coating, is that the lustre or natural blue-white appearance of the molten zinc is preserved and perpetuated in the finally completed article. The lack of air within the gas dome prevents the coating from becoming thick and variously viscous (which would result if contaminated by air), as well as lack of uniformity in the final product, which viscosity or thickening would result from contact of air with the coating before it had become set or fixed.

In the galvanizing of high carbon wire (rope or bridge wire) by the ordinary methods much of the tensile strength is lost; whereas, by my method only slight reductions are noted in the tensile strength, because of the short immersion of the article in the zinc bath, the low temperature of the zinc bath, immediate cooling of the article when it leaves the bath, and the speed of travel of the article through the bath. Such treatment as I give the article prevents the annealing of the article, thereby retaining to a great extent its original strength.

The shield 35 of Fig. 2, the shield 59 of Fig. 4, and the shield 77 of Fig. 5 are not so wide as the gas chamber, thus allowing zinc flowing over the sides to flow around the ends and into the bath.

The flow of the bath, under pressure of the pump, can be regulated to a certain extent by increasing or decreasing the speed of the pump.

The gas which I have employed to create an oxygen-free atmosphere is natural or illuminating gas. Other gases may be used.

No claim is made or retained herein for the divisible subject matter of my invention involving the disclosed apparatus and article, these now being included in the co-pending applications Ser. No. 98,607, filed August 29, 1936 (Apparatus for coating metallic materials), and Ser. No. 98,608 filed August 29, 1936 (Metal coated iron or steel article), these applications having been filed in compliance with official requirement for such division.

What I claim is:

1. The method of galvanizing an article, comprising immersing the article in a molten zinc bath, effecting movement of a part of said bath to an oxygen-free atmosphere and liberating the same in said atmosphere, withdrawing the coated article from the bath through the moving part of the bath and in the general direction of movement of the latter, exposing the coated article to said oxygen-free atmosphere beyond the point of said liberation of the moving part of the bath, quenching the coating on withdrawal of the coated article from the oxygen-free atmosphere, and protecting the coated article from contact by air during said quenching and from extraneous abrasive contacts as the coated article leaves the bath and until its coating is quenched.

2. The method of galvanizing an article, comprising immersing the same in a molten zinc bath, withdrawing the coated article from the bath after its immersion therein for a period of approximately from three to six seconds to take on the coating material desired while avoiding the formation of any substantial zinc-iron alloy throughout the outer major portion of the zinc coating whereby to leave the same substantially pure, and localizing iron constituents within narrow range adjoining the normal surface of the article, the withdrawing of the coated article from the bath being by quick elevation thereof directly into an oxygen-free atmosphere to preliminarily cool the coating and protect the same from air, effecting a movement of a surplus part of the bath into an oxygen-free atmosphere along with the moving coated article and liberating the surplus material in said oxygen-free atmosphere, and immediately subjecting the coated article to a final cooling and setting treatment beyond the oxygen-free atmosphere and in the presence of a supplemental oxygen-free atmosphere before any substantial exposure thereof to air.

3. The method of galvanizing an article, comprising immersing the article in a molten zinc bath, effecting movement of a part of said bath, withdrawing the coated article from the bath through the moving part of the bath and in the general direction of movement of the latter, subjecting the coated article and surplus moving part of the bath to the influence of an oxygen-free atmosphere during the withdrawing movement of the coated article, quenching the coating on withdrawal of the coated article from the oxygen-free atmosphere, and protecting the coated article from contact with extraneous abrasive contacts as the coated article leaves the bath and until its coating is quenched, and freeing the surplus moving bath material from the coated article within the oxygen-free atmosphere, the immersing of the coated article in the zinc bath being of relatively short duration and terminating before the formation of any substantial zinc-iron alloy throughout the outer major portion of the zinc coating whereby to leave the same substantially pure, and localizing iron constituents within narrow range adjoining the normal surface of the article.

4. The method of galvanizing an article, comprising immersing the same in a molten zinc bath, withdrawing the coated article from the bath, substantially protecting the coated article from air until the coating is cooled and set, and cooling and setting the same by contacting water with the coating while the same is protected by a non-oxidizing gas and flame, the delivery of water being in a direction transverse to the movement of the coated article and the flame being in adjacence to the same and therebelow so that a non-oxidizing gas exerts its influence substantially throughout this area of treatment.

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