

[54] **PROCESS OF HOT DIP METALLIZING OF METALLIC ARTICLES**

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[51] Int. Cl.<sup>2</sup> ..... **B05C 3/02**

[58] Field of Search ..... 117/114 R, 114 A, 114 C, 117/71 M, 51

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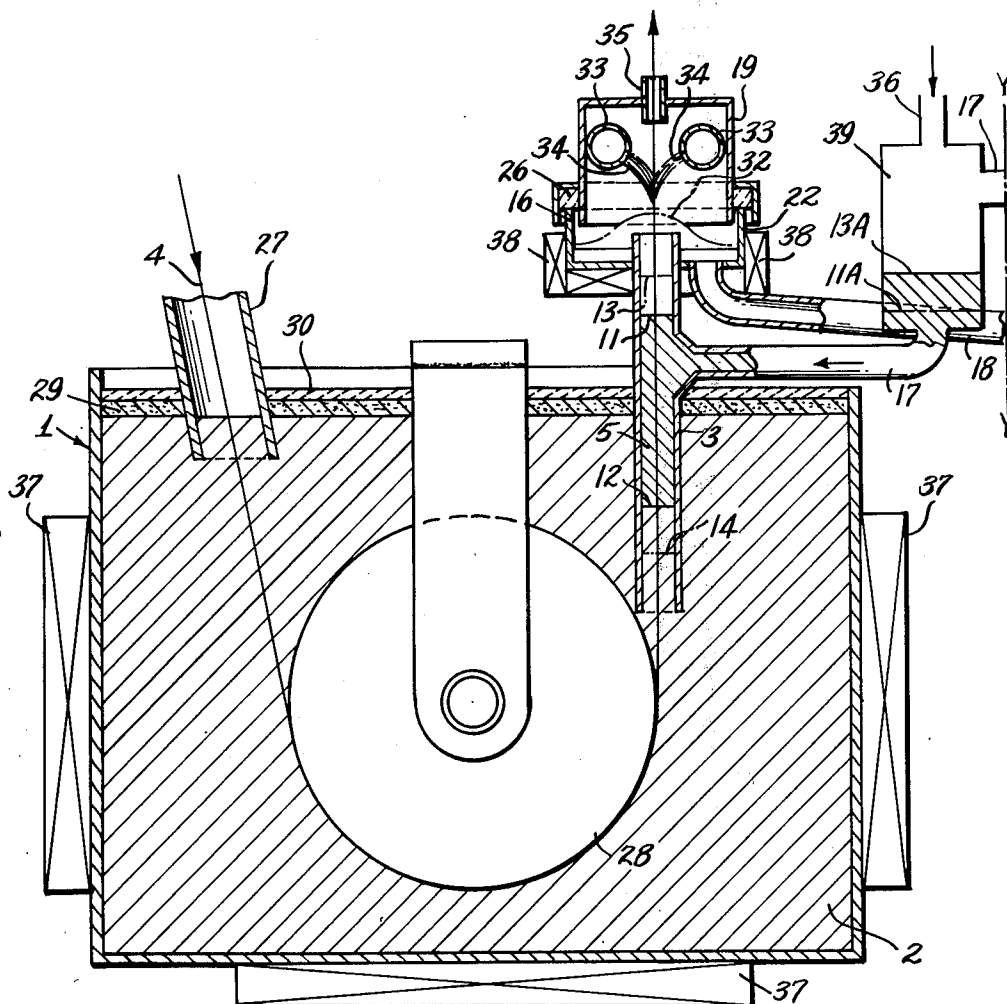
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[57] **ABSTRACT**

The improved hot dip metallizing process of this invention comprises passing the article to be metallized, such as a ferrous article, through a bath of a molten heavy metal, such as lead, and conducting the article therefrom through a layer of molten coating metal, such as zinc, confined in a stack-like structure of a cross-sectional area being a small fraction of the surface area of the heavy metal bath. The coated article is preferably quenched or hot blasted and quenched immediately after leaving the stack. The top dross of the confined layer of coating metal can be automatically removed by overflow and is conducted into the coating metal melting oven where the metal oxides contained therein are reduced to the coating metal.

**4 Claims, 19 Drawing Figures**



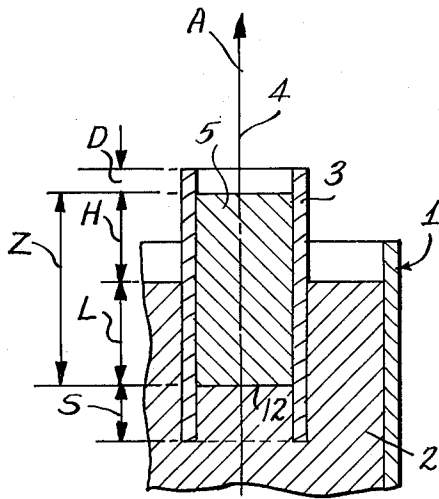


**Fig. 1.**

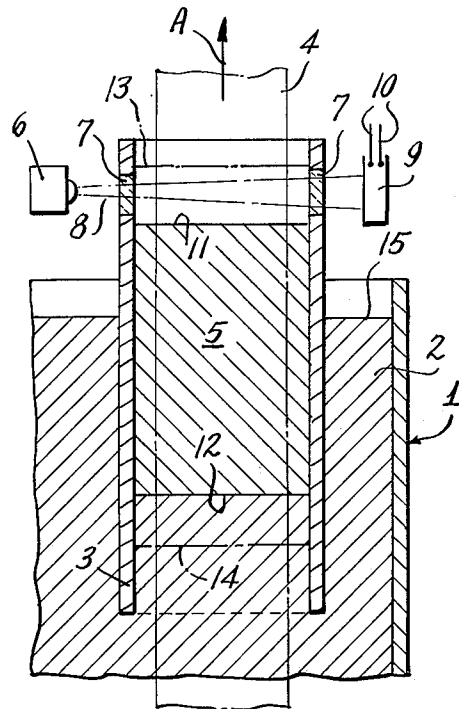


**Fig. 2.**

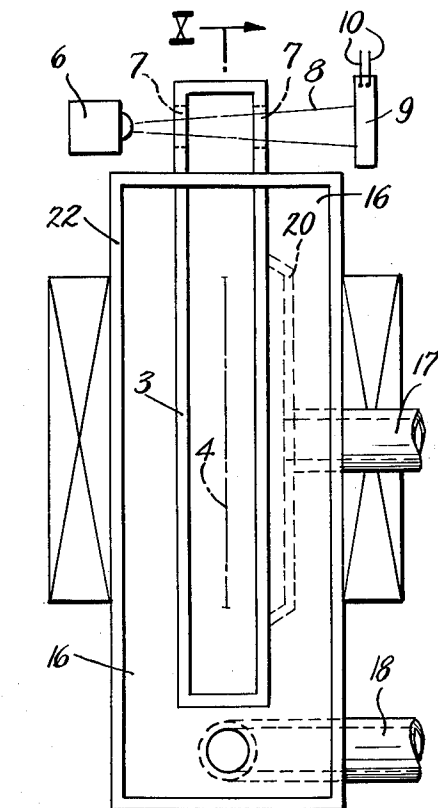


**Fig. 3.**

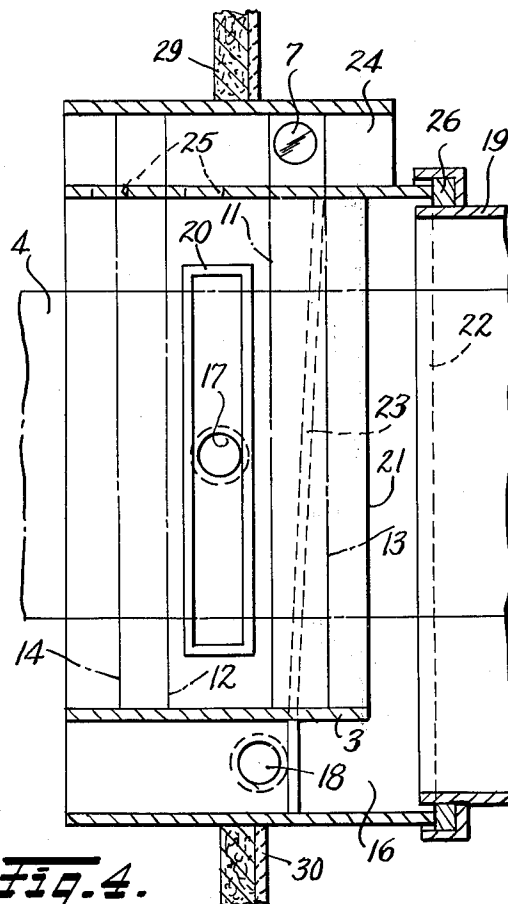
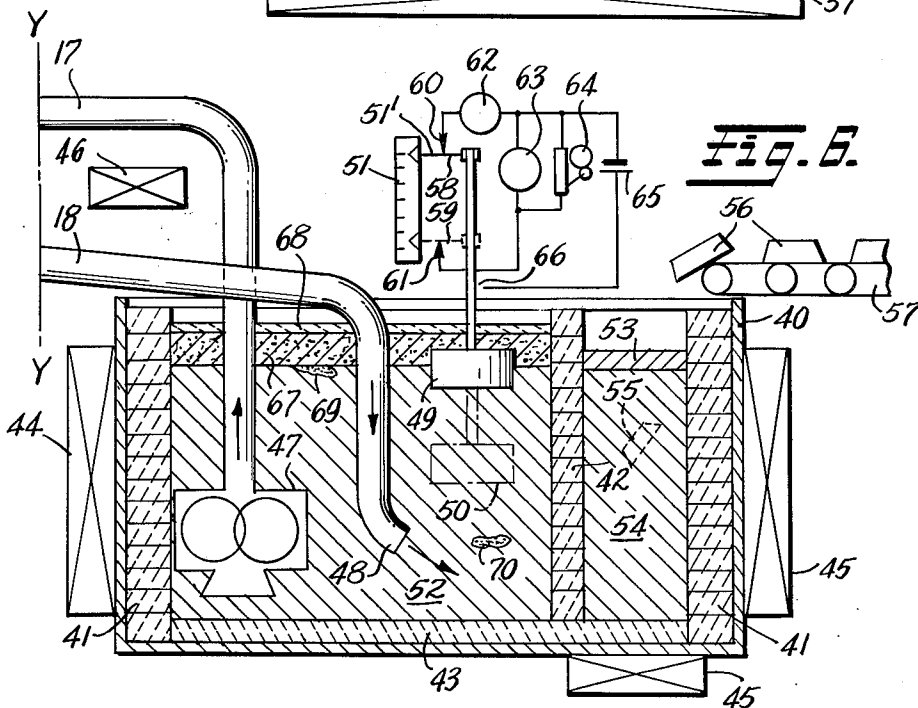
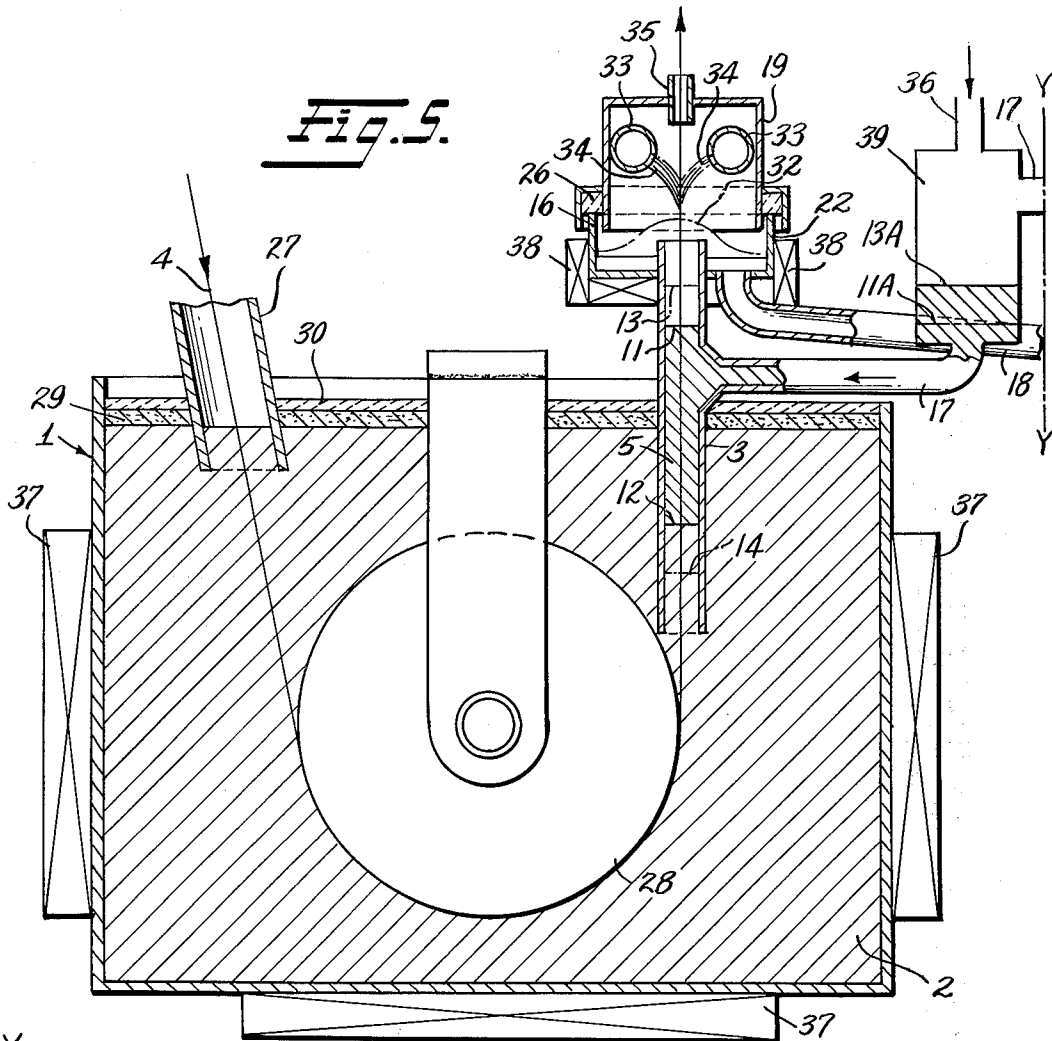
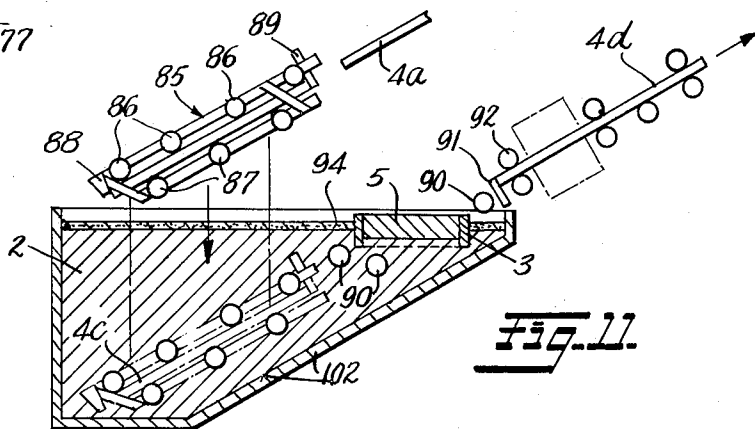
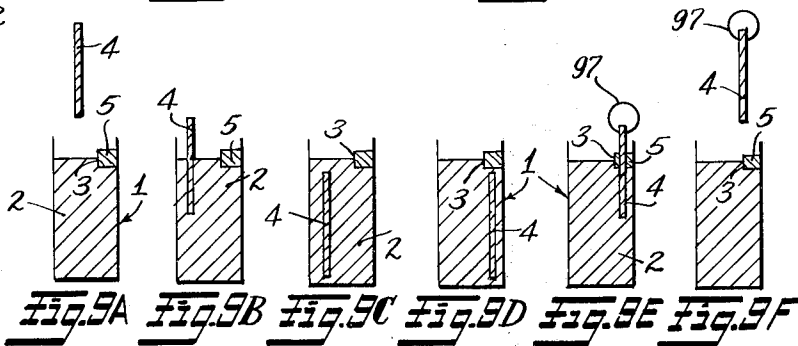
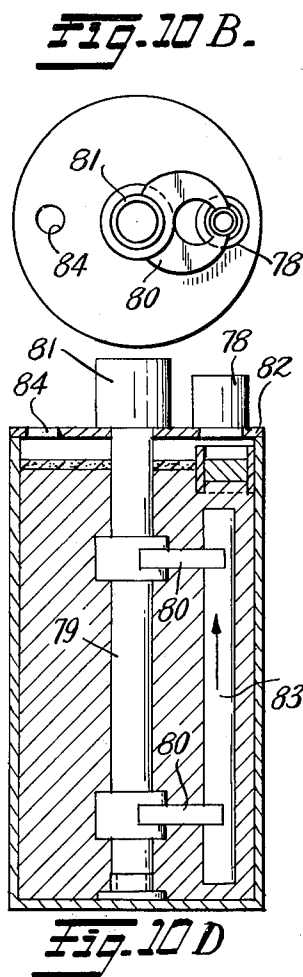
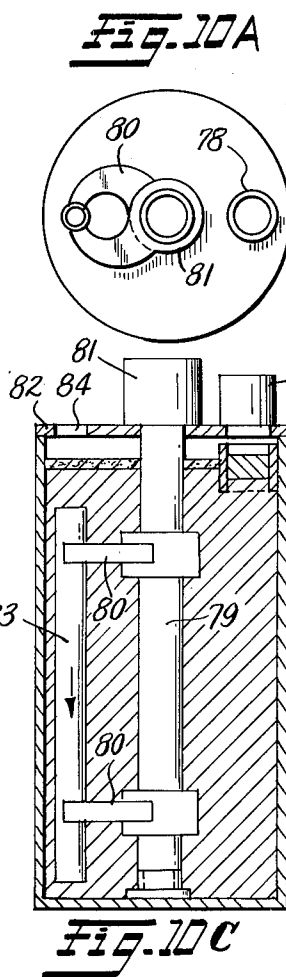
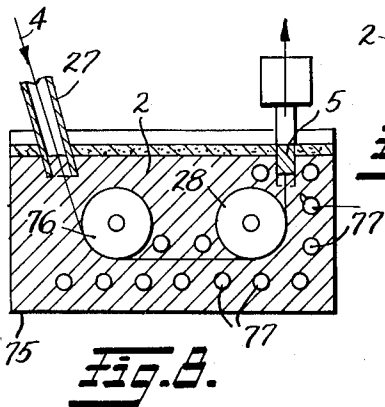
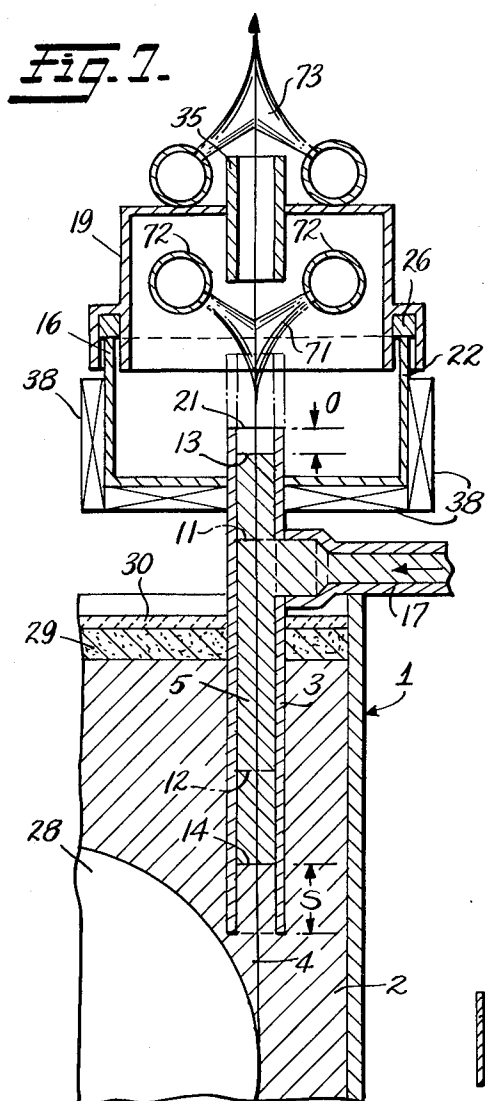


**Fig. 4.**





## PROCESS OF HOT DIP METALLIZING OF METALLIC ARTICLES

### BACKGROUND OF THE INVENTION

#### 1. FIELD OF THE INVENTION

The present invention relates to an improved process of applying metallic coatings to metal articles and more particularly to hot dip metallizing of steel and other ferrous articles and to hot dip metallized articles obtained thereby.

#### 2. DESCRIPTION OF THE PRIOR ART

Metallizing by hot dipping is one of the methods of coating one metal with another. This process consists in dipping the article to be coated in a molten metal bath whereby the coating is formed from the molten metal which adheres to the article. The metals used commercially for such coatings are zinc, tin, lead, and aluminum, i.e. metals of a relatively low melting point to avoid thermal changes in the metal to be coated.

Hot dip metallizing of steel or other ferrous articles has certain inherent drawbacks. Thus, in conventional operation, for instance, for strip galvanizing the metallizing container, i.e. the pot itself as well as all parts of the coating machine, such as the submerged deflector roll, its journals, bearings, supporting brackets, etc. are severely attacked by the molten coating metal, thus considerably shortening their working life, increasing the maintenance costs, requiring an enormous stock of spare parts, the necessary replacement of the parts causing frequent stops of the plant resulting not only in production loss but also in inferior quality of the coatings at the periods of stopping and re-starting the equipment.

Quite often, especially when operating in externally heated coating metal pots, the walls of the pots will be "eaten through", i.e. corroded by the coating metal. As a result of the holes in the pot the coating metal level will be lowered rapidly and, especially in continuous strip metallizing, the snout seal of the heat treatment furnace preceding the hot dip metallizing pot will become uncovered so that atmospheric oxygen can enter into the snout and can thus create critical conditions whereby explosion in the heat treatment furnace will occur resulting in damage to the latter and causing the coating metal to violently splash out of the pot around the exit of the coating line.

Special attention is required of the coating metal "pot man" for watching the coating metal level.

The article to be coated remains in the coating metal during the time required for introducing it into the molten coating metal and removing it from the bath. When coating indefinitely elongated articles such as strip, wire, etc. the length of path of such articles into and through the bath, around the deflecting pulley and out is of importance. The longer the article to be coated remains in the bath, the more the article is attacked by the coating metal.

The product of the coating metal attack on the ferrous metal article to be coated and on the ferrous metal equipment involves, which is called dross and is specifically heavier than the coating metal, falls to the bottom of the pot and has to be removed from there periodically. This also causes disruption of the continuity of the metallizing process with corresponding inevitable losses, as described above.

### SUMMARY OF THE INVENTION

It is one object of the present invention to provide a simple and improved hot dip metallizing process which is free of the disadvantages and drawbacks inherent in the known processes.

Another object of the present invention is to provide hot dip metallized steel or other ferrous articles by coating by means of the hot dip metallizing process of the present invention.

Other objects of the present invention and advantageous features thereof will become apparent as the description proceeds.

In principle the improved hot dip metallizing process according to the present invention consists in

a. passing the article to be metallized through a bath of a molten heavy metal having a specific gravity higher than that of the coating metal, said metal causing substantially no corrosion to the article to be metallized, and

b. conducting the article from said molten heavy metal bath through a confined layer of the molten coating metal floating on said heavy metal, said layer being of predetermined minimum height, the surface area of said confined coating metal layer being a small fraction of the surface area of the heavy metal bath, to cause coating of the article with said coating metal.

Thereby, the time of contact between the article and the coating metal is limited to a predetermined minimum of time sufficient to achieve a coating of the desired characteristics, and any attack by the coating metal of the equipment in which metallizing is carried out is avoided.

While the main application of the hot dip metallizing process of the present invention is for indefinitely elongated articles like strip, wire, and the like, it is also applied under certain conditions to elongated articles like bars, pipes, structural sections, etc., although obviously appropriate equipment is required for this purpose.

In order to carry out the process of this invention, the metal article to be hot dip galvanized is first passed through a kettle which is filled with a molten metal heavier than the coating metal and which does not attack the article and the equipment including the pot. The pot is usually made of low carbon steel.

While in the known processes of lead-zinc hot dip metallizing the entire surface area of the heavy metal layer is covered by the molten coating metal, the molten coating metal is confined according to the present invention in a small framed area or layer floating on said heavy metal layer. Preferably the molten coating metal is confined in a stack-like enclosure open on its top and bottom, such as a pipe or a box of quadrangular or rectangular or other cross-section depending upon the shape of the article to be metal coated, the lower end of which is immersed into the molten heavy metal. Such a pipe or box or the like open-ended enclosure of the molten coating metal will be designated hereinafter and in the claims annexed hereto as "stack". The diameter or cross-section of the stack is only a small fraction of the surface area of the heavy metal kettle or pot, i.e. of the heavy metal bath. The stack is partly filled with the molten coating metal which thus floats on top of a small part of the surface area of the molten heavy metal. Thereby, the equipment and apparatus to conduct the article to be hot dip metallized from the pre-treatment furnaces through the bath of molten heavy

metal into and through the stack containing the molten coating metal, such as guiding means, deflecting pulleys as well as the pot itself, do not contact the coating metal and thus are protected from attack by said coating metal and this takes place in the known processes in which the entire surface of the heavy metal bath, or most of it, is covered by the molten coating metal. The complete coating machinery is submerged in the heavy metal bath and the article to be metallized runs through a relatively short zone of molten coating metal when it comes out of the heavy metal bath.

In this way all parts of the coating machine, the coating equipment, and the pot itself have no contact with the coating metal and are not attacked by it at all, whereas the duration of contact between the article to be coated and the coating metal is limited to a small fraction of the time of such contact in the conventional systems.

Moreover, by varying the height of the coating metal layer confined in the stack, the actual time of contact between the article to be coated and the coating metal can be varied too. This cannot be done in existing metal coating systems.

It is also obvious that since no coating metal attacks the pot and its various parts, the service life of the pot and the equipment therein is very considerably prolonged and, when coating strip, wire, and the like articles, there is no danger of explosion as described above.

Furthermore, the process according to this invention operates, virtually, "bottom dross" free.

The stack confining the coating metal layer has to be coated metal-resistant, at least on its inner surface which contacts the molten coating metal. This stack is only a relatively small part of the entire arrangement and can be made of ceramic, pyrex glass, or any other molten coating metal-resistant material.

Due to the fact that the specific gravity of the heavy metal is greater than that of the coating metal, the latter will always be hydrostatically pushed to a higher level in the stack than that of the heavy metal outside of the stack.

It will be noted that for reasons to be explained later, the actual coating metal section in the stack (locking down) is only a small fraction of the surface of the pot and the heavy metal in it. Therefore, the method of feeding cold blocks of coating metal directly into the coating metal bath, as this is still done in the known processes, is preferably replaced by providing a coating metal melting oven in communication with the stack, which oven permits to maintain a much more accurate and uniform temperature of the coating bath, resulting in a more uniformly coated product of optimum quality.

Since, as mentioned above, the horizontal cross-section of the stack is quite small compared to that of the heavy metal pot, it will be understood that the coating metal, taken out by the article to be coated emerging from the coating metal bath, will lower its level more rapidly than if the entire surface of the pot were involved. Therefore, means are provided to promptly restore the upper coating metal level, which means, preferably, act automatically.

While floats, gages, and other indicator equipment may be used for determining the moment when more coating metal must be introduced into the stack, the preferred method of maintaining a substantially con-

stant level of the coating metal in the stack is as follows:

Due to the difference in the specific gravities of the two molten metals, the coating metal and the heavy metal, the upper level of the coating metal column in the stack will always be higher than the level of the heavy metal outside of the stack in the pot. This difference in height of the levels of the coating metal and the heavy metal allows to make use of the variations in the upper level of the coating metal column in the stack and to observe these variations by means of an electric eye excited by a source of rays, for instance, by light, through appropriate windows in the walls of the stack, which windows are transparent to the rays used. This level controlling system is placed so that, when the coating metal level in the stack is at a desired maximum, the "body" of the coating metal column in the stack interrupts the action of the rays on the electric eye while, when the coating metal level is at its minimum, the rays act upon the electric eye and cause operation of the means supplying the stack with the molten coating metal. To achieve this result, the electric eye emits its signal to an amplifier and then to the switch of the motor of the coating metal pump. In this manner the variations in the upper level of the coating metal in the stack control and operate the motor of the coating metal pump.

As will be seen hereinafter, it is of advantage to position the coating metal oven so that the molten coating metal could, if required, return from the stack to the coating metal melting oven by gravity. A non-return device is preferably provided to prevent molten coating metal from returning back into the coating metal melting oven.

In order to limit fluctuations of the amount of coating metal and, thereby, of the level of the coating metal in the stack, a reservoir of coating metal can be provided, said reservoir being of a larger surface area than that of the coating metal column in the stack. The electric eye control could be placed on the reservoir with the same effect as if it were on the stack, but farther removed from the actual working coating area of the plant. Thus it is less exposed to rough handling by the operating workmen.

In contrast to the conventional strip coating installations, the danger of explosion is completely eliminated due to the fact that the pot is not attacked by the heavy metal filling it, that, therefore, no run-out can occur, and finally that, even if the automatic coating metal feeding arrangement fails, all what will happen is that the stack will run out of coating metal so that the article to be metallized, on leaving the stack, will immediately start to oxidize. This is a very clearly observable signal for the pot man to supply the stack with coating metal. In no case, however, will the air seal of the snout between the reducing and thus explosive atmosphere of the furnace and the surrounding atmosphere be broken, thus preventing any explosion.

The level of the heavy metal in the pot while, of course, requiring a periodic check, does not vary to any great extent. No part of the equipment moves through the surface of the heavy metal bath, whereas the article to be coated enters said bath through the furnace snout and comes out of it through the stack, never breaking through an atmosphere-exposed surface of the heavy metal bath. It is, therefore, possible to protect said surface around the snout and the stack with a loose layer

of an oxidation-protecting or even de-oxidizing agent such as charcoal.

The charcoal layer will gradually burn away when left standing in the open air at the temperatures involved. To limit burning away of said layer, it may be covered by a solid, gas-tight, and heat insulating plate shaped to cover the exposed surface of the heavy metal in the pot. Besides the chemical protection this "shield" will also limit heat losses of the heavy metal bath.

After passing through the layer of the molten coating metal in the stack, the article to be coated is run into the surrounding atmosphere where, by appropriate means, the superfluous molten coating metal is removed from its surface, for instance, by means of skimming rollers, fluid blasts, and the like.

In general it is advantageous to combine in a single operation removal of excess coating metal from the coated article and rapid cooling and even quenching of the emerging coated article. As a result thereof formation of the intermediate layer of an alloy of the coating metal and the metal of the article will be arrested immediately. Such an intermediate alloy layer must be kept as thin as possible to achieve best adherence between the metal of the article to be coated and the coating metal. Preferably, quenching is effected in an atmosphere which is not oxidizing to the coating metal or any additional alloying metal such as aluminum added to the metallizing bath.

Fluid blasting has the advantage of preventing formation of the undesirable "tears" or beads, for instance, on the edge of a strip.

If blasting of the metal coated article is effected by means of water mist, it can be combined with a chemical treatment, for instance, with chromic acid dissolved in the spray water, or with a phosphatizing treatment by means of chemicals as they are used for this purpose. One of the advantages of this combination treatment in comparison with the known methods whereby the coated article is conducted through an appropriate aqueous bath containing the required chemical, is the continuity of the process and the ease of change from one treatment to the other, whereby in addition extremely little space is required.

The use of a heavy metal, lead in particular, underlying the layer of the coating metal is not new; however, in such known systems the coating metal is spread over the heavy metal in a thin layer and the inventors of these processes claim that the article to be coated remains in the coating metal for a short time only. This, however, is not correct because, once the article to be coated has penetrated into the heavy metal layer after passing through the coating metal, it remains in a state of being "wetted" by the adhering molten coating metal. Thus the metal of the article to be coated and the coating metal are in liquid contact with each other during its entire passage through the lead bath and thereafter, until the coating metal has solidified.

Even in the most advanced conventional coating arrangement the article to be coated emerges from the coating metal bath, the surface of which is fully exposed to the atmosphere. Thereby, the entire surface of the bath produces "top dross", i.e. in the case of galvanizing, zinc oxide, and if aluminum has been added, aluminum oxide. This top dross is removed by hand, for instance, every 5 to 10 minutes for 24 hours a day. Although this de-drossing does not affect normal opera-

tion, the losses due to the de-drossed coating metal are considerable.

Efforts have been made to protect the open surface of the coating metal against oxidation by covering it with charcoal or a similar de-oxidizing agent; but, unfortunately, these materials will stick, even in minute quantities, to the surface of the coated articles which is not permissible when producing coated articles of prime quality.

10 Preferably the stack is made of a cross-section as narrow as possible so as to achieve the following advantages:

1. The amount of coating metal in the stack is very small compared to that required in conventional pots and

2. the surface of the coating metal which it presents to the atmosphere is many times smaller than in the known systems. It follows that under like atmospheric conditions, formation of coating metal oxides, which is proportional to the exposed surface area of the bath, will also be very small, for instance, 25 times smaller than in the known metallizing processes. Furthermore, replacement of consumed coating metal by a fresh supply of molten coating metal can be effected much more rapidly, so that the coating metal has no time and opportunity to accumulate any considerable amounts of top dross as in the conventional processes.

In fact the fluid sprays create an atmosphere around the exit of the article to be coated from the stack which has, at the most, only a partly oxidizing effect on the coating metal and additives thereto.

Should it become necessary to remove any top dross formed on the upper level of the coating metal in the stack, the provision of the stack according to the present invention presents two solutions for doing so. The one solution will facilitate the de-drossing and the other one will render the top de-drossing operation quasi-automatic and practically eliminates top dross losses by returning the top dross to the coating metal melting oven where it will be de-oxidized.

For hand de-drossing the aforementioned electric eye action is electrically paralyzed so that the amount of coating metal in the stack is increased until the coating metal level reaches the upper rim of the stack. Then the skimming device for the coated article, such as means for rolling off or fluid blasting of excess coating metal is lifted so as to give immediate and very easy access to the coating metal surface and to allow de-drossing by hand, whereafter the skimmer is lowered back into position. Once the coating metal level has reached the top of the stack, hand de-drossing should not require more than several seconds.

Automatic de-drossing of the coating metal surface in the stack is effected, for instance, by supplying the molten coating metal to the stack to a level above its upper rim to cause the molten coating metal to overflow. Thereby, the top dross is carried along with the overflowing coating metal to be discarded or, as will be seen hereinafter, completely recovered as metallic coating metal. The following description of the coating metal melting oven and reservoir will explain how such automatic de-drossing is carried out.

The melting oven and reservoir consist of a steel tank, the walls of which are lined with coating metal-resistant and heat insulating material such as brick, ceramic, and others. The heated bottom part of said melting oven tank carries a layer of heavy metal which pre-

vents the iron corroding coating metal to contact said bottom part. The oven is divided by a brick or the like partition wall into two compartments whereby, however, a free passage is provided at the bottom part of this partition, the top of said passage opening being above the surface of the heavy metal.

The smaller one of these two compartments, i.e. the cake melting compartment is intensely heated and fresh coating metal cakes are introduced by hand or automatically thereinto. The other one of these two compartments, i.e. the pumping and circulating compartment which is less intensely heated, carries a motor driven coating metal pump, a floater with contact-equipped level indicator, and a return conduit carrying the spills of the overflow from the above mentioned automatic top de-drossing operation of the stack. The surface of the cake melting compartment is covered with an anti-oxidizing protecting layer such as salt, while the second pumping compartment is protected against the oxidizing effect of the atmosphere by a layer of charcoal and by insulating plates covering the charcoal layer as they are used on the surface of the heavy metal containing pot.

The coating metal pump is started and stopped automatically by the action of the electric eye or by other means. Overflowing is arranged either at will by the action of the coating pot attendant or, periodically, by a suitable timing device.

The reservoir mentioned hereinabove in connection with the coating metal melting oven which serves to reduce the level fluctuations in the stack, can also be used for producing the stack overflow so as to effect top de-drossing of the coating metal in the stack.

The bottom of the reservoir is preferably located at a level somewhat lower than the level of the heavy metal in the main coating pot around the stack.

The molten coating metal is pumped into the reservoir at its upper portion, somewhat higher than the level at which the coating metal in the stack overflows its upper rim.

Normal working levels of the coating metal in the reservoir correspond to those of the coating metal in the stack and room is left above the highest working level of the coating metal. Said space is filled by non-oxidizing gas conducted, for instance, from the pre-treating furnace which feeds the articles to be coated into the metallizing machine main pot.

During normal work the pressure of this gas in the reservoir is kept at values similar to those used in said furnace, i.e. for instance, between  $\frac{1}{2}$  inch and 3 inches of water column.

To effect top de-drossing, a surge of pressure of said gas is applied for an instant to the reservoir causing the level of the molten metal in the reservoir to decrease and the level of the molten coating metal in the stack to increase so that the molten metal overflows the upper rim of the stack. The resulting overflow carries with it as top dross any metal oxide which may have been formed. The pressure surge will also cause part of the molten metal to be driven back towards the coating metal pump without any ill effect.

The duration of the pressure surge is determined by the amount of coating metal to be removed at each de-drossing operation, and is dependent on the cross-section of the stack and that of the coating metal conduit section between the reservoir and the stack.

As soon as the pressure in the reservoir returns to normal, the levels of the coating metal in the stack and in the reservoir will become equal and the electric eye system (or the like) will keep the level value at the predetermined height.

Since the top de-drossing operation will invariably remove some coating metal from the stack, the pressure surge should, preferably automatically, start the electric eye controlled pump.

The overflow is caught in heated troughs and is conducted into the coating metal melting oven. Any metallic coating metal present in said overflow joins the mass of the coating metal in said oven. If any of the coating metal in the overflow has become oxidized, it will flow into the mass of molten coating metal but when leaving the conduit from the stack, being lighter than the coating metal, it will float up until it touches the charcoal layer where it will be de-oxidized into metallic coating metal.

All conduits and the reservoir are, preferably, made of or lined with a coating metal-corrosion-resisting material. They are heated sufficiently to prevent solidification of the coating metal therein, said metal, preferably, also being protected against oxidation.

A float is provided in the melting oven to indicate the level of the coating metal therein. Said float may be fitted with contacts which will cause alarm signals to act if the level of the coating metal in the oven gets out of control.

Preferably a trough-like structure surrounds the upper part of the stack. The height of its outer walls exceeds that of its inner walls over which the coating metal overflow runs. Its bottom is preferably inclined so as to facilitate outflow of the coating metal together with its oxides, if present, back into the coating metal melting oven.

When positioning the ray-window-electric eye control system in such a manner that the rays do not pass through the stack itself but through a separate communicating pocket, the advantage is achieved that the passing rays cannot be obscured by the article to be coated conducted through the stack if it deviates from its normal track.

A thin anti-oxidizing protective layer of salt or the like is preferably kept on top of the molten coating metal in such a communicating pocket. Said layer will prevent oxide formation on the surface of the molten coating metal in the pocket which may cause incorrect operation of the electric eye because the coating metal oxide is light and will be built up on the heavier metallic coating metal. Also, there will be very little exchange of coating metal in the pocket.

The molten coating metal may have a certain affinity to the molten heavy metal. When carrying out the galvanizing process with lead as the heavy metal, this affinity is smaller if the zinc is kept free of oxides and other impurities. When proceeding according to the present invention and using the stack arrangement, the stack can be made extremely narrow, thus limiting the area of contact of the molten coating metal and heavy metal to a minimum. In contrast thereto, in a conventional lead containing galvanizing pot, the two metals will be able to contact each other and mix with each other many times more than in the stack arrangement of the present invention. Reduction of zinc oxide formation in the zinc melting oven also very considerably

reduces dissolution of the zinc in the lead layer of the melting oven.

When proceeding as heretofore described, usually a small amount of aluminum is added to the zinc galvanizing bath. This addition retards formation of the brittle zinc-iron alloy. With the extremely short exposure of the article to be galvanized to the zinc in the stack followed immediately by quenching the deposited zinc, the amount of aluminum added can be reduced and even completely omitted, so that the aluminum oxide content of the top dross is considerably reduced or even completely eliminated.

It is known that the tendency of molten lead to stick to ferrous metal surfaces decreases with the increase in the temperature of the lead bath. It is, therefore, of advantage to keep the temperature of the heavy metal bath high and to provide cooling means just before the article to be coated enters the stack.

The heavy metal bath can also be used for exchanging part of the heat of the preceding heat treatment from the article to be coated, as it is much easier to control the temperature of the article to be coated by a passage through a molten metal, i.e. the heavy metal, than to control it by its passage through a gas filled chamber as presently used. The cooling chamber of the furnace can also be shorter and thereby cheaper in its construction.

For this purpose in strip operation an elongated heavy metal pot and two deflecting pulleys in the heavy metal bath are provided, one of said pulleys taking the strip coming out of the furnace snout and the other one, arranged at a certain distance away from the first one, said second pulley, after the strip has passed substantially horizontally between the pulleys, deflecting the strip upwardly into the stack. Cooling means can be provided in the zone between the two pulleys and just before the stack.

The channel in the stack through which the article to be coated passes is advantageously made as narrow as possible, especially in the zone where the heavy metal contacts the coating metal. For easier introduction of the molten coating metal into the stack an enlargement, to which the conduit for supplying molten coating metal is connected, may be provided thereon.

When the coating metal overflows the top rim of the stack, the lower coating metal surface should never go beneath the bottom rim of the stack. For this purpose a safety extension of the stack is provided with a safety margin length guaranteeing that no coating metal will ever penetrate into the heavy metal bath.

Automatic feeding of cakes of fresh coating metal into the coating metal melting oven can be effected as follows:

When the float indicating the level of the coating metal in the coating metal melting oven has descended sufficiently low, it closes a contact which produces a warning light or a sonar signal and will also give an impulse to the motor of the conveyor on which the cold cakes of coating metal are being warmed up. The conveyor starts moving and drops the cake nearest to the melting oven into the salt-protected, smaller cake melting compartment of the coating melting oven. This compartment is heated more intensely as cold coating metal is introduced thereinto. In the other compartment, the pumping compartment, it is merely necessary to adjust the temperature so that the coating metal remains molten and at the required coating temperature.

When the level of the coating metal in the oven has risen sufficiently, the float contact breaks the circuit, the conveyor motor stops, and no more cold cakes of coating metal are fed into the cake melting compartment of the oven.

According to another embodiment of the feeding operation the conveyor motor is run at an average speed and the signals indicating a high and a low level of coating metal in the oven as they are given by the float will only cause adjustment to a higher or lower speed than its average speed.

The above described system of feeding fresh coating metal cakes into the coating metal melting oven results in a better heat balance and thermal stability of the process.

Should, for some reason, the rising coating metal level in the oven not discontinue the supply of fresh coating metal cakes into the oven, for instance, in case of a stuck contact or the like, the continued rise of the coating metal level in the oven may close another contact and thus set off a warning signal different to the one described above. A "make" contact is usually much more reliable than a "break" contact.

A small addition of lead to a zinc coating bath produces a somewhat different appearance of the surface of the galvanized product without impairing its mechanical or corroding properties. For special applications, when the lead content is to be kept as low as possible, the entire tank of the coating metal melting oven can be lined with coating metal resisting material. Heating can then be effected by induction.

Induction heating of the coating metal pots in hot dip metallizing has been suggested heretofore. However, it was not successful because whirling of the metal mass which cannot be avoided with induction heating, causes circulation of the bottom dross throughout the entire coating bath and prevents it from settling at the bottom of the pot where it does not interfere with clean coating.

However, the conditions when proceeding according to this invention are different. There is no dross in the melting oven and whirling and circulation of the metal in the coating metal melting oven may even accelerate any required coating metal oxide reduction by thoroughly stirring all components of the reduction process.

Because of the large bulk of the metal to be heated and stirred, there is no need for the employment of high frequency alternating current; industrial frequencies are adequate for such induction heating.

The devices for removing undesirable excess coating metal from the coated articles leaving the stack and also for cooling and even quenching them preferably have only limited communication with the surrounding atmosphere. Apart from skimming rollers which are frequently used in strip galvanizing practice, the present invention is especially concerned with the fluid spray method which can also be used for quenching the coated article coming out of the stack.

As mentioned heretofore, a substantially nonoxidizing atmosphere is to be created in the quenching zone. On the other hand, excess coating metal blown off from the emerging coated article is preferably conducted back into the stack or to the trough from where it is returned to the coating metal melting oven.

A substantially gas tight chamber may be provided for this purpose. Said chamber contains the fluid carry-

ing conduits with appropriate fluid projecting nozzles. This chamber has a very narrow upward exit and is supported by the outer rims of the trough surrounding the upper portion of the stack. Substantial gas tightness can further be enhanced by using relatively long lips in place of a simple slot at the place where the coated article emerges from said chamber.

Preferably said chamber is kept under some positive pressure with respect to the surrounding atmosphere so as to facilitate retaining a non-oxidizing medium in the chamber. While the coating metal return trough is heated, said chamber is, at least, heat insulated.

The chamber is readily removable so as to obtain quick access to the upper part of the stack for inspection and cleaning by hand of the upper surface of the coating metal in the stack to remove top dross.

An advantageous alternate solution of the combined blasting and quenching treatment of the coated article consists in carrying out these two operations separately in the following manner:

The coated article is first blasted by means of a hot reducing or, at least, non-oxidizing gas which blows off excess coating metal from its surface and thereby also prevents formation of bead-tears on the edges of the article in case of strip metallizing. Such blasting does not oxidize the very 'oxygen-hungry' aluminum if added to the molten coating metal and unchanged blast off coating metal is returned to the coating metal melting oven for re-use. Such blasting takes place in a "hot" chamber.

It is followed by quenching in another, also substantially air-tight compartment in which the coated article is subjected to a quench blast, aqueous or other, which causes immediate solidification of the coating metal on the surface of the coated article, thereby radically interrupting formation of the brittle coating metal ferrous alloy.

Any aluminum addition to the coating metal which remains on the coated article may now harmlessly be oxidized to aluminum oxide as in conventional galvanizing processes, but none of it will be returned into the coating metal melting oven, because it is only part of the coating metal remaining on the coated article and is carried along as part of the coating.

The coating metal droplets blown off the metallized article in the first, hot after-treatment compartment, which are not oxidized, will either fall back into the stack and will be re-used therein, or they will fall into the heated trough intended to catch the coating metal overflow during automatic top de-drossing whence, without contacting the surrounding atmosphere, they will be conducted to the coating metal melting oven.

The arrangement of the stack principle according to the present invention can also be applied in galvanizing or metallizing elongated articles, such as pipes, structural sections, composite beams, and others. Thereby, the coating metal may be zinc or another coating metal while the heavy metal may be lead.

The pot or metallizing container used for metallizing such elongated articles is a vertical container somewhat longer than the articles to be coated. The de-scaled and preheated articles are plunged down into the molten lead bath, where they are heated up to approximately the temperature of the molten zinc provided in the stack. They are then moved underneath the stack by appropriate manipulator means whereby they are held down against their buoyancy in the heavier lead. They

are then released upwardly and pass through the molten coating metal layer, for instance, the zinc layer in the stack. Thereby an appropriate exit velocity is imposed upon the article by first holding it down against its buoyancy and then by pulling it out of the stack towards the end of the passage through the coating metal.

In this process as in the process of, strip or wire galvanizing, preferably a coating metal melting oven, for instance, for melting zinc is used in communication with the stack.

Another semi-automatic application of the stack principle for hot dip metallizing according to this invention makes use of a device by which elongated articles to be metallized are fed into the heavy metal bath and are treated in an inclined position. The advantage is achieved thereby that the depth of the lead bath for a given length of the article to be coated is considerably reduced.

The pot or metallizing container for hot dip metallizing of elongated articles preferably is of a triangular vertical cross-section with the stack being located at the shallow end of the pot. A likewise triangular carriage with an up and down movement which carries the articles between a series of rollers provided above and below said articles, is loaded with the article outside the lead bath from a crane or the like. End stops limiting the movement of the article to be coated in longitudinal direction are applied. The carriage with the article to be coated is then lowered into the lead bath, wherein it will be heated to the proper coating temperature. The upper end stop is then released and the article to be coated, under the influence of its buoyancy in the lead bath, but restricted by the upper rollers, will advance through the zinc or coating metal provided in the stack onto the next roller bed which, located after the stack, will have to support the weight of the coated article after it has emerged from the blasting treatment of its surface similar to the blasting treatment of the strip, wire, or the like coatings.

Although any combination of metals can be used in the process of the present invention, the heavy metal is usually lead, while the coating metal is zinc, aluminum, cadmium and, with certain limitations, tin and an alloy of lead and tin, as it is used forterne coating.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, advantages, and uses of the present invention will become more apparent from a reading of the following specification and claims taken in connection with the attached drawings which form a part of the specification and wherein

FIG. 1 is a vertical cross-sectional view showing part of the heavy metal container or pot and the stack with the coating metal therein;

FIG. 2 is a vertical cross-sectional view as in FIG. 1 but schematically illustrating at the upper part of the stack the electric eye means for controlling the supply of coating metal to the stack;

FIG. 3 is a cross-sectional plan view of the stack with an overflow trough and the electric eye control means;

FIG. 4 is a sectional view of the stack across line X — X of FIG. 3;

FIG. 5 is a vertical cross-sectional view through the central plane of the metallizing equipment with pot, stack, and coating metal supply and overflow equipment;

FIG. 6 is a vertical cross-sectional view of the coating metal melting oven;

FIG. 7 is an enlarged vertical cross-sectional view of the metallizing equipment of FIG. 5 with stack and coating metal supply and overflow equipment;

FIG. 8 is a schematic cross-sectional view of the metallizing equipment similar to FIG. 5;

FIGS. 9A through 9F are schematic views illustrating the metallizing of elongated articles;

FIGS. 10A and 10B are top views of the manipulator for metallizing elongated slender articles;

FIG. 10C is a vertical cross-sectional view of the manipulator of FIG. 10A;

FIG. 10D is a vertical cross-sectional view of the manipulator of FIG. 10B; and

FIG. 11 is a schematic cross-sectional view of the equipment for metallizing elongated articles whereby the heavy metal container is relatively shallow.

Like numerals in said FIGS. indicate like parts of the equipment.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

In said drawings FIG. 1 demonstrates the principal features of the present invention. In said FIG. 1 wall 1 of the main container of a metallizing pot, holds the heavy metal 2, the upper surface 15 of which is penetrated by stack 3, where the article to be coated (in strip form) 4 passes vertically through the coating metal layer or zone 5 with its upper coating metal surface or level 11 and its lower coating metal surface or level 12.

Measured from the lower surface 12 of the coating metal in stack 3, the height of column Z of the coating metal is related to the corresponding height of column L of the heavy metal outside of stack 3 inversely proportional to the specific gravities of the two molten metals, H being the difference of levels between the upper coating metal level 11 and that of the heavy metal 15 outside stack 3.

The greater the difference of the specific gravities of the two metals, the greater will be this level difference H.

FIG. 2 shows, in addition to the information given by FIG. 1, the basic features of controlling the coating metal supply to zone 5 by means of an automatic electronic supply device.

The upper level 11 and the lower level 12 of the coating metal zone 5 indicate a minimum amount of coating metal in said zone 5, while the upper level 13 and the lower level 14 illustrate the maximum amount of coating metal which can be present in said zone 5.

Rays 8 emitted from a source 6 pass through windows 7 which are transparent for said rays 8, when the upper coating metal level is at 11. Their passage is interrupted, however, when the upper coating metal level is at 13.

When the coating metal level is low, at 11, the rays 8 hit the electric eye 9, which transmits an electric signal by wires 10 to a relay and activates the motor of the coating metal pump (not shown). The pump feeds additional coating metal into the coating metal zone 5, the upper coating metal level rises, for instance, to level 13 until the mass of coating metal interrupts the ray 8 causing stopping of the motor of the coating metal pump.

In this FIG. 2 which shows the strip 4 to be metallized facewise, arrow A shows its direction of movement.

FIGS. 3, 4, 5, and 6 are schematic drawings of an embodiment of the invention applied to continuous coating, for instance, galvanizing of strip, wire, and other shaped articles.

FIG. 3 is a plan view of stack 3 showing the electric eye control system 6, 7, 8, 9, and 10 described hereinabove, overflow trough 16, coating metal inlet conduit 17 and coating metal outlet conduit 18 with the blast hood 19 (shown in FIG. 4) removed. Distributor 20 is provided between coating metal inlet conduit 17 and stack 3. Strip 4 to be metallized is passed through stack 3.

FIG. 4 is a section through the centerline of FIG. 3 along the line X — X, showing upper rim 21 of stack 3, outer walls 22 of trough 16, and its sloping bottom 23 and transparent window 7. Pocket 24 communicates with the coating metal zone 5 through holes 25.

The height of the pocket walls 24 should be higher than that of the walls 21 of stack 3 so that coating metal and, if provided, salt cover (not shown) do not overflow when de-drossing stack 3. Skirt seal 26 separates the interior of blast hood 19 from the outside. In this view strip 4 to be metallized is seen "on flat".

FIG. 5 is a section through the central plane of the metallizing machine showing snout 27 of the pretreating furnace (not shown) whence strip 4 merges into heavy metal bath 2; submerged deflecting drum 28 with its journals, bearings, holding brackets, etc; main container 1 of the heavy metal; the layer of charcoal 29 and its, substantially, gas tight blanket 30; stack 3 with its distributor 20 between coating metal inlet conduit 17 and stack 3; trough 16 with its outer walls 22 being higher than its inner walls 21. FIG. 5 also shows coating metal overflow 32 used for automatically cleaning the surface of the coating metal in stack 3; the sloping conduit 18 conducting overflow 32 to the coating metal melting oven (see FIG. 6).

Also are shown spray headers 33, sprays 34, blast hood 19 with its exit lips 35 and skirts seal 26; the coating metal inlet pipe 17.

Heating elements 37 are provided for heating main pot 1, while heating elements 38 serve to heat trough 16.

Reservoir 39 is arranged between melting oven and stack 3. Said reservoir 39 reduces fluctuations of the coating metal levels in stack 3 and serves to create the overflow for de-drossing of the stack. Lower coating metal level 11 A and upper coating metal level 13 A in reservoir 39 correspond to lower level 11 and upper level 13 in stack 3. Pipe 36 conducts non-oxidizing gas from the gas producer (not shown) into reservoir 39, said gas serving to break the siphon between stack 3 and pump 47 (FIG. 6) and, on the other hand, provide pressure surges for the de-drossing overflows 32 of coating metal over the rim of stack 3.

The drawing of FIG. 5 is broken off at YY to be continued in FIG. 6 at YY of that drawing showing the melting oven.

FIG. 6 is a section through the center line of the coating metal melting oven showing container or tank 40, side lining 41 of coating metal resistant material, partition wall 42 with an opening at its lower part; general coating metal temperature regulating heating element 44, intense heating elements 45 for melting the cold coating metal cakes, and heating elements 46 for keep-

ing the coating metal conducting circuits 17 and 18 above its melting temperature.

Layer 43 of heavy metal is provided in and protects the bottom of tank 40 from corroding attack by the coating metal.

Coating metal pump 47 is connected by pipe 17 to distributor 20 supplying coating metal, by means of reservoir 39, to stack 3 (see FIG. 5).

Sloping pipe 18 returns the overflow 32 of the coating metal from trough 16 (FIG. 5) to the mass of metal in the coating metal melting oven. Snout 48 of pipe 18 is turned away from the pump, as mentioned hereinabove.

Coating metal level-indicating float 49 is shown in its "full" upper position while the lowest position of the same float is shown at 50. Scale 51 indicates the amount of coating metal. An anti-oxidizing layer 53, for instance, of salt covers the surface of the molten metal 54 of the cake melting compartment, into which a cake 55 has just been thrown in. A cold coating metal cake 56 is on the verge of being dropped into the molten metal 54 of the cake melting compartment from the 'cake-warm-up', motor-driven conveyor 57.

The pointer 51 moves up and down with the float in its highest and lowest positions as indicated by 49 and 50 and establishes or breaks, at its highest position 58 or its lowest position 59 on scale 51, electric contacts 60 and 61, according to the position of the float (49 or 50) and in said limit positions (58 or 59) closes or breaks electric circuits showing or sounding alarm signals 63 and 64. The circuit is powered by an electromotive force, for instance, battery 65. Sliding contact 66, closing the circuit, is provided. Of course, other circuit arrangements are also possible.

When the "low" coating metal contact 61 closes, an extra parallel circuit (not shown) controls the motor-reducer (not shown) driving conveyor 57 in either a "stop-run" or a "faster-slower" mannner according to the system used.

If, by some malfunctioning, conveyor 57 continues to feed more cakes of cold coating metal into heating chamber 54 of the melting oven, the pointer of float 49 closes upper contact 60, thereby producing a different alarm signal 62.

There are provided charcoal layer 67 floating on the main mass 52 of coating metal in the pumping compartment and protecting blanket 68 covering charcoal layer 67 in a similar manner as described hereinabove in connection with pot 1.

Flakes of coating metal oxide 69 and 70 which were washed away from the top level of the coating metal in stack 3 during the cleaning of its upper surface are indicated as floating in the coating metal. Some flakes 69 have reached the top level of the coating metal mass 52 and one flake 70 is rising to the top of said coating metal mass. Flakes 69 which come in contact with the charcoal layer 67 are reduced by said layer 67 to metallic coating metal.

FIG. 7 shows the apparatus as used for separately hot blasting the coated article to remove therefrom excess coating metal followed by final quenching of the coated article which may be of strip, wire, or other shape. Certain parts not referring directly to the device have been omitted in this FIG. 7.

Main container 1, the mass of heavy metal 2, and stack 3 with its four working levels 11 and 14 or, respectively, 12 and 13 of the coating metal, are illus-

trated in said FIG. 7. This FIG. 7 shows the difference between the rise "O" of the coating metal before it overflows upper rim 21 of stack 3 and the extension "S" below level 14 corresponding to said rise "O". The proportions illustrated in this FIG. 7 correspond to the specific gravity of the heavy metal being two times greater than that of the coating metal.

In this FIG. 7 blasting hood 19 encloses the hot non-oxidizing blast 71 coming from headers 72. The quenching sprays of fluid 73 coming from headers 74 are located outside of hood 19 and do not have to be non-oxidizing.

FIG. 8 shows the arrangement in which the heavy metal bath 75 has been lengthened beyond the length usually required for carrying out the metallizing process. Said additional length allows fine adjustment of the temperature of the article to be coated entering into the metallizing zone 5. The additional deflecting drum 76 leads the article to be coated 4 (strip or other shaped article) to the deflecting drum 28. It then passes between cooling elements 77, which can be used for heating-up the gas used in the "hot blast" step 71 of FIG. 7.

FIG. 9 A shows the article to be coated 4 approaching the metallizing arrangement of this invention.

FIG. 9 B shows the article to be coated 4 half way down the heavy metal bath 2. It has to be pushed down into the heavy metal bath 2 against its buoyancy in the heavy metal.

FIG. 9 C shows the article to be coated 4 as it has come to the bottom of the heavy metal bath 2 where it must be held down while transferred under stack 3.

FIG. 9 D shows the article to be coated 4 as it has arrived under stack 3 and is going to be released through the coating metal 5 contained therein.

FIG. 9 E shows the article to be coated 4 half way up through the stack 3 and coating metal 5 contained therein. It is being grabbed by tongs 97 or the like. Finally

FIG. 9 F shows the coated article 4 removed out through stack 3 and being held by crane carried tongs 97 or the like.

FIGS. 10 A and 10 B are top views of a manipulator means for use in FIGS. 9A through 9F, and FIGS. 10 C and 10 D are vertical cross-sectional views thereof.

The device consists of a cylindrical container 101, filled with heavy metal 2, a stack 3 with a coating metal zone 5, and a blasting device 78 above the stack. For obvious reasons the stack will have to be of a section corresponding as close as possible to the profile of the article to be coated (not shown).

Swingable column 79 is equipped with two grab tongs 80 which seize the article to be coated when it has been pushed down into the heavy metal bath 2 (positions 'A' and 'C' of FIG. 10). The column is then rotated 180° to position 'B' and 'D' of FIG. 10. The tongs 80 release the article to be coated (phase 'E' and 'F' of FIG. 9), whereafter the device returns to its original position 'A' and 'C' (FIG. 10).

Means 81 are provided to effect said 180° rotation, said means also comprising means for closing and opening the grab-tongs 80. Cover 82 with holes 84 for introducing and withdrawing the article to be coated covers container 101. For simplicity's sake heating elements and insulation have been omitted in these FIGS. 10A through 10D. Of course, a charcoal layer and a protecting blanket may be used. Said layer and blanket

are pushed aside by the article to be coated 83 entering the container 101.

FIG. 11 illustrates schematically the method of applying the stack metallizing system of the present invention to elongated articles without the use of very deep tanks. (The hydrostatic pressure of heavy metal being lead is 10.5 times that of water).

The triangular, heavy metal containing tank 102 contains the heavy metal 2. The heavy metal is covered by protective layer 94 of charcoal and a blanket which may be a layer of hollow ceramic or glass balls or the like. Stack 3 with coating metal zone 5 is arranged at the shallow part of tank 102. The various positions of the article to be coated are indicated by 4a, 4b, 4c, and 4d. The article to be metallized 4a, for instance, a pipe is introduced in position 4b into the sinkable carriage 85 having upper idle rollers 86 and lower idle rollers 87. Thereby the article 4b abuts fixed stop 88 and is held in said carriage 85 by closing movable stop 89.

Carriage 85 with the enclosed article to be coated 4b is lowered into the heavy metal bath 2, the article to be coated then occupying position 4c. The movable stop 89 is released and the article is propelled by its buoyancy through the coating metal 5 in stack 3 into position 4d, guided by fixed rollers 90 and is either stopped at the end of its run by collapsing stop 91 or is propelled further by drive roll 92 to be blasted in a manner described hereinbefore.

The process according to the present invention of hot dip metallizing metallic articles and especially of providing ferrous articles with a zinc coating is carried out in the apparatus and devices as shown in the drawings. While the metallic articles to be hot dip metallized and the coating metal as well as the heavy metal may be of any type, the process of this invention has been found to be of special importance in metallizing steel and other ferrous articles and especially steel strip or sheets, wire cloth, fencing, pipes, structural-steel members such as beams, and other articles of various shapes and sizes.

The preferred heavy metal is lead which does not attack the iron containers and equipment in which the coating metal is only sparsely soluble.

The most commonly used coating metals for hot dip metallizing are zinc and aluminum, which can be applied to iron base articles of various shapes and nature using the process of the present invention. Under certain precautions the process can also be used for applying hot dip tin and terne coatings. Also other relatively light metals of a low melting point which form a ferrous alloy when molten, such as cadmium, may be used as coating metal.

Before entering the metallizing arrangement of the present invention, the articles to be coated are preferably first subjected to a pretreatment, for instance, to pickling, neutralizing, fluxing, drying, and preheating.

Other known pretreatment operations consist in superficially oxidizing the article to be coated, then reducing the oxide layer by conducting it at the appropriate temperature through a reducing atmosphere, and cooling the thus pretreated article before immersing it into the heavy metal bath of the main metallizing pot followed by passing it through the coating stack.

Other known processes of pretreating the article to

be coated may precede the heavy metal bath.

Due to the very short time of contact between the article to be metallized and the coating metal in the stack and because the coated article can be subjected to blasting off excess coating metal and quenching after it has left the stack, it is possible to work with a very fluid, i.e. hot bath, of the coating metal which is much hotter than used in the present practice of continuous hot dip metallizing.

Thus, for zinc which melts at 420° C. the minimum temperature in the stack is preferably not below 425° C., while the maximum temperature can be as high as 575° C. and even higher.

For aluminum which melts at 660° C., the minimum temperature in the stack is preferably not below 670° C., while the maximum temperature can be as high as 850° C. and even higher.

Within the limits shown, lower temperatures of the coating metal in the stack are used for producing thicker coatings, while the higher coating temperatures, whereby the hot dip coating is followed by a strong fluid hot blast and immediate quenching, are employed for producing the thinnest possible hot dip coatings which are almost equal in the thinness of the coating to heavier coatings obtained by electrolyte coating.

I claim:

1. In a process of hot dip metallizing ferrous metal articles by immersing said articles into a molten coating metal bath, said coating metal being selected from the group consisting of zinc, aluminum, cadmium, tin and tin-lead alloy, the improvement which consisting essentially of

a. passing the article to be metallized through a bath of molten lead,

b. conducting the article from said molten lead bath through a confined space containing a layer of the molten coating metal, the surface area of said confined space being a small fraction of the surface area of the lead bath,

c. continually supplying the molten coating metal to said confined space so as to maintain substantially constant the level of the molten coating metal in said confined space, and

d. continually removing the top dross formed on top of the molten coating metal from its surface by overflowing the molten coating metal in said confined space.

2. The process of claim 1, in which

e. the overflow with the top-dross is conducted into the supply means for the molten coating metal, and

f. causing metal oxide present in the dross to be reduced to the coating metal by contact with a reducing agent floating on the molten coating metal supply means.

3. The process of claim 1, in which the coating metal is zinc.

4. The process of claim 1, further comprising the step of continuously, automatically detecting the height of said molten coating metal in said confined space and generating signals representative thereof and wherein said molten coating metal is supplied to said confined space in response to said signals.

\* \* \* \* \*

UNITED STATES PATENT OFFICE  
CERTIFICATE OF CORRECTION

Patent No. 3,914,481 Dated October 21, 1975

Inventor(s) Theodore Bostroem

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 62: "involves" should read -- involved --.  
Column 2, line 54: "ro " should read -- or --.  
Column 3, line 31: "vertually" should read -- virtually --.

Column 3, line 44 "locking" should read -- looking --.  
Column 4, line 52: After "metallized" the period "."  
should be changed to a comma -- , --.  
Column 5, line 64: "aluninum" should read -- aluminum --.  
Column 7, line 51: "isntance" should read -- instance --.  
Column 9, line 10: "even" should read -- even --.  
Column 13, line 33: "lever" should read -- level --.  
Column 14, line 18: "communiates" should read -- communicates --.  
Column 14, line 41: "skirts" should read -- skirt --.  
Column 15, line 24: "pointer 51" should read -- pointer 51' --.

Signed and Sealed this  
thirtieth Day of March 1976

[SEAL]

Attest:

RUTH C. MASON  
Attesting Officer

C. MARSHALL DANN  
Commissioner of Patents and Trademarks