Dec. 15, 1931. S. H. DAVIS ET AL 1,836,579

METHOD OF AND APPARATUS FOR ELECTROPLATING PIPE

Filed April 12, 1929 2 Sheets-Sheet 1

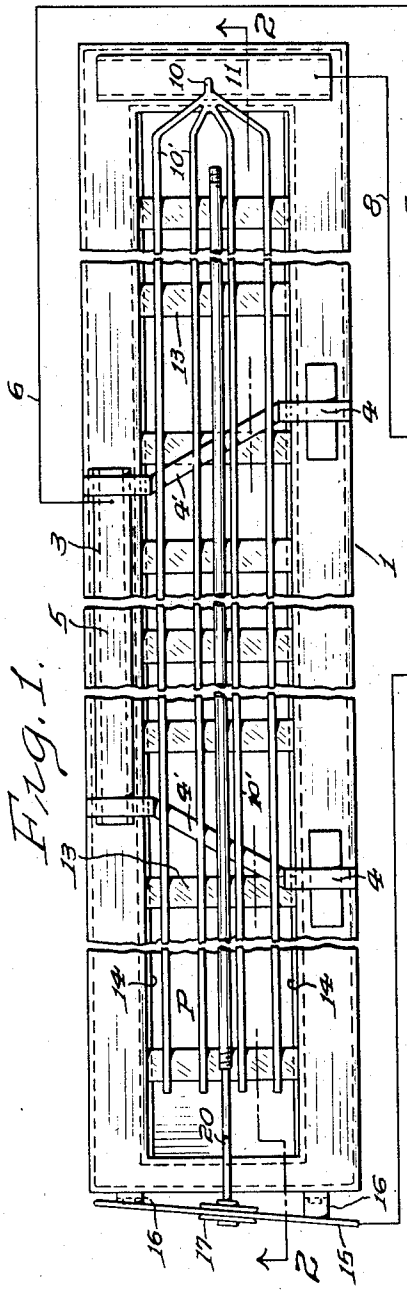


Fig. 1.

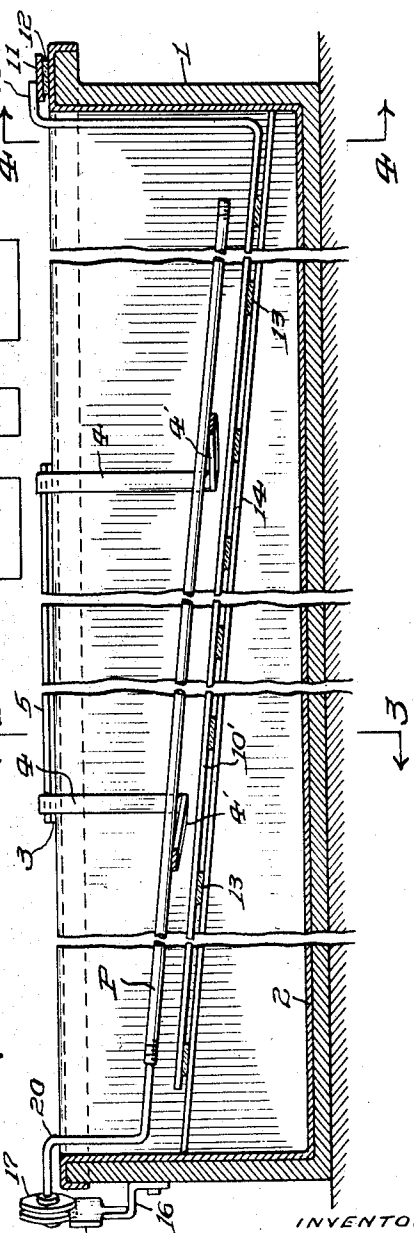


Fig. 2.

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METHOD OF AND APPARATUS FOR ELECTROPLATING PIPE

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Fig. 4.

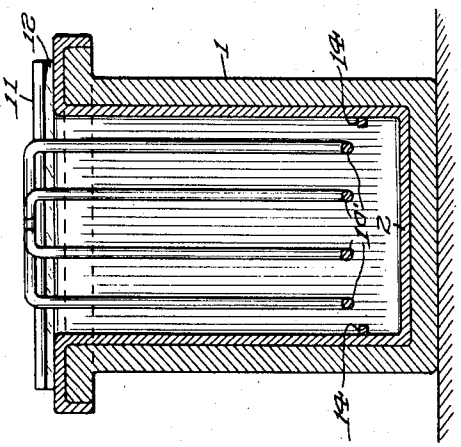


Fig. 3.

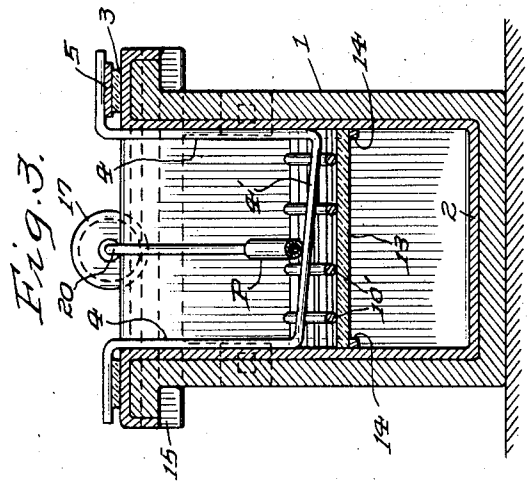


Fig. 6.

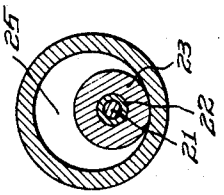
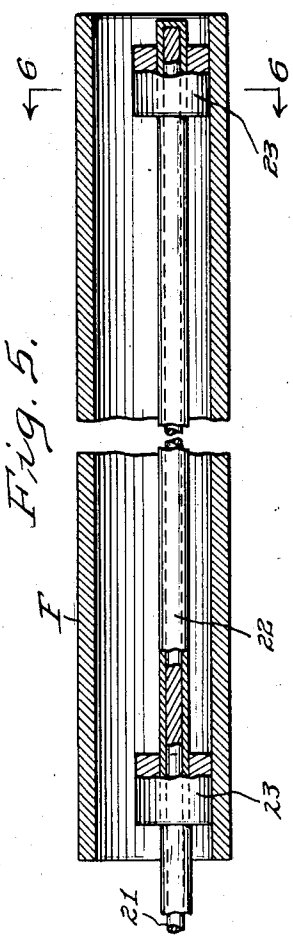


Fig. 5.



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UNITED STATES PATENT OFFICE

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METHOD OF AND APPARATUS FOR ELECTROPLATING PIPE

Application filed April 12, 1929. Serial No. 354,472.

Our invention relates primarily to the simultaneous electro-plating of both the inside and the outside surfaces of pipe, is especially adapted to the electrodeposition of zinc on ferrous pipe, and is directed to providing a smooth, hard coating which will protect the pipe from corrosion or deterioration from rust or other causes while adhering to the pipe with sufficient tenacity and also being sufficiently flexible to permit bends to be made in the plated pipe without cracking or peeling of the plating at the bend.

Other objects of our invention are to provide a method and apparatus by means of which a zinc coating of the character mentioned may be economically and satisfactorily produced on pipe or tubes in a commercial way; to provide means whereby a coating of any desired thickness, within limits, may be uniformly produced on the inside of the pipe independently of the thickness of the coating on the outside of the pipe, although the deposition of the outer coating is concurrent with that of the inner coating; to provide a method and apparatus capable of producing a zinc coating of good appearance and wearing qualities and highly resistant to corrosion by the weak acids and other corrosive agents frequently encountered by zinc-coated ferrous pipe under ordinary conditions of usage, and more especially when in use for underground electrical cable conduits and other similar purposes where a cheap commercial product both internally and externally highly resistant to corrosion is required.

Other objects, advantages, novel features and characteristics comprehended by our invention are hereafter more specifically mentioned or will be apparent to those skilled in the art as a more detailed understanding of the invention is acquired from the following description of one manner of performing the same.

It has heretofore been the practice to produce zinc-coated ferrous pipe by several different methods, one of which has been to dip the pipe in a mass of molten spelter to thereby form a coating of zinc on the pipe, the internal coating being obtained by permitting the spelter to flow into the interior of the pipe from the open ends. This hot dip method is disadvantageous in that, among other things, the coating is brittle, is apt to crack or peel when the pipe is bent, is not of uniform thickness throughout and is very susceptible to corrosion due, among other causes, to the presence of alloyed iron resulting in highly corrosive galvanic action within the coating when in the presence of weak acids.

Another method has been to suspend the pipe in convenient lengths in a neutral or slightly alkaline electrolytic bath of a zinc sulphate solution or one containing zinc cyanide or other zinciferous compound in solution, and, using the pipe as an electrolytic cathode, to deposit thereon from a soluble zinc anode a zinc coating of the desired thickness. Disadvantages of this method are that the coating may be too soft for satisfactory use and satisfactory and economical internal plating of the pipe is virtually impossible.

A method of electrodeposition of zinc on ferrous articles in an acid solution of a zinc salt, using an anode insoluble in the electrolytic bath, has heretofore been invented by us and forms the subject of an application for Letters Patent of the United States entitled "A method of electroplating zinc on ferrous articles" which was duly filed by us March 13, 1929, and in the practice of the present invention we employ the principles thereof with such modifications as are requisite or desirable in the attainment of the purposes and objects thereof. Thus in the performance of the present invention in zinc-plating ferrous pipe, we employ as the electrolyte acid solutions of zinc sulphate using anodes of which the surfaces exposed to the electrolyte are of some material not attacked by or soluble in the electrolyte, for example, lead, and obtain the desired ultimate coating by the production of successive coatings in solutions of different acidities and by currents of different strengths as in the case of our invention as disclosed in our said application.

In describing the present invention more particularly, reference will be had to the accompanying drawings which show, to some extent diagrammatically, one form of means

suitable for the performance thereof and in which Fig. 1 is a top plan view, partly broken away, of one of the plating tanks and adjacent parts, the electrical wiring and accessories being shown diagrammatically; Fig. 2 is a longitudinal section on the line 2—2 in Fig. 1; Fig. 3 is a transverse section through the tank on plane of line 3—3 in Fig. 2; Fig. 4 is a transverse section thereof on the plane of line 4—4 in Fig. 2; Fig. 5 is a longitudinal fragmentary section of a pipe in condition for plating and showing the internal anode in position therein and partially in central vertical section, and Fig. 6 is a cross section of the same through one of the anode insulators on the plane of line 6—6; Figs 5 and 6 are, for the sake of clearness, drawn to a much larger scale than Figs. 1, 2, 3 and 4 and the several sectional views are taken in the directions indicated by the arrows.

In the practice of our invention we employ a plurality of plating tanks, three being usually preferred, and as all of these tanks and auxiliary apparatus are preferably similar, a description of one of them will suffice, applying, as it does, equally to the others. Thus each electrolytic tank or cell 1 is of dimensions sufficiently large to accommodate the pipe to be plated, for example, a tank for plating 10 foot lengths of conduit pipe may conveniently be constructed about 11 ft. long by 12 in. wide by 19 in. deep and may be made of wood or any other suitable material. When wood is used for the tank, a lining 2 may be provided to protect the tank from the action of the electrolytic solution and to prevent leakage, for example, a lead lining, as it affords satisfactory protection from the acid zinc sulphate we use as the electrolyte in zinc coating pipe. The tank may also be made of suitably treated concrete, if desired, in which case the lining of lead or other conductive material will usually be omitted with corresponding omission of the necessity for insulating certain parts of the electrical equipment therefrom; however, as lead lined tanks are quite usual in this class of apparatus, we have chosen to illustrate a tank of that character as well as the insulating means requisite or desirable in connection therewith. Suspended from the sides of the tank, but insulated therefrom by glass or other suitable plates 3 are preferably U-shaped cradles 4 which serve both to support the pipe P to be plated and as cathode contacts. These cradles may be of any suitable nature but preferably extend across the tank angularly to the transverse plane thereof as best shown in Fig. 1 for reasons which will later appear. The cathode contact of the cradles may be provided directly by the cradles themselves or by means of a strip (not shown) of some metal which does not receive electrolytic deposition of zinc and which is insoluble in acid solutions, as for example platinum, so positioned on the cradles as to make contact with the pipe P when placed thereon. Otherwise the cradles may be of any material satisfactory for the purpose, but when made of a material subject to attack by the electrolyte, or on which the metal of the electrolyte would be deposited, it is desirable to protect them by a coating of some insoluble insulating material, as paraffine or bakelite. Aluminum may also be used for the cathode contact strip, but as it will receive a deposit of zinc during the plating operation, it must be stripped of such zinc from time to time to prevent undesirable irregularities in the pipe plating. It will be observed that the pipe supporting surfaces 4′ of the cradles are at different levels so that the pipe P, when placed thereon, lies at an angle to the horizontal desirably with a slope of about 1 in 20 or even a little greater; the importance of this feature will later appear.

A busbar 5 connects the cradles 4 and thus the pipe P is provided with a plurality of cathode contacts, two only, however, being shown, and the busbar is connected by suitable wiring 6 to the negative lead of a generator G or other direct current source. A voltmeter V may be shunted across the current source, and the positive lead 7 therefrom is desirably divided into two branches 8 and 9, each respectively provided with ammeters A—A′ and rheostats R whereby the current in either branch may be varied as desired independently of the other. This manner of current control in connection with the use of independent external and internal anodes as hereinafter described, enables the thickness of the external or internal plating and other characteristic features which depend on current strength to be independently controlled as desired.

The external anode 10 is connected through a busbar 11 supported at one end of the tank on an insulating plate 12, to the branch 8 of the positive lead and may be of any suitable construction; we prefer, however, to form the anode of a plurality of spaced lead rods 10′ extending longitudinally in the tank beneath the cradles 4 for substantially the length of the tank and supported therein, parallel to the pipe P, in any convenient manner as by glass or other insulating plates 13 resting on lead strips 14 burned to the sides of the tank, the rods converging near the end of the tank to connect with the busbar 11 as shown. Copper may also be used for these parts and is desirable because of its conductivity but in such case the portions which are subjected to contact with the electrolyte should be coated with lead or otherwise protected from its corrosive action.

The positive lead branch 9 is connected to a busbar 15 supported at the opposite end of

secured thereto or in any other suitable way. This busbar is disposed in a vertical plane and angularly to the tank end as shown, its upper edge serving both as a contact and guide for a grooved wheel 17, the axle of which is connected to or is formed by a portion of the internal anode generally designated as 20, the arrangement being such that the wheel can rotate but is restrained from longitudinal movement with respect to the anode.

The internal anode comprises an electro-conductive rod 21, preferably of copper, which is sheathed with lead or other suitable electro-conductive material 22 for protection against the electrolyte and is of such length that it may be bent as shown and when in place within the pipe P will extend substantially the full length thereof. That portion of this internal anode which extends within the pipe is provided with annular insulators 23, of rubber or the like, at intervals along its length to prevent contact of the anode with the pipe, and while it is important that these insulators be of sufficient size to prevent such contact, it is also desirable that they be small enough to leave a free space 25 longitudinally of the pipe between themselves and its upper internal surface.

For the most satisfactory results, it is requisite that the pipe to which the zinc coating is to be applied be given a suitable surface conditioning before its introduction to the first operating cell. This conditioning may consist of immersion in an alkali cleaning solution to effect grease removal, followed by rinsing and pickling to remove scale, again followed by rinsing or brushing and rinsing. The pipe may then preferably be immersed in a weak solution of nitric acid, that is, a solution containing 10% or less per volume of acid, for a short interval, say about 30 seconds, and again rinsed in water. We also consider it advisable to vigorously brush the pipe after its final washing while frequently a similar brushing before the final washing will be found advantageous.

The pipe having thus been rendered properly zinc-receptive by the conditioning operations to which we have referred or others of corresponding efficacy, is now ready to receive the primary strike coating in the first plating tank, and the internal anode 20 may therefore be inserted within the pipe and the latter placed in the tank upon the cradles 4 and the wheel 17 placed on the busbar 15. For the primary or strike coating of zinc we prefer to use a low acid electrolyte, for example, a zinc sulphate solution of an acidity of 2% to 2½%, i. e. containing 20 to 25 grammes H_2SO_4 per litre of solution, enough of the latter being supplied to nearly fill the tank and insure complete immersion of the pipe. The current is then switched on, the current strength as read on the ammeters A—A′ being preferably about 150 amperes per square foot of cathode surface, the outer surface of the pipe P being referred to for the current strength in the external anode lead 8, and the inner surface being referred to for the current strength in the internal anode lead 9. During the passage of the current a small amount of hydrogen is evolved upon the surfaces of the pipe and oxygen is also evolved upon the anode surfaces. These gases are given off in small bubbles and as the bubbles within the pipe rise they collect in the space 25 above the internal anode, and, due to the sloping position of the pipe when in place upon the cradles 4, travel longitudinally through this space and out of the pipe at its higher end. This movement of the bubbles through the pipe is effective to maintain a constant circulation of the electrolyte through the pipe and the spent solution, i. e. that from which zinc has been deposited on the inner surface of the pipe, is thus continuously replaced with other fresh solution of the original zinc sulphate concentration. And herein lies a very important feature of our invention resulting, as it does, in the continuous and automatic supply of fresh zinc-containing solution throughout the bore of the pipe and consequent free and even deposition of zinc over its entire inner surface.

During the electroplating process the pipe is rolled across the tank, thus permitting the parts of the pipe surface resting upon the cradles 4 to receive a zinc deposit, the angular disposition of the cradles assuring continual longitudinal change of the contacting portions of the pipe as it moves across the tank; thus, blanking off of those parts of the outer pipe surface which engage the cradles during the plating period is prevented but as an additional precaution auxiliary external lead anodes (not shown) may be suspended above the cradles 4 if desired. As the pipe is rolled across the tank, which may be accomplished mechanically by any suitable means or manually with the aid of a wooden bar or the like, the wheel 17 travels along the busbar 15 and gradually moves the internal anode 20 longitudinally in the pipe for a distance at least equal to the width of the insulators 23 so that blanking off of the inner surface of the pipe by the insulators is likewise prevented.

After the initial strike coating has been applied, as when the plating above described has continued for a short time, for example, 1 to 2 minutes, a second strike coating may desirably be given the pipe in a higher acid solution. The application of this second coating is preferably performed in another tank or cell similar to that employed for the primary strike coating except that the zinc sulphate solution employed as the electrolyte is desirably of higher acidity, for example, 4% to

the tank from the busbar 11 by brackets 16 5%. To this cell, after the completion of the primary strike coating, the pipe and the internal anode may be transferred, the internal anode being allowed to remain in the pipe and being used in the second cell precisely as in the first. As soon as the pipe is immersed in the electrolyte and the wheel 17 properly positioned on the busbar, the second strike coating is formed on both the inner and outer surfaces of the pipe by passing a direct current of high density through the cell for example, the same as that used for the first strike coating, for a sufficient time, ordinarily about two minutes under the conditions stated, to thoroughly coat the pipe with the harder zinc deposit obtainable in the presence of the high acid solution; the prompt and rapid formation of the second strike coating substantially prevents injurious attack by the high acid electrolyte in the second cell upon the relatively soft zinc of the primary strike coating, or upon the pipe itself. The formation of this second strike coating, however, is not attended with a material evolution of hydrogen because of the presence of the primary zinc coating upon the article which not only facilitates the deposit of the zinc by preventing the hydrogen evolution which would occur in its absence, with corresponding enhancement of the current efficiency, but also prevents the high acid electrolyte from injuriously attacking the ferrous base.

While under certain conditions it is feasible to continue the plating operation with the very high density current utilized for the formation of the second strike coating until an ultimate deposit of the desired thickness is obtained, the use of currents of such character for material periods of time such as required to complete the plating operation is undesirable and uneconomical both from the standpoint of current efficiency and also because of the difficulties inherent in the transport and handling of such currents, the installation cost of the busbars and other connections and instrumentalities required therefor and the correspondingly great maintenance expense. Therefore in accordance with the preferred practice of our invention, as soon as the second strike coating has been formed the current flowing through the cell is materially reduced, say to a density of about 100 amperes per square foot of pipe surface, and the plating operation then continued with this relatively lower current until ultimate exterior and interior coatings of the desired thickness are obtained. This final plating operation may be carried out in the second operating cell, or after the second strike coating has been formed therein, the current may be shut off entirely and the pipe and internal anode transferred to a third operating cell desirably containing an electrolyte of substantially similar acidity as that in the second cell and the plating completed in this third cell by the use of the lower density current as above described. However, irrespective of which method may be adopted under practical conditions, it is apparent that as the extremely high density current is utilized in the formations of the primary and of the second strike coatings for but relatively short intervals it is unnecessary to provide instrumentalities and connections for handling the same of as great size and capacity as would be required if the currents were employed for longer periods so that both initial installation and upkeep cost are materially reduced from what they would otherwise be, while as the second strike coating when completed is extremely receptive to the deposition of the zinc during the subsequent plating and by its complete coverage of the ferrous base prevents any appreciable hydrogen evolution, the relatively lower current thereafter employed operates at equal or even better efficiency than the current used for the second strike coating with resultant economy in production costs.

During the plating operations in the respective cells the pipe is maintained in inclined position and moved across each cell from one side to the other as heretofore explained; in consequence, any blanking of parts of the outer surface of the pipe by the cathode contacts is prevented by the constant change of the points of engagement of the pipe therewith while equally so, the longitudinal movement of the internal anode in the pipe effected through the cooperation of the wheel 17 and angularly disposed busbar 15 prevents any blanking of the interior surface of the pipe by the internal anode insulators. Furthermore, the desirable continuous circulation of the electrolyte through the pipe is likewise maintained during the second strike coating and final plating operations through the evolution of oxygen from the internal anode, enough of this gas being continually given off during these operations to satisfactorily effect this result. As hitherto pointed out, during the formation of the primary strike coating and to a much lesser extent during the formation of the second strike coating a certain amount of hydrogen is also evolved from the surfaces on which the zinc is being deposited and of course this gas, while it is being given off, assists the evolved oxygen from the anode in maintaining the circulation of the electrolyte through the pipe although, as stated, enough oxygen is evolved to alone maintain the circulation with sufficient rapidity, as during the final plating operation when substantially no hydrogen is given off, without the assistance of the hydrogen.

After the final plating operation has been continued for a sufficient length of time to

produce coatings of the desired thickness, the pipe is removed from the last cell, washed and brushed if desired, and is then ready for the market.

Under ordinary conditions the currents supplied to the external and internal anodes are regulated so as to produce coatings of substantially similar thickness on the outside and inside surfaces of the pipe but it will be readily apparent that by suitable variation of these currents it is possible, in accordance with our invention, to produce coatings of different thicknesses upon these surfaces if desired. Furthermore, it will of course be understood that from time to time additional zinc sulphate solution must be supplied to the different tanks so as to maintain their respective acidities at the desired point as well as to compensate for the zinc which has been plated out of the electrolyte upon the pipes, since, in accordance with our invention, the entire amout of zinc deposited thereon is abstracted from the solution instead of being obtained from soluble anodes as in the usual electroplating processes.

Mention has heretofore been made of the desirability of immersing the pipe before its introduction to the bath in the first operating cell in a weak solution of nitric acid and this step we therefore prefer to employ where possible as we have found that by so doing, particularly in the case of pipe having slightly uneven or irregular surfaces or those in which the surface has been cut into by threading or other machining operations, the tendency to "gas pit" during the subsequent plating operations is materially reduced. Additionally, we have found that if during the said operations the pipe be more or less gently tapped with a wooden bar or the like at intervals of 15 seconds or thereabout the tendency to formation and adherence of gas bubbles with resulting gas pitting is likewise reduced, and therefore, with a view to substantially eliminating all gas pits or similar imperfections we prefer to employ the nitric acid treatment and also to tap the pipe or otherwise slightly agitate it at intervals throughout the plating operations.

By the practice of our improved method of electroplating ferrous pipe we are able to produce thereon simultaneously an exterior and an interior zinc coating, each of which is more perfect in appearance, more resistant to corrosion in the presence of weak acids and otherwise responds to the Preece, bending, and other commercial tests ordinarily employed in testing coatings on ferrous pipes more satisfactorily than any other zinc coating or plating which, so far as we are advised, it has been possible to produce upon such pipe by way of any methods heretofore employed. While of course the attainment of this end constitutes the primary object of our invention, the fact that it may be practiced in a commercially satisfactory way upon pipe of large as well as of small diameter, such for example as conduit pipe, and also as to initial apparatus installation and upkeep costs, simplicity of procedure, high current efficiency and economy render it extremely desirable from a practical operating standpoint; we therefore believe it constitutes a distinct contribution to the art.

While the apparatus we have herein described is satisfactorily operative for the performance of our improved method, we do not desire or intend to confine ourselves solely to the use of such apparatus in the performance thereof as other forms of apparatus may be employed if desired or changes made in the details of construction and arrangement of the form of apparatus to which we have chosen to refer, while irrespective of the particular type of apparatus employed, variations and modifications may be made in the method itself, particularly with respect to the acidities of the electrolyte in the different cells, in the densities of the various currents employed and in the periods in which they are permitted to flow, in accordance with the particular results desired or the particular operating conditions encountered without departing from the spirit and scope of the invention as defined in the appended claims.

Having thus described our invention, we claim and desire to protect by Letters Patent of the United States:

1. The method of electroplating a ferrous pipe with zinc on its inner and outer surfaces simultaneously which comprises the steps of supporting the pipe in an electrolytic bath with one of its ends higher than the other, passing a current between the outer surface of the pipe and an anode insoluble in the electrolyte, simultaneously passing a current between the inner surface of the pipe and an anode disposed therein and also insoluble in the electrolyte and effecting relative longitudinal movement between the internal anode and the pipe while said currents are passing.

2. The method of simultaneously electroplating the inner and outer surfaces of ferrous pipe with zinc which comprises the steps of supporting the pipe in a horizontally inclined position in a bath of a solution of zinc sulphate of relatively low acidity, passing a current of high density between the outer surface of the pipe and an anode disposed exteriorly thereof and insoluble in said solution, simultaneously passing between the inner surface of the pipe and an anode disposed therein and similarly insoluble in said solution, a current of substantially similar density until a thin coating of metallic zinc is formed on both surfaces of the pipe, then transferring the pipe to another bath of an acid solution of zinc sul-

phate of relatively higher acidity and similarly passing currents of densities substantially similar to said first mentioned currents to form additional coatings on the inner and outer surfaces of the pipe and then reducing the strength of said currents and continuing the plating operation until coatings of the desired ultimate thickness are formed on said surfaces.

3. The method of electroplating zinc on the inner and outer surfaces of pipe simultaneously which comprises the steps of supporting the pipe in a horizontally inclined position in a bath of a zinc sulphate solution of predetermined acidity, passing a current between the outer surface of the pipe and an anode disposed exteriorly thereof, simultaneously passing a current between the inner surface of the pipe and an anode disposed therein while permitting the gases generated from said anode to escape from the upper end of the pipe and thereby effect a continuous circulation of the electrolyte therethrough until a thin coating of zinc is formed on both surfaces of the pipe, then transferring the pipe to an electrolytic bath of higher acidity and similarly passing currents of densities substantially corresponding to those of the currents used in the first bath to thereby form an additional coating on each of said surfaces and then continuing the plating operation in a bath of like acidity but with currents of lower densities until coatings of the desired ultimate thickness are formed on both of said surfaces.

4. In apparatus for electroplating pipe, the combination of a tank, means adapted to support the pipe in the tank in horizontally inclined position, an anode adapted to extend adjacent but outside of the pipe, a separate anode adapted to extend within the pipe and means interconnected with the last mentioned anode for causing relative longitudinal movement of said anode and the pipe during the plating operation.

In witness whereof we have affixed our signatures.

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HERBERT R. HANLEY.

CERTIFICATE OF CORRECTION.

Patent No. 1,836,579. Granted December 15, 1931, to

SIDNEY H. DAVIS ET AL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, line 1, strike out the words "the tank from the busbar 11 by brackets 16" and insert same as line 1, page 3; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 16th day of February, A. D. 1932.

M. J. Moore,
Acting Commissioner of Patents.

(Seal)