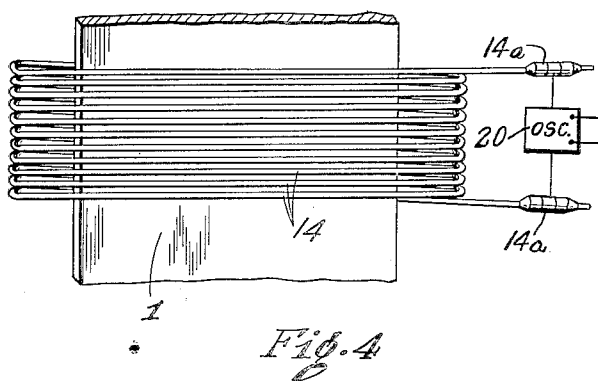
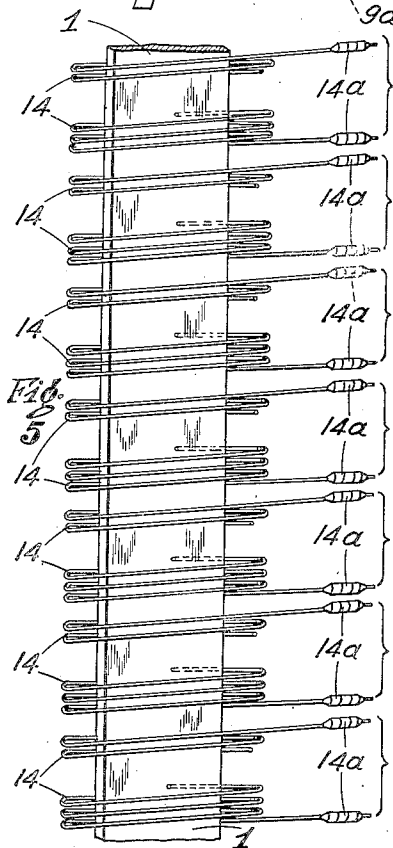
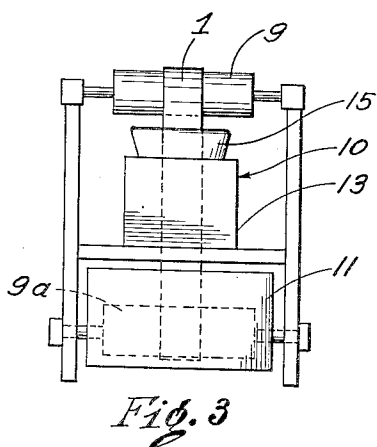
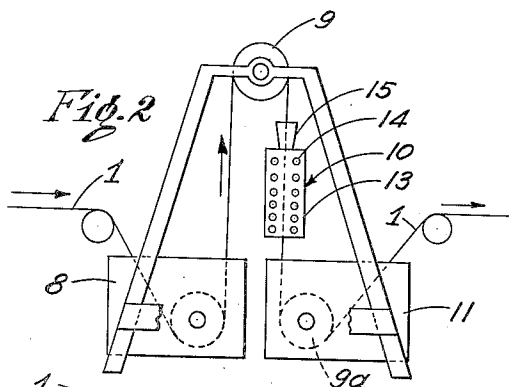
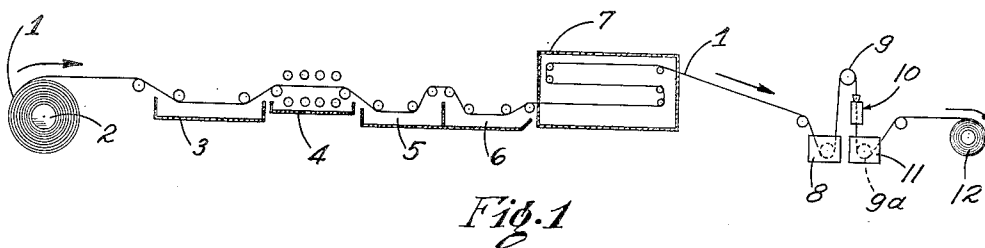


Nov. 27, 1951

C. J. DUBY
METHOD FOR FLOW BRIGHTENING ELECTRODEPOSITED
TIN ON TINPLATE
Filed Nov. 13, 1943

2,576,902



INVENTOR.
CLARENCE J. DUBY
BY
Richy & Watts
ATTORNEYS

UNITED STATES PATENT OFFICE

2,576,902

METHOD FOR FLOW BRIGHTENING ELECTRODEPOSITED TIN ON TINPLATE

Clarence J. Duby, Youngstown, Ohio, assignor to
Republic Steel Corporation, Cleveland, Ohio, a
corporation of New Jersey

Application November 13, 1943, Serial No. 510,144

4 Claims. (Cl. 204—36)

1

This invention relates generally to the manufacture of electroplated articles and more particularly to a new and improved method of, and new and improved apparatus for, making articles which are continuous, or of great length, and which comprise steel in strip form covered with a very thin layer of tin having a smooth bright surface.

When tinplate is made by electroplating tin on ferrous metal strip the tin coating has a dull, mat finish or surface. For many uses a bright, mirror-like finish is desired and may be obtained by heating the strip to melt the tin and then quenching the melted tin in a fluid such as oil or water, or a blast of air. This operation of melting and quickly cooling the tin coating has been commonly known as "flow brightening" because the dull appearance of the surface of the tin coating was thereby changed to a bright appearance.

Various devices have been used, or proposed, for flow brightening tinplate, including oil baths, gas fired radiant tube furnaces, and means for passing electrical current lengthwise thru the sheet or strip.

Each of these prior devices and their methods possessed one or more serious and inherent disadvantages. The hot oil bath apparatus and method had the disadvantages that the oil was a fire hazard and that the oil which adhered to the surface of the tinplate had to be removed at considerable expense and could not readily be recovered without added expense. The temperatures of the oil bath and tube furnaces could not be quickly changed from the high temperature required, when the tinplate was moving therethru at normal speeds, to the low temperature which was required when the tinplate was moving thru at low speed, as when the ends of two coils of tinplate were being welded together.

The electrical resistance apparatus and method required the passage of current of electricity to and from metal rolls engaging the tinplate. The contacts of the current-carrying rolls with the tinplate had to be constant and uniform to prevent arcing, overheating of the tin, and pitting of the rolls. Pinch rolls were proposed to insure the proper contact but they had a tendency to mar the tin coating which was quite thin and which was quite soft, especially when near its melting temperature. The flow brightening produced by this resistance method was not uniform when the thickness of the steel varied, as it does, for the thinner parts of the steel were heated more quickly and to a higher temperature than the thicker parts.

The present invention avoids these and other disadvantages of the prior used and proposed methods and apparatus and at the same time makes it possible to flow brighten tinplate uniformly. This invention is predicated on the dis-

2

covery than new and unexpected advantages can be obtained by heating a moving metal coated article inductively by high frequency electrical current, that is, by inducing a flow of current in the article and concentrating such flow in the outer surface portions of the article by means of high frequency.

In the drawings accompanying and forming a part of this specification,

Figure 1 is a diagrammatic view of flow brightening apparatus embodying the present invention associated with continuous electroplating apparatus;

Figures 2 and 3 are, respectively, somewhat diagrammatic side and end views of the form of flow brightening apparatus shown in Fig. 1;

Figure 4 is a perspective view of the induction coil of Fig. 3 with a strip of tinplate therein and with an oscillator for generating high frequency current connected thereto; and,

Figure 5 is a view similar to Fig. 4 but showing a plurality of induction coils and a strip therein.

In Fig. 1, which shows one form of apparatus embodying the present invention, a coil of ferrous metal strip 1 is mounted on a take-off reel 2. The strip is unwound from the coil and is passed continuously and progressively thru cleaning tank 3 and scrubber 4 to remove foreign materials from its surface, then thru an acid tank 5 where it is etched, then thru a water rinse tank 6 to remove the acid, then thru the plater 7 where a very thin "flash" coating of tin is deposited on the surfaces of the strip. This coating may be as thin as .00003" in thickness or thinner. The strip, with this electroplated coating of tin thereon, then continues on thru a preheating tank 8 containing hot water or flux, or the tank may be without any solution or water, over pulley 9, then thru an induction heater 10, around pulley 9a in a quencher tank 11, in which the tin coating which was melted during passage thru the heater 10 is quenched, and is finally wound on reel 12, or the reel may be bypassed and the strip run directly into a "flying shear" line (not shown) where the strip is cut into uniform lengths continuously. This shear line may incorporate classifying equipment to reject automatically off-gauge sheets, pinholes and other faults, allowing only the first class sheets to continue on to the prime piler.

The leading end of a new coil may be welded to the trailing end of the coil which is being unreel from reel 2 but, since the welding operation requires some little time to complete, the speed of travel of the strip thru the apparatus of Fig. 1 should be decreased sufficiently to afford time for such welding.

The parts of the flow brightening unit of Fig. 1 are diagrammatically illustrated on a somewhat larger scale, and with additional parts, in Figs.

3

2 and 3. In these figures the induction heater 10 is shown as comprising a casing 13 enclosing a coil 14 which has an air core corresponding in cross-sectional size and shape to, but larger than, the cross-sectional size and shape of the strip 1. A guide 15 serves to direct the strip 1 thru the air core of the coil and out of actual contact with the convolutions of the coil.

The coil 14 may conveniently consist of a copper tube thru which cooling liquid, such as water, may flow. The ends 14a of the coil are connected to an electronic oscillator 20. As appears from Figs. 1 and 2, the upper roll 9 and the lower roll 9a in tank 11 are so disposed that the strip between these rolls is aligned with the axis of the induction coil 14. Since tension is applied on the strip by reel 12, the strip is taut between rolls 9 and 9a and one main function of guide 15 is to prevent any vibration or whipping of the stretch of strip as it enters or while it is within the coil.

By correlating the factors of weight of strip, speed of travel of strip 1, length of coil 14 and character of the current flowing in the coil, the temperature created in the strip by the flow of current induced therein may be so regulated that while any given portion of the strip is passing thru the coil 14 the tin coating on that portion of the strip will be heated to its melting temperature and will be molten when that portion of the strip leaves the exit end of the coil 14. While the tin is still molten it enters the quenching fluid in tank 11 and is quickly cooled to below its melting temperature with the result that its surface will be smooth and bright. Since the strip comes up to its melting temperature while it is passing through the induction heater and becomes molten after sufficient energy has been furnished thereto to supply the heat of fusion of the tin, a restricted length of the strip surface is actually molten, dependent upon the relationship between the factors aforementioned, which determine the ratio at which energy is supplied to the strip.

An illustration of a suitable correlation of these factors which has been found to be satisfactory is as follows: A strip of tinplate steel 30" wide and .01" thick, and having a coating of tin on the surfaces thereof approximately .00003" thick, was passed thru an induction coil which had eleven turns and an axial length of one foot and which was like that shown in Fig. 4, at the rate of approximately 200 ft. per minute. The turns of the coil were spaced about 6" from the sides of the strip. An electronic oscillator 20 with a power output of 200 kilowatts, at a voltage of 17,500 and a frequency of approximately 200,000 cycles per second was connected to the terminals of the coil. When the strip entered the coil its temperature was about 160° F. and when it emerged from the coil the tin coating was molten. To allow the strip to be passed on the processing line at higher speeds, a plurality of coils and oscillators can be used, and one commercially satisfactory installation could consist of seven coils like coil 14, and seven 200 k. w. oscillators with each oscillator being connected to its coil, for operating at line speeds up to 1400 ft. per minute. In using a plurality of oscillators and coils it has been found advisable to have each oscillator tuned to a slightly different frequency than the frequency of its adjacent coils. For example, if the frequencies of the successive oscillators are set at 170,000 cycles, 175,000 cycles, 180,000 cycles, 185,000 cycles, 190,000 cycles, 195,000 cycles, and

4

200,000 cycles, satisfactory operation will be experienced.

It will be understood by those skilled in the electrical art that current of the desired value may be obtained by many different means. One means which has been found satisfactory is as follows: Three-phase current at 2300 volts and 60 cycles was led thru an oil switch to an induction regulator and thence to a transformer where the voltage was stepped up to 12,600 volts, 3-phase, 60 cycles. That current was converted into direct current by an electronic rectifier (not shown) and the resulting direct current was converted into alternating current having a frequency of about 200,000 cycles per second by an electronic oscillator (not shown), and this alternating current was passed thru the induction coil 14.

It will be understood that this illustration merely indicates one set of conditions under which the present invention may be carried out, and that a wide range of adjustments in weight of strip metal, speed of strip travel, length of coil and in the current flowing in the coil may be made without departing from the present invention. The following general observations will be sufficient for those skilled in the art to make the necessary correlations without experiment.

The preferred axial length of the coil is about one foot for each 200 k. w. oscillator, with the coil having 9 to 11 effective turns, but both the length and number of turns may vary depending on the amount of heat which must be supplied to the coated metal while it is in the coil. Since the tinplate is heated while within the coil, each coil may be considered as a heating zone.

The speed of strip travel may vary widely from 100 ft. per minute or less, when the ends of coils are being welded together, to as much as 1400 ft. per minute or more when the strip is moving normally, with the total number of 200 k. w. coils and oscillators required being one for each 200 ft. per minute of strip travel. Therefore, for 1400 ft. per minute maximum speed, seven 200 k. w. output oscillator units and seven coils would be used. It is to be understood that the oscillators could be built of any practical capacity but that 200 k. w. is a capacity which is well suited to the power tubes now available. The scope of this invention is not limited to any particular capacity of oscillator or coil. This capacity can be made any value consistent with practical considerations and consistent with the power required to heat the material at the speed best suited for the process.

The induction coil thru which the strip is passed may, in some electronic circuits, actually be a component part of the high frequency generating circuit rather than a separate coil energized from a high frequency current source.

The frequency of the current may vary widely, between about 100,000 cycles and about 300,000 cycles per second, but a frequency of about 200,000 cycles per second is suitable for tinplate of the average size. The current values and frequency required for any given set of speed, coil length and strip size conditions may be readily determined by taking into account the weight of material in the strip within the coil, and the heat required to raise the temperature of that material from its entering temperature to the melting temperature of coating metal while the strip is in the coil.

There are many advantages possessed by the present invention. One advantage is that tinplate may be flow brightened at speeds of as much

as 1400 feet per minute or greater. Another advantage is that the fire hazards incident to hot oil baths are avoided and the flow brightened strip does not carry any film of oil which must be removed. Another advantage is that all current-carrying contacts with the strip are eliminated with their attendant disadvantages and troubles, and the thin film of tin is not broken with resultant exposure of the ferrous metal of corroding influences. A further and unexpected advantage is that the current induced in the strip is very large and is mainly concentrated in the immediate vicinity of the tin which is to be melted, as distinguished from prior methods where heat was expended in heating the interior portions of the strip remote from the coating metal.

Altho the foregoing detailed description has been restricted to the making of tinplate composed of ferrous metal having a flow brightened thin coating of tin, it will be understood by those skilled in the art that the present invention is not limited to the size or shape of the coated metal or the nature of the coated or coating metals. While the invention is particularly valuable on metal of long lengths, it is also applicable to lengths which are short and which may be placed within the induction coil before the current is applied thereto and removed from the coil after the current is turned off and, by obvious modifications of apparatus, to other lengths of metal.

Having thus described the invention so that others skilled in the art may be able to understand and practice the same, I state that what I desire to secure by Letters Patent is defined in what is claimed.

What is claimed is:

1. The method of flow brightening electro-deposited tin on tinplate which comprises the steps of continuously moving tinplate endwise, generating a plurality of separate alternating currents and flowing said currents separately around and in inductive relation to said tinplate in separate zones arranged along the line of tinplate travel, each of said currents having a frequency ranging between about 100 kc. and about 300 kc. and sufficient wattage to melt the tin on tinplate while traveling through its zone at a lineal speed of about 200 feet per minute, the number of such zones being sufficient to heat the tin coating progressively while in said zones and to bring it to molten condition near the exit end of the last zone when the tinplate is traveling at the desired speed between about 200 feet per minute and more than 1,400 feet per minute, and quenching the molten tin immediately after the tinplate leaves the last zone.

2. The method of flow brightening electro-deposited tin on tinplate which comprises the steps of continuously moving tinplate endwise, generating a plurality of separate alternating currents and flowing said currents separately around and in inductive relation to said tinplate in separate zones arranged along the line of tinplate travel, each of said currents having a frequency ranging between about 100 kc. and about 300 kc. and sufficient wattage to melt the tin on tinplate while traveling through its zone at a lineal speed of about 200 feet per minute, the frequencies of said currents varying from one another successively by at least about 5 kc., the number of such zones being sufficient to heat the tin coating progressively while in said zones and to bring it to molten condition near the exit end

of the last zone when the tinplate is traveling at the desired speed between about 200 feet per minute and more than 1,400 feet per minute, and quenching the molten tin immediately after the tinplate leaves the last zone.

3. The method of flow brightening electro-deposited tin on tinplate which comprises the steps of continuously moving tinplate endwise, generating a plurality of separate alternating currents and flowing said currents separately around and in inductive relation to said tinplate in separate zones arranged along the line of tinplate travel, each of said currents having a frequency ranging between about 100 kc. and about 300 kc. and a wattage of about 200 kw., moving the tinplate through the zones at a lineal speed of about 200 feet per minute per zone and thereby heating the tin coating progressively while in said zones and bringing it to molten condition near the exit end of the last zone, and quenching the molten tin immediately after the tinplate leaves the last zone.

4. The method of flow brightening electro-deposited tin on tinplate which comprises the steps of continuously moving tinplate endwise, generating a plurality of separate alternating currents and flowing said currents separately around and in inductive relation to said tinplate in separate zones arranged along the line of tinplate travel, each of said currents having a frequency ranging between about 100 kc. and about 300 kc. and a wattage of about 200 kw., the frequencies of said currents varying from one another successively by at least about 5 kc., moving the tinplate through the zones at a lineal speed of about 200 feet per minute per zone and thereby heating the tin coating progressively while in said zones and bringing it to molten condition near the exit end of the last zone, and quenching the molten tin immediately after the tinplate leaves the last zone.

CLARENCE J. DUBY.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
496,208	Procunier	Apr. 25, 1893
1,043,089	Gibbs	Nov. 5, 1912
1,377,574	Frary	May 10, 1921
1,646,498	Selde	Oct. 25, 1927
1,811,522	Shover et al.	June 23, 1931
1,900,573	McArthur	Mar. 7, 1933
1,900,843	Northrup	Mar. 7, 1933
1,937,420	Wood et al.	Nov. 28, 1933
2,079,867	Meyers	May 11, 1937
2,085,543	Oplinger	June 29, 1937
2,192,303	Ferm	Mar. 5, 1940
2,202,759	Denneen et al.	May 28, 1940
2,266,330	Nachtman	Dec. 16, 1941
2,329,188	Denneen et al.	Sept. 14, 1943
2,381,323	Vore	Aug. 7, 1945
2,434,599	Stoltz	Jan. 13, 1948

FOREIGN PATENTS

Number	Country	Date
258,633	Great Britain	Sept. 21, 1926

OTHER REFERENCES

Westinghouse Engineer, Feb. 1942, page 21.
Reprint 4043 from Westinghouse Engineer, Nov. 1942, pp. 1-8, inclusive.
Business Week, Nov. 7, 1942, pp. 74 and 76.
Scientific American, Jan. 1943, pp. 7-9.