Nov. 10, 1953 G. H. RENDEL 2,658,982

HEATING CIRCUIT AND METHOD

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FIG. 1.

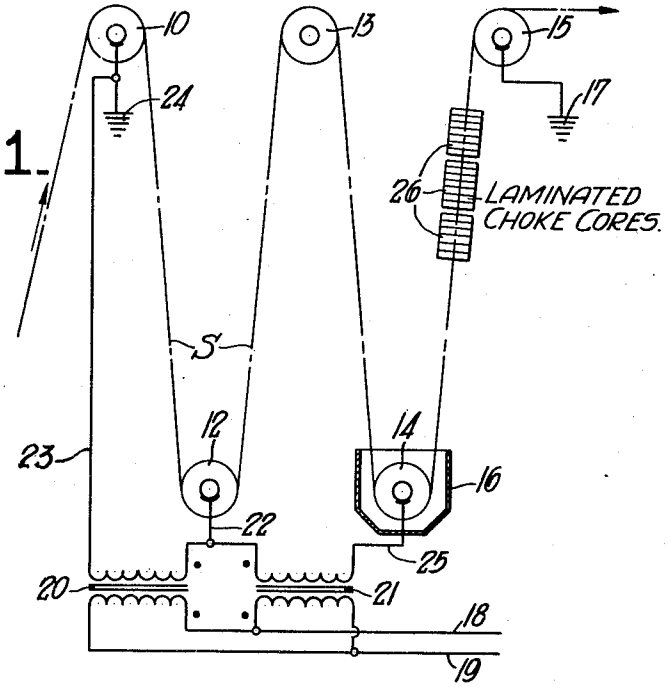
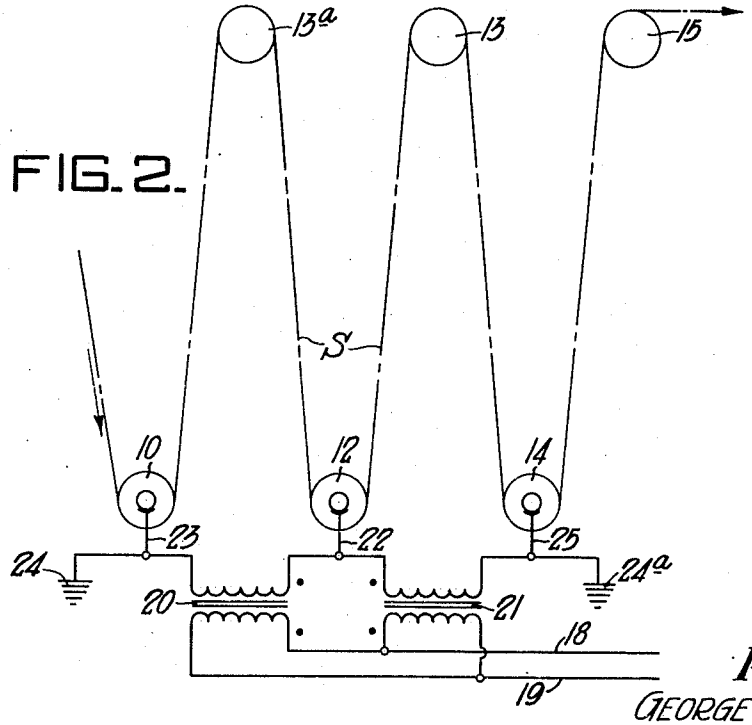


FIG. 2.



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HEATING CIRCUIT AND METHOD

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3 Claims. (Cl. 219—11)

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This invention relates to improved circuits and methods for electric resistance heating of metal in continuous processing lines.

Although not restricted to any specific metal product, the invention is especially applicable to heating tin coated steel strip in electrolytic tinning lines for the purpose of melting the coating and thereby improving its properties. Commonly such strip is heated by passing a high amperage alternating current through a portion thereof, the current being introduced at two spaced apart conductor rolls around which the strip travels. The power or wattage required to produce a given temperature rise in the strip is directly proportional to the strip speed, and the current and voltage are proportional to the square root of this speed. If the density of the current transferred between a conductor roll and the strip becomes too high at any one spot, there is a tendency for arcing to occur between the strip and the conductor roll and to damage the coating. Therefore the operating speed has been limited by the density of current that can be introduced to the strip without causing arcing. Such lines must be equipped with means for preventing current from flowing through an alternative path through ground which path is parallel to that through the strip in the heating zone. In practice such means usually includes choke cores through which the strip travels outside the conductor rolls and which create a high impedance in the strip and thus in effect break or reduce the alternative current path. Of course the same effect could be obtained by electrically insulating the entire strip from ground, although this latter practice is avoided for reasons of safety.

An object of the present invention is to provide improved heating circuits and methods which reduce the density of current which flows between the rolls and the continuous metal product at any one place without reducing the total current or power input, thereby enabling processing lines to operate at higher speeds without arcing.

A further object is to provide improved heating circuits and methods which cut down on the total length of choke cores needed to break the alternate current path or else eliminate such choke cores altogether.

A further object is to provide improved circuits and methods which reduce both the voltage from the conductor rolls to ground and the current intensity between the conductor rolls and the metal product at any portion.

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A more specific object is to provide circuits and methods in which current is introduced to the continuous metal product at a minimum of three conductor rolls, thereby producing two heating zones, the current always flowing in opposite directions with respect to the direction of travel of the product in the two zones.

In accomplishing these and other objects of the invention, I have provided improved details of structure, preferred forms of which are shown in the accompanying drawings, in which:

Figure 1 is a schematic view of a portion of a processing line equipped with an improved heating circuit embodying features of the present invention; and

Figure 2 is a schematic view which shows a modification.

Figure 1 shows schematically a portion of a processing line which includes rolls 10, 12, 13, 14 and 15, around which travels a continuous length metal product S moving from left to right. When the product is electrolytically tinned steel strip, roll 14 is situated in a quench tank 16. The heating circuit hereinafter described heats the strip so that its coating melts just ahead of said tank. The quench then solidifies the coating before the strip contacts the next roll.

In accordance with the present invention, three rolls 10, 12 and 14 are conductor rolls through which current is introduced to the metal product, roll 13 is an insulated roll, and the remaining roll 15 is conducting and grounded, as indicated at 17. The rolls can be of any standard or desired construction and consequently are not shown in detail. The metal product wraps around the intermediate conductor roll 12 through an appreciable arc that furnishes more than a single line contact. The portion of the metal product between rolls 10 and 12 can be considered an initial heating zone and that between rolls 12 and 14 a final heating zone, although in electro-tinning applications the power input to the two zones is balanced to achieve a uniform, heating rate throughout. In Figure 1 the length of the final zone is substantially double that of the first zone, although obviously their relative lengths can vary.

The circuit includes lines 18 and 19 which are connected to any suitable A. C. source and to the primary windings of two transformers 20 and 21. These windings are connected in parallel with each other and in like phase relation, as shown in Figure 1. Commercially made transformers commonly bear polarity marks, as indicated by the dots in Figure 1, and in the pres-

ent circuit the transformers conveniently can be connected with the polarity marks arranged as indicated in this figure. A conductor 22 connects one end of the secondary windings of both transformers to the intermediate conductor roll 12. A conductor 23 connects the other end of the secondary winding of transformer 20 to the conductor roll 10 at the entry end of the initial heating zone and preferably is grounded, as indicated at 24. A conductor 25 connects the other end of the secondary winding of transformer 21 to the conductor roll 14 at the exit end of the final heating zone. I prefer that the voltages across the secondary windings of the two transformers be in the same ratio as the lengths of the two heating zones. With the voltages thus adjusted, the amperage is the same in both zones. In Figure 1 the voltage across the secondary winding of transformer 21 would be twice that of transformer 20.

Since the transformers 20 and 21 are in like phase relation, the intermediate conductor roll 12 is always of polarity opposite that of the entry and exit conductor rolls 10 and 14, and current always flows in opposite directions with respect to travel of the product in the two heating zones. The voltage outputs from the secondary windings are subtractive; that is, the voltage at conductor roll 14 referred to ground equals the voltage across the secondary winding of transformer 21 minus that across the secondary winding of transformer 20. For example, in Figure 1 if the voltages across the secondary windings of transformers 20 and 21 are 50 and 100 volts respectively, the voltage from conductor roll 14 to ground is only 50 volts. The processing line is shown equipped with the usual choke cores 26, but since they need offer only sufficient impedance to stop current at a much smaller voltage than usual, they can be considerably reduced in length. In the present example they need be only half the usual total length.

It is known that current flow between a conductor roll and a length of metal wrapped thereabout is concentrated adjacent lines of tangency at which the metal leaves or comes into contact with the roll. At the intermediate conductor roll 12 there are two regions of maximum current flow, one at the line where the strip comes in from the initial heating zone and another where the strip leaves to the final heating zone. Consequently the current which flows between this roll and the metal product S is divided between two such regions, rather than concentrated in only one, and considerably more total current can be applied without exceeding at any one place the current density limit beyond which there is arcing between the product and the roll. The metal product must wrap around roll 12 through an appreciable arc to assure that current flow is properly divided. Likewise the current introduced to the metal product S through each of the rolls 10 and 14 is only a fractional part of the total current applied. Therefore a considerable larger total amount of current can be applied to the metal product without exceeding the aforementioned limit at any one place. Since the circuit makes it possible to introduce more current to the metal without causing arcing, it is possible to operate the line at higher speeds.

It is to be observed that there is the same voltage drop per unit length of product on opposite sides of the intermediate conductor roll 12. Consequently corresponding spots on the metal on opposite sides of this roll are at the same potential and there is no tendency for current to flow between them. I believe this feature may be of benefit in further minimizing the tendency for arcing at this particular roll.

Figure 2 shows a modification in which the two heating zones are of equal length. Another insulated roll 13*a*, similar to roll 13, is interposed between conductor rolls 10 and 12. The two transformers are connected in the same fashion as in Figure 1, except in this instance the voltages are equal across their secondary windings. The voltage at both the entry and exit conductor rolls 10 and 14 when referred to ground is zero, since these voltages are equal and are subtractive. Therefore both these conductor rolls 10 and 14 can be grounded, as indicated at 24 and 24*a*, and the choke cores are eliminated altogether. The modification cuts down the amperage of the current introduced to the strip at any one place in the same way as already described for Figure 1.

While two embodiments of my invention have been shown and described, it will be apparent that other adaptations and modifications may be made without departing from the scope of the following claims.

I claim:

1. In a line for processing metal products in continuous lengths and including a plurality of spaced apart rolls around which a metal product travels, at least three of which rolls are electrically conductive, an electric resistance heating circuit comprising two transformers whose windings are connected in like phase relation, conductors connecting one end of the secondary windings of each of said transformers to one of said electrically conductive rolls which is situated intermediate the other two, and conductors connecting the other ends of the secondary windings repectively to the others of said electrically conductive rolls, said rolls being positioned to wrap the metal product around the electrically conductive intermediate roll through an appreciable arc.

2. In a line for processing metal products in continuous lengths and including a plurality of spaced apart rolls around which a metal product travels, at least three of which rolls are electrically conductive and define an initial heating zone and a final heating zone for the metal product, an electric resistance heating circuit comprising two transformers whose windings are connected in like phase relation, the voltage output at the secondary windings of said transformers being in the same ratio as the lengths of said zones, conductors connecting one end of the secondary windings of each of said transformers to one of said electrically conductive rolls which is situated intermediate the other two, and conductors connecting the other ends of the secondary windings respectively to the others of said electrically conductive rolls, said rolls being positioned to wrap the metal product around the electrically conductive intermediate roll through an appreciable arc.

3. In a line for processing metal products in continuous lengths and including a plurality of spaced apart rolls around which a metal product travels, at least three of which rolls are electrically conductive and constitute an entry conductor roll, an intermediate conductor roll and an exit conductor roll, said entry conductor roll and said intermediate conductor defining an initial heating zone for the metal product and said exit conductor roll and said intermediate con-

ductor roll defining a final heating zone, an electric resistance heating circuit comprising two transformers whose windings are connected in like phase relation, conductors connecting one end of the secondary windings of each of said transformers to said intermediate conductor roll, and conductors connecting the other ends of the secondary windings respectively to said entry and exit conductor rolls, the voltage output of said transformers being in same ratio as the lengths of the heating zones to which they are connected,

said rolls being positioned to wrap the metal product around said intermediate conductor roll through an appreciable arc.

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