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ELECTRIC INDUCTION FURNACE FOR CONTINUOUSLY HEATING METAL STRIPS

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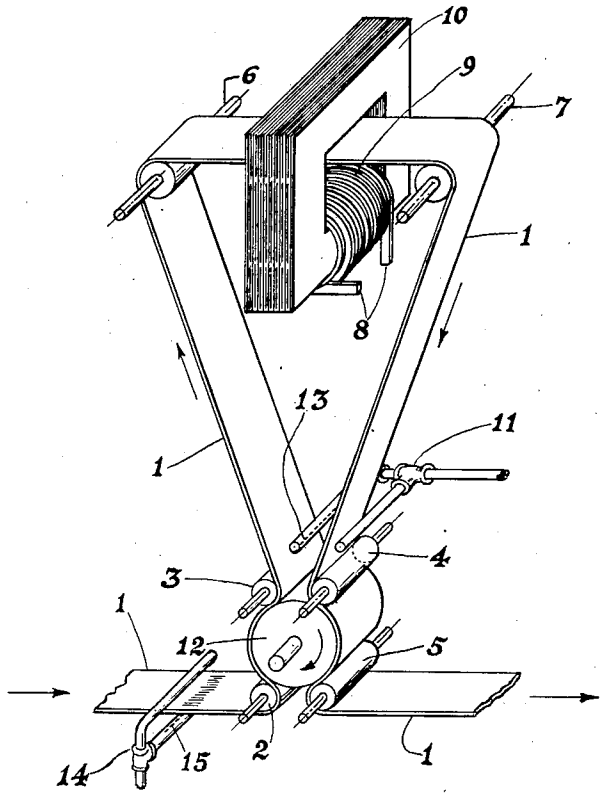

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ELECTRIC INDUCTION FURNACE FOR CONTINUOUSLY HEATING METAL STRIPS

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9 Claims. (Cl. 219—13)

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This invention relates to the heating of metal strip by means of electric induction.

It has heretofore been well known that the heating of metal can be accomplished by employing the transformer principle in which a primary coil is supplied with an alternating electric current, and the metal, when placed in inductive relationship with the primary coil, is heated by its resistance to the induced electric or magnetic current.

The means proposed heretofore for bringing the metal into inductive relation with the primary coil have had numerous disadvantages. For instance in one method, the metal in the form of a strip was continuously passed in an axial direction through a primary coil, the metal being heated by the locally induced magnetic and electric eddy currents. Such methods and apparatus have the disadvantage that with high electrical conductivity non-magnetic strip, it is difficult to induce electrical eddy currents of sufficient magnitude to heat the strip to an effective treating temperature.

According to other methods, the metal, in the form of rod or wire, was fed in the path of a helix around or through a primary coil. Such methods and apparatus have among others the disadvantages of requiring complex means for feeding and guiding the wire or rod in the helical or spiral path and of not being suitable for use with wide metal strip, due to the difficulty involved in forming such strip into a helix.

In still another method, two wires were continuously passed in parallel paths on opposite sides of a primary coil. A complete electrical circuit about the primary coil through the wires was provided by means of metal bars having rollers on their ends in electrical contact with the moving wires. Such methods and apparatus, in which bearings, brushes, and the like are involved in the secondary circuit, have the disadvantage that a portion of the induced current is consumed in overcoming the resistance offered by such parts, and, in some instances the contact parts are subject to wear requiring frequent replacement.

An object of this invention is, therefore, to provide an improved apparatus for the electric induction heating of metal strip overcoming such disadvantages.

Another object of the invention is to provide improved means for economically effecting the continuous heating of metal strip of either high or low electrical conductivity.

Another object is to provide apparatus for

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efficiently heating flat metal strip of any desired width by means of electric induction.

Other objects and advantages will become apparent from the following description and accompanying drawing, which is a diagrammatic perspective view of metal strip heating apparatus illustrating an embodiment of this invention.

The above objects and advantages are accomplished in accordance with this invention by the provision of a novel process and apparatus in which the metal to be heated in the form of strip is advanced in contact with one side of a metal roll, through an alternating electromagnetic field, and finally in contact with the opposite side of the metal roll. A complete electric secondary circuit is thus provided by the loop formed by the moving metal strip short circuited through the contact roll. The induced current is accordingly not required to pass through any bearings, brushes and the like and it is not necessary to bend or warp the strip into the form of a helix or any such similar shapes.

The single figure of the drawing is a diagrammatic perspective view of an electric induction furnace illustrating an embodiment of this invention.

Referring to the figure of the drawing, the flat metal strip 1 is the metal to be heated and it may be fed continuously or semi-continuously through the furnace by employing any suitable means for advancing the strip, a number of such means being well known in the art and not shown in the drawing. The rolls 2, 3, 4, 5, 6 and 7 may be formed of metal or preferably of a heat resistant electrical non-conductor and if desired, may be hollow so that a cooling medium can be circulated through them. These rolls, if formed of metal or other electrical conductor, should be supported by an insulating framework or in such manner that no electrical connection is provided between them except through the strip 1.

The primary induction means, employed to set up an alternating electromagnetic field, may be of any suitable form. For instance, in the preferred form, it is composed of a coil 9 with leads 8 and laminated iron core 10. If desired, however, the coil 9 may be placed on a leg of the core outside the loop formed by the strip 1, or in some applications, the core 10 may be omitted.

The electrical contact roll 12 is formed of metal, preferably of high electrical conductivity,

such as an aluminum alloy and may if desired be hollow so that a cooling medium can be circulated therethrough. If the roll is formed of copper or copper-base alloy, it is preferably plated with platinum, chromium or the like, so that a non-oxidizing surface will be provided if the roll attains an elevated temperature.

The rolls 2, 3, 4, 5, 6, 7 and 12 may be so mounted as to turn freely, or may be driven at a speed commensurate with the speed of the strip in contact with them so that there is no abrasive action or slippage between the rolls and strip 1.

Pipe systems 11 and 14 having perforations 13 and 15 respectively, may be employed to inject a fluid onto the strip 1 and/or rolls. For instance, wet steam may be injected through pipe 11 on the heated strip to lower its temperature prior to contact with roll 12 or prior to its discharge from the furnace.

An alternating electric current, which may be of either high or low frequency or, for instance, any of the available commercial frequencies, is applied to the primary leads 8. For instance, in heating flat brass strip 16 inches wide and 0.015 inch thick, an ordinary 440 volt, 60 cycle line may be connected to the leads 8 through a suitable autotransformer for controlling the power input.

In operation the strip 1 is advanced over roll 2, around and in contact with one side of roll 12, over rolls 3 and 6, through and in inductive relation to the alternating electromagnetic field set up by the primary coil 9, over rolls 7 and 4, around and in contact with the opposite side of roll 12, and finally over roll 5.

Rolls 2 and 3 and oppositely disposed rolls 4 and 5 have the primary function of holding the strip 1 in good electrical contact with a large or major portion of the surface of opposite sides of the contact roll 12, so that a large area of contact is provided with a resultant low amperage per square inch between the strip 1 and contact roll 12, to prevent arcing and burning. Although such rolls are preferred for making suitable contact between contact roll 12 and the strip 1, any other suitable and equivalent means may be employed, for instance continuous belts or the like travelling in a path designed to maintain the strip 1 in suitable contact with opposite sides of the contact roll 12. The rolls 6 and 7 have the primary function of serving as support members for guiding the strip as it passes through the alternating electromagnetic field. Any other suitable means may be employed for supporting and guiding the strip.

A complete secondary electric circuit is thus formed around the primary coil 9 in the loop formed by the moving strip 1 and the contact roll 12. The strip is advanced substantially without lateral displacement, or in other words its center is maintained in substantially one plane, for instance, as illustrated in the specific embodiment, in a vertical plane, so that no warping, twisting or deleterious bending of the flat strip is necessary. Further, there are no brushes, bearings or the like in the secondary circuit offering resistance to the flow of induced current, so that a highly efficient heating of the strip is effected.

If it is desired to rapidly cool the strip, any suitable means may be employed, for instance wet steam may be sprayed on the hot strip, or, if it is desired to quench the strip, water may be sprayed on the strip through a pipe system such as indicated at 11. Further, in order to clean the metal by removing any foreign particles, such as dust, dirt and oil from its surface, medium or high temperature steam may be sprayed on the strip before it comes in contact with roll 12 by means of a pipe system 14 provided with perforations such as at 15. Fluid spray pipe systems 11 and 14 or other suitable means may likewise be employed to maintain the temperature of the strip passing over the discharge side of contact roll 12 equal to the temperature of the strip passing over the charge side of contact roll 12, thus eliminating any tendency toward a continuous enlargement of the loop due to the expansion of the metal when heated by the induced current. Likewise, after leaving the furnace the strip may be passed in the usual way through a quenching or pickling tank. If it is desired to bright anneal metal strip, or heat it in an inert or controlled atmosphere, this may be readily accomplished by enclosing the furnace, or the hot strip, in a suitable housing and introducing the desired atmosphere into the housing. Further, if desired, the furnace may be inverted, that is arranged so that the contact roll 12 is above the primary induction means 9, or it may be so arranged that the primary induction means 9 is at any desired vertical or horizontal angle with respect to the contact roll 12. Likewise the primary induction means 9 may be disposed at the side of the loop between rolls 3 and 6 or between rolls 4 and 7 instead of at the end of the loop between rolls 6 and 7.

Magnetic or nonmagnetic metal of either high or low electrical conductivity may be continuously heated in the form of flat strip having any desired width. Likewise the heating may be accomplished by applying current to the primary coil of any desired frequency within practical limits and the temperature attained by the strip can be easily controlled by either, or both, the speed of travel of the strip through the furnace or the power input to the primary induction means.

This invention accordingly provides means for the economical continuous heating of metal in the form of flat strip and has a wide field of utility without being subject to all the disadvantages obtained with prior processes and apparatus. It is to be understood that the embodiment of the invention as shown and described is only illustrative and that the scope of the invention is not to be limited thereby except insofar as is defined in the following claims.

Having thus described the invention, what is claimed and desired to secure by Letters Patent is:

1. An electric induction furnace for continuously heating metal strip comprising means for advancing said strip through the furnace, a metal roll, support means on opposite sides of said roll for holding said strip in electrical contact with a substantial portion of the surface of said roll, means between said support means for holding said moving strip out of contact with said roll to form a loop of said strip, and an alternating electromagnetic field for inducing an electric current in said loop.

2. An electric induction furnace for continuously heating metal strip comprising means for advancing said strip through said furnace, a metal contact roll, spaced support rolls on opposite sides of said contact roll for holding said moving strip in contact with a substantial portion of the surface of said contact roll, means between said support rolls for holding said moving

strip in the form of a loop out of contact with said contact roll, and an alternating electromagnetic field for inducing an electric current in said loop.

3. An electric induction furnace for continuously heating metal strip comprising means for advancing said strip through said furnace, a cylindrical metal contact roll, a plurality of spaced support rolls on opposite sides of and parallel to said contact roll for holding said moving strip in contact with a substantial portion of the surface of said contact roll, means between said support rolls for holding said strip out of contact with said contact roll in the form of a loop, and means for inducing an electric current in said loop.

4. An electric induction furnace for continuously heating metal strip comprising a cylindrical metal contact roll, a primary induction means, means for advancing said strip in a path in which the moving strip is in contact with said contact roll on the charge side of the furnace and in which said strip is passed in inductive relation to said primary induction means and in which said strip is maintained in contact with said contact roll on the discharge side of said furnace, a plurality of spaced support rolls on opposite sides of and parallel to said contact roll for holding said moving strip in contact with a substantial portion of the surface of said contact roll on each side thereof, and means for maintaining substantially the same temperature in the strip on the charge side and discharge side of said contact roll.

5. In an electric furnace for continuously heating metal strip in which the strip is heated by an induced electric current, the combination comprising means for establishing an alternating electromagnetic field, means for advancing said strip through said alternating electromagnetic field, a metal roll maintained in contact with both the portion of the strip advancing toward said field and the portion of the strip leaving said field, means disposed on opposite sides of said roll for maintaining the moving strip in contact with a substantial portion of the surface of the roll, and means for supporting said moving strip in said field and between said oppositely disposed means out of contact with said roll.

6. In an electric furnace for heating metal strip by means of an electric current induced in the strip, the combination which comprises means for establishing an alternating electromagnetic field, means for advancing the strip through said alternating electromagnetic field, a metal roll, means disposed on one side of said roll for holding the portion of the strip advancing toward said field in electrical contact with a major portion of the surface of said roll on said side, means disposed on the opposite side of said roll for holding the portion of the strip leaving said field in electrical contact with a major portion of the surface of said roll on said opposite side, and means for supporting said moving strip in said field and between said oppositely disposed means out of contact with said roll.

7. In an electric furnace for continuously heating metal strip by means of an electric current induced in the strip, the combination which comprises means for establishing an alternating electromagnetic field, means for advancing said strip through said alternating electromagnetic field, a metal contact roll, support rolls disposed on one side of said contact roll for holding the portion of the strip advancing toward said field in electrical contact with a major portion of the surface of the contact roll on said side, support rolls disposed on the opposite side of said contact roll for holding the portion of the strip leaving said field in electrical contact with a major portion of the surface of said roll on said opposite side, and means for supporting said moving strip in said field and between said oppositely disposed support rolls out of contact with said contact roll.

8. An electric induction furnace for heating metal strip comprising means for advancing said strip through the furnace, a metal roll, support means on opposite sides of said roll for holding said strip in electrical contact with a substantial portion of the surface of said roll, means between said support means for holding said moving strip out of contact with said roll to form a loop of said strip, means for maintaining the portions of the strip in contact with said roll at subtantially the same temperature, and a primary induction means for inducing an electric current in said loop to heat the strip.

9. In an electric furnace for heating metal strip in which the strip is heated by an induced electric current, the combination comprising means for establishing an alternating electromagnetic field, means for advancing said strip through said alternating electromagnetic field, a metal roll maintained in contact with both the portion of the strip advancing toward said field and the portion of the strip leaving said field, means disposed on opposite sides of said roll for maintaining the moving strip in contact with a substantial portion of the surface of the roll, means for maintaining the portions of the strip in contact with said roll at substantially the same temperature, and means for supporting said moving strip in said field and between said oppositely disposed means out of contact with said roll.

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