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ELECTRIC INDUCTION FURNACE FOR CONTINUOUSLY HEATING METAL STRIP

Filed May 22, 1944

2 Sheets-Sheet 1

Fig. 1

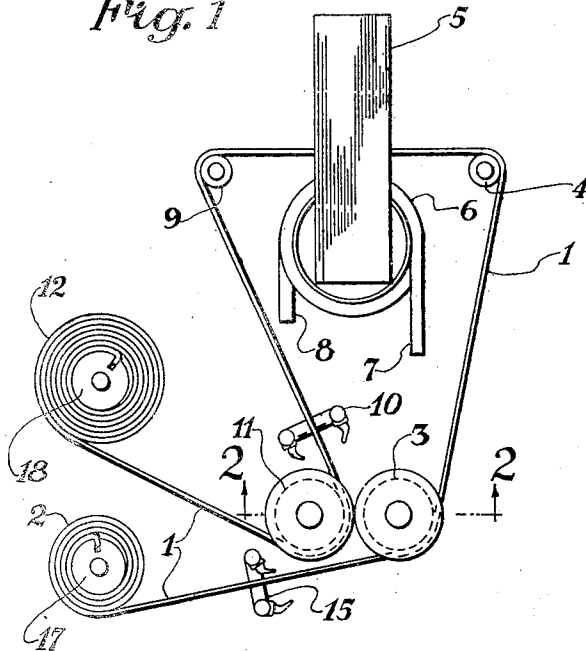
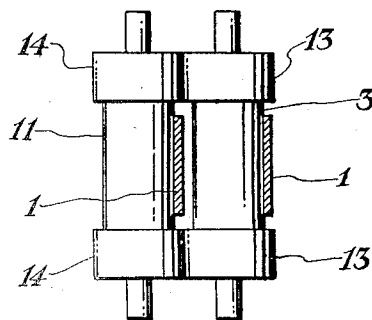


Fig. 2



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Fig. 3

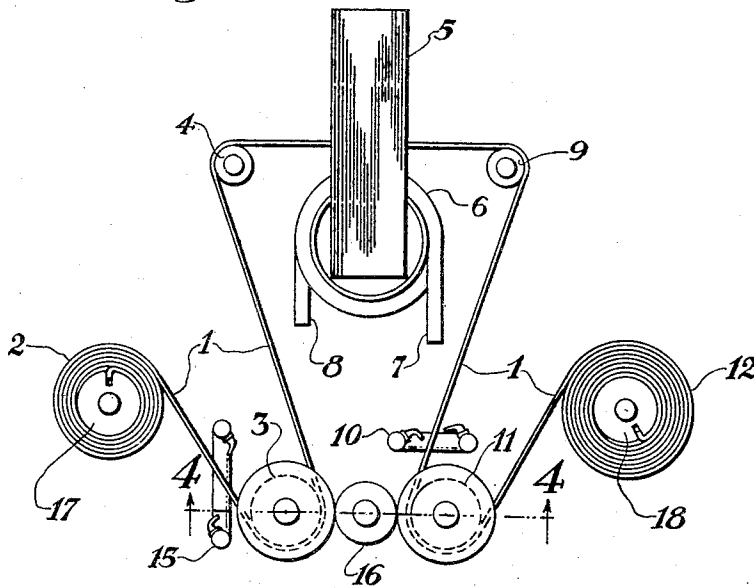
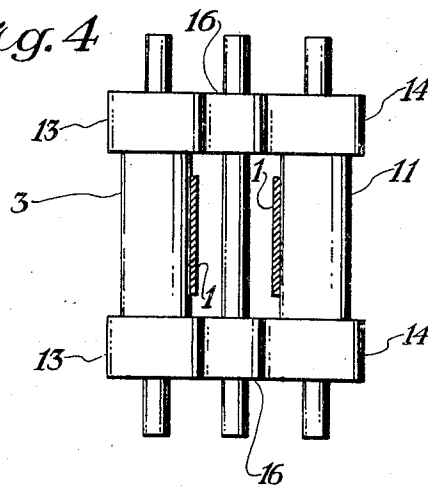


Fig. 4



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ELECTRIC INDUCTION FURNACE FOR CONTINUOUSLY HEATING METAL STRIP

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

In electric heating, the transformer principle is well known, in which a primary coil is supplied with an alternating electric current and the metal to be heated, when placed in inductive relationship with the primary coil, is heated by its resistance to the induced electric or magnetic current.

Various means have been proposed heretofore for continuously bringing the metal to be heated into inductive relationship with the primary coil but all such prior means have been attended by one or more serious disadvantages. For instance, according to one method, the 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. This method has the disadvantage that with high 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 another method, two wires were continuously passed in parallel paths on opposite sides of a primary coil. A complete electric 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 a method has the disadvantage that a portion of the induced current is consumed in overcoming the resistance offered by bearings, brushes and the like, and, in some instances the contact parts are subject to wear requiring frequent replacements.

It is an object of this invention therefore to provide means of heating metal in strip form overcoming such disadvantages.

Another object of the invention is to provide an improved method and apparatus for the efficient and economical continuous heating of metal strip by electric induction.

Another object is to provide improved means for effecting the continuous heat treatment of metal strip having either high or low electrical conductivity.

Still another object of the invention is to provide an improved process and electric furnace suitable for the heat treatment of non-magnetic metal such as copper or its alloys in the form of strip.

Other objects and advantages will become apparent from the description and accompanying drawing, in which

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of a metal strip heating apparatus illustrating an embodiment of this invention,

Figure 2 is a plan view of the contact roll assembly of the apparatus of Figure 1,

Figure 3 is a diagrammatic elevational view of a metal heating apparatus illustrating another embodiment of this invention, and

Figure 4 is a plan view of the contact roll assembly of the apparatus of Figure 3.

The above objects and advantages are accomplished in accordance with this invention by providing a novel process and apparatus in which a strip of the metal to be heated is advanced in contact with a metal roll, then through an alternating electromagnetic field, and finally again in contact with another metal roll, said metal rolls being electrically connected to form with the moving strip a complete secondary electrical loop about the primary induction means. In operation the portions of the strips in contact with the metal contact rolls are preferably all kept at about the same temperature.

Referring to the drawing, in the embodiment illustrated in Figure 1, the strip 1 is unwound from the coil of metal strip 2, passes around the metal roll 3 over support roll 4 through the laminated iron core 5 of the primary coil 6 with leads 7 and 8, over support roll 9 around metal roll 11, and is wound up on a reel to form the coil of metal strip 12. Spray system 15 may be employed for instance to clean and pre-heat the metal strip 1 prior to its contact with metal roll 3. The spray system 10 may be employed for instance to cool the metal strip 1 prior to its contact with metal roll 11.

Referring to Figure 2, it may be seen that metal rolls 11 and 3, around which strip 1 is passed, have enlarged roller portions 14 and 13, respectively, at their ends. The roller portions 14 and 13 are in intimate contact so that a good electrical connection is provided between the metal rolls 3 and 11.

In the operation of the heating apparatus illustrated in Figure 1, the support rolls or reels 17 and 18 may be driven by any suitable means to pass the metal strip through the furnace, and if desired, rolls 3, 4, 9 and 11 may also be driven, or may be so mounted as to merely turn freely with the movement of the strip over them. A source of alternating current is applied to the leads 7 and 8 of the primary coil 6 which then sets up an alternating electromagnetic field through which the strip 1 passes, and an electric current is thereby induced in the electrical loop

Figure 1 is a diagrammatic elevational view

formed by the strip and contact rolls 3 and 11 with their enlarged roller portions 13 and 14.

In the embodiment illustrated in Figure 3 the strip 1 is unwound from the coil of metal strip 2, passes around metal roll 3, over support roll 4, through laminated iron core of the primary coil 6 with leads 7 and 8, over support roll 9, around metal roll 11, and is wound up into the coil of metal strip 12. Spray system 15 may be employed to clean and pre-heat the metal strip 1 prior to its contact with metal roll 3, for instance, by spraying live steam onto the metal strip 1. Spray system 10 may be employed to cool strip 1 prior to its contact with metal roll 11, for instance, by spraying wet steam or a cold liquid such as water on the metal strip 1.

Referring to Figure 4, the metal rolls 3 and 11 around which the metal strip 1 is passed have enlarged roller portions 13 and 14 respectively. The metal contact rollers 16 is in intimate contact with the enlarged portions 13 and 14 of the metal rolls so that a good electrical connection is provided between the metal rolls 3 and 11.

In the operation of the furnace illustrated in Figure 3 the support rolls or reels 17 and 18 may be driven by any suitable means to pass the metal strip through the furnace. The rolls 3, 4, 9, 11 and 16 may, if desired, likewise be driven by any suitable means. For instance, one or more of such rolls may be driven in the case of very thin metal strip which might tend to be deformed or pull apart when tension is applied at elevated temperature. A source of alternating electric current is connected to the leads 7 and 8 of the primary coil 6 and an electromagnetic field is set up through which the metal strip 1 passes. An electric current is thereby induced in the electrical loop formed by the moving strip, the metal rolls with their enlarged portions 13 and 14, and contact roller 16. Current of sufficient density may be thus induced in the strip to heat the strip to any desired practical temperature.

The strip 1 is bent around a substantial portion of the surface of the metal rolls 3 and 11 so that a large area of contact is provided with good electrical connection and low amperage per square inch between the strips and the metal rolls to prevent arcing and burning of the strips.

The alternating electric current applied to the primary leads 7 and 8 may be of either high or low frequency or, for instance, any of the available standard commercial frequencies. The temperature of the metal strip 1 can be regulated either by varying the speed at which the strip travels through the furnace or by varying the power supplied to the primary coil 6. The core 5 may be mounted on any suitable support and the rolls 3, 11, 4, 9, and 16 may likewise be mounted on any suitable support. If the support rolls 4 and 9 are made of metal or other electrical conductors, care must be taken to avoid providing any electrical connection between them through their support, since the induced current might then flow through the support instead of being confined to the strip 1. Such short circuiting can be avoided with metal rolls in any of the well known ways, for instance by supplying the rolls with bearings made of an insulator or by providing separate supports or supports made of an insulator. It is preferred, however, to form the support rolls themselves from an insulator.

Any other suitable means may be employed for supplying the alternating electromagnetic field through which the metal strip 1 passes. For instance, the primary induction means may con-

sist of a primary coil wound about a leg of the core 5 outside of the loop formed by the metal strip or, for instance, may consist of a coreless primary coil disposed within the loop formed by the strip 1.

In accordance with this invention magnetic or non-magnetic 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.

If desired a stitching apparatus may be placed between the reel 17 and metal roll 3 so that successive coils of metal strips can be stitched end to end and a continuous length of metal strip passed through the furnace.

The furnace of this invention may be employed to anneal brass or other metal strip or may be employed for such operations as "normalizing," "quenching," and "drawing," for instance as is carried out on steel strips, or for the reflowing of tin or other metal coating on metal strip, or for making copper clad steel sheet, or other laminated sheets, and the like. The temperature to which the metal strip is heated will depend upon the time of passage and current density of the electric current induced in the loop formed by the strip, which as stated above can be controlled by either or both, the input to the primary coil 6 or by the speed of travel of the strip through the furnace.

This invention accordingly provides means for the economical continuous heating of metal in strip form and has a wide field of utility without being subject to all the disadvantages obtained with prior processes and apparatus. The current induced in the metal strip is not required to pass through any brushes, bearings, or the like of high resistance and the contact rollers, for instance made of copper alloy, which close the electrical secondary loop have a very low resistance so that highly efficient heating is accomplished. It is to be understood that the embodiments of the present invention as shown and described are 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 heating metal strip comprising a primary induction means, means for advancing said strip about said primary induction means, a metal roll in contact with the portion of the strip advancing toward said induction means, a metal roll in contact with the portion of the strip leaving said induction means, and metal roller means electrically connecting said metal rolls.

2. An electric induction furnace for heating metal strip comprising means for establishing an electromagnetic field, means for advancing said strip through said electromagnetic field, spaced metal contact rolls, means holding the portion of the strip advancing toward said field in electrical contact with one of said contact rolls, means holding the portion of said strip leaving said field in electrical contact with the other of said rolls, and metal roller means electrically connecting said contact rolls.

3. In an electric furnace for heating metal strip by means of an electric current induced in said strip the combination comprising means for establishing an alternating electromagnetic field, means for advancing said strip through said al-

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ternating electromagnetic field, parallel metal contact rolls, metal roller means electrically connecting said contact rolls, support rolls holding the portion of the strip advancing toward the said field in electrical contact with one of said contact rolls, and support rolls holding the portion of the strip leaving said field in electrical contact with the other of said contact rolls.

4. An electric induction furnace for continuously heating metal strip comprising means for establishing an alternating electromagnetic field, means for advancing said strip through said alternating electromagnetic field, a metal roll in contact with the portion of the strip advancing toward said field, a metal roll in contact with the portion of the strip leaving said field, said rolls having a strip-contacting portion and a portion of larger diameter at their ends and so disposed that the said end portions of one roll are in contact with the end portions of the other roll.

5. In an electric furnace for heating metal strip by means of an electric current induced in said strip the combination comprising means for establishing an alternating electromagnetic field, means for advancing said strip through said alternating electromagnetic field, parallel metal contact rolls having a strip-contacting portion and having end portions of larger diameter, the said end portions of one contact roll being in contact with those of the other, support rolls holding the portion of the strip advancing toward the said field in electrical contact with one of said contact rolls, and support rolls holding the portion of the strip leaving said field in electrical contact with the other of said contact rolls.

6. An electric induction furnace for continuously heating metal strip comprising means for establishing an alternating electromagnetic field, means for advancing said strip through said alternating electric magnetic field, in inductive relation thereto, a metal roll in contact with the portion of the strip advancing toward said field, a metal roll in contact with the portion of the strip leaving said field, roller means electrically connecting said contact rolls, and means for cooling the strip leaving said field prior to its contact with the metal roll.

7. An electric induction furnace for continuously heating metal strip comprising means for establishing an alternating electromagnetic field, means for advancing said strip through said alternating electromagnetic field in inductive relation thereto, a metal roll in contact with the portion of the strip advancing toward said field, a metal roll in contact with the portion of the strip leaving said field, said rolls having a strip-contacting portion and a roller portion of larger diameter at their ends, and a metal roller in contact with and electrically connecting said end portions of larger diameter.

8. An electric induction furnace for continuously heating metal strip comprising means for establishing an alternating electromagnetic field, means for advancing said strip through said alternating electromagnetic field and in inductive relation thereto, spaced metal contact rolls, means holding the portion of the strip advancing

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toward said field in electrical contact with one of said rolls, means holding the portion of the strip leaving said field in electrical contact with the other of said rolls, said rolls being disposed in parallel position and having end portions of larger diameter than the strip-contacting portions of said rolls, and a metal roller in contact with and electrically connecting said end portions of said contact rolls.

9. In an electric furnace for heating metal strip by means of an electric current induced in said strip the combination comprising means for establishing an alternating electromagnetic field, means for advancing said strip through said alternating electromagnetic field, parallel metal contact rolls having a strip-contacting portion and having roller end portions of larger diameter, a metal roller in contact with and electrically connecting said end portions, support rolls holding the portion of the strip advancing toward said field in electrical contact with one of said contact rolls and support rolls holding the portion of the strip leaving said field in electrical contact with the other said contact roll.

10. In an electric furnace for heating metal strip by means of an electric current induced in said strip the combination comprising means for feeding said strip through said furnace, means for pre-heating said strip prior to induction of an electric current in said strip, means for establishing an electromagnetic field, means for guiding said strip through said electromagnetic field and in inductive relation thereto, parallel metal contact rolls having a strip-contacting portion and having end portions of larger diameter, the said end portions of one contact roll being in contact with those of the other, means holding the strip advancing toward the said field in electrical contact with a substantial portion of the surface of one of said contact rolls, means holding the portion of said strip leaving said field in electrical contact with a substantial portion of the surface of the other of said contact rolls, and means for cooling said strip leaving said field prior to its contact with said contact roll.

11. An electric induction furnace for continuously heating metal strip comprising means for establishing an alternating electromagnetic field, means for advancing said strip through said alternating electromagnetic field and in inductive relation thereto, a metal roll in contact with the portion of the strip advancing toward said field, a metal roll in contact with the portion of the strip leaving said field, roller means electrically connecting said contact rolls, means for pre-heating the strip before contact with said first contact roll, and means for cooling said strip leaving said field prior to contact with said last contact roll.

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

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