May 23, 1944. G. P. WILSON 2,349,569

PROCESSING OF METAL STRIPS

Filed March 24, 1943 2 Sheets-Sheet 1

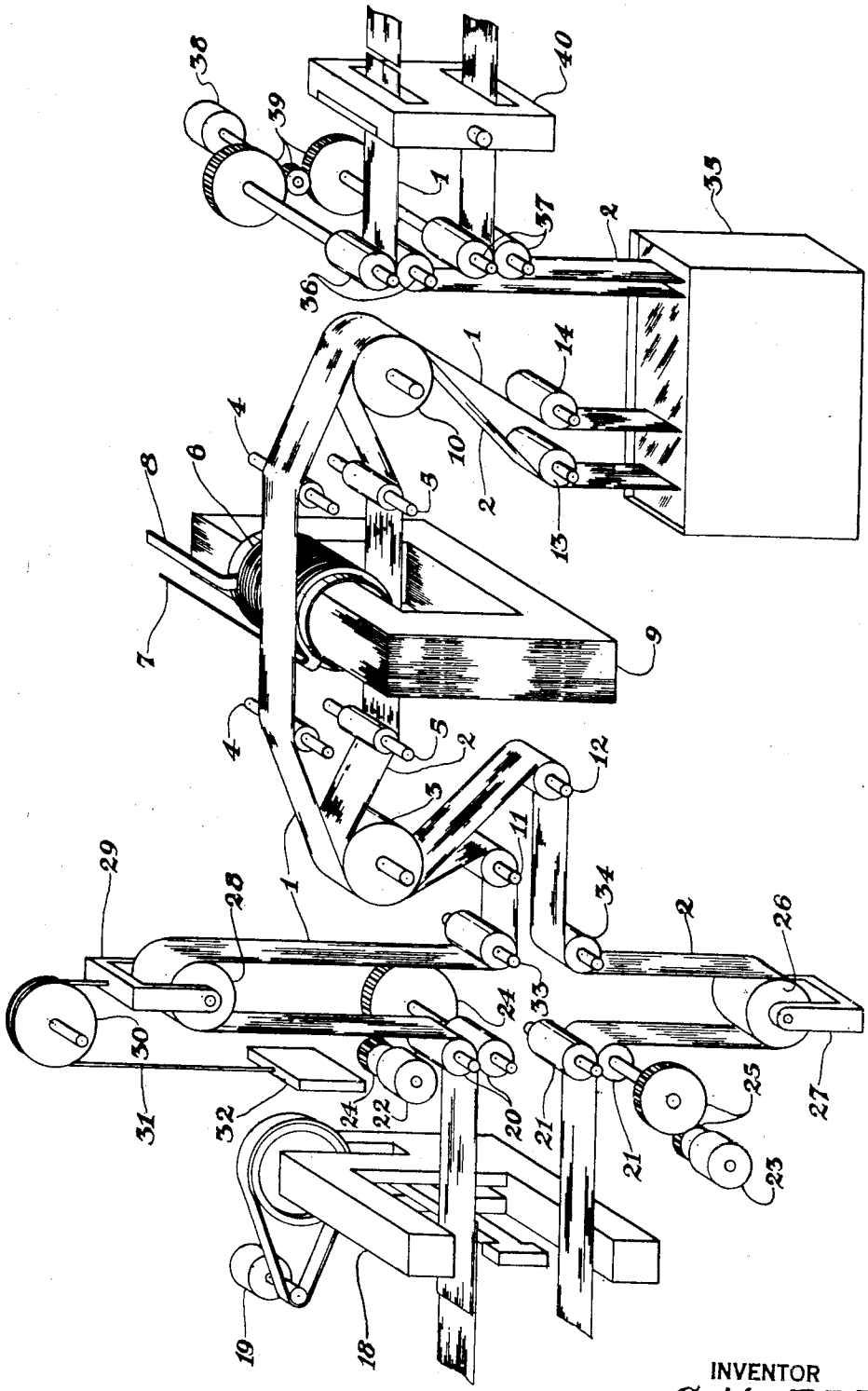

Fig. 1

INVENTOR
Golder P. Wilson
BY Lionel E. Goff
ATTORNEY

May 23, 1944. G. P. WILSON 2,349,569

PROCESSING OF METAL STRIPS

Filed March 24, 1943 2 Sheets-Sheet 2

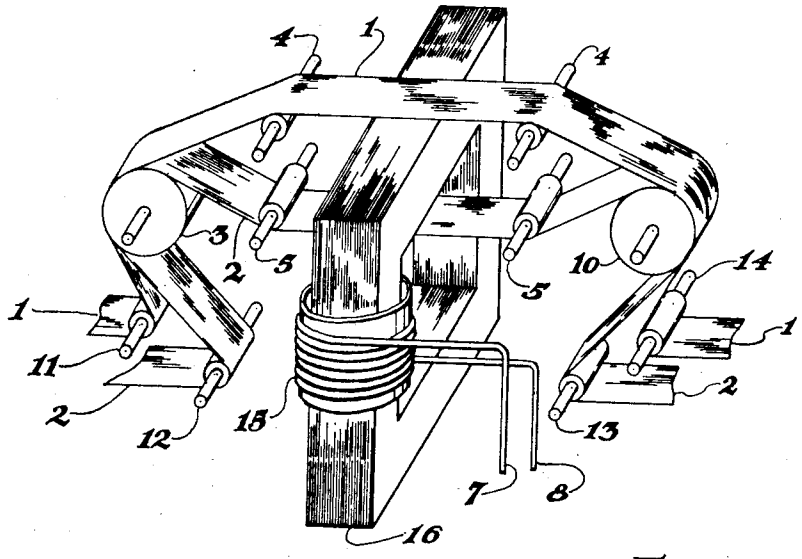

Fig. 2

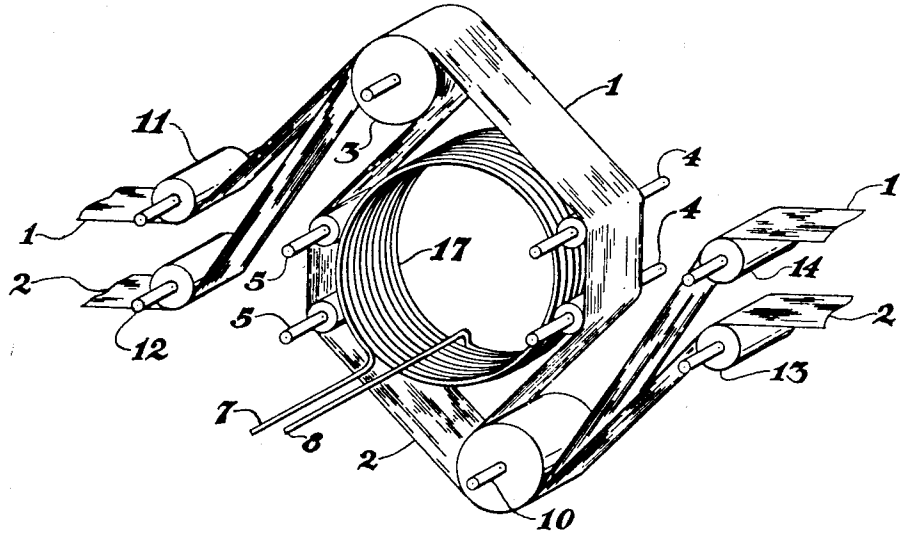

Fig. 3

INVENTOR
Golder P. Wilson
BY Lionel & Goff
ATTORNEY

Patented May 23, 1944 2,349,569

UNITED STATES PATENT OFFICE

2,349,569

PROCESSING OF METAL STRIP

Golder P. Wilson, Alton, Ill., assignor to Western Cartridge Company, East Alton, Ill., a corporation of Delaware

Application March 24, 1943, Serial No. 480,397

16 Claims. (Cl. 219—13)

This invention relates to the continuous heat-treatment of metal strip by means of electric induction.

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

Various methods and apparatus have been described heretofore for bringing the metal into inductive relationship with the primary coil. For instance, in one method for treating metal strip, a length of the strip was rolled up to provide a ring formed of several layers of the strip and the ring was then heated by the current induced therein from a surrounding primary coil. Such methods and apparatus have the disadvantages of being limited to intermittent operation, and in the case of very thin wide strip, the individual layers in the ring tend to become warped at the higher temperatures due to their own weight, and owing to the large cross section of the ring formed by the layers of strip, a current of very high amperage must be induced in order to bring the ring to the effective temperature.

In another 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. Such methods and apparatus have the disadvantage that with high conductivity non-magnetic strip it is difficult to induce electrical eddy currents of sufficient magnitude to bring the strip to an effective treating temperature.

According to other methods, the metal in the form of wire, or coiled rod, was fed in the paths of a helix around, or through, a primary coil, but such methods and apparatus have among others the disadvantage of not being suitable for use with wide strip, due to the difficulty involved in forming such strip into a helix.

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

All such prior methods and apparatus for the electric induction heat-treating of metal have been attended by one or more serious disadvantages and it is an object of this invention to provide an improved method and apparatus overcoming all such objections.

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

Another object of the invention is to provide an improved process and an efficient electric induction furnace for economically 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 an electric induction furnace suitable for the heat treatment of a non-magnetic metal such as a copper alloy in the form of strip.

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

Figure 1 is a diagrammatic perspective view of metal strip treating apparatus illustrating an embodiment of this invention,

Figure 2 is a diagrammatic perspective view of an electric induction furnace illustrating another embodiment of this invention, and

Figure 3 is a diagrammatic perspective view of an electric furnace illustrating another embodiment of this invention.

The above objects and advantages are accomplished in accordance with this invention by providing a novel process and apparatus in which at least two strips of the metal to be treated are simultaneously advanced lengthwise along paths designed to maintain the moving strips in contact on either side of an alternating electromagnetic field while maintaining them separated in the field and in inductive relation thereto. Thus a secondary or complete electric circuit is formed by the moving strips, each strip forming a part of the loop and heating being effected by the resistance of the metal to the current induced in the loop.

Referring to the drawings, in Figure 1 the metal strips 1 and 2 in one embodiment of the invention are continuously advanced lengthwise from rolls 11 and 12 through the furnace over sup-

port roll 3 at the charge end of the furnace, respectively over guide rolls 4 and under guide rolls 5 which maintain the strips separated while passing through the electromagnetic field set up by the primary induction coil 6 with leads 7 and 8 and core 9, over support roll 10 on the discharge end of the furnace, and respectively over rolls 14 and 13. In passing over rolls 3 and 10 the wide surfaces of the strips 1 and 2 are in contact and they are bent around a substantial portion of the surface of the rolls 3 and 10 so that a large area of contact is provided with good electrical connection and low amperage per square inch between the strips to prevent arcing and burning. A complete secondary electric circuit is thus provided around the primary coil 6 in the loop formed by the moving strips, 1 and 2, between rolls 3 and 10.

An alternating electric current, which may be of either high or low frequency or, for instance, any of the available standard commercial frequencies, is applied to the primary leads 7 and 8, and the strips are heated by the current induced in the loop. The temperature of the strips can be regulated either by varying the speed at which the strips travel or by varying the power supplied to the primary coil 6. The core 9 may be of laminated iron mounted on any suitable support and the rollers 11, 12, 13, 14, 3, 4, 5 and 10 may likewise be mounted on any suitable supports. If the rollers, 3, 4, 5 and 10 are made of metal or other electrical conductor, care must be taken to avoid providing any electrical connection between them through their supports, since the induced current might then flow through the supports instead of being confined to the strips 1 and 2. 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 rolls themselves from an insulator.

Any other suitable means may be employed for supplying the alternating electromagnetic field. For instance, as illustrated in Figure 2, the primary induction means may consist of a primary coil 15 wound about a leg of the core 16 outside the loop, or as illustrated in Figure 3, may consist of a coreless primary coil 17 disposed within the loop. In the illustrations of Figures 1, 2, and 3 the strips 1 and 2 are guided by rolls 11, 12, 3, 4, 5, 10, 14 and 13, but in practicing the invention, instead of such rolls any other suitable means that do not act destructively on the strips may be employed for guiding the strips in the proper paths.

In accordance with this invention 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.

As a specific example illustrating an embodiment of the invention, the annealing of brass will be described in detail with reference to the accompanying drawings.

The brass to be annealed is in the form of flat strips, work-hardened by successive rolling operations and wound in coil form, such strips being about 380 feet long, 15 inches wide, and 0.10 of an inch thick.

Referring to Figure 1, two such coils are unrolled and the strips simultaneously advanced successively through a stitcher, a looping device, the induction furnace, a quenching or pickling tank, pinch rolls for advancing the strips, and a cutting device.

The stitcher 18, shown as operated by motor 19 may be any of the well known devices for fastening metal pieces together, and is used to join the work-hardened strips. For example, when the end of one 380 foot length of the strip reaches the stitcher, the end of another strip of the work-hardened material is fastened to the end of the strip in stitcher merely by operating motor 19 and stitching the two pieces together. If desired, however, the ends of the strips may be joined by welding or any other suitable means.

The looping device may be any suitable device for providing slack in the strips and as shown in Figure 1 may consist of pinch rolls 20 and 21, operated respectively by motors 22 and 23 and gears 24 and 25, of roll 26 with weight 27, of roll 28 with bracket 29 and pulley 30 and cable 31 and weight 32, and of rolls 33 and 34. The looping device is operated in conjunction with the stitcher, that is, when it becomes necessary to stitch the ends of two of the strips together, the pinch rolls 20 and 21 are stopped, thus stopping the movement of the strips through the stitcher so that the stitching can be accomplished.

This, however, does not prevent the continuous movement of the strips through the furnace. When the rolls 20 and 21 are stopped, the rolls 28 and 26 are drawn by the pull of the strips toward each other, thus raising the weights 32 and 27 and permitting the continuous movement of the strips 1 and 2 through the furnace during the stitching operations. At the end of the stitching operation, the pinch rolls 20 and 21 are rotated at an accelerated rate to lower the weights 32 and 27 and separate the rolls 28 and 26 the distance required for providing sufficient slack in the strips for the next stitching operation. If desired the strips used in forming continuous strips 1 and 2 may be so staggered that it is not necessary to stitch on 1 and 2 at the same time. Likewise, if desired, the stitching operation need not be employed, and the metal of individual rolls of the work hardened material can be progressively annealed, by simultaneously feeding at least two of such strips through the furnace along paths 1 and 2.

After leaving the looping device strip 1 passes over roll 11 around roll 3, over rolls 4 in close relation to primary coil 6, around roll 10 and over roll 14. Strip 2 simultaneously passes over roll 12, under strip 1 and in contact therewith around roll 3, over rolls 5 in close relation to primary coil 6, under strip 1 and in contact therewith around roll 10, and over roll 13. The paths taken by the brass strips thus result in the continuous formation of a loop, strip 1 forming the upper part and strip 2 the lower part, about the primary coil 6. Good electrical connection between the strips is provided at rolls 3 and 10, and since the two strips are constantly changing their contact surface, little or no oxidation can take place to increase the electrical resistance at these points of contact.

The strips after leaving the annealing furnace may, if desired, be passed through a quenching or pickling tank 35 before being advanced through pinch rolls 36 and 37, which are synchronously operated by motor 38 and gear train 39 and are used to pull the strips 1 and 2 simultaneously through the furnace. Pinch rolls such as 36 and 37 may also be used on the charge

end of the furnace to assist in advancing the strips through the furnace.

After treatment, the strips 1 and 2 may be cut, for instance by a flying shear 40, into any lengths suitable for further treatment or shipment.

In annealing the work-hardened brass, the strips 1 and 2 are advanced through the furnace at the rate of about 1 foot per second by means of pinch rolls 36 and 37. A 60 cycle current of 440 volts is supplied to the primary leads 7 and 8, which results in the heating of strips 1 and 2 to an annealing temperature of about 650° C. In practical operation the degree of hardness of the annealed strip will depend within certain limits on the temperature of the strip and time of treatment at this temperature during the annealing operation. If, therefore, it is desired to obtain annealed strip having a certain degree of hardness, this is readily accomplished by changing either the speed of travel of the strip or the power input to the primary, or both, until the temperature and time of treatment necessary for the desired strip hardness is obtained.

Due to the proximity of the secondary loop and the primary coil 6 and the good electrical connection between the strips 1 and 2 as they travel over rolls 3 and 10, a very high power factor is obtained, namely about 0.90.

If it is desired to bright anneal the brass, this may readily be accomplished by enclosing the furnace, for instance including rolls 11, 12, 13 and 14, in a housing supplied with an inert atmosphere in the usual manner. If no such housing is used, any oxide film or discoloration, which may form on the strips at the annealing temperature employed, may be readily removed by passing the strips through an acid pickling solution in tank 35.

In the above specific example the application of the present invention to the annealing of brass is described in detail, but it should be understood that the invention is likewise applicable to other metals and other heat treatments, for instance, it may be used for "normalizing," "quenching," and "drawing" of steel strip, for the reflowing of tin on iron strip, for making copper clad steel sheet or other laminated sheet, and the like.

If it is desired to treat more than two strips at a time in a single induction unit, this can readily be accomplished in accordance with this invention. For instance, instead of passing a single strip about each side of the induction means, several strips may be simultaneously passed about each side of the induction means, either with one on top the other or with narrow strip side by side in parallel paths. Or, for instance, when the induction means consists of a coil 6 or 15 with a core 9 or 16, Figures 1 and 2, two or more strips may be passed about the top and bottom legs of the core in the manner illustrated in Figures 1 and 2 for strips 1 and 2.

This invention accordingly provides means for the economical continuous heat treating 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.

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 is:

1. In an electric induction furnace, the combination which comprises means for simultaneously advancing a plurality of metal strips through said furnace, means for bringing said strips together to provide a plurality of electrical contacts therebetween, means intermediate said electrical contacts for separating said strips and means for inducing an electric current in the electrical loop formed by said strips between the said electrical contacts.

2. In an electric induction furnace, the combination which comprises means for simultaneously feeding a plurality of metal strips through said furnace, contacting means for bringing said moving strips together to form a plurality of electrical contacts between said strips, means intermediate said contacting means for separating said moving strips, and means for inducing an electric current in the electrical loop formed by said moving strips between said electrical contacts.

3. In an electric induction furnace, the combination which comprises electric induction means, means for simultaneously advancing metal strips through said furnace, means for separating and maintaining said moving strips on opposite sides of and in inductive relation to said electric inducing means, and means for holding said moving strips together in electrical contact before and after passing said electric inducing means in traveling through said furnace.

4. In an electric induction furnace, the combination which comprises a primary induction means, means for simultaneously advancing metal strips through said furnace, means for separating and maintaining said moving strips on opposite sides of and in inductive relation to said induction means, and roller means for holding said moving strips together in electrical contact both before and after passing said induction means in traveling through said furnace.

5. In an electric induction furnace for heating metal strip, the combination comprising an alternating electromagnetic field, means for simultaneously advancing metal strips through said furnace, means for separating and maintaining said moving strips spaced on opposite sides of and in inductive relation to said field, and means for holding said moving strips together in electrical contact on each side of said field.

6. In an electric induction furnace for heating metal strip, the combination comprising an alternating electromagnetic field, means for simultaneously moving said strips through said field, means for maintaining said moving strips separately spaced in said field on opposite sides thereof and in inductive relation thereto and means for holding said moving strips together in electrical contact on each side of said field.

7. In an electric induction furnace for heating metal strip, the combination comprising means for simultaneously moving a plurality of strips through said furnace, means on the charging end of said furnace for holding said moving strips together in electrical contact, an alternating electromagnetic field adjacent said holding means, means for separating said moving strips and guiding them in separately spaced paths through opposite sides of said field in inductive relation thereto, and means on the discharge end of said furnace for holding said moving strips together in electrical contact.

8. In an electric induction furnace for heating metal strip, the combination comprising means for simultaneously moving a plurality of strips through said furnace, a roll on the charging end of said furnace for holding said moving strips to-

gether in electrical contact, a primary induction means adjacent said roll, means for separating said moving strips and guiding them in separate paths on opposite sides of said induction means, and a roll on the discharge end of said furnace for holding said moving strips together in electrical contact.

9. A method for heat-treating metal strip which comprises simultaneously moving a plurality of strips lengthwise in paths such that they are in contact on each side of an alternating electromagnetic field and separately spaced in opposite sides of said field in inductive relation thereto.

10. A method for the heat-treating of metal strip which comprises advancing a plurality of strips through an alternating electromagnetic field in spaced paths on opposite sides thereof and in inductive relation thereto while holding said moving strips in electrical contact on each side of said field.

11. A method for heat-treating metal strip, which comprises simultaneously advancing metal strips in a path on opposite sides of an electric induction means, while providing a complete electric circuit about said induction means through said strips by holding said moving strips together in electrical contact on each side of said induction means, and supplying said induction means with an alternating electric current to induce a current in said strips.

12. A method for the heat-treating of metal strip, which comprises advancing a plurality of strips in electrical contact, separating said moving strips and guiding them along opposite sides of an electric induction means and again bringing said strips together into electrical contact, while supplying said induction means with an alternating electric current and inducing a current in the loop formed by said moving strips about said induction means.

13. A method for the heat-treating of metal strip comprising simultaneously advancing a plurality of said strips lengthwise in paths holding them together in electrical contact in at least two positions along said paths, while maintaining them separately spaced between said contact positions, and inducing a current in the loop formed by said moving strips intermediate said contact positions.

14. In an electric induction furnace for heating metal strip, the combination comprising means for simultaneously advancing a plurality of said strips lengthwise, means holding said moving strips together in electrical contact in at least two positions, means for separating said strips between said contact positions, and means for inducing a current in the loop formed by said moving strips intermediate said contact positions.

15. In an electric induction furnace, the combination comprising roller means for simultaneously advancing a plurality of metal strips lengthwise in paths holding them together in electrical contact in at least two positions, means holding them separately spaced intermediate said contact positions, and means for inducing a current in the loop formed by said moving strips intermediate said contact positions.

16. In an electric induction furnace, the combination which comprises means for advancing metal strips through said furnace, a primary induction means, roller means guiding said strips about opposite sides of said induction means, and means for holding said moving strips together before and after passing said induction means, whereby a complete electric secondary loop is formed by said moving strips about said induction means.

GOLDER P. WILSON.