

F. C. FRARY.
 METHOD OF AND APPARATUS FOR ANNEALING SHEETS OF METAL.
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1,377,574.

Patented May 10, 1921.

FIG. 1.

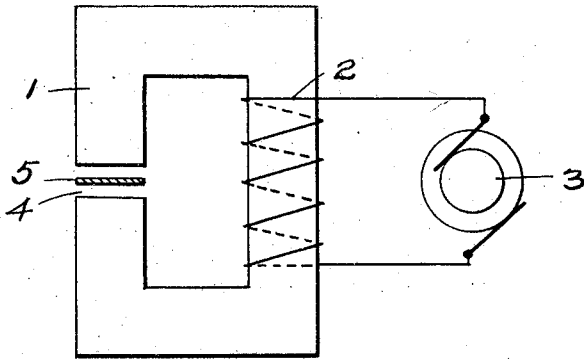


FIG. 2.

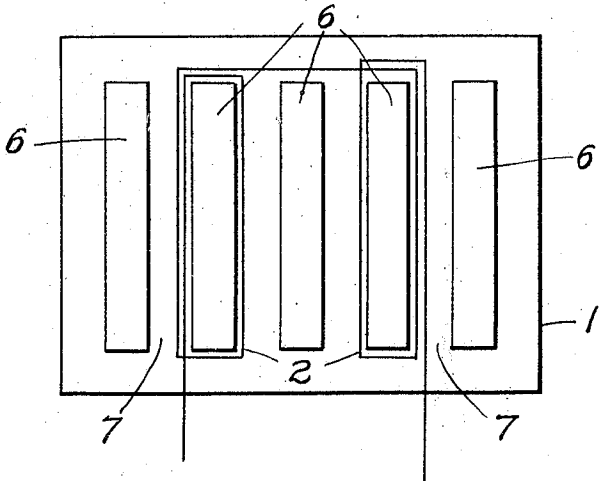
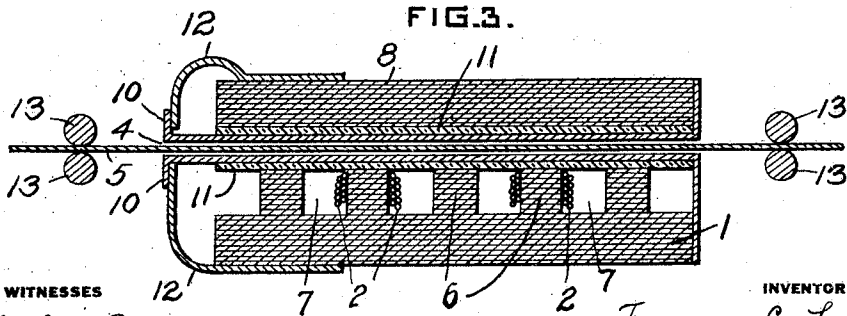


FIG. 3.



WITNESSES

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METHOD OF AND APPARATUS FOR ANNEALING SHEETS OF METAL.

1,377,574.

Specification of Letters Patent.

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To all whom it may concern:

Be it known that I, FRANCIS C. FRARY, a resident of Oakmont, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Methods of and Apparatus for Annealing Sheets of Metal, of which the following is a specification.

This invention relates to method of and apparatus for annealing sheets of metal, such as aluminum, copper, or other metal. Its object is to provide a method and apparatus whereby such sheets may be progressively and continuously annealed at a predetermined temperature and much more rapidly and uniformly than by existing methods.

Generally stated, the invention comprises a method by which the sheet of metal to be annealed is moved through an alternating magnetic field of controlled strength, and in which the field and sheet are preferably so positioned relative to each other that the magnetic lines of force are approximately perpendicular to the surface of the sheet; whereby powerful eddy currents are set up in the sheet and develop heat uniformly throughout the body of the metal (*i. e.*, between its two surfaces) in that portion of the sheet through which the magnetic field passes. Thus by moving the sheet in its own plane across such magnetic field all portions of it are subjected to the same heating effect and for the same period of time, and since the radiation losses are constant for a given set of conditions, all parts of the sheet can be quickly brought to the same temperature. Furthermore this temperature can be controlled for a given thickness of sheet by varying the strength of the magnetic field and the number of oscillations per second.

It is known that if the metal of a sheet can all be brought to the proper temperature, the annealing action is extremely rapid, if not instantaneous. The long time required for annealing the metal in ordinary types of annealing furnaces is due to the difficulty of heating all of the metal to the desired temperature without danger of overheating and the resultant injury to some of it unless the temperature of a furnace is kept very close to the annealing temperature, and furthermore to the long time which must be allowed for the heat to penetrate

into the piles of metal. Since by the use of the present method all parts of the metal can be quickly brought to the same temperature, the foregoing difficulties are overcome and a very rapid annealing is effected and in a manner to avoid overheating and injuriously affecting any part of the sheet.

In the accompanying drawing Figure 1 is a diagrammatic view illustrating the principle of the invention; Fig. 2 is a longitudinal sectional view of one form of apparatus suitable for carrying out the method; and Fig. 3 is a plan view of the lower transformer member of Fig. 2.

The principle of my invention is illustrated in simple form in Fig. 1 in which there is illustrated a transformer consisting of an iron magnetic circuit 1, and an exciting coil 2 connected to a suitable source of alternating current 3, and in which the magnetic circuit is provided with an air gap 4 through which a sheet or strip of metal 5 (such as aluminum foil or sheet) is moved by means of any suitable mechanism, such for instance as feed rollers (not shown). The movement of this sheet or strip, as will be understood, is in a direction perpendicular to the plane of the paper, so that such sheet or strip is caused to continuously pass through the field at the gap 4, and at such a rate that the eddy currents produced in any given portion of the sheet or strip during its passage through this field are just sufficient to heat it to the desired temperature. After such heating is attained the sheet or strip cools to room temperature and is ready for the next operation which it may be desired to perform upon it. The maximum temperature to which a sheet or strip of given metal of a given cross section can be raised in this manner is dependent upon (1) the time that a given portion of it remains in the magnetic field, (2) the strength of the field; (3) the number of alternations of the exciting current per second, and (4) the rate of loss of heat from the surface of the sheet or strip by radiation. Inasmuch as the strength of the field and the number of alternations of the exciting current per second, as well as the other conditions named, can be readily varied and controlled, any given sheet or strip of metal can be quickly raised to the desired annealing temperature, without danger of overheating any portion thereof.

This principle can obviously be applied in many different ways and by various forms of apparatus. Figs. 2 and 3 show a suitable form of apparatus for the continuous annealing of aluminum sheet or foil. These views illustrate a structure 1 of transformer steel (laminated) which is built up to form a magnetic field having poles 6 and spaces or slots 7 for holding the exciting coils 2 through which the magnetizing current flows. The coils may be arranged around alternate poles only, as shown in the drawings, or they may be wound around each pole if desired; but in either case it is preferred to so arrange the windings that, as indicated in Fig. 3, at any given instant alternate poles will have the same magnetic character and adjacent poles will be of opposite character.

A laminated pole piece 8 is supported in any suitable way a short distance above the magnet described, leaving a suitable gap between the two for the passage of the strip or foil 5. In order to minimize radiation from the strip or sheet to the magnetic circuit, suitable sheets 10 of an electrically conducting but non-magnetic material (such as nickel sheets) are placed parallel to and immediately above or below the sheet being annealed,—between it and the two halves of the steel magnetic circuit,—and the spaces between each of these sheets and the magnetic circuit are filled with some refractory heat insulating substance 11 such as infusorial earth. When the magnet is excited by alternating currents from a suitable source, these nickel sheets will be heated by eddy currents set up within them, and will radiate heat toward each other, and also tend to radiate heat toward the steel magnetic circuit, but the latter radiation is to a large extent prevented by the heat insulation 11. Eddy currents will also, of course, be set up in the strip or sheet 5 of metal passing between the nickel sheets. By properly choosing the thickness and electrical resistance of the nickel sheets a condition can be secured such that the power consumed in them is just sufficient to maintain them at approximately the desired annealing temperature, thus enabling substantially all the heat which is produced by the eddy currents in the material being treated to be utilized for the purpose of raising the temperature of the material being treated to the desired point, and by preventing radiation losses to bring the surface of the moving sheet to the same temperature as the interior thereof. This is particularly easy when the metal to be treated is one having a good electrical conductivity, such as aluminum or copper. The nickel sheets 10 tend to expand on being heated and therefore suitable springs 12, or equivalent devices are provided to maintain them in a state of tension and thus prevent

buckling. 13 indicates suitable feed rolls for progressively moving the sheet or strip through the magnetic field.

This apparatus described permits the maximum temperature which is to be attained by the material being treated to be closely controlled and also permits this temperature to be attained through the whole mass of each successive sheet, it enables the conditions to be so chosen that the metal being treated may be only partially annealed, that is, softened to a predetermined extent, instead of being completely annealed, or made dead soft. This feature is of particular advantage with metal, such as aluminum foil, where complete annealing of the material would make it too weak for certain subsequent operations, for instance, too weak to stand the necessary tension involved in subsequent passages through reducing rolls.

The arrangement shown in the drawings is illustrative merely of the principal features of suitable apparatus. Actual commercial apparatus may differ considerably in detail from that illustrated, as will be apparent to a person skilled in the art.

I claim:

1. The method of continuously annealing sheet metal, consisting in passing it through an alternating magnetic field whose lines of force cut transversely through the sheet, and thereby inducing in the metal eddy currents of sufficient intensity to cause the metal to be uniformly heated to an annealing temperature during its passage through said field.

2. The method of continuously annealing sheet metal, consisting in passing it through an alternating magnetic field whose lines of force cut transversely through the sheet, and thereby inducing in the metal eddy currents of sufficient intensity to cause the metal to be uniformly heated to an annealing temperature during its passage through said field, and controlling the annealing temperature by varying one or more of the factors,—rate of movement of the metal, strength of the magnetic field, and frequency of the exciting current.

3. The method of continuously annealing sheet metal consisting in passing the same between stationary metallic sheets disposed on both sides of the sheet to be annealed and located in an alternating field whose lines of force cut said stationary sheets, the electrical resistance and thickness of the stationary sheets being such that they become heated to the desired temperature by eddy currents induced therein.

4. The method of continuously annealing sheet metal, consisting in passing it through an alternating magnetic field whose lines of force cut the plane of the sheet, thereby inducing in the metal eddy currents of sufficient intensity to cause the metal to be heat-

ed to an annealing temperature during its passage through said field, and reducing the amount of heat radiated from the moving sheet during its passage through the magnetic field by inducing eddy currents in stationary metallic sheets disposed in said magnetic field on both sides of the moving sheet.

5. The method of partially annealing sheet metal, consisting in passing it through an alternating magnetic field and thereby inducing in the metal sheet currents of sufficient intensity to raise it momentarily to a definite temperature somewhat below that at which it becomes completely annealed, and maintaining the magnetic field at such strength and moving the sheet at such rate that all parts of the metal are heated to the same temperature and for the same interval of time.

6. An apparatus for the continuous annealing of sheet metal, comprising a mag-

netic circuit having oppositely-disposed poles with a gap between them, means for exciting said circuit with an alternating current, and means for passing a sheet of metal through the gap between the poles whereby the lines of force passing from pole to pole cut transversely through the plate.

7. Apparatus for the continuous annealing of sheets or strips, comprising an open magnetic circuit, an alternating current source for exciting said magnetic circuit and thereby producing a magnetic field, a pair of electrically conducting sheets located in said field and spaced apart, and means for passing the sheets or strip to be annealed between said electrically conducting sheets and through said magnetic field.

In testimony whereof, I have hereunto set my hand.

FRANCIS C. FRARY.

Witness:

G. G. TRILL.