Oct. 30, 1928. 1,689,369

M. TAMA

ELECTRIC FURNACE FOR GLOWING METAL BANDS BY INDUCTION CURRENTS

Filed Nov. 29, 1927 4 Sheets-Sheet 1

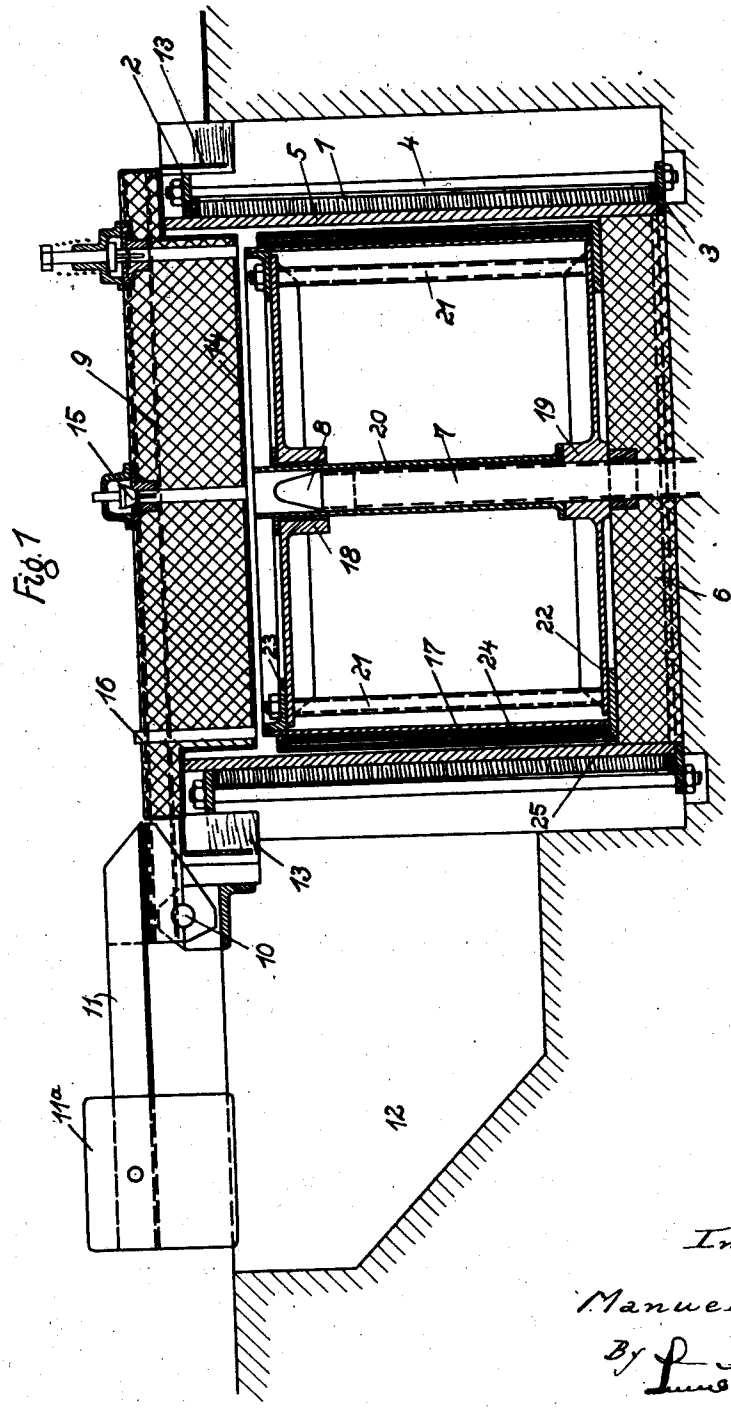


Fig. 1

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Filed Nov. 29, 1927 4 Sheets-Sheet 2

Fig. 2

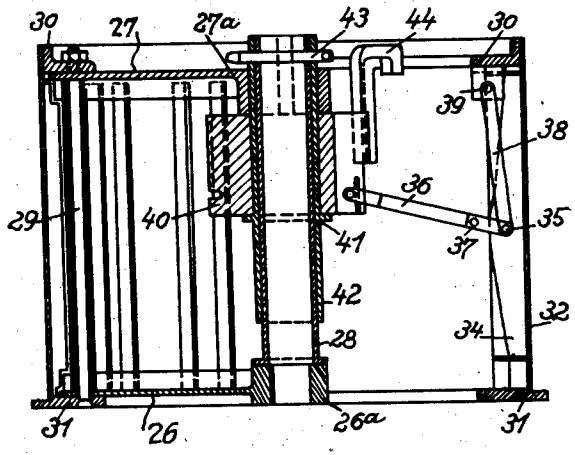
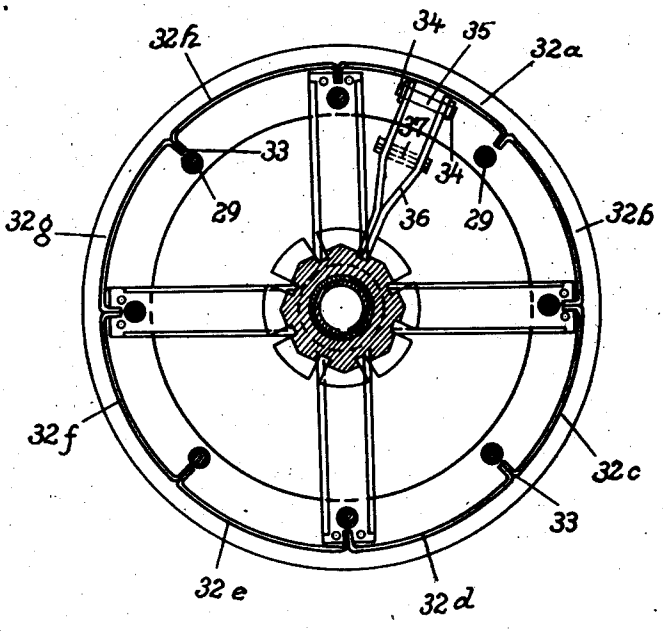


Fig. 3



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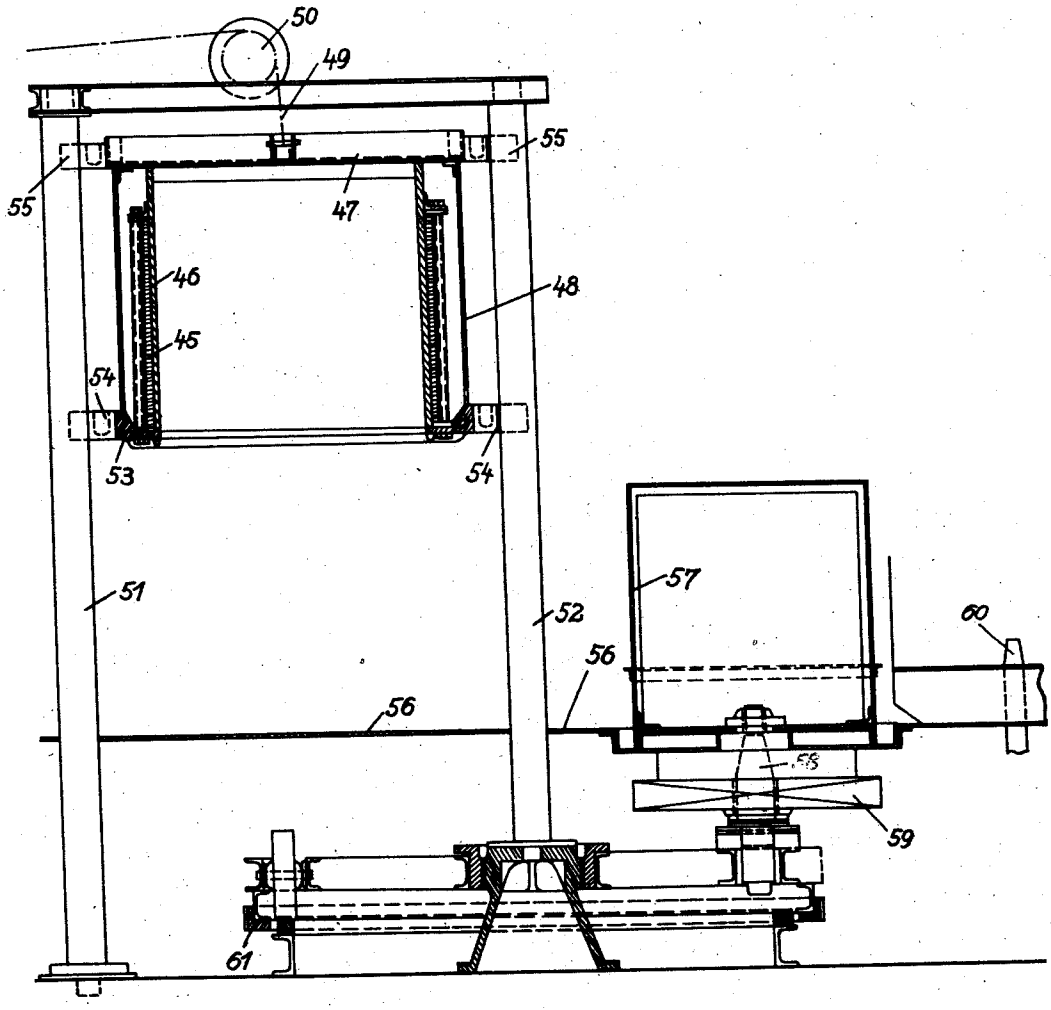
Oct. 30, 1928. 1,689,369

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ELECTRIC FURNACE FOR GLOWING METAL BANDS BY INDUCTION CURRENTS

Filed Nov. 29, 1927 4 Sheets-Sheet 3

Fig. 4



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Oct. 30, 1928. 1,689,369

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ELECTRIC FURNACE FOR GLOWING METAL BANDS BY INDUCTION CURRENTS

Filed Nov. 29, 1927 4 Sheets-Sheet 4

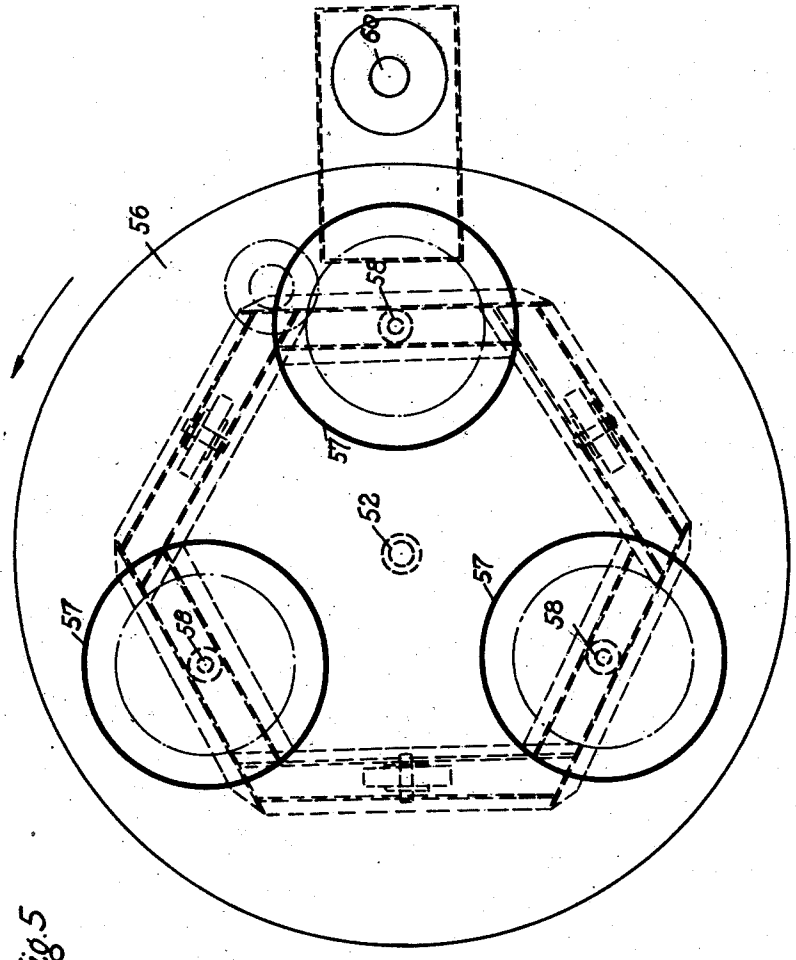


Fig. 5

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UNITED STATES PATENT OFFICE.

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ELECTRIC FURNACE FOR GLOWING METAL BANDS BY INDUCTION CURRENTS.

Application filed November 29, 1927, Serial No. 236,505, and in Germany September 17, 1927.

When manufacturing sheet-metal or metal-bands it is customary to roll plates of comparatively great weight to strips which have sometimes a considerable length, as long as several hundred meters, and in order to be able to manipulate these strips conveniently it is customary to wind them up after every rolling operation. The annealing of the wound-up strips which is necessary either after every rolling operation or at least after a certain number thereof is effected by inserting the rings or coils into annealing boxes or, as is also done often times, into gas-fired muffle furnaces, but as the diameter of the metal-strip rings or coils is considerable and their weight is great it is difficult to obtain a uniform temperature throughout the entire bulk of metal. In most cases the outer portions are heated too strongly and the inner ones not strongly enough.

It has already been proposed to pull the metal-strips through a heated chamber, winding them off a reel located outside of one end of the heating chamber and winding them on again on a reel provided outside the other end of said chamber but this procedure is uneconomical because a large radiating surface is required and the thermic efficiency is low.

Another proposal has been to heat the metal strips by electric induction, the strips being employed as secondary conductor of a transformer, but the means designed for this purpose proved unsuited for it, as iron-coupled transformers were used, the iron core forming an obstacle for inserting and withdrawing the rings.

The present invention overcomes this drawback by making use of a so-called air-transformer, that is to say, a transformer without an iron core so that the furnace consists chiefly of two concentric coils, viz an outer stationary solenoid and the metal-ring introduced into this solenoid and lying concentrically with respect to it. The electric current induced in the metal coil to be annealed is so-to-say forced outwardly by reason of the "skin-effect" that is to say, there flows a stronger current in the outer layers of the metal-coil than in the inner layers so that the ring is heated ununiformly. It is known that the "skin-effect", in other words: the depth of penetration, depends upon the frequency of the current, as well as upon the conductivity of the metal treated and the permeability of the same. Tests have shown that for the sizes or dimensions occurring in the metal industry, especially as regards the annealing of brass strips and sheet-brass, a frequency of from 50 to 60 cycles per second is particularly suited. With these frequencies a uniform heating of the ring to be annealed is obtained if the dimensions of the ring are the usual ones, but as is known, there takes place at said number of periods a rather considerable lagging between the current and the voltage whereby the power factor is reduced. This phase-lagging can, however, be reduced by connection up to the circuit condensers or other means known in electrotechnics for the purpose stated. The employment of a frequency of from 50 to 60 cycles presents, besides, the further advantage that no separate frequency transformer is required.

Carrying through the invention is effected most practically in this manner that the metal rings to be annealed are wound upon a drum which then is inserted into the solenoid coil, particular provisions being made to prevent the drum itself from being heated which would mean a loss of heat.

The invention is illustrated diagrammatically and by way of examples on the accompanying drawings on which Figure 1 is a vertical section through an electric furnace designed according to this invention, the drum with the metal-strip thereon being just present in the furnace; Figure 2 is an axial section through another form of the drum alone, Figure 3 is a plan of the drum shown in Figure 2; Figure 4 is a vertical section through a modification of the furnace, and Figure 5 is a plan of this modification.

In Figure 1 of the drawings 1 denotes the primary coil which is wound in the usual manner either of flat copper strip or of flattened copper tube. This latter form is made use of when cooling by water is necessary. The layers of the windings are insulated from one another by suitable insulating material, for instance asbestos, micanite, or the like. The coil 1 is clamped fast between two flanges 2 and 3 by bolts 4, and lined interiorly with a ring 5 of an insulating material. The solenoid formed in this manner constitutes the exterior cylindrical shell of the heating or annealing furnace. Within this shell, in the lowermost portion thereof, is a layer 6 of a refractory material which forms the bottom of the furnace, and centrally from this bottom extends upwardly an axle-forming member 7 which has a pointed upper end 8 and upon which the drum with the material to be an-

nealed is to be shoved which is facilitated by said pointed end. The furnace is closed with a cover 9 which can be turned upwardly on a suitably supported horizontal axle 10. An arm 11 affixed to the cover and extending rearwardly beyond the axle 10 is provided with a counter-weight 11^a in order to facilitate lifting the cover.

It is assumed that the furnace shown in Fig. 1 is inserted into the floor of the workshop, and it is therefore necessary to provide a space 12 for the reception of the counterweight 11^a when the cover 9 is lifted. It is, of course, as well possible to place the furnace directly upon the floor.

In order to close the furnace perfectly tight, a waterseal 13 may be provided, as shown, and it is in this case practical to arrange the water-seal eccentrically with respect to the cover 9 in order to prevent any disturbance of the proper upward and downward movement of the cover.

The cover 9 consists of a casing or shell 14 of a non-magnetic metal, and of a filling of a refractory material. It is important to make use of a non-magnetic metal for the casing or shell 14 in order to obviate a disturbance in the formation of the field. Chrome-nickel alloys are best suited for said casing or shell, the more so since the resistance to heat is very great. The cover is provided with a non-return valve 15 permitting the air enclosed in the furnace and expanding in a hot state to escape. Also an inspection channel 16 closed with refractory glass is provided in the cover.

The material 17 to be annealed is coiled upon a separate drum. It is located in close proximity to the insulating wall 5 in order to bring about a possibly good coupling between the primary and the secondary coil. For the same reason a high-grade insulating material is used for the wall 5 so that this latter need have only a slight thickness, and the primary and the secondary coil can lie in close proximity to one another.

The thickness of the ring 17, that is to say, of the superposed turns forming it, is such that with the known conductivity of the metal to be annealed and with the known frequency of the current the depth of penetration of the induced current is either equal to, or greater than, the thickness of the secondary coil.

The drum comprises chiefly an upper and a lower hub 18 and 19 connected with each other by a sleeve 20. The sleeve is shoved upon the vertical axle 7. The hubs 18 and 19 are preferably made integral with disks (or spoke-stars) 18^a and 19^a, of which the upper is connected with a flange 23 of angular section and the lower with a flat flange 22, and these flanges are connected with each other by bolts 21 passing also through the disks or spoke-stars 18^a and 19^a. All these members are enclosed in a sheet-metal shell 24 and its projecting portion 25 serves as support for the coiled metal strip to be glowed.

When the annealing procedure has been finished, the cover 9 is swung upwards, whereafter the drum with the metal coil is lifted out of the furnace by a crane or the like. Then another drum with another section of metal-strip to be annealed is inserted into the furnace, this latter is again closed, and another annealing procedure is carried through.

In order to prevent the drum from being heated also, which would cause a loss of heat, it is made of a material of a greater electric resistance than the metal-strip to be annealed. It may also be subdivided into parts in such a manner that no closed path for the secondary current exists within it. If the furnace is employed for the annealing of brass it is sufficient to make the drum of wrought-iron in which case it will not become excessively hot.

Owing to the ununiform heating of the drum and the metal-strip and to the different coefficients of expansion of these two parts, if they are made of different materials, the metal-strip coil to be annealed will expand more strongly than the drum and will consequently move off the drum correspondingly. But this takes place not uniformly, as has been discovered by way of tests; in fact, the material just being annealed moves off usually at certain places and remains at other places in contact with the drum, in consequence whereof the strip becomes ondoyant. It also occurs that the individual layers or turns separate from one another. In this case it occurs easily that sparks jump over and destroy the metals at such places, at all events at the surface of the same. It is, therefore, necessary to provide means for preventing such occurrences, that is to say, to keep the windings of the metal-strips, in close contact with one another, and the entire strip in close contact with the drum. A means for this purpose consists in binding the metal-strip coil fast to the drum by wire 17^a or the like, but it is possible as well to design the drum in such a manner that its diameter is mechanically increased during the annealing procedure in order to follow the increase of the diameter of the coiled metal-strip as it is annealed.

A drum designed in this manner is illustrated in Figs. 2 and 3. The two hubs 26^a and 27^a are connected with each other by a sleeve 28, and are preferably made integral with disks 26 and 27 provided with flanges 30 and 31. These members are practically the same as those in Fig. 1. The flanges are connected by bolts 29, as well as by a shell 32 which is not, however, an actual cylinder but composed of eight segments designated 32^a, 32^b, 32^c, 32^d, 32^e,

32^f, 32^g, and 32^h. The vertical rims of the segments are bent inwardly and contact with each other, and each of them is capable of a certain slight radial movement, being then guided by the appertaining contacting vertical rims. Each segment is provided with two spaced vertical ledges 34 located about midway between the appertaining vertical rims and being connected with each other by a bolt 35. I have shown this arrangement and combination of parts in Figs. 2 and 3 only in connection with the segment 32^a, but also all other segments are designed in just the same manner.

The bolt 35 serves also for connecting the segment with an arm 36 which, in the constructional form shown as an example, is forked. The two legs forming the fork are stiffened with respect to one another by a bolt 37. The inner end of the arm 36 is hinged to a weight-forming heavy body 40 bearing upon a flange 41 of a sleeve 42 embracing the sleeve 28. The sleeve 42 can be shifted upon the sleeve 28, but it is also possible to couple the two sleeves with each other by a bolt 43 which can be placed through holes or slots provided in the upper ends of said sleeves. The bolt 35 is also connected with an arm 38 extending upwardly to a lug 39 projecting downwardly from the flange 30. Also this arrangement and combination of parts is the same with all segments. Finally, the heavy member 40 is provided with upwardly extending hooks 44, the position and shape of which is distinctly shown in Fig. 2.

The manner of operation of this drum is as follows: The metal-strip to be annealed is coiled upon the shell 32 and secured in its position in the above mentioned manner. Now the bolt or pin 43 which up to then had coupled the sleeves 28 and 42 with each other is withdrawn and the drum (which must be supposed to be suspended from a crane with the aid of the hooks 44) is lowered down into the furnace, in such a manner, that the sleeve 28 slides down upon the axle 7 (Fig. 1). Now the chains or ropes (not shown) of the crane are disconnected from the hooks 44, in consequence whereof the heavy member 40 presses the rods 36 outwardly, the action being practically similar to a toggle-joint lever, and owing to this action also the segments 32^a—32^h are pressed radially outwards. The segments follow the expansion of the metal-strip and keep it continually stretched, that is to say, the heavy member 40 holds it continually under tension by the intermediary of the arm 36. In other words, the diameter of the drum increases in strict correspondence with the increase of the diameter of the metal-strip coiled upon the drum. When the annealing procedure has been finished the crane chains or ropes are again attached to the hooks 44 (of which there are at least three). When then the drum is lifted, first the heavy member 40 is lifted until it contacts with the hub 27^a, and simultaneously therewith the segments are drawn radially inwards by the arm 36, that is to say, they are withdrawn from the metal-coil, and this can now be easily removed from the segments, in other words: from the drum. When the sleeve 42 has been lifted together with the member 40 and has arrived in its uppermost position, it is again coupled with the sleeve 28 by the pin or bolt 43, and the drum remains now contracted and receives another coiled metal-strip.

While in the constructional form shown in Fig. 1 the furnace is stationary and the drum receiving the metal-strip is vertically movable in order to be inserted into, and removed from the furnace, Figs. 4 and 5 show a modification in which instead of the drum being vertically movable, the furnace is movable.

There is, however, in this case a plurality of drums, three in the example shown (Fig. 5), and each can co-operate with said furnace. In Fig. 4 45 denotes the primary coil and 46 a cylinder of an insulating material. The cylinder 45 is open at its lower end, but closed at its top by a cover 47. 48 denotes an outer shell enclosing the parts mentioned. A rope 49 attached to the cover 47 runs over a roll 50 to a winch or the like (not shown), by means of which the furnace can be lifted and lowered along two standards 51 and 52 with the aid of guide members, 54 and 55 projecting forth from the bottom flange 53 and the cover 47 as shown.

A rotary platform 56 is arranged approximately on a level with the floor and can be locked in the three positions corresponding to the three drums 57 shown in Fig. 5. These positions differ from one another by 120°. In the one thereof (righthand in Figs. 4 and 5) the metal-strip is coiled on and off the drum. There is near this place, righthand from it, a stationary vertical pivot 60 which receives that drum (not shown) with the metal-strip thereon which comes from the rolling mill, and the metal-strip is then coiled from this drum onto the drum 57. This latter drum is carried by a vertical pivot 58 connected with a horizontal cog-wheel 59 driven by any suitable mechanical or electrical means (not shown) whereby the new metal-strip from the rolling mill is wound from the mill drum onto the drum 57, as already stated. There are three such driving devices (58, 59 etc.) carried by a frame 62 provided with rolls 65 running upon a circular rail 64, and there is connected with the frame 62 a toothed ring 61 meshing with a cog-wheel (not shown) driven intermittently (corresponding to the three positions of the rotary platform, as already stated) by any suitable device. The arrow in Fig. 5 indicates the direction of rotation of the rotary platform. When a drum 57 with the metal-strip thereon has arrived below the

furnace 45/46/47/48 this latter is lowered down upon that drum and the annealing procedure is now carried through. This having been effected, the furnace is lifted off the drum and the platform is again turned for 120° whereby the drum with the annealed metal-strip is turned to that place where it can cool down while the next following metal-coil is being annealed in the furnace.

There are obviously always three drums with three metal-coils in course of treatment. While one drum with a metal-coil thereon is treated in the furnace another drum receives another metal-coil, and a drum with its metal-coil is cooled down, as just mentioned. The period of time necessary for annealing a metal-coil is sufficient for winding another band onto another drum, as well as sufficient for the cooling down of the metal-coil removed from the furnace. The constructional form shown in Figs. 4 and 5 renders, thus, possible, to work practically continually and the primary coil of the furnace can be nearly continually traversed by the current. The electric part of the plant can be utilized, therefore, practically to its utmost capacity.

If a constructional form of the type shown in Fig. 1 is chosen it is practical to make use of two furnaces which are operated alternately so that also in this case a practically continuous service is maintained. While a drum with a metal-strip thereon is treated in one of the two furnaces, the drum with a metal-strip thereon having been treated in other furnace is permitted to cool down in this latter whereafter this drum is removed and another is inserted, and vice versa. Of course, also these drums may be used in connection with means for coiling the metal-strip from the rolling mill drums thereon. There may be used simple reels with vertical axle for this purpose. Finally, instead of a rotary platform, as shown and described, a reciprocating platform may be used, and there may be provided on the one or the other type of platform a greater number of drums than three in order to prolong the time for the cooling down of the annealed metal-strip.

I claim:

1. An electric furnace for annealing metal-strips by induction current, comprising a drum adapted to receive the metal-strip to be annealed and adapted to be wound thereabout; and a coil adapted to generate the induction current, said drum being adapted to be inserted into and removed from the coil and forming with the metal-strip a transformer of which the metal-strip forms the secondary coil for said transformer.

2. An electric furnace for annealing metal-strips by induction current, comprising a drum adapted to receive the metal-strip to be annealed and adapted to be coiled thereabout; and a coil adapted to form the primary winding of a transformer and to generate the induction current, said metal-strip and drum forming the secondary coil of the transformer.

3. An electric furnace for annealing metal-strips by induction current, comprising a drum adapted to receive the metal-strip to be annealed and adapted to be coiled thereabout; and a coil adapted to form one of the coils of a transformer and to generate the induction current, said metal-strip forming the other coil of the transformer.

4. An electric furnace for annealing metal-strips by induction current, comprising a drum adapted to receive the metal-strip to be annealed; means for holding the metal-strips in contact with the drum; and a coil adapted to form the primary winding of a transformer and to generate the induction current, said drum and metal-strip being adapted to be inserted into and out of the primary coil and forming the secondary coil of the transformer.

5. An electric furnace for annealing metal-strips by induction current, comprising a drum adapted to receive the metal-strip to be annealed; a coil adapted to form the primary winding of a transformer and to generate the induction current, said drum and metal-strip being adapted to be inserted into and out of the primary coil and forming the secondary coil of the transformer; a bottom for closing said primary coil; and a pivot located centrally upon the bottom and adapted to receive and guide the drum.

6. An electric furnace for annealing metal-strips by induction current, comprising a drum adapted to receive the metal-strip to be annealed; a coil adapted to form the primary winding of a transformer and to generate the induction current, said drum and metal-strip being adapted to be inserted into and out of the primary coil and forming the secondary coil of the transformer; a bottom for closing said primary coil; a pivot located centrally upon the bottom and adapted to receive and guide the drum; and a cover hinged to the primary coil and adapted to cover the transformer.

7. An electric furnace for annealing metal-strips by induction current, comprising a drum adapted to receive the metal-strip to be annealed; a coil adapted to form the primary winding of a transformer and to generate the induction current, said drum and metal-strip being adapted to be inserted into and out of the primary coil and forming the secondary coil of the transformer; a bottom for closing said primary coil; a pivot located centrally upon the bottom and adapted to receive and guide the drum; a cover hinged to the primary coil and adapted to cover the transformer; and a water seal for the cover.

8. An electric furnace for annealing metal-strips by induction current, comprising a

drum adapted to receive the metal-strip to be annealed and adapted to be coiled thereabout; and a coil adapted to form the primary winding of a transformer and to generate the induction current, said metal-strip and drum forming the secondary coil of the transformer and the electric conductivity of the metal of the drum being lower than the conductivity of the metal-strip.

9. An electric furnace for annealing metal-strips by induction current, comprising a drum consisting of two hubs, a sleeve connecting the hubs to each other, a sheet-metal cylinder adapted to receive the metal-strip to be annealed, means for supporting the metal-strip upon said cylinder, and means for connecting said cylinder with said hubs; and a coil adapted to form the primary winding of a transformer and to generate the induction current, said drum and metal-strips being adapted to be inserted into and out of the primary coil and forming the secondary coil of the transformer.

10. An electric furnace for annealing metal-strips by induction current, comprising a drum consisting of two hubs, a sleeve connecting the hubs to each other, a sheet-metal cylinder adapted to receive the metal-strip to be annealed, means for supporting the metal-strip upon said cylinder, means for connecting said cylinder with said hubs, and tension bolts for securing the means and cylinder together; and a coil adapted to form the primary winding of a transformer and to generate the induction current, said metal-strip and drum forming the secondary coil of the transformer and being adapted to be inserted into and out of the primary coil.

11. An electric furnace for annealing metal-strips by induction current, comprising a drum adapted to receive the metal-strip to be annealed and being adapted to expand radially; and a coil adapted to form the primary winding of a transformer and to generate the induction current, said drum and metal-strip being adapted to be inserted into and out of the primary coil and forming the secondary coil of the transformer.

12. An electric furnace for annealing metal-strips by induction current, comprising a drum adapted to receive the metal-strip to be annealed and having its wall subdivided into segments; means for forcing the segments radially outwards to contact with the metal-strip; and a coil adapted to form the primary winding of a transformer and to generate the induction current, said drum and metal-strip being adapted to be inserted into and out of the primary coil and forming the secondary coil of the transformer.

13. An electric furnace for annealing metal-strips by induction current, comprising a drum adapted to receive the metal-strip to be annealed and having its circumferential wall subdivided into segments; a heavy body arranged centrally in the drum and adapted to be moved axially; means for guiding said body axially; rods connecting said body with the segments, said body and rods providing for contact of the segments with the metal-strip; and a coil adapted to form the primary winding of a transformer and to generate the induction current, said drum and metal-strip being adapted to be inserted into and out of the primary coil and forming the secondary coil of the transformer.

14. An electric furnace for annealing metal-strips by induction current, comprising a drum adapted to receive the metal-strip to be annealed and having its wall subdivided into segments; a heavy body arranged centrally in the drum and adapted to be moved axially; means for guiding said body axially; rods connecting said body with the segments; members fixed to the body adapted to lift it and thereby draw the segments radially inwardly and away from the metal-strip; and a coil adapted to form the primary winding of a transformer and to generate the induction current, said drum and metal-strip being adapted to be inserted into and out of the primary coil and forming the secondary coil of the transformer.

15. An electric furnace for annealing metal-strips by induction current, comprising a drum adapted to receive the metal-strip to be annealed; a primary coil adapted to generate the induction current, said metal-strip acting as a secondary coil for a transformer; and means for raising and lowering the primary coil over the drum and metal-strip.

16. An electric furnace for annealing metal-strips by induction current, comprising a drum adapted to receive the metal-strip to be annealed; a primary coil adapted to generate the induction current, said metal-strip acting as a secondary coil for a transformer; means for raising and lowering the primary coil over the drum and metal-strip; and a movable platform adapted to transport the drum and metal-strip.

17. An electric furnace for annealing metal-strips by induction current, comprising a rotary platform; a plurality of drums uniformly distributed on said platform and each being adapted to receive the metal-strip to be annealed; a primary coil adapted to generate the induction current, said metal-strip acting as a secondary coil for a transformer; means for rotating said platform with the drums and metal-strips; and means for raising and lowering the primary coil over the drums and strips.

In testimony whereof I have affixed my signature.

MANUEL TAMA.