Feb. 25, 1947. E. M. CHANDLER ET AL 2,416,378

HEAT TREATMENT OF ALUMINUM STRIP

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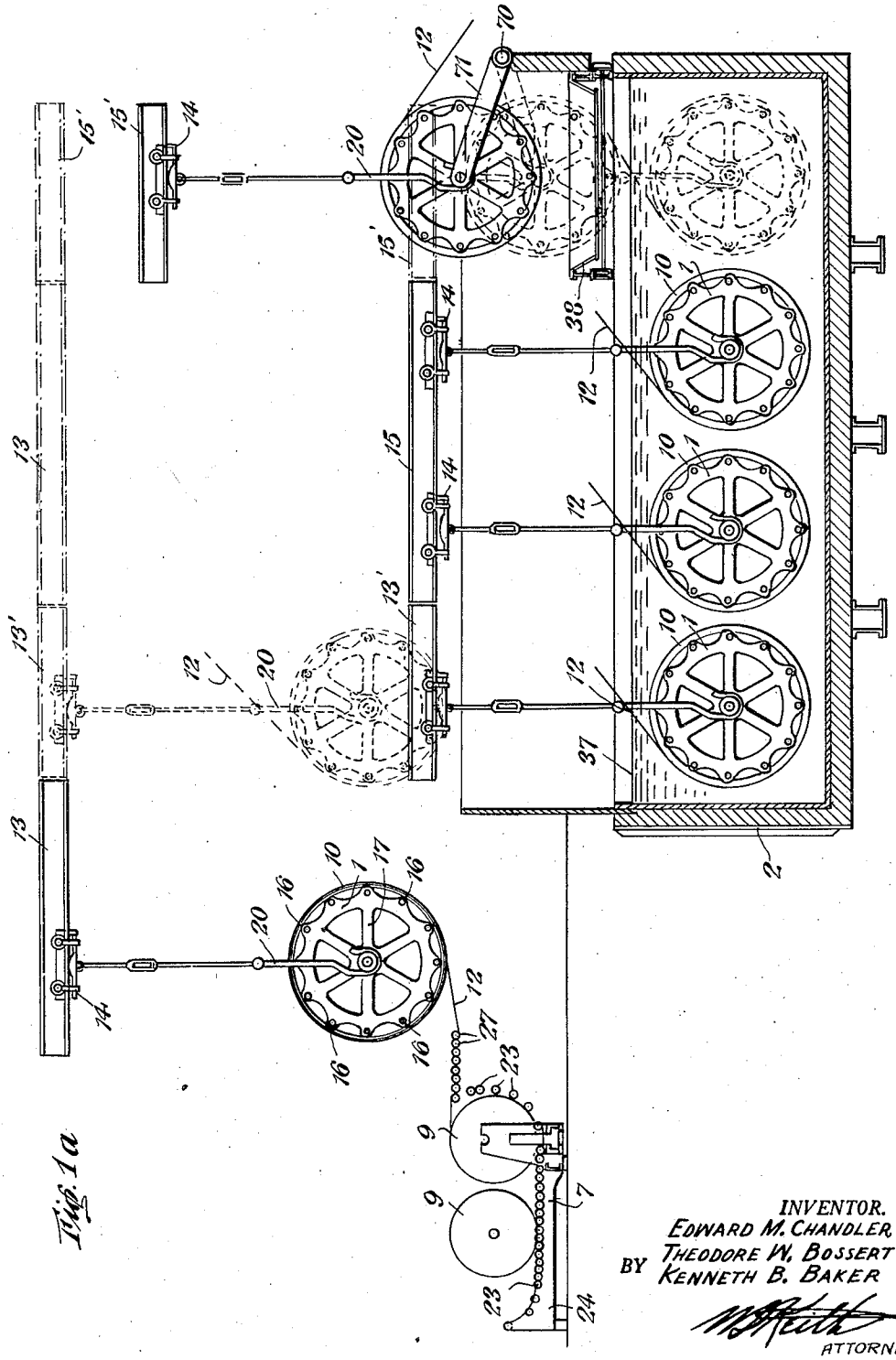


Fig. 1a

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HEAT TREATMENT OF ALUMINUM STRIP

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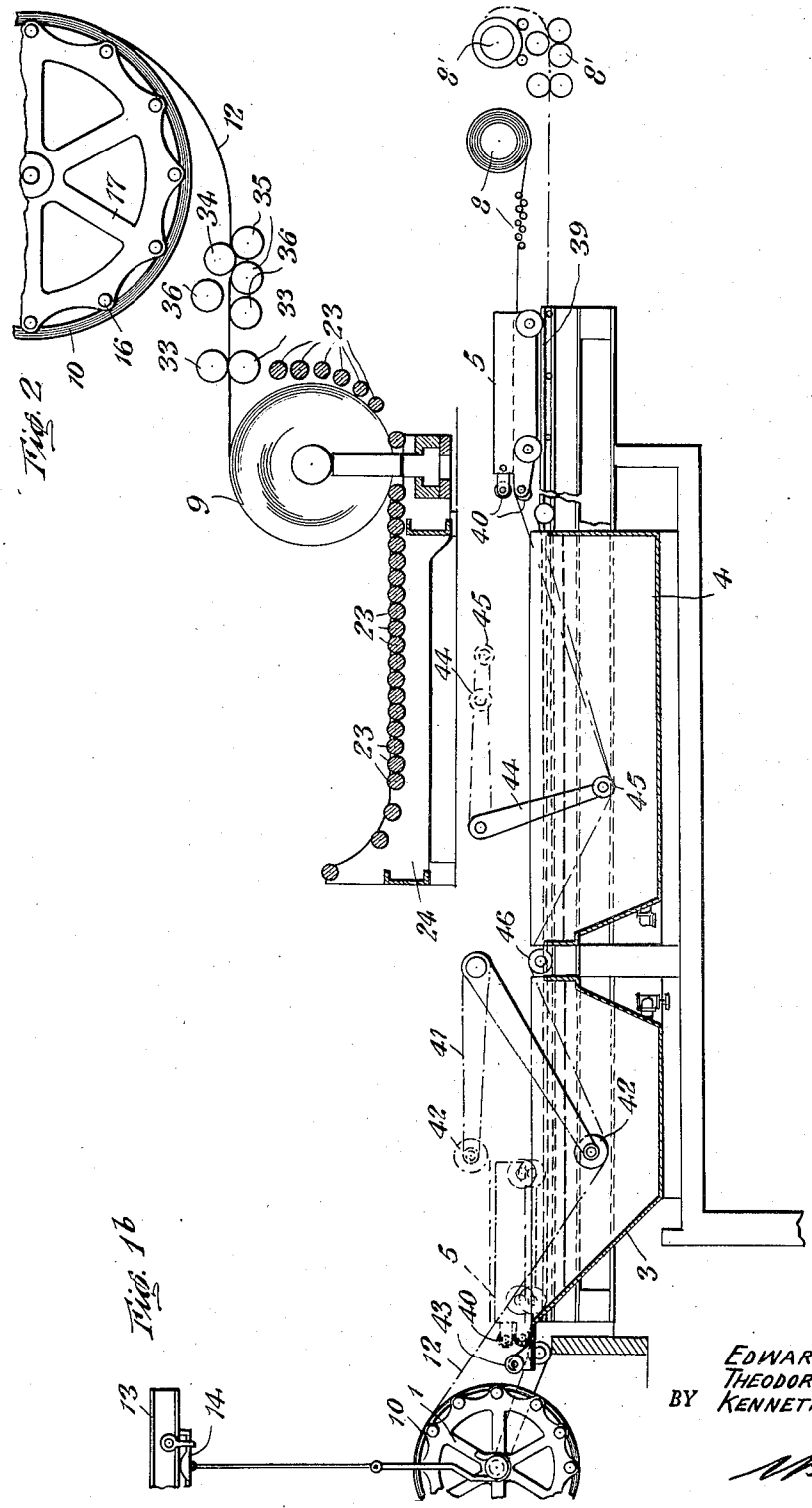


Fig. 2

Fig. 1b

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HEAT TREATMENT OF ALUMINUM STRIP

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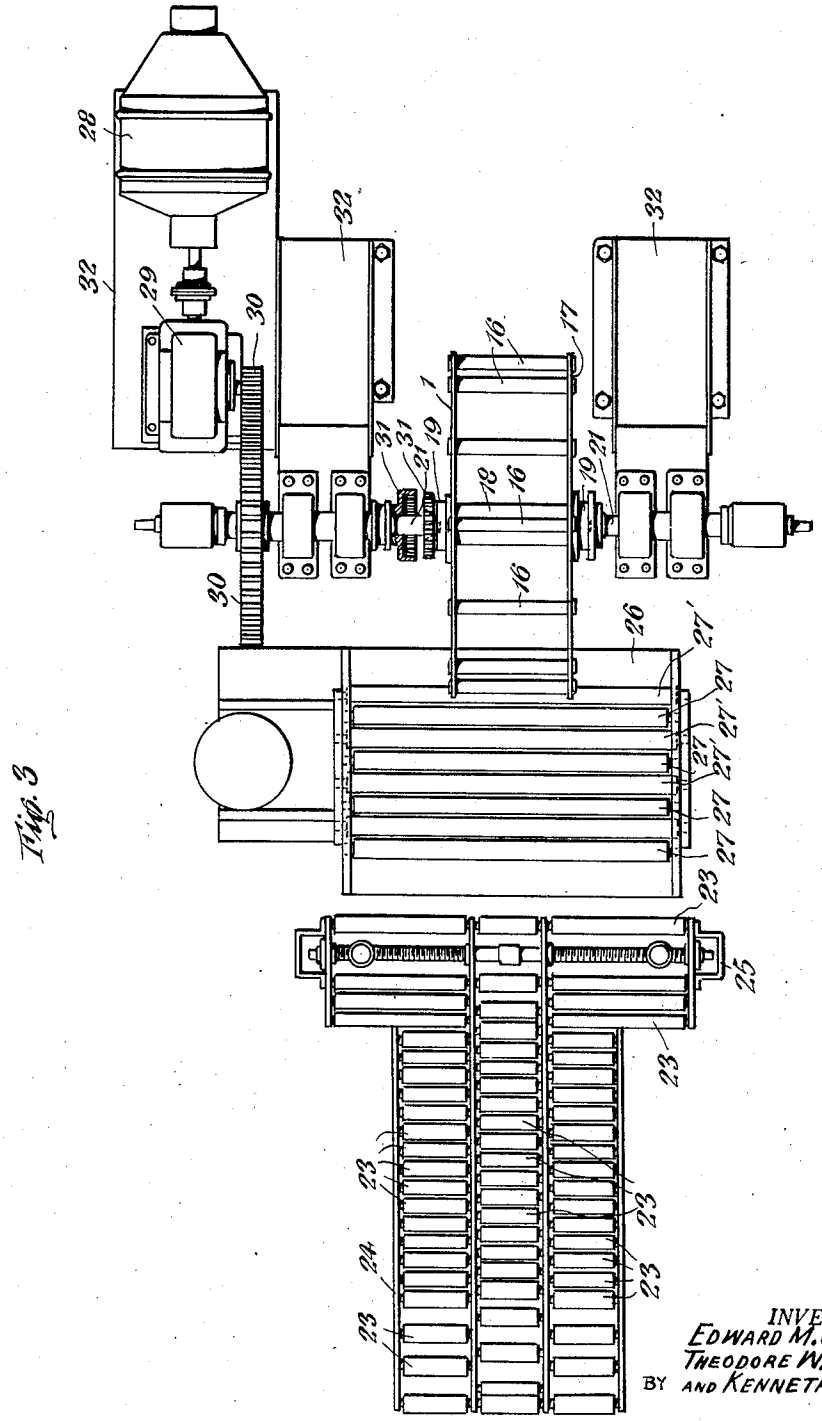


Fig. 3

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HEAT TREATMENT OF ALUMINUM STRIP

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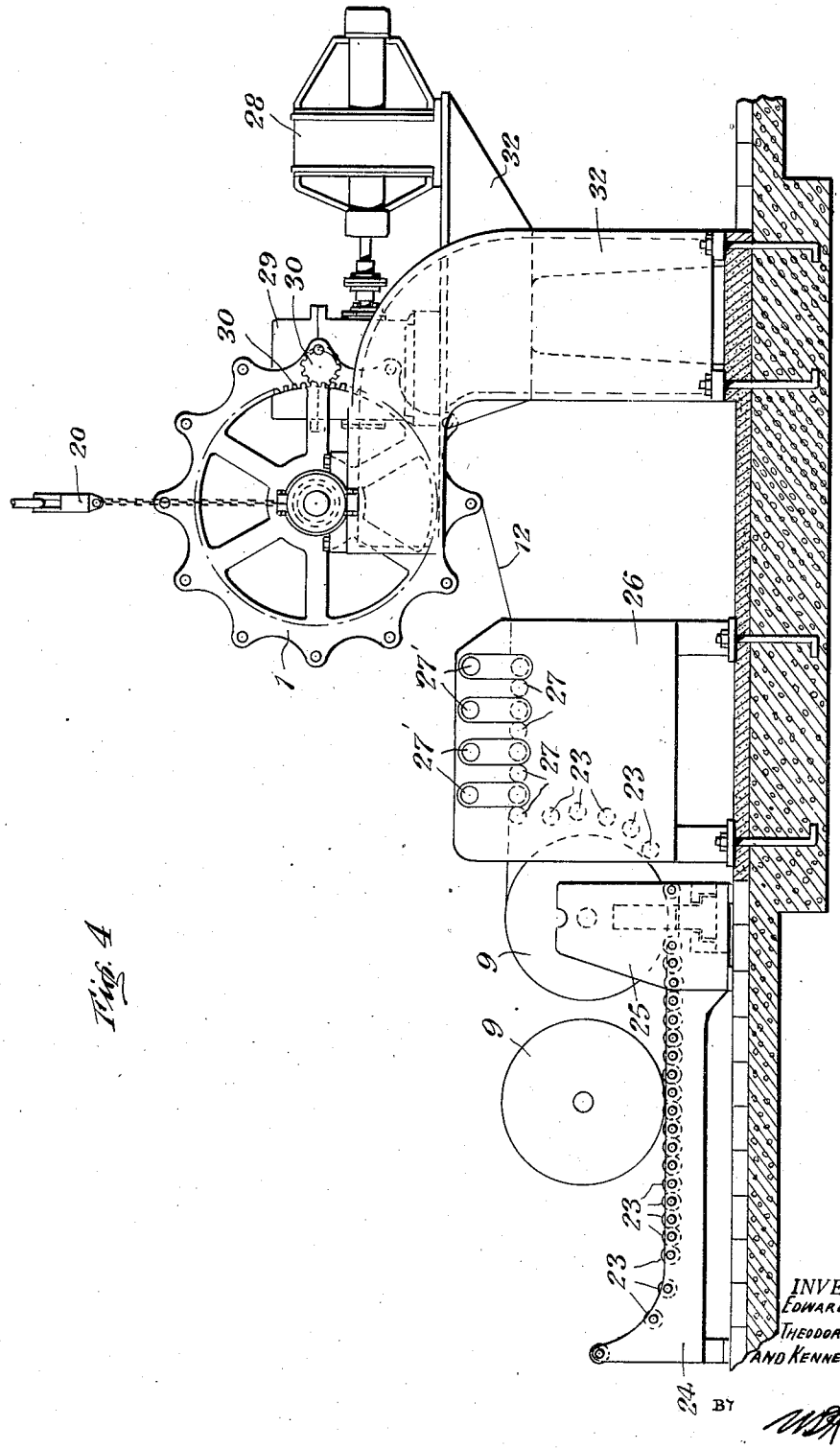


Fig. 4

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HEAT TREATMENT OF ALUMINUM STRIP

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Fig. 5

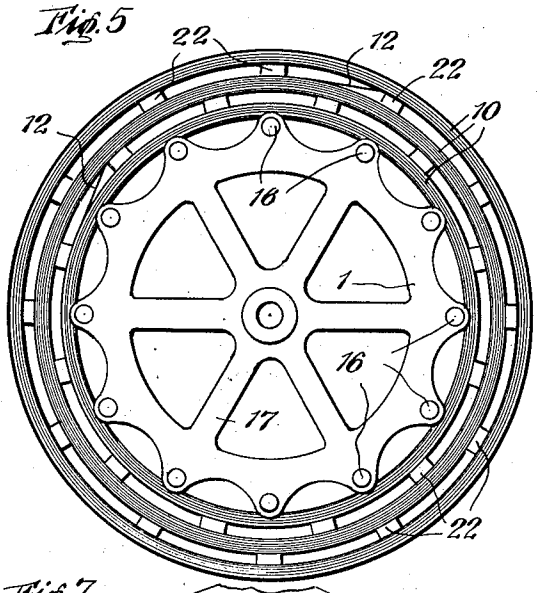


Fig. 6

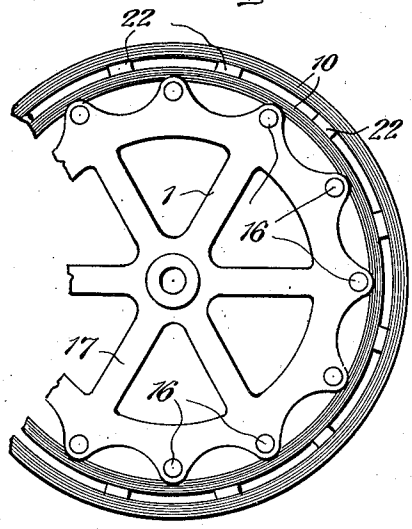


Fig. 7

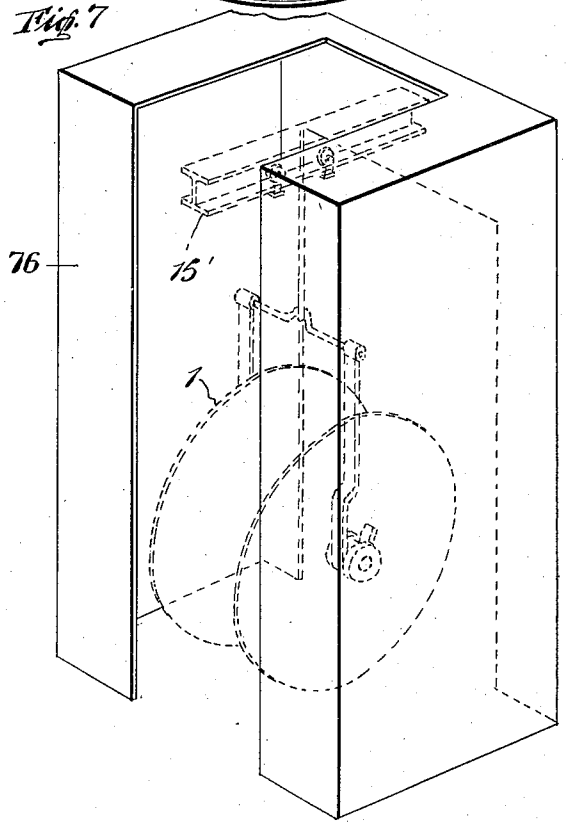
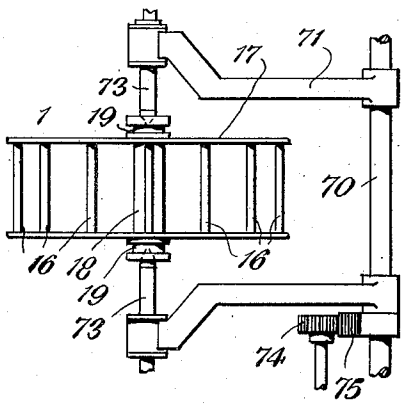


Fig. 8



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HEAT TREATMENT OF ALUMINUM STRIP

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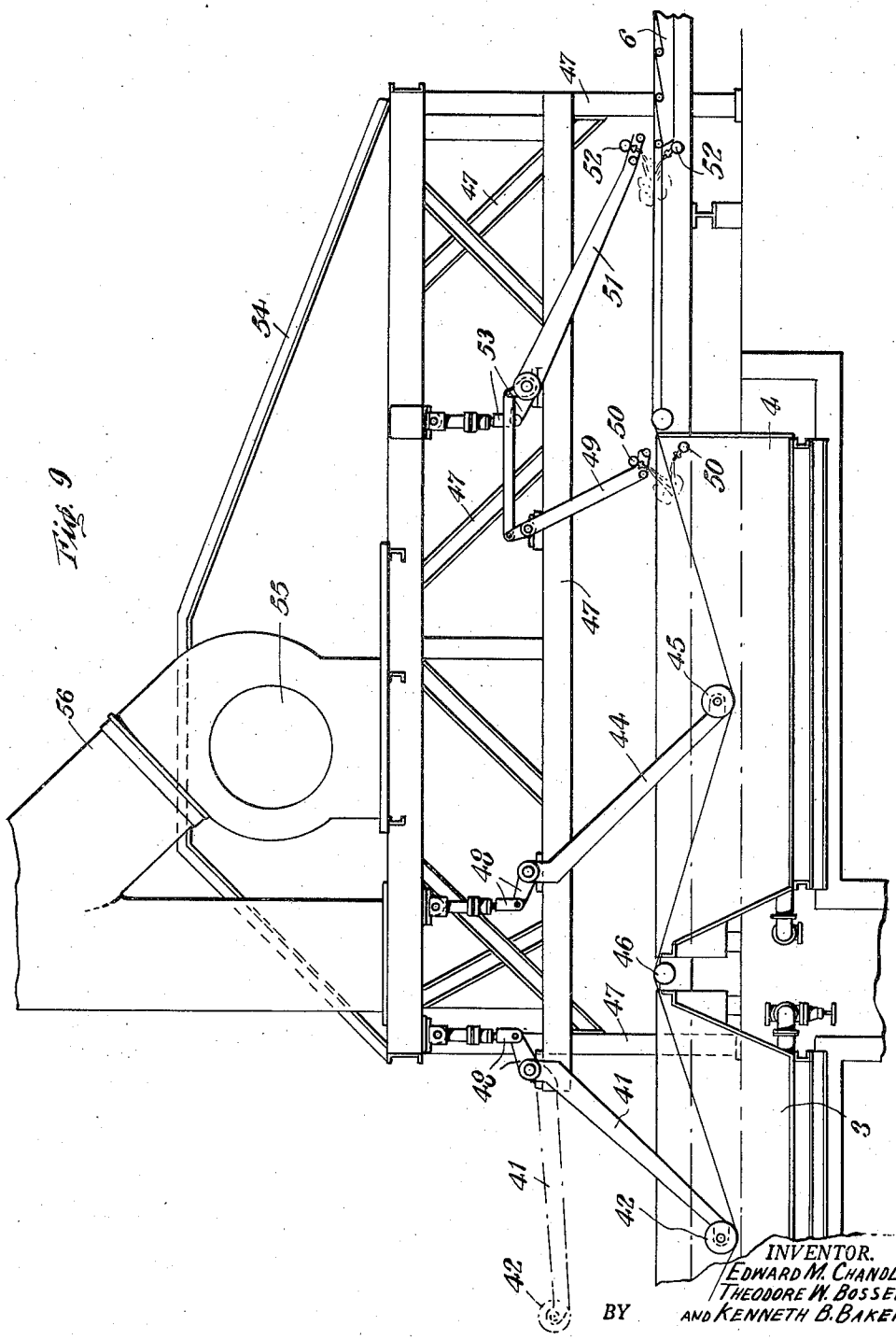


Fig. 9

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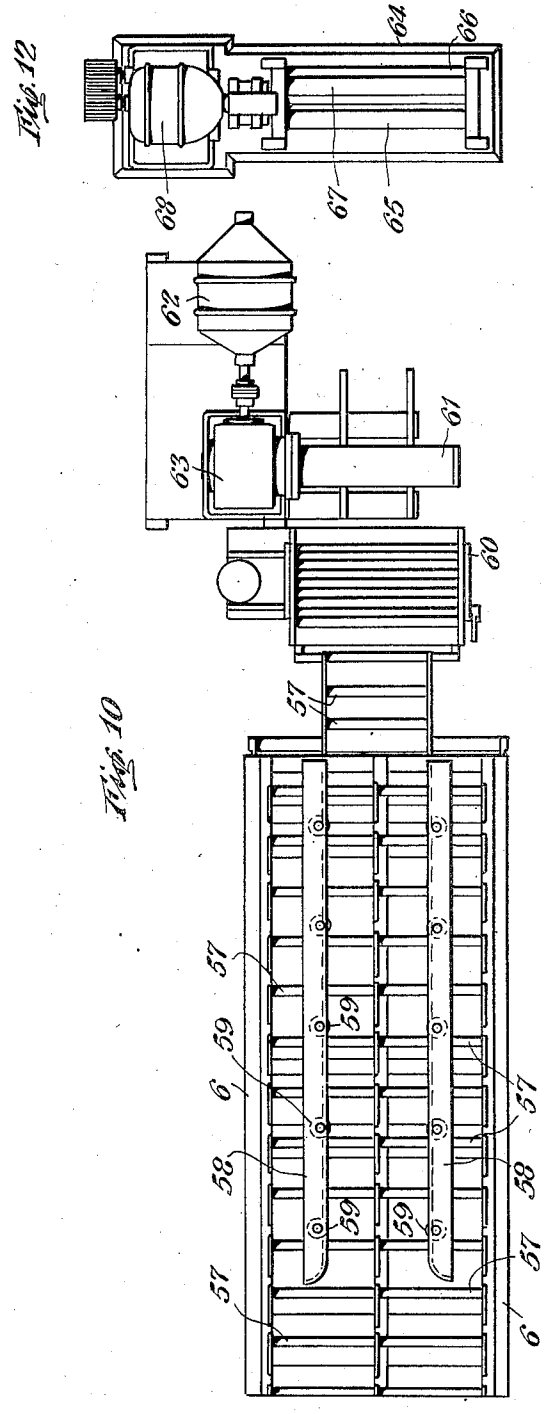
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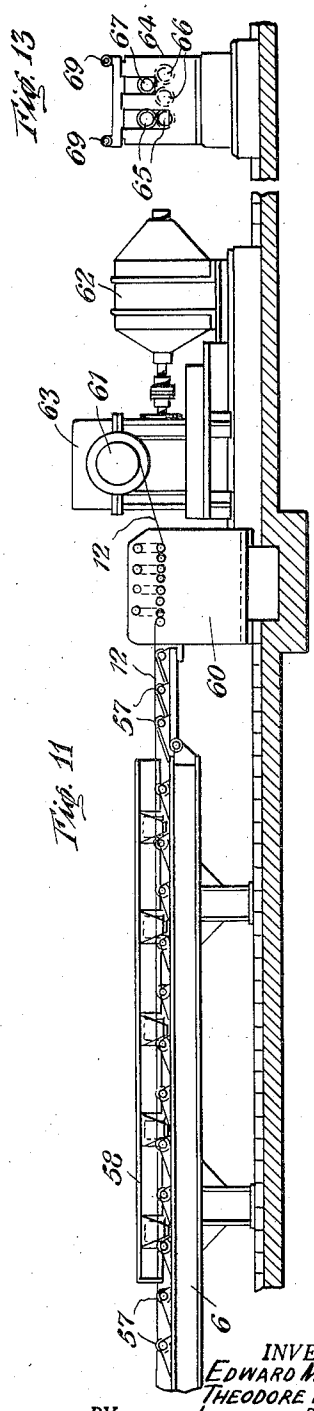
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HEAT TREATMENT OF ALUMINUM STRIP

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Patented Feb. 25, 1947

2,416,378

UNITED STATES PATENT OFFICE

2,416,378

HEAT TREATMENT OF ALUMINUM STRIP

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Application December 5, 1944, Serial No. 566,748

4 Claims. (Cl. 148—21.1)

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This invention relates to the thermal treatment of strip or sheet made of aluminum base alloys.

The problems with which this invention is concerned involve the nature of the material, the performing of thermal operations thereon and the machines and methods by which the material is handled immediately before, during and immediately after the thermal operations. These problems are not new to the art but have increased in degree year by year as improved sheet and strip fabrication methods and machines have increased the variety, amount and size of the material produced.

The material with which this invention is concerned is strip, or sheet of considerable length, made of heat treatable aluminum base alloy. Heat treatable aluminum base alloys are those containing alloying elements which, when the alloy is heated to elevated temperatures, form solid solution with the aluminum. Such alloys are well known and the solid solution forming elements which the alloys may contain are numerous, common examples being copper, zinc, magnesium and silicon. It is a further characteristic of such alloys that they usually contain at least about 80% by weight of aluminum. This material will hereinafter be defined as "aluminum strip," the word "aluminum" being used to define these heat treatable aluminum base alloys and the word "strip" being used to denote shapes of the alloy fabricated in a form commonly called strip or sheet and characterized by a cross-section of considerable width as compared to thickness.

Aluminum strip is manufactured in substantial length ranging, depending upon its cross-sectional areas and the size of the metal ingot from which it has been fabricated, from a few tens of feet to several hundred feet. It is usually produced in coiled form and often has a smooth and polished surface. The strip must be heat treated if its optimum physical properties are to be developed. This heat treatment is essentially a two-step process consisting, first, in heating the strip to relatively high temperatures to induce the formation of solid solution and, second, in rapidly cooling the sheet to a relatively low temperature. This heat treatment while well known and essentially simple in outline, in fact, is extremely critical and unless conducted properly the properties desired in the final aluminum strip may not be obtained or may not be uniformly obtained. This sensitivity to thermal conditions extends to the ability of the sheet to

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withstand in use such normal corrosive agents as may be found in the atmosphere as well as more severe corrodents such as, for instance, sea water. Quite often the heat treatment, unless properly conducted, will cause the strip to be highly susceptible to inter-granular corrosion. The problem that has faced the art in the heat treatment of this aluminum strip has been partly caused by the difficulty of handling large coils of this strip during high temperature heat treatment and subsequent cooling and has been in part caused by the difficulties of so handling the aluminum strip that it will retain its shape, i. e. will not buckle or riffle during heating and cooling. Further problems arise by reason of the fact that excessive, rough or careless handling of the strip may scratch or otherwise mar its polished surface. It is to these major problems that this invention is directed and the invention has as an object the provision of methods and means by which these problems may be solved in whole or in part.

It will simplify the explanation of this invention to refer to the drawings in which:

Fig. 1A is a schematic outline, partly in side elevation and partly in cross-section, of a portion of a preferred device in which the method of this invention may be practiced;

Fig. 1B is a similar view of the remainder of the device particularly shown in Fig. 1A;

Fig. 2 is a schematic view partly in side elevation and partly in cross-section of an alternate form of the unwinding device shown at the extreme left in Fig. 1A;

Fig. 3 is a top plan view of the winding device shown at the extreme left of Fig. 1A;

Fig. 4 is a vertical cross-sectional view taken through the winding device shown in Fig. 3;

Figs. 5 and 6 are side elevational views of a mandrel carrying a plurality of wound coils;

Fig. 7 is a schematic perspective view of a heat retaining device such as may be positioned over the end of the furnace shown at the right of Fig. 1A;

Fig. 8 illustrates in top plan view a mandrel holding device such as that indicated at 11 in Fig. 1A;

Fig. 9 is a view partly in side elevation and partly in vertical cross-section illustrating in more detail a portion of the device schematically indicated in Fig. 1B and showing a hood positioned over said device;

Figs. 10 and 11 are top plan and side elevational views, respectively, of a runout or layout table and recoiling device which may be positioned at

the right of the device shown in Fig. 1B as partially indicated in that figure; and

Figs. 12 and 13 are top plan and side elevational views, respectively, of an alternate form of recoiling device.

The mechanism shown in these drawings comprises the following main elements which are indicated in Figs. 1A and 1B;

A mandrel 1 on which the aluminum coil is wound, a furnace or heating device 2 through which the mandrel with its wound coil is passed, a cooling device or tank 3 in which the heated aluminum strip is cooled, a rinse device 4 the use of which may be desirable (depending upon the previous conditions of heat treatment) and a draw head, here shown as traveling carriage 5, by which the heated strip may be unwound from mandrel 1 and drawn through the cooling device 3, the rinse device 4, and, if desired, on to a layout table 6 (best shown in Figs. 10 and 11). Since aluminum strip is produced in coiled form and comes to this mechanism in a coil and, when finally heat treated, is again coiled for delivery to the customer or for the purpose of subsequent operations, the mechanism described includes as desirable components a means (generally indicated at 7) for expediting the winding of the strip on the mandrel 1, and another means (indicated at 8 and 8' in Fig. 1B) for rewinding the strip into a coil after the heat treating operation is complete. The means 7 preferably takes one of two general forms, depending upon the gauge of the aluminum strip which is being handled. When the strip is of relatively heavy gauge, an apparatus such as shown in Fig. 2 is used. Where the aluminum strip is of a relatively light gauge a device such as shown in Figs. 3 and 4 is used. An example of means 8 is shown in Figs. 10 and 11 while an example of the alternate means 8' is shown in Figs. 12 and 13. The draw head or carriage 5 may take any form consistent with its indicated functions. A preferred type of draw head is described and claimed in the co-pending application of Edward Lafayette Lyle, filed January 30, 1945, Serial Number 575,216.

The aluminum strip comes to the device herein described in the form of the coils 9 and at the end of the operation is coiled into coils of similar type. These coils may be of any size, depending upon the choice of the operator. The forming of the coils 10 from the strip of coil 9 by winding the strips upon the mandrels 1 so that such coils 10 shall be of a certain thickness, the speed with which these coils 10 move through the heating device 2, the manner in which the coils 10 are heated and the manner in which the strip from these coils is cooled comprise, in the preferred practice of the heat treating methods of this invention, important steps, all of which are best used to obtain optimum results. Before describing these preferred practices, the mechanisms by which they are best carried out and the preferred form of certain of cooperating parts of this mechanism will be more specifically described.

General operation of the strip handling, heating and cooling mechanism

Referring to Figs. 1A and 1B, an aluminum strip coil 9 is brought to the mechanism 7 and a mandrel 1 is positioned to receive metal from coil 9, the mandrel being transported to position by any suitable means such as the monorail 13 and the traveling shoe 14 which operates on said rail. The end of the coil 9 is fed to the mandrel

and the mandrel is turned, by a device later described herein, to tightly wind strip from coil 9 upon the mandrel to form the coil 10. When winding is complete the end of the strip 12 is secured, as by resting it against the bail 20, and the mandrel 1 is moved along the monorail until it is over the furnace 2 (in position shown in dotted line in Fig. 1A). Removable section 13' of monorail 13 is then lowered by suitable means until it registers with the lower monorail 15 which is positioned directly over the furnace. This movement lowers the mandrel and its coil 10 into the heating area at one end of that area and further movement of the mandrel on its shoe 14, finally brings it, as indicated in Fig. 1A, to the other end of that area where the shoe 14 rests on the movable portion 15' of the lower rail 15. Heating of coil 10 being complete the movable rail portion 15' is moved upwardly to place the mandrel into a threading position where it is contacted and held by arms 71. The strip having been threaded into a draw head the mandrel is moved into an unwinding position (shown in full line in Fig. 1A) and finally, after the coil 10 has been unwound from the mandrel, the monorail 15' is moved upwardly to register with the upper rail 13 thus allowing the shoe 14 and its suspended mandrel to be moved, as by gravity, onto the rail 13 and along that rail to the left to again deliver the empty mandrel to the coil winding operation. When the mandrel 1 is thus lifted from the furnace 2 to the first or threading position it is firmly gripped by a device consisting of arms 71 mounted on shaft 70 which support it on its axis for turning movement. The operator adjusts the end of the strip 12 to the horizontal position where it is threaded into pinch rolls 40 carried by the traveling carriage 5, these rolls are closed to tightly grip the strip 12 and the carriage 5 is started on its path of travel through or over, as the case may be, the cooling device 3. Soon or almost immediately thereafter, the arms 71 raise mandrel 1 to the unwinding position and the action of the carriage 5 unwinds the coil 10 from the mandrel. As the strip 12 unwinds it passes first through the cooling device 3 and thereafter, if desired, through the rinse device 4 and is finally delivered by the carriage 5 to the recoiling device 8 (or 8') where the end of the strip held by carriage pinch rolls 40 is loosened and fed to the rewinding device. It may be desirable to lay the strip 12 as it comes from the cooling device 3 or, in the case illustrated from the rinse device 4, upon a layout table such as 6 in which case the carriage 5 first travels over the layout table before delivering the end of the strip to the recoiler.

The mandrel 1

The mandrel may take any form convenient to its purpose which is to present a relatively thin coil of strip to the heating medium. Preferably the mandrel defines a coil holding surface of large diameter so that it will hold a thin coil formed from a substantial amount of strip. This coil holding surface should be discontinuous and is best made up of separated members such as the elements 16 (see Figs. 3 and 8) disposed to outline a circular surface. This arrangement insures that the inner surface of the coils 10 will be efficiently contacted by the heating medium. In the form shown the mandrels 1 consist of side members 17 connected by and supporting the elements 16. The members 17 are preferably spoked, as shown, to insure efficient circulation of heating medium

through the mandrel structure. The mandrels are also provided with a central hub element 18 which extends outwardly of the side members 17 to provide a grooved portion 19 (see Fig. 3) adapted to seat the bail 20. The hub 18 is likewise adapted to receive the retractable shafts 21, the purpose of which will be later described. The number of mandrels used in the operation will depend upon the size of the furnace and other equipment used. In any event, two or more mandrels may, if desired, be passing through the furnace at one time as indicated in Fig. 1A.

The mandrel 1 may be used to hold more than one coil 10. One convenient method of accomplishing this is to first wind a coil 10 on the elements 16 and then place separators 22 on the surface of the thus wound coil and wind another coil 10 over said separators, as indicated in Fig. 6. If the strip being handled is of a length greater than that desired to be placed in a coil 10, a coil of proper size may first be wound, the separators 22 placed on its peripheral surface and the winding of the strip then continued. In this way more than one coil 10 may be formed of a single strip, the strip 12 passing from one coil to another as shown in Fig. 5.

Coil handling device and winding of strip on the mandrel

The winding of the strip on the mandrel to form the coil 10 may be performed in many ways and by means of various types of apparatus but in practice the devices shown in Figs. 2, 3 and 4 are preferred. Where the aluminum strip is of light gauge, not greater than about .05 inch in thickness, the strip is best handled by a light bridle such as is shown in Figs. 3 and 4. Here the coils 9 are delivered to a coil handling platform 24, the coil handling surface of which is formed of the highly polished and free running rolls 23 to insure easy movement of the coils without marring the surface of the strip. At one end this platform is provided with means, indicated at 25, for centering the coil 9. Located adjacent to the platform 24 is the bridle 26, the face of which also bears rollers 23 which, combined with the rollers 23 on platform 24, provide a cradle in which the coil is held during the time it is being unwound. The bridle structure also contains the free running bridle rollers 27, 27'. Rollers 27' are adapted to be moved away from rollers 27 so as to allow passing or threading of the strip through the bridle. In Fig. 4 the bridle rollers 27' are shown in their lifted or open position (their closed position being indicated in dotted) and the end of the strip 12 has been passed between the sets of rollers 27 and 27' and has been hooked to one of the elements 16 of the mandrel 1 prior to the beginning of winding. Before winding is begun the rollers 27' will be brought to the closed position. This bridle serves the purpose of exerting tension on the strip against the winding action of the mandrel 1 thus insuring that coil 10 will be tightly wound. The bridle also serves to remove from the strip entering it any substantial arcuate characteristic resulting from the previous winding of the strip into the coil 9. For the purpose of the winding operation mandrel 1 is seated in the winding device by means of the retractable shafts 21. These shafts firmly seat in a recess in mandrel hub 18 provided for that purpose. A winding mechanism consisting of motor 28, transmission 29 and gears 30 turns the mandrel through a clutch arrangement such as indicated at 31. This mechanism and the retractable shafts 21 are conveniently mounted on frame 32 to hold the mandrel at proper height with relation to the bridle rollers 27 and 27'. When a coil 10 of suitable thickness has been wound the mandrel is moved on monorail 13 to the position where, as previously described it enters the heating device 2.

When heavy gauge aluminum strip is being wound a similar winding device and coil platform and cradle device are used but the bridle roller arrangement is changed as schematically set forth in Fig. 2 which figure illustrates the winding operation just prior to the time when the winding of coil 10 on mandrel 1 is complete. Pinch rollers 33, driven by means not shown, uncoil the strip from coil 9 and push it between a three-roller coiler consisting of upper roller 34 and lower rollers 35 which coiler forms in the strip a curvature which will insure that the strip winds tightly on mandrel 1. During the winding operation rollers 33 are normally closed and roller 34 is drawn or forced down on the strip passing over rollers 35 all as shown in Fig. 2. In the meanwhile rollers 36 remain open until all but the last few feet of strip has passed between them at which time rollers 36 close, rollers 33 open and roller 34 moves upwardly from rollers 35 the result being that the end, or tail, of the strip is pulled straight against the winding action of the mandrel 1 and forms a straight tail portion which is as indicated above, threaded into the pinch rollers 40 of the traveling carriage 5 after the heating operation.

The heating device 2

For the purpose of heating the coils 10 thus tightly wound on mandrel 1, a variety of mediums might be used. For instance conventional furnaces in which the coils are heated in air might be provided or baths of various heated liquids may be used. However in the preferred practice of the methods of this invention the heating of the coil is carried out in fused salt baths. Thus in the preferred design of the apparatus intended to carry out these methods the heating device 2 (Fig. 1A) takes the form of a tank the walls of which may be heated electrically or by oil flame or other means. The fused salt bath contained in the tank is deep enough, a proper level is indicated at 37, to completely contain the mandrel 1 and coil 10. The furnace may be provided with a safety top 38 which is closed as the mandrel is removed to the winding position. This top prevents loose articles such as the separators 22 from falling into the furnace. The fused salt used in the heat treatment of aluminum strip is usually composed of alkali metal nitrate such as sodium or potassium nitrate. The mandrel 1 having entered the furnace at one end and having been immersed in the fused salt bath is moved on the monorail 15 through the bath to the other end of the furnace, the movement being timed if desired, so that travel is continuous over the time in which the mandrel is in the heating area.

Removal of mandrel and its coil 10 from the furnace 2 and the cooling of the strip

When heating is complete the mandrel 1 is raised from the fused salt bath, as heretofore described, until it has reached the approximate level of the threading position at which place the tail of the strip 12 is inserted in the draw head 5. To hold the mandrel at this level in a rotatable position there is provided a device such as that schematically shown in Fig. 8. This device consists of arms 71 fixed on the shaft 70. Carried on arms 71 are retractable shafts 73 which engage

the hubs of the mandrel and form a fixed rotation center. A brake, not shown, may be provided on one of the shafts 73 to prevent too rapid rotation of the mandrel during the unwinding operation. A gear 74 and gear segment 75, the latter mounted on shaft 70, provide means for limited rotation of the shaft to move arms 71 from the threading into the unwinding position. The carriage 5 which constitutes a means for handling the strip in the subsequent operations is now started along the tracks 39, being either pulled on those tracks by a drawing device such as a cable, or moving over the tracks under individual power furnished by a motor. In so doing the carriage 5 unwinds the strip 12 from the mandrel and carries it across the cooling tank 3 which is filled with a cooling medium such as water. As soon as the carriage has passed beyond the position of the swing arm 41 bearing the roller 42 (as shown in dotted line in Fig. 1B), this arm 41 is swung to move the roller 42 downwardly against the unwinding strip and to force the strip into the cooling medium in the position shown in the full line in Fig. 1B. Up to this moment the mandrel 1 has remained in the lower or threading position thus causing the strip to pass over the idler roll 43, but as the roll 42 forces the strip into the cooling medium, the arms 71 are raised to bring the mandrel to the unwinding position and the strip thereafter travels in the path indicated in Fig. 1B.

There is, of course, a possibility that during the threading and manipulating operations just described the heated coil 10 will cool below the temperatures desired. In such a case this may be prevented by providing around the mandrel in its threading and unwinding position, a supplementary heating or heat retaining device, one example of which is schematically shown in Fig. 7. This device 76, which may be positioned above furnace 2 in any suitable way, consists of a box-like structure cut away at its top, front and back to allow passage of mandrel 1 therethrough as shown. The mandrel manipulation device of Fig. 8 may likewise be enclosed by said box. While the effect of this device may be merely that of a shield to partially contain heated air arising from the furnace 2 and heat radiating from the mandrel 1 and its coil 10, the device may if desired be separately heated.

In so far as the broad aspects of the heat treatment methods of this invention are concerned, necessary manipulation of the strip being treated is complete when the strip is cooled, as in the cooling device 3, and further disposition and manipulation of the strip, unless such consist of further heat treatment or artificial aging steps, will have no effect on the results obtained by the thermal treatment and is therefore not essential to the practice of the methods of this invention. However, when fused salt is used as a heating medium, a rinse of the treated strip after cooling is desirable to remove any excess salt and, in any event, immediate and positive drying of the strip is always desirable after cooling or rinsing in order to prevent staining of the strip, and is even necessary where, as in the case of most high quality aluminum strip products, staining caused by improperly dried strip interferes with its intended use. Therefore, in the preferred practice of the invention apparatus is provided for this purpose such as the rinse tank 4 and the drying devices and layout table hereinafter described. In the device shown in the drawings the draw head 5 continues its travel on tracks 39 over the rinse tank 4; when it passes under the swing arm 44, and its depressing roller 45, positioned as shown in dotted line in Fig. 1B, that arm is swung downwardly to the position shown in full line thereby depressing the strip by means of roller 45 into the rinse tank. Idler roll 46 located between the cooling device 3 and the rinse tank then furnishes a bearing area for the strip. A preferred assembly of the swing arms and various other related parts is shown in Fig. 9. Here the swing arms 41 and 44 are mounted on a frame 47 and are actuated hydraulically by means of toggle links 48. Also mounted on frame 47 are the swing arms 49 bearing one of two sets of steam or air jets 50, and swing arm 51 bearing one of two sets of air jets 52. The other sets of jets are permanently mounted to lie under the surface of the traveling strip as shown. Arms 49 and 51 are linked for simultaneous movement by the hydraulically operated toggle arrangement shown at 53. A hood 54, provided with exhaust fan 55 and exhaust stack 56 is likewise mounted on frame 47 and provides means for removing steam and water spray from the area of the rinse tank and the jets. Until carriage 5 has passed on its tracks 39 under the hood and beyond the jets 50 and 52, the swing arms 49 and 51 remain retracted to allow the passage of the carriage but thereafter these arms swinging downwardly to the position shown in Fig. 9 and upon reaching that position the jets 50 and 52 operate to deliver air or steam, as the case may be, to clean and dry the strip.

The layout table 6

As the carriage 5 unwinds the strip 12 from the mandrel 1 the strip passes, as above described, through the cooling device 3 and the rinse tank 4 and, as the carriage proceeds over the tracks 39, the sheet is eventually led to the layout table 6 best shown in Figs. 10 and 11. This table is conventional and may be of any suitable design consistent with its function which is to provide a handling area for the strip on which the strip may be further cooled or dried or otherwise treated. As shown in the drawings, the table 6 is provided with raised free-running rollers 57. To center the strip at the end of the table and guide it into the succeeding mechanisms, manipulator arms 58 may be provided, these arms being actuated to move the strip laterally of the table. Rollers 59 are provided on arms 58 to contact the edge of the strip and present to the strip a rotating surface which the strip contacts as it moves over the table rollers 57 and between the arms of the manipulator.

The rewinding of the processed strip

After the strip 12 has been coiled on the mandrel 1, heat treated and cooled, it is usually again wound in coils. This may be accomplished in any one of several ways familiar to the art and at any time after the cooling operation. Depending upon the quality of product desired, the coolant used and the possibility of staining, this recoiling can be accomplished immediately after the strip has passed through the cooling device 3 or after it has passed through the rinse tank 4 (this latter condition being schematically indicated in Fig. 1B) or after the strip has passed over the layout table 6. The preferred time of recoiling is as indicated in Figs. 10 and 11. There the strip is fed to the rewinding mechanism after it has passed over the layout table 6. In rewinding the strip the same considerations apply as have been described above with reference to the unwinding of the strip from the coil 9 on to the mandrel 1. That is to say, if the strip is of light

gauge, one set of rewinding equipment is preferred. If the strip is of heavy gauge, another set of equipment is preferably used.

The apparatus as shown in Figs. 10 and 11 is set up for the rewinding of light gauge strip. It consists of the bridle 60 and the blocker 61, which latter is driven by motor 62 through the transmission 63 to wind the strip. The bridle contains two sets of bridle rollers which function in all respects in the same way and for the same purpose as described in connection with bridle rolls 27 and 27' of the previously described bridle 26 (see Fig. 4). The strip 12 is threaded through the bridle 60 and attached to the blocker 61, the bridle rolls are closed and the blocker winds the strip against the pull of the bridle rolls to a coil of any desired size. If the strip is of heavy gauge the device shown in Figs. 12 and 13 is preferably substituted for the bridle and blocker arrangement just described. This device consists of a base 64 on which are mounted a pair of power driven pinch rolls 65 and a three-roll coiler comprised of lower rollers 66 and upper roller 67. A motor 68 drives the rolls 65. When this device is used as a rewinding means the rolls 65 are opened and roll 67 is raised and the end of the strip is threaded through the open rolls. The rolls are then closed and the pinch rolls 65 are driven to push the strip through the three-roll coiler. As the coil is formed and builds up in thickness it rests upon and turns upon idler rollers 69.

In operation the carriage 5 moves to the end of the table 6 where its pinch rolls 40 are opened and the end of the strip is inserted in the rewinding mechanism. The carriage 5 then is returned to the furnace 2 to receive and uncoil another coiled strip from a mandrel 1.

It will be realized from the above description that the movement of any or all of the devices described may be coordinated by suitable means or may be separately controlled. Thus once the winding of the coil 10 is complete and the mandrel 1 enters the furnace 2, the succeeding steps of lifting the mandrel from the furnace to the threading position, engaging the mandrel at said position with the arms 71 and shafts 73, lifting the mandrel to the unwinding position, depressing the unwinding strip into the cooling tank 3 and then into the rinse tank 4, projecting steam and air on the surface of the strip and finally inserting the strip into the recoiling device may, together with subsidiary and related mechanical operations, be automatically controlled and synchronized through electrically operated hydraulic means suitably actuated in proper sequence by the passage of the draw head, or carriage 5, from its strip receiving to its strip releasing position. However, such arrangements form no part of the invention herein claimed.

The drawings just referred to are merely schematic and are intended to merely illustrate a general arrangement of cooperating devices such as may be utilized in the practice of the methods of the invention. While the thickness of the coils 10, is, as hereinafter pointed out, a feature of this invention, no attempt has been made in said drawings to show a proper thickness.

Having thus described one general arrangement and device by which the methods of this invention may be practiced, such methods will now be more specifically explained.

The invention is a method of heat treating aluminum strip which comprises forming the strip into an open center tightly wound coil of limited thickness, heating the tightly wound coil to a temperature, at which the desired solid solution is formed between the aluminum and the solid solution forming elements, and thereafter cooling the strip by unwinding the tightly wound coil and passing the unwound strip through a cooling medium, usually, but not necessarily, a quenching bath. In order that the full advantages of the benefits of this invention may be achieved, the thickness of the tightly wound coil should not exceed three inches and the coil should preferably be about one to two inches in thickness. A thickness of less than one-half inch is not desirable. The coil should be tightly wound in the sense that its various coiled layers closely contact each other with each layer exerting some pressure on adjacent layers. In other words, the coiled layers should not be open, as has been prior common practice in the art, to allow the heating medium to directly contact the surface of each layer of the coil. The coil should, in accordance with this invention, be open in the center so as to allow free access of heat to its inner surface, and for consistent results the inner coil surface should not be covered over the greater part of its surface area. Where the aluminum strip to be treated is of such length that a single coil of limited thickness cannot be formed therefrom, this invention contemplates, as above described, the formation of a plurality of concentric separated coils of proper thickness unconnected except for the passage of a single layer of strip from one coil to the next, and even when the aluminum strip is in short length, the formation of concentric tightly wound coils of proper thickness on a single mandrel may be desirable. Preferably, the tightly wound coil is heated in fused salt baths and is maintained at required heat for not more than 60 minutes and, preferably, not more than 45 minutes. While the temperature of heating will vary with the type and characteristics of the solid solution to be formed, it never exceeds the lowest temperature at which incipient fusion takes place in the aluminum alloy under treatment and usually, with this limitation, is carried out in the range of 800 to 1100° F.

After heating is complete, the coiled strip is then, in accordance with this invention, unwound so that the strip is cooled in the uncoiled form. This is a highly desirable step in the preferred operation of this invention. While cooling may be accomplished in various mechanical ways, immediate and rapid cooling is a desired result and this is best obtained by passing the unwinding strip through a bath of water or a similar liquid contact medium maintained at relatively low temperatures, i. e. preferably under 212° F. When these conditions of treatment are maintained, the resulting heat treated aluminum strip has substantially uniform physical properties throughout and is free of unusual susceptibility to inter-granular corrosion. An example of the advantages of the preferred practice of the invention is the case of aluminum strip composed of a core of strong heat treatable aluminum alloy covered on either side with a thin layer of pure aluminum or of a different aluminum alloy. Such clad products are exemplified by the products described in the following United States Letters Patent: No. 1,805,488 to F. C. Frary, No. 1,865,089 to E. H. Dix, Jr., and Nos. 1,997,165 and 1,997,166 to R. H. Brown.

This class of aluminum strip product is particularly susceptible to irreparable damage dur-

ing its heat treatment, and prior heat treatment methods have required very close control and inspection in order to obtain uniformity of product in commercial production. This invention eliminates, in substantial degree, prior sporadic and unpredictable variations in properties. By the use of the methods of this invention a consistent product of relatively uniform physical properties and of low susceptibility to intergranular corrosion attack has been regularly and commercially produced from this class of aluminum strip over extended periods and in large tonnage.

Similar advantages accrue in the heat treatment of other and more common varieties of aluminum strip which have previously responded more satisfactorily to prior methods of heat treatment than has the class of aluminum strip just above described. The methods of the invention are useful in the treatment of any aluminum strip toward the end of producing a heat treated product of consistent properties and in large quantity.

What is claimed is:

1. That method of heat treating aluminum strip in coil form which comprises forming the strip into an open center tightly wound coil having a thickness of not less than about one-half inch or more than about three inches, heating said coil at temperatures at which aluminum solid solutions are formed and thereafter cooling said strip by unwinding the coil and passing the unwound strip through a cooling medium.

2. The method of heat treating aluminum strip in coil form which comprises forming the strip into a plurality of tightly wound concentric coils separated from one another by spacing means each of said coils having a thickness of not less than one-half inch nor more than about three inches and thereafter heating said coils.

3. That method of heat treating aluminum strip in coiled form which comprises forming the strip into an open center tightly wound coil having a thickness of greater than about one-half inch but not more than about three inches, immersing the coil in a fused salt bath held at temperatures of about 800 to 1100° F. but below the lowest temperature at which incipient fusion would take place in said strip and thereafter cooling said strip by unwinding said coil and passing the unwound strip through a cooling medium.

4. The method of heat treating aluminum strip which comprises forming on supporting elements a tightly wound coil having a thickness of about two inches, not less than about one-half inch and not greater than about three inches, the greater part of the inner surface of such coil being out of contact with said elements, heating the coiled strip and thereafter cooling said strip by unwinding said coil and passing the unwound strip through a cooling medium.

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