July 8, 1952 F. T. COPE 2,602,653

BRIGHT STRIP ANNEALING APPARATUS

Filed July 6, 1948 2 SHEETS—SHEET 1

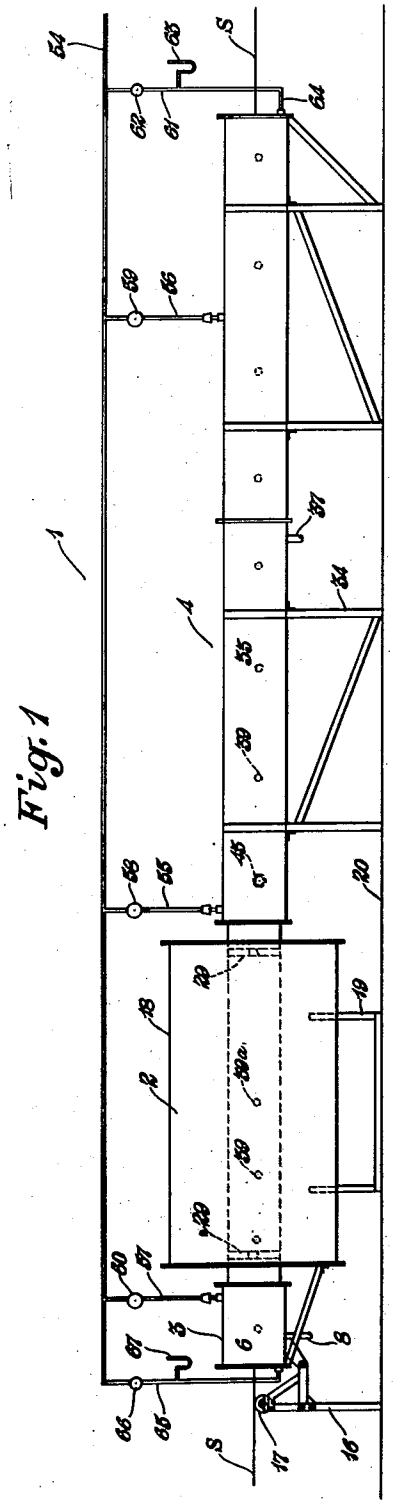


Fig. 1

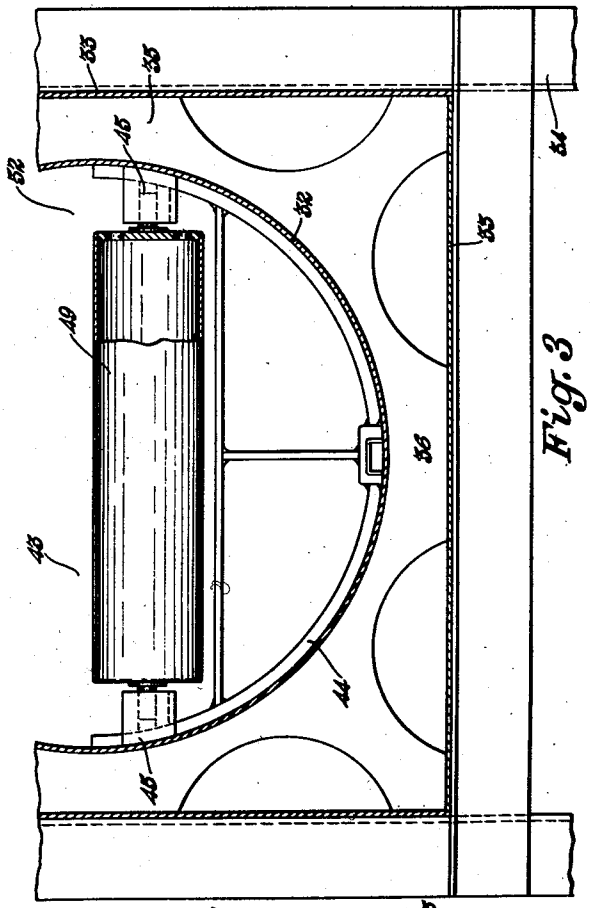


Fig. 3

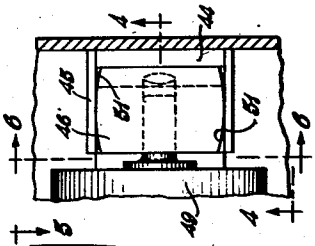


Fig. 5

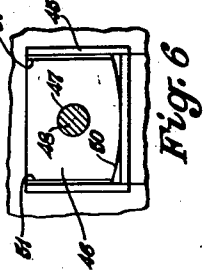


Fig. 6

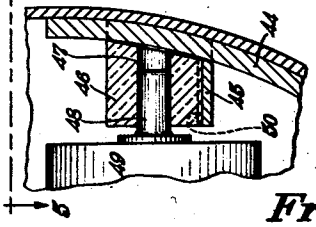


Fig. 4

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July 8, 1952 F. T. COPE 2,602,653

BRIGHT STRIP ANNEALING APPARATUS

Filed July 6, 1948 2 SHEETS—SHEET 2

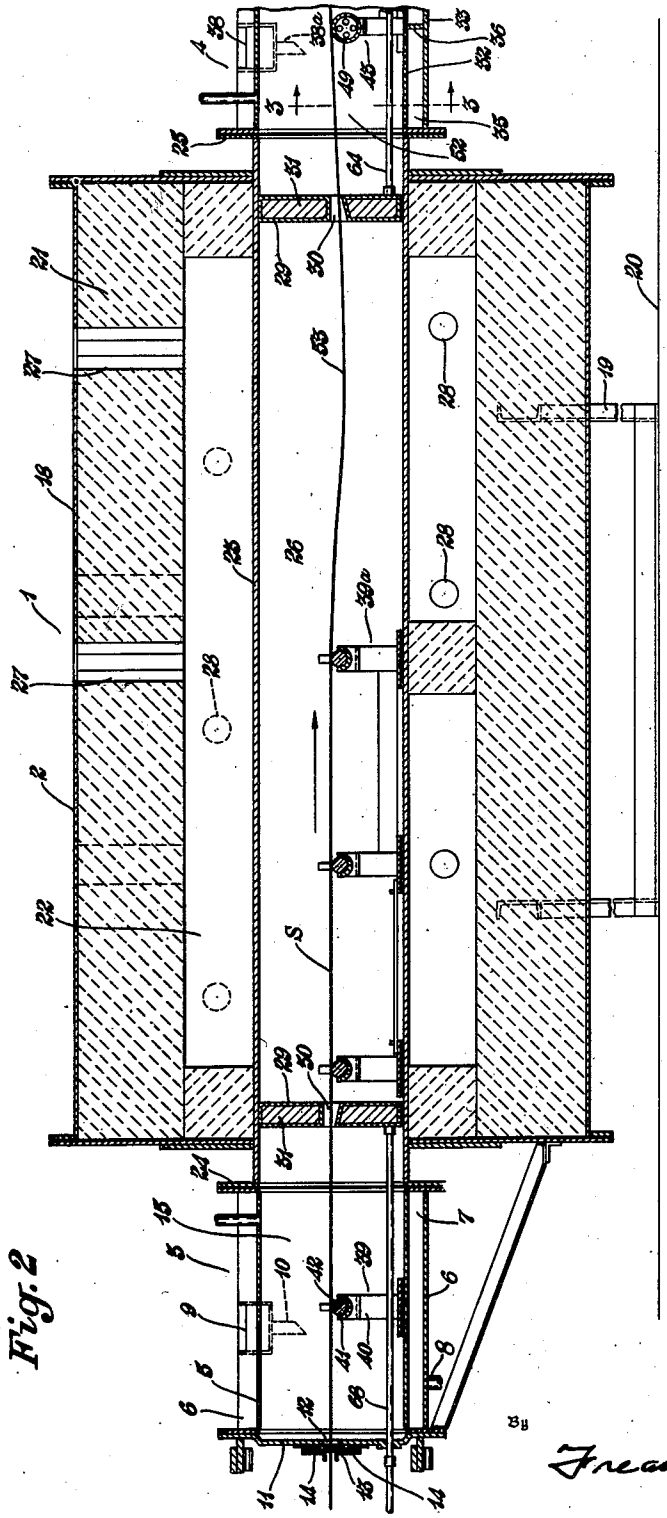


Fig. 2

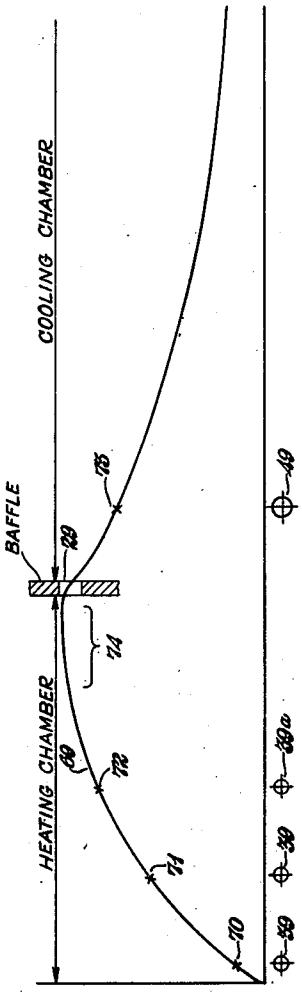


Fig. 7

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BRIGHT STRIP ANNEALING APPARATUS

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4 Claims. (Cl. 263—3)

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The invention relates generally to furnaces and more particularly to a furnace construction for continuously bright annealing light gauge stainless steel strip and the like.

The presence of any oxygen in the atmosphere enveloping a stainless steel strip may cause discoloration on the surfaces of the strip during the bright annealing thereof because stainless steel is particularly sensitive, under such conditions, to even the slightest traces of oxygen. This condition has rendered the bright annealing of stainless steel particularly difficult. The possibility of scratching and the avoidance thereof are additional difficulties when it is desired to continuously bright anneal stainless steel strip.

Many efforts have been made to overcome these difficulties. Thus, a continuous furnace has even been provided with a metal carrier strip in attempting to solve the difficulties in continuously bright annealing stainless steel strip. The carrier strip serves as a conveyor support for the strip being treated, as the treated strip is passed through the furnace, so as to eliminate any possibility of scratching the strip being treated. However, the operation of a carrier strip furnace is very inefficient because it is necessary at all times to heat not only the strip being treated but also the carrier strip.

The problem is further complicated by a number of factors not encountered in the usual or normal heat treatment of strip metal.

Thus, it is impossible to satisfactorily bright anneal stainless steel in a brick-lined furnace, because there may be some oxygen pickup from the brick lining even though a special atmosphere is used in the furnace chamber. Accordingly, a muffle type furnace is required having metal walls formed of a metal or alloy which will not rust or oxidize in operation and use. The metal walled muffle must be constructed so that a sealed chamber may be provided therein through which the strip is passed during heat treatment. A cast nickel-chrome-iron alloy is satisfactory for such purpose. A muffle chamber of considerable length and cross-sectional area and capable of withstanding high temperatures is required. A practical shape for the muffle walls is a tubular form, circular in cross section, although modifications of this shape which may be fabricated may be used, such as a D-shape with a flat bottom or a rectangular shape. The circular muffle tube is appropriate because it may be centrifugally cast if desired, and no salient points are presented by the muffle wall that are likely to be subject to flame impingement. A muffle tube

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of circular or other shape also may be formed of plates welded together. If the muffle tube is centrifugally cast, there are limitations as to the size thereof which may be so made of nickel-chrome-iron alloy, the present limit being of the order of about two feet in diameter.

If a centrifugally cast muffle tube circular in cross-section is used, the diameter limitation thereof in turn limits the width of strip that may be bright annealed therein. Furthermore, if a carrier strip is to be eliminated, some other means of supporting the strip being treated during its travel through the muffle must be provided, because, due to the long length of the muffle chamber and its relatively small diameter, the strip will sag and drag or scratch on the bottom muffle wall if unsupported.

The amount of sag may be controlled by the spacing between strip supports in the muffle chamber and by tension applied to the strip. However, there are limitations upon the amount of tension that may be applied to the strip to minimize sag, since a large amount of tension applied to the strip may exceed the elastic limit of the strip and pull the strip apart when in heated condition.

If an excessive amount of sag occurs, either because of a relatively large spacing between strip supports or because of the limitations upon the amount of tension that may be applied to the strip, then an otherwise unnecessary extremely deep muffle will be required to prevent dragging or scratching the strip on the bottom muffle wall. For this further reason it is desired to keep the sag at a minimum. This is particularly so if a circular muffle tube is used because a circular form therefor decreases the effective depth of the muffle when passing a strip therethrough having a width approaching the muffle diameter. However, the muffle tube should permit as wide a strip as possible to be passed therethrough.

These conditions would indicate the requirement of support means spaced at intervals throughout the length of the muffle tube with a minimum spacing to minimize the amount of strip sag. This, however, is undesirable because every contact of the strip while in heated condition with any object as it passes through the heating chamber creates the possibility of scratching the strip surface at any such point of contact.

Furthermore, the exposed surfaces and strip-contacting portions of the support means must be formed of a material which will not react to cause discoloration of the strip and which

will not scratch the strip. Also, the support means construction must be such that it is substantially unaffected, as by warpage, upon being heated to the relatively high temperatures involved (1750° F. to 2000° F.).

Graphite rods or graphite rolls spaced at intervals along the muffle tube seemed to offer a solution for this problem. Such graphite supports should resist the high temperature heat involved and should not scratch the strip as it passes thereover. However, it has been discovered in actual operation that graphite rods or rolls as strip support means located entirely throughout the length of the furnace heating chamber are unsatisfactory since scratching occurs on the under surface of the strip. It was finally determined that the scratching occurred where the strip contacted the graphite supports (either stationary or rotatable graphite rods or rolls) which were located in the high temperature zone of the furnace.

An exact explanation of the actual cause of such scratching at this place is not known. It is possible that the scratching may have occurred at the supports located in the high temperature zone because the strip is at that zone fully heated, softest, and therefore most subject to scratching; or it is possible that the rods or rolls failed to rotate. Another possible explanation is that minute particles of foreign materials, such as flakes or splinters of metal on the strip surface, may rub on, collect upon and finally become imbedded in the graphite supports, at the temperature involved, ultimately causing scratching.

These difficulties, therefore, require the elimination of any supporting means for the strip being treated in the high temperature zone or latter one-third to one-half of the muffle heating chamber so as to avoid any contact of the strip in said zone with any other object; and also require a freely rotatable support roll as the first support means for the strip in the cooling chamber.

Another complicating factor is the necessity of providing and maintaining a special atmosphere devoid of oxygen in the entire furnace and particularly in the heated zone of the furnace muffle. The special atmosphere may comprise dissociated ammonia gas.

In order to insure the presence, and the presence only of an oxygen-devoid atmosphere in the heating chamber, the heating chamber is closed at either end within the muffle by a baffle having a minimum sized opening therein through which the strip may be passed. The special atmosphere is introduced into such chamber under pressure so as to insure the presence only of the special atmosphere therein.

Entry and exit compartments are provided beyond each baffle at either end of the heating chamber. These compartments are also maintained filled with the special atmosphere under pressure, and are preferably cooled, the exit compartment being cooled for the purpose of rapidly cooling the strip after the desired heat treatment temperature has been obtained.

Accordingly, it is a primary object of the present invention to provide an improved furnace construction for the continuous bright annealing of stainless steel strip.

Furthermore, it is an object of the present invention to eliminate the use of a carrier strip in continuously bright annealing stainless steel strip.

Also, it is an object of the present invention to provide a furnace structure for bright annealing stainless steel strip continuously, in which an atmosphere devoid of oxygen may be maintained within the furnace heating chamber.

Furthermore, it is an object of the present invention to provide a furnace structure for continuously bright annealing light gauge stainless steel strip in which support means for the strip are utilized within the heating chamber, but in which strip scratching is avoided because of the particular arrangement and location of the strip supporting means.

Moreover, it is an object of the present invention to provide an improved furnace construction for continuously bright annealing light gauge stainless steel strip having a metal-lined muffle type heating chamber baffle-sealed at both ends, except for baffle openings providing for the passage of strip through the chamber, and having graphite strip supporting means within said chamber.

Also, it is an object of the present invention to provide an improved furnace construction for continuously bright annealing light gauge stainless steel strip wherein strip scratching is avoided without utilizing a carrier strip and while supporting the strip at intervals in certain regions of the heating chamber.

Furthermore, it is an object of the present invention to provide apparatus for continuously bright annealing light gauge stainless steel strip of maximum width in a relatively long, heated muffle chamber of relatively small cross sectional area with a minimum of strip sag within the heating chamber between support means located therein and without exceeding the elastic limit of the strip in pulling the strip through the chamber for moving the strip and for maintaining the sag at a minimum.

Finally, it is an object of the present invention to provide new apparatus for the continuous bright annealing of light gauge stainless steel strip which are simple to carry out and use, and are precise, effective and accurate in operation; which avoid scratching of the strip surfaces while supporting the strip within the heating chamber without the use of a carrier strip; which overcome the foregoing prior art difficulties; which solve longstanding problems in the art; and which obtain many new results and advantages herein set forth.

These and other objects and advantages apparent to those skilled in the art from the following description and claims may be obtained, the stated results achieved, and the described difficulties overcome, by the processes, methods, steps, procedures, operations, discoveries, principles, apparatus, combinations, parts, sub-combinations and elements which comprise the present invention, the nature of which are set forth in the following general statements, a preferred embodiment of which—illustrative of the best mode in which the applicant has contemplated applying the principles—is set forth in the following description, and which are particularly and distinctly pointed out and set forth in the appended claims forming part hereof.

The nature of the improvements in apparatus for continuously bright annealing light gauge stainless steel strip of the present invention may be stated in general terms as preferably including a horizontal, preferably externally-heated, muffle type furnace having a preferably circular metal retort heating chamber therein, baffles at

either end of said heating chamber, a preferably water-cooled entry chamber ahead of the baffle at the entrance end of the heating chamber, a water-cooled cooling chamber beyond the baffle at the exit end of the heating chamber, means for passing a strip continuously into and through said entry, heating and cooling chambers, preferably graphite support means in said entry and cooling chambers, preferably graphite strip support means in the heating-up zone of said heating chamber at spaced intervals, and a rotatable metal roll support of considerable diameter journaled in self-aligning bearings in the cooling chamber immediately adjacent the baffle separating said heating and cooling chambers rotated by contact therewith of the strip being treated.

By way of example, a preferred embodiment of improved bright annealing apparatus is illustrated in the accompanying drawings forming part hereof wherein:

Figure 1 is a diagrammatic side elevation of a preferred arrangement of the improved continuous strip bright annealing apparatus;

Fig. 2 is an enlarged longitudinal section of the entry chamber, heating chamber and a portion of the cooling chamber of the apparatus illustrated in Fig. 1;

Fig. 3 is a fragmentary section looking in the direction of the arrows 3—3, Fig. 2;

Fig. 4 is an enlarged fragmentary section of the self-aligning bearing mounting for the roll illustrated in Fig. 3, looking in the direction of the arrows 4—4, Fig. 5;

Fig. 5 is a fragmentary top plan view of the parts shown in Fig. 4, looking in the direction of the arrows 5—5, Fig. 4;

Fig. 6 is a section taken on the line 6—6, Fig. 5; and

Fig. 7 is a diagrammatic heating curve illustrating the heating and suporting of a strip in accordance with the present invention.

Similar numerals refer to similar parts throughout the various figures of the drawings.

The improved continuous furnace for bright annealing stainless steel strip and the like is generally indicated at 1 and includes a muffle type heating furnace 2, an entrance vestibule 3 and a cooling tunnel 4. The furnace 2, vestibule 3 and tunnel 4 are aligned, as shown, and the entrance vestibule 3 preferably includes inner, tubular, preferably circular metal walls 5 and spaced bottom and side walls 6, forming a compartment 7 which may be maintained filled with water or other cooling liquid, introduced through pipe 8, and which may overflow at 9 to drain 10.

The entry end of entrance vestibule 3 is closed by a door plate 11 having a narrow slot opening 12 therein, through which the strip S being treated may be passed. Preferably felt sealing means 13 are mounted on the door plate 11 having upper and lower felt strips 14 engaging the upper and lower surfaces of the strip S so as to effectively seal the opening 12 and prevent the entry of atmospheric air into chamber 15 formed by inner vestibule wall 5.

Referring to Fig. 1, an entrance support 16 including roll 17, preferably formed of asbestos cloth discs, is provided ahead of entrance vestibule opening 12, the strip S passing over or being supported by roll 17 as it passes into the bright annealing apparatus.

Referring more particularly to Fig. 2, the muffle type furnace 2 preferably comprises a circular shell 18 suitably reinforced and supported by structural steel members 19 on the floor 20. The furnace is preferably lined with suitable insulating refractory material 21 to provide a circular heating chamber 22 within which is located a horizontally extending preferably circular metal retort furnace muffle 23, preferably formed of centrifugally cast heat resisting alloy metal, such as nickel-chrome-iron. Thus, muffle 23 has a continuous tubular muffle wall, circular in cross-section. Muffle 23 is provided with flanged ends 24 and 25 which may be connected in any usual gas-tight manner, respectively, with the aligned entrance vestibule 3 and the cooling tunnel 4. A chamber 26 is formed in the interior of the muffle tube 23 wherein the strip S is heated.

Suitable openings 27 may be provided in the refractory walls 21 of the furnace 2 to serve as flues or to receive thermocouples and other regulating and control equipment, not shown.

The heating chamber 22, surrounding the muffle 23, is heated by a number of fuel burners 28 which preferably are gas burners, although any suitable type of fuel may be used. The gas, or other fuel, and air for combustion, may be supplied by any usual suitable equipment, not shown. Control valves associated with the burners and drive mechanism therefor, operated by usual automatic temperature control mechanisms, are provided so that the temperatures in various zones and throughout the heating chamber 26 may be ordinarily controlled at any desired degree.

A baffle partition member 29 is located within muffle tube 23 near each end thereof and each baffle member 29 is preferably formed as a hollow metal-walled disc having a slotted opening 30 therethrough, through which the strip S may be passed. The interior of each baffle member 29 is filled with preferably insulating refractory brick 31 and the refractory material is sealed in a gas-tight manner within the metal walls of the baffles 29 for a purpose to be later described.

The cooling tunnel or duct 4, is formed with inner cylindrical metal shell walls 32 and spaced outer side and bottom walls 33, supported in a suitable manner as of 34 on floor 20. A chamber 35 is thus formed between the walls 32 and 33 maintained filled with cooling liquid such as water, introduced through inlet pipe 37 and which may overflow as at 38 to drain 38a.

Referring to Fig. 3, perforated support and spacer plates 36 may be located at intervals throughout the length of the cooling tunnel for supporting the inner tube 32 within the outer walls 33. Perforations in plates 36, as shown, permit proper circulation of cooling fluid in chamber 35.

Strip support means generally indicated at 39 are located at spaced intervals within the entrance vestibule 3, a portion of muffle 23 and along cooling tunnel 4.

The strip support means 39 may each comprise generally semicircular bracket or pedestal members 40 having trough-like portions 41 at the top thereof in which rods 42 are received. If desired, rolls may be journaled for ready rotation in suitable, preferably self-aligning, bearings on the pedestal supports 40 in place of the rods 42. Where rods are used, they may be, and preferably are, formed of graphite. If rolls are used, they must be light in weight and must be provided with smoothly finished surfaces and with proper bearings for extremely easy rotation.

In accordance with the present invention, the first strip-supporting member in the cooling

tunnel 4, generally indicated at 43, is of different construction than the remaining support means 39 (Figs. 2, 3, 4, 5, and 6). The support member 43 includes a generally semicircular bracket or pedestal 44 at the upper portion of which bearing boxes 45 are provided. A graphite bearing block 46 is located in each bearing box 45 having a journal opening 47 formed therein in which is journaled a suitable shaft 48 provided on each end of a hollow tubular metal roll 49. A large ratio of diameter of roll 49 to diameter of trunnion shaft 48 is provided for a purpose to be described.

Each bearing block 46 is provided with a convex circular undersurface 50 resting on the flat bottom wall of box 45; and each bearing block 46 is provided with convex circular side walls 51 adapted to contact the flat side walls of bearing box 45. The described construction of the bearing blocks 46 and their mounting within the boxes 45 provides a self-aligning bearing mounting for the support roll 49.

Thus, referring to Figs. 1 and 2, there are supports 39 at intervals along the path of travel of the strip S, over which the strip S moves and by which the strip S is supported in the entry vestibule 3, in the first half or heating-up zone of the furnace 2, and in the cooling tunnel 4. Also in cooling tunnel 4 there is the special support 43. There are no supports between the last support 39*a* at the middle of furnace 2 and the special support 43 in the cooling chamber 52 formed by inner wall 32 of the cooling tunnel 4.

The strip S, in being pulled through the annealing furnace, is subjected to tension within allowable limits, and passes along the path shown by the solid line S in Fig. 2. While there may be some slight sag in the strip between supports 39, the spacing of these supports is relatively small, so that the sag is not appreciable. However, some more appreciable sag will occur, as indicated at 53, in the strip S between support 39*a* and roll 43. The amount of this sag is determined by the pulling tension applied to the strip and by a braking action applied to the strip prior to its entry into the furnace.

The hollow support roll 49 is formed of metal with light gauge walls so as to be light in weight and it has a smoothly finished peripheral surface. The roll 49 has a relatively large diameter of the order of say 3½ inches, and the ratio of roll diameter to trunnion diameter is relatively large, say 7 to 1 or more. Roll 49 thus constructed and mounted in self-aligning bearings (which minimize any resistance to rotation of the roll 49 by strip contact) provides a construction in which friction is minimized and easy rotation of the roll is promoted. Even a light gauge strip S by contact with roll 49 will cause rotation of the roll 49 in its bearings. Therefore, the possibility of scratching the strip as it passes over and rotates the roll 49 is avoided.

The hollow tubular metal support roll 49, as indicated, is located immediately adjacent the baffle 29 separating the heating and cooling chambers. The location of this roll very close to the heating chamber is possible because the highest rate of cooling of the strip occurs at the beginning of the cooling cycle and the strip is thus abruptly cooled and its temperature is substantially reduced when it contacts roll 49. Furthermore, the roll 49 as it rotates is exposed to and radiates to the cooling water jacket in chamber 35, and is, therefore, relatively cool and has a considerable chilling action of its own upon the strip.

The chambers 15, 26 and 52 are maintained completely filled with a special atmosphere devoid of oxygen so as to avoid any possibility of oxygen contacting the strip being treated while the same is at a temperature at which staining or discoloration of the strip surfaces might result. The special atmosphere may comprise dissociated ammonia gas supplied from a producer, not shown, through pipe 54 (Fig. 1) to inlets 55 and 56 to the chamber 52 in cooling duct 4 and through inlet 57 to chamber 15 in entrance vestibule 3.

Each line 55, 56 and 57 may be controlled by a suitable valve indicated, respectively, at 58, 59 and 60. A line 61, controlled by valve 62 and equipped with a manometer 63, is connected with supply line 54 through pipe 64 to the interior of baffle 29 at the exit end of heating chamber 26; and a similar line 65, controlled by valve 66 and equipped with a manometer 67, connects supply line 54 through pipe 68 with the interior of baffle 29 at the entry end of heating chamber 26.

In heating up the furnace, valves 62 and 66 are opened when the furnace is cold and remain open during the heating-up period until the furnace is at full operating temperature. The valves are then temporarily closed and the pressure readings on manometer 63 and 67 are observed. If the pressure decreases and continues until it is zero, it indicates that the metal walls of the baffles are not gas-tight and that they may be giving off some gas other than the special atmosphere, which might cause discoloration of the strip. In this event, the cause of leakage must be corrected.

Moreover, the connection of the interior of the baffles 29 with the supply line of the special atmosphere enables any air which may be trapped within the baffles to be purged, and enables expansion or contraction of any gases within the baffles upon heating or cooling to be compensated for in the gas supply line. Moreover, it is necessary to isolate the interior of the baffles 29 from the heating chamber 26 because gaseous communication between the refractory material in the baffles and the strip S passing through the heating chamber 26 might cause discoloration of the strip.

The special atmosphere introduced under pressure through pipes 55, 56 and 57 into the cooling chamber 52 and entry chamber 15 when the furnace is started purges all other gases from these chambers and from the heating chamber, and the continuous supply of special atmosphere under pressure maintains the entry, heating and cooling chambers 15, 26 and 52 completely filled with the special atmosphere. The valves 58, 59 and 60 may be adjusted to provide for the necessary flow of special atmosphere to obtain balanced conditions throughout during operation of the furnace.

The entry vestibule is water cooled primarily for the purpose of preventing warpage of the metal walls 5 of the entry chamber 15 which might occur from heat transmitted or radiated to it from the heating chamber.

In operation, coils of stainless steel, of either the straight chrome or the 18–18 type, are uncoiled in the usual manner and are passed over roll 17 between seals 14 and through slot 12 into entry vestibule 3, then through slot 30 in left hand baffle 29 (Fig. 2), through heating chamber 26 and slot 30 in right hand baffle 29, over roll

49 and along cooling tunnel 4. The strip S is then discharged to the atmosphere and is subsequently coiled or otherwise processed or treated.

Stainless steel strip 0.004" x 12" may be continuously bright annealed in this manner at a speed of about 25 feet per minute; 0.010" x 12" strip may be bright annealed at a speed of say 10 feet per minute; and 0.015" x 12" strip may be bright annealed at a speed of say 6 feet per minute, where the furnace capacity is designed to handle say approximately 250 pounds of metal per hour.

In passing through the heating chamber 26, the first one-half to two-thirds of the chamber functions as a heating-up zone wherein the strip temperature is somewhat uniformly raised as it continuously passes through the chamber to the maximum desired strip temperature. The latter one-third to one-half of the chamber 26 constitutes the hot or final heating zone, wherein the strip temperature is finally raised to and is held for a short time substantially at the desired annealing temperature of say 1950° F. or somewhere within the range of 1750° F. to 2000° F.

The strip is then passed to the cooling duct and cools rapidly and abruptly from maximum temperature so that its temperature is substantially reduced before it passes over roll 49. The strip continues to cool until it emerges from the cooling duct 4 at a temperature not much higher than room temperature. The heating and cooling thus imparts an annealing or austenitizing heat treatment to the stainless steel strip, the surfaces of which have been maintained bright by enveloping the strip in the special atmosphere devoid of oxygen maintained in the furnace chambers.

In pulling the strip through the furnace, care must be taken to limit the amount of pull in pounds per square inch of sectional area such that the elastic limit of the strip in heated condition in the furnace is not exceeded. On the other hand, the pull on the strip must be sufficient to control the amount of sag occurring between supports 39*a* and 43 so as to prevent the strip from touching or dragging along any portion of the muffle tube or baffle walls.

Fig. 7 illustrates diagrammatically a heating and cooling curve 69 for the strip S passing through heating chamber 26 and cooling chamber 52. Points 70, 71, 72 and 73 indicate the passage of the strip, respectively, over the first two supports 39, the support 39*a* and the support 49. The strip, in passing from point 70 to 72, is rapidly heated in the heating-up zone of the chamber 26. The heating continues until maximum strip temperature is obtained, indicated at zone 74, after which the strip temperature drops rapidly as it passes into cooling chamber 52 and before it contacts roll 49.

It has been impossible to determine the exact temperature at and above which scratching will occur when a stainless steel strip passes over a graphite support rod, and below which scratching will not occur. It is difficult, if not impossible, to obtain exact temperature readings of the strip temperature at varioun places along its path of travel through the heating chamber 26 in the operation of the furnace illustrated.

However, it is known that if the strip passes over a graphite support at any time when its temperature is at or close to the maximum temperature of 1750° to 2000° F., scratching will occur. It is also known that when the strip temperature is several hundred or more degrees lower than maximum temperature, as when it passes over graphite support 39*a*, substantially halfway through the heating chamber, no scratching occurs. Also, it is known that when the strip passes over and rotates a light weight, readily rotatable metal roller 49 in the cooling chamber when the strip temperature is quite a few hundred degrees lower than maximum temperature, as illustrated in Fig. 7, no scratching occurs.

Accordingly, the present invention is characterized by the elimination of all supports for a continuously moving strip in the high temperature zone or latter one-third to one-half of a furnace as the strip passes through a bright annealing furnace; and by suspending the strip as it moves through such high temperature zone.

Stated in another way, the strip temperature is controlled to be below that temperature at which the strip will scratch, when the strip is supported by graphite or metal roll support means as it is passed over such support means in the continuous bright annealing of a strip.

Stated in still another way, the present invention is characterized by so locating the support means over which a continuously moving stainless steel strip passes during the bright annealing thereof, with respect to the strip temperature at the time of passing over such support means, that no scratching occurs.

Thus, there are support means in that portion of the heating chamber where the strip temperature is insufficient upon contact of the strip with the support means to result in scratching or marring of the strip; support means are omitted in that portion of the heating chamber where the strip temperature is high enough and the strip is soft enough to result in marring or scratching of the strip by contact with support means if present; and supporting of the strip on support means is resumed in the cooling chamber when the strip has cooled to a temperature insufficient to result in marring or scratching of the strip upon contact with the support means.

Accordingly, the present invention provides a fundamentally new and different procedure for bright annealing light gauge stainless steel strip; provides improved apparatus for carrying out such procedure; eliminates the use of a carrier strip in continuously bright annealing stainless steel strip; provides for avoiding scratching while continuously bright annealing stainless steel strip; provides for supporting the strip at spaced intervals during the heating-up period and suspending the strip during the final heating period of bright annealing stainless steel strip; and overcomes prior art difficulties and solves long-standing problems in the art.

In the foregoing description, certain terms have been used for brevity, clearness and understanding; but no unnecessary limitations are to be implied therefrom beyond the requirements of the prior art, because such terms are utilized for descriptive purposes herein and not for the purpose of limitation and are intended to be broadly construed.

Moreover, the description of the improvements is by way of example, and the scope of the present invention is not limited to the exact details, strip widths, gauges, and temperatures set forth.

Having now described the features, discoveries and principles of the invention, the operation and procedures of preferred method steps thereof, the arrangements of new apparatus, and the advantageous, new and useful results obtained thereby; the new and useful processes, methods, steps, pro-

cedures, operations, discoveries, principles, apparatus, combinations, parts, sub-combinations and elements, and mechanical equivalents obvious to those skilled in the art, are set forth in the appended claims.

I claim:

1. In apparatus for continuously bright annealing strip steel without scratching the strip, a furnace having a tubular metal retort muffle wall forming a heating chamber, baffle partition members within said metal retort wall at either end of said heating chamber provided with strip-passage slots, a tubular metal entrance vestibule wall connected with said muffle wall forming an entry chamber at the entry end of said furnace, a tubular metal cooling tunnel wall connected with said muffle wall forming a cooling chamber at the exit end of said furnace, said entry and cooling chambers being aligned with and communicating with said heating chamber through said baffle slots, means for supplying an enveloping atmosphere devoid of oxygen under pressure to said chambers, means for passing strip steel continuously into and through said aligned entry, heating and cooling chambers, strip support members mounted at spaced intervals in said entry and cooling chambers and in a portion of said heating chamber, a rotatable metal roll journaled in self-aligning bearings in said cooling chamber immediately adjacent the baffle between said heating and cooling chambers, means for externally heating the muffle wall to heat the strip to annealing temperature in said heating chamber, the strip being suspended in the last half to one-third of said heating chamber between one of said strip support members and said metal roll, and the strip rotating said metal roll in passing thereover.

2. In apparatus for continuously bright annealing light gauge stainless steel strip without scratching the strip, a furnace having a tubular metal retort muffle wall forming a heating chamber, baffle partition members within said metal retort wall at either end of said heating chamber provided with strip-passage slots, a tubular metal entrance vestibule wall connected with said muffle wall forming an entry chamber at the entry end of said furnace, means for cooling said entry chamber, a tubular metal cooling tunnel wall connected with said muffle wall forming a cooling chamber at the exit end of said furnace, means for cooling said cooling chamber, said entry and cooling chambers being aligned with and communicating with said heating chamber through said baffle slots, means for supplying an enveloping atmosphere devoid of oxygen under pressure to said chambers, means for passing stainless strip steel continuously into and through said aligned entry, heating and cooling chambers, graphite support members mounted at spaced intervals in said entry and cooling chambers and in a portion of said heating chamber, a rotatable metal roll journaled in self-aligning bearings in said cooling chamber immediately adjacent the baffle between said heating and cooling chambers, means for externally heating the muffle wall to heat the strip to annealing temperature in said heating chamber, the strip being suspended in the last half to one-third of said heating chamber between one of said graphite support members and said metal roll, and the strip rotating said metal roll in passing thereover.

3. In apparatus for continuously bright annealing light gauge stainless steel strip without scratching the strip, a furnace including tubular metal walls forming aligned communicating entry, heating and cooling chambers; means for supplying an enveloping atmosphere devoid of oxygen under pressure to said chambers; means for passing stainless steel strip continuously through said chambers in the order named; graphite support members mounted at spaced intervals in said entry and cooling chambers; graphite support members mounted at spaced intervals in the first half to two-thirds of said heating chamber; a rotatable metal roll journaled in self-aligning bearings mounted in said cooling chamber immediately adjacent the exit end of said heating chamber; means for heating the strip to annealing temperature in said heating chamber; and the strip being suspended in the last half to one-third of said heating chamber between one of said graphite support members and said metal roll.

4. In apparatus for continuously bright annealing light gauge stainless steel strip without scratching the strip, a furnace having a tubular metal retort muffle wall forming a heating chamber, baffle partition members within said metal retort wall at either end of said heating chamber provided with strip-passage slots, a tubular metal entrance vestibule wall connected with said muffle wall forming an entry chamber at the entry end of said furnace, a tubular metal cooling tunnel wall connected with said muffle wall forming a cooling chamber at the exit end of said furnace, said entry and cooling chambers being aligned with and communicating with said heating chamber through said baffle slots, said baffle members having heat insulating material therein, means for supplying an enveloping atmosphere devoid of oxygen under pressure to said chambers, means for passing stainless steel strip continuously into and through said aligned entry, heating and cooling chambers, strip support members mounted at spaced intervals in said entry and cooling chambers and in a portion of said heating chamber, a rotatable roll having trunnions journalled in self-aligning bearings in said cooling chamber immediately adjacent the baffle between said heating and cooling chambers, means for externally heating the muffle wall to heat the strip to annealing temperature in said heating chamber, the strip being suspended in the last half to one-third of said heating chamber between one of said strip support members and said rotatable roll, and the strip rotating said rotatable roll in passing thereover.

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