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HEAT TREATING METHOD AND APPARATUS

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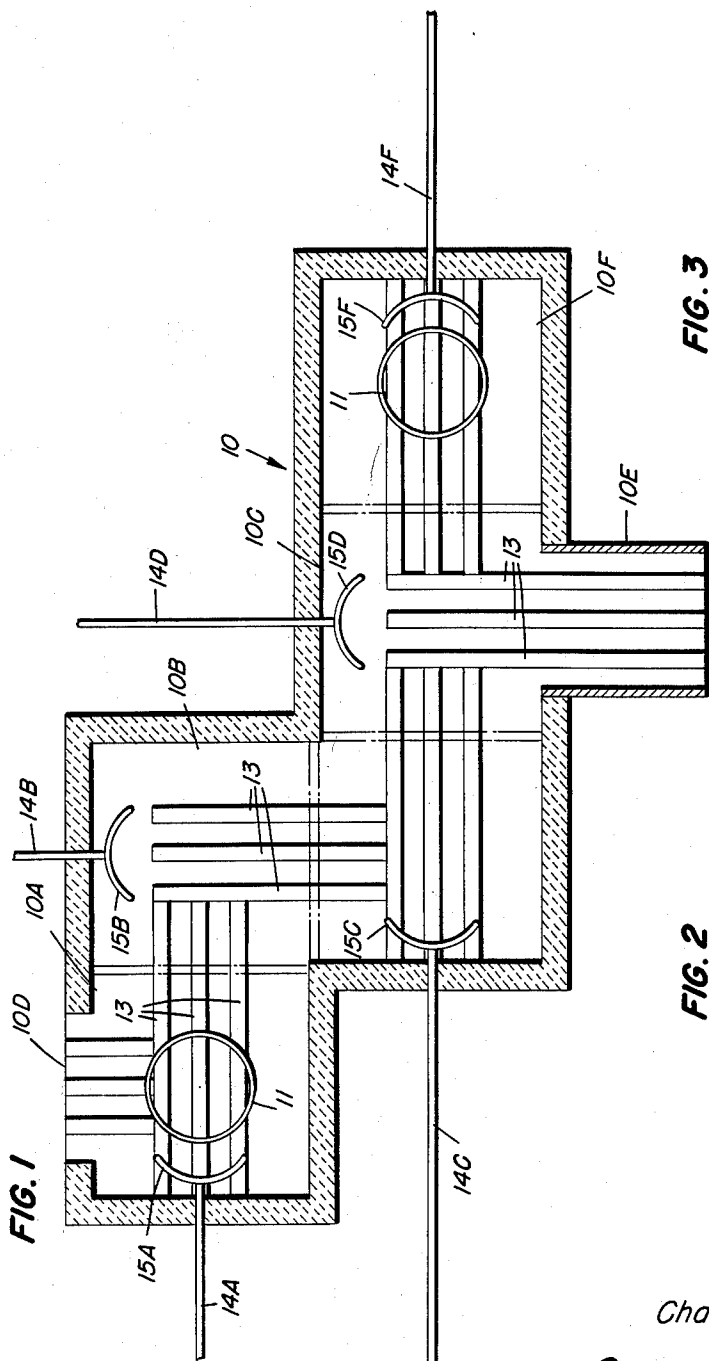


FIG. 1

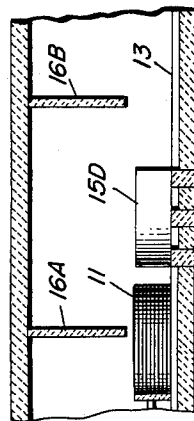


FIG. 3

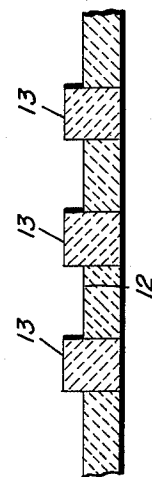


FIG. 2

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HEAT TREATING METHOD AND APPARATUS

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1 Claim. (Cl. 266—5)

My invention relates generally to the heat-treating of coils of wire, particularly stainless steel wire. More particularly, it concerns both the provision of a new furnace for annealing coils of wire of the type indicated, and the provision of a method for performing such annealing operation.

An object of my invention is to provide a furnace for annealing coils of metal wire, wherein the furnace is substantially sealed against the atmosphere during operation, in which loss of metal from the coils to scaling and oxidation are reduced to a minimum, and wherein the requisite linear passage of the individual coils along the length of the furnace is obtained with minimum application of force and this applied in comparatively gentle manner and against each individual coil, in the use of which furnace deformation of the coils is substantially eliminated with dimensions thereof retained substantially unchanged; and wherein, to accomplish the foregoing objectives, the coils are pushed through the furnace in the substantial absence of friction and independently of and without contact with each other.

Another object is to treat substantial quantities of wire in unit time, while in coiled form, without subjecting the coils to prolonged exposure to elevated temperatures, the same being accomplished by what essentially is a continuous method of operation, and without scratching, denting, bending or otherwise deforming the coils in handling the same.

A further object of my invention is to provide a method of operating a furnace of the general type described, which method itself is basically simple, directed and certain in operation, permitting ready modification of the furnace to adapt the same to precise thermal requirements for proper annealing of the particular grade of steel undergoing treatment and providing a finished product which, regardless of composition and physical size, admirably responds to specifications with requisite uniformity throughout each coil, and the heat-treated coils themselves retaining original coil dimensions and configurations, all without change in size of the wire.

Other objects and advantages will in part be obvious and in part more fully pointed out hereinafter during the course of the following description, particularly when taken in the light of the accompanying drawings.

From the foregoing, it may seem that my invention resides in the several parts, arrangement thereof, materials, elements, and features of construction; in the several procedural and manipulative steps; and in the relation of each of the same to and with one or more of the others, the scope of the application of all of which is more fully set forth in the claim at the end of this specification.

In the several views of the drawings, wherein I have disclosed that embodiment of my invention which I prefer at present:

Fig. 1 discloses a furnace in accordance with my invention, in schematic and top plan view;

Fig. 2 is a fragmentary transverse vertical section,

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showing details of the anti-friction floor forming part of my new furnace, and

Fig. 3 is a detached sectional elevation of the furnace of Fig. 1.

Like reference characters denote like parts in the two views.

To facilitate a more ready understanding of my invention, it may be noted at this point in the disclosure that the problem of heat-treating coils of wire has long presented considerable practical difficulty. For it is to be kept in mind that these coils of wire typically are about four feet in diameter. They are quite heavy, say in the neighborhood of 200 pounds in a typical instance. The continuous wire comprising these coils, following the working thereof which is necessarily incident to drawing to required size, displays qualities of high hardness and low ductility. Particularly is this true of those grades of stainless steel which are workhardenable. It therefore becomes necessary to heat-treat these coils; that is, to subject them to an annealing treatment to restore the essential ductility.

In earlier efforts to anneal coils of wire, two modes of treatment have largely been resorted to. One of these, a batch treatment, provides for simultaneous treatment of a large number of coils at one time. The second accepted mode is a so-called continuous treatment.

In the first or batch treatment a number of coils are placed together on a rack. This rack, thus loaded, is thereupon passed through the large furnace. In the so-called continuous treatment, the wire is unwound from the coil and is passed, as a single strand, through a small furnace. A number of highly practical difficulties, serious in nature, attend each of these recognized prior art practices.

Illustratively, with the so-called batch process there is required a furnace of substantial diameter and hence substantial cost of operation. In addition the coils must be maintained within the furnace over a long period of time, this to insure that all parts of the several coils on the carrying rack are brought to requisite temperature of treatment for required interval of time. Thus, the surface of the coils is subjected to high temperature oxidation of prolonged duration. Scaling losses are emphasized and important in nature. While a large number of coils may be handled in a single operation, the initial investment in plant and cost of operating the same are substantial. And refractory losses are considerable.

On the other hand, where a continuous wire of single strand is treated, the metal is raised to elevated temperature and is maintained there for a much shorter period of time. Thus, oxidation losses and scaling losses are both reduced. Important practical disadvantage exists, however, in that production is necessarily low because only a small quantity of wire can be passed through the furnace at any one time. Additionally, with so-called continuous process, only wire of small size can be treated. For where the wire is $\frac{3}{8}$'s of an inch or more in diameter it cannot be readily uncoiled and rewound. Hence, the continuous process is particularly unsatisfactory and unsuitable in the treatment of larger wire sizes.

Efforts have been made in the past to avoid in some measure, the known disadvantages attending the recognized practices. Thus, some use has been made of an elongated furnace having a slot in the roof thereof through which a series of hooks project into the furnace. The hooks ride along a track which is disposed exteriorly of and above the furnace, the hooks extending through the slot in the roof thereof and serving to support coils of wire for treatment.

Experience has demonstrated conclusively, however, that this semi-continuous method is not fully satisfactory. This is largely because the coils, which have already

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been stated to be of considerable weight, tend to drop or become out of round under prolonged heat-treating. Additionally, the supports or hooks get hot and tend to burn out, i.e. become oxidized. This is particularly true of those parts of the hooks which come into contact with the air, exteriorly of the controlled atmosphere of the furnace; that is, just outside the slot in the roof. Additionally, the hook portions of the supports themselves tend to droop, contributing to the loss of roundness of the coil.

Another method heretofore employed comprises loading the coils onto a series of trays. The trays, thus loaded, are then passed through the furnace in a semi-continuous process, one tray serving to push another to effect passage through the furnace. It is apparent, however, that this practice is not entirely satisfactory in actual use, since the trays soften under high temperatures to which they are subjected. And while the trays are in this softened condition, the heavy forces necessary to push the whole series of trays through the furnace are sufficient to buckle the individual trays, jamming them and giving rise to unreliable operation.

For one reason or another, therefore, the methods and apparatus heretofore suggested in the prior art have proven unsatisfactory from a practical standpoint in the proper handling of coils of metal wire during annealing treatment. Either the suggested practices have proved too costly, or they have failed to display requisite reliability in operation, or they have failed to produce end products which properly retain their initial configuration and dimensions. Losses to scaling both in dimension and in material have assumed detrimental importance. Either unit production is smaller, or furnace size is large and hence costly. In many instances, substantial damage is observed to furnace refractory.

An important object of my invention, therefore, is to avoid in substantial measure the many disadvantages and defects heretofore confronting the art, and at the same time to produce both a furnace for and a method of heat-treating coils of wire whereby, with minimum investment and with certain and predictable results, the wire coils are effectively heat-treated, all with satisfactory rate of production, with faithful conformity to original dimensioning and geometry of the wire coils and of the component wire itself, and with the substantial absence of detrimental scaling or oxidation of the wire product and without appreciable loss of furnace refractory.

In the practice of my invention I provide an elongated furnace which is closed against the atmosphere save only at its entrance and exit. These portals to the furnace are sealed against the atmosphere. The furnace provides a labyrinthal path therein, along the length of which the wire coils are moved. Preferably, this path is of zig-zag configuration. In the presently preferred embodiment each section or leg of the zig-zag construction is disposed at approximately right angles to its adjacent sections or leg portions. Thus alternate leg portions are disclosed in substantially parallel but offset arrangement to each other.

In accordance with my invention, conveniently located pushers serve to push the separate coils independently of each other along the furnace floor. These pushers project from the exterior into the furnace, in sealed relation thereto, thus effectively precluding the admission of air into the furnace. Preferably but not necessarily, each pusher is provided in an end wall of its related zig-zag section and sweeps along the furnace floor in linear path along the length of its related section. And in operation, each coil is swept laterally and from the side of a furnace section, at the inlet end thereof and into the path of the pusher. This occurs at the termination of the stroke of the pusher disposed immediately upstream in the furnace. The pushers operate on the individual coils.

Preferably, one pusher is provided for each section or leg portion of the zig-zag furnace arrangement. Thus,

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operating against an individual coil, one pusher shoves the coil along the floor of the furnace and at the end of its stroke this pusher passes the coil, into the field of control of the pusher of the next successive downstream station in the direction of work flow through the furnace. This second station also comprises one section of leg portion of the zig-zag furnace. And preferably it is at right angles to the first-mentioned station. In the second station the related pusher contacts and operates against the coil which has been introduced into its path. It shoves the coil along the length of this second station. At the terminal end thereof it ejects this coil into the next subsequent station and into the path of its related pusher. Here this third pusher operates against the coil, progressing the latter along the length of the furnace, in direction substantially parallel, but in laterally offset relation, to the direction of movement of the first mentioned pusher.

It is to be noted that typically, the pushers are operated by a rack and pinion mechanism. Where desired, an electric motor operates the pinion for reciprocal linear movement of the rack. Similarly, a crank mechanism is employed where desired. As has been stated, a quick return mechanism preferably is provided. These rack-operated pushers serve to shove the coil through the furnace, and then return quickly to receive and push another coil therethrough. Where desired, these pushers may be operated hydraulically, to that end employing a hydraulic piston and plunger. In certain instances, the pusher may be operated through pneumatic means. It is apparent that the precise means of operating this pusher do not in themselves form a part of my invention, as heretofore stated. Accordingly, these details are omitted in the following detailed description, for clarity and emphasis of disclosure.

To facilitate operation of my apparatus and method and to permit the exertion of minimum forces on the coils by the pushers, I form the floor of the furnace of a suitable anti-friction material. Such material may comprise a complete floor. Alternatively raised rails formed of anti-friction material may be provided on the floor, the coils sliding along these rails. I find Carbofrax to be a suitable refractory for this purpose. This material presents requisite smooth surface, retaining this over long periods of use. Other suitable refractories may be employed with satisfactory results, provided only the characteristics be displayed of retained smooth surface in the presence of prolonged high temperature operations.

Upon consideration, it becomes apparent that staged pusher action is desirable, in timed sequence. Thus each coil is subjected to successive impulses in successive regions of the furnace, along its staggered or labyrinthal path therethrough. At the exit of the furnace, and at its final stage, the coil is ejected therefrom, generally into a quenching vat. Alternatively, where additional prolonged heat treatment is required, the coil is pushed into a lateral or side compartment, for soaking, and then back into the main zig-zag path for ejection.

Having reference now and more particularly to the disclosure of the several views of the drawings, it will be seen that the elongated furnace, indicated generally at 10, is divided into a number of operating stations 10A, 10B and 10C. These operating stations are disposed in zig-zag arrangement with respect to each other, with adjacent stations or leg portions at approximately right angles to each other. The entrance to furnace 10 is indicated generally at 10D, while the exit therefrom is indicated generally at 10E, from whence the coils are ejected to a quenching vat or the like, not shown. The furnace, typically having an internal height of approximately 3½ feet, is formed of suitable material having requisite refractory lining.

Rails of Carbofrax, raised above the surface of the furnace floor 12, extend along the length thereof, and are indicated generally at 13 in the two figures of the draw-

ing. Carbofrax retains its smooth anti-friction qualities over long periods of heavy duty service at elevated temperatures, particularly when operating in a non-oxidizing atmosphere.

When coil 11, one of which is shown in Fig. 1, is introduced at entrance 10D of the furnace 10, the related pusher 14A which passes through the side wall of the furnace in a suitable manner and in sealed relation to the exterior is brought into reciprocating motion through suitable impelling means heretofore briefly alluded to. As shown, pusher 14A terminates its working end in an arcuate head 15A which is concave towards the related coil 11, the head 15A being of radius complementary to that of coil 11. Pusher 14A contacts the coil on one side thereof and impels it along the rails 13. This carries coil 11 through the first station or leg portion 10A of the zig-zag furnace 10, and into the path of control of the next related pusher 14B.

In the second station 10B coil 11 is impelled through contact thereagainst of head 15B of pusher 14B in direction along the length of the furnace section 10B. Movement along the length of furnace section 10B is generally at right angles to the direction of the movement which occurs in furnace section 10A.

From section 10B coil 11 is moved into the zone of control within the furnace section 10C of the related pusher 14C with its arcuate head 15C. This pusher serves to push the coil 11 through the furnace section 10C in a path which is generally parallel but offset relation with respect to direction of travel in the initial furnace section 10A. Coil 11 is thereby carried into the zone of influence of the pusher 14D. This latter serves to discharge the coil through the furnace exit 10E, such movement being generally at right angles to the direction of the movement of the coil through furnace section 10C and in generally parallel but offset relation to the movement of the coil through furnace section 10B.

It is noted that the quantum of force required to be exerted upon each coil 11 is just sufficient to permit ready, gentle and uniform movement thereof along the anti-friction flooring. Even at the elevated temperatures at which the furnace operates the force required to move the coil through the furnace is not sufficient to create any appreciable distortion in the coil itself. This is so, despite the softening of the coil which necessarily attends high temperature annealing operation.

It is to be recalled, as briefly mentioned at an earlier point herein, that the pushers are so timed in their operation that when the pusher 14A has completed its working stroke and has brought coil 11 into the path of the second pusher 14B, this latter has just begun its working stroke. It serves to bring the coil 11 into the field of control of the third pusher 14C. It is at this moment that pusher 14C starts through its cycle. The same is true of the final or discharge pusher 14D, which ejects the coil 11 to the exterior of the furnace, through exit portal 10E.

In the practical operation of my furnace, as for example in the annealing of different grades of stainless steel wire wherein a coil of one grade may require an additional annealing time, I find it desirable to provide, at some convenient location along the length thereof, a laterally disposed holding or soaking furnace section, indicated generally at 10F. Preferably, but not necessarily, I dispose this holding section 10F towards the exit portal 10E of the furnace. I choose this location so that the coil may be brought to full annealing temperature before the holding operation is undertaken. In Fig. 1, I disclose this holding section 10F as a continuation of the furnace section 10C.

To carry the coil 11 into section 10F from section 10C, I provide the pusher 14C with extra elongated shaft portion so as to permit a single stroke of increased length. Where desired, however, I may employ a second pusher having a stroke greater than that of pusher 14C, for

carrying the coil 11 into the holding station or furnace section 10F.

Upon conclusion of the soaking or holding of coil 11 in the furnace section 10F, this coil is returned into ejection position in furnace section 10C by impeller or pusher 14F, with its characteristic arcuate head 15F. Thereupon impeller 14D serves to eject the coil 10 into exit portal 10E.

While of course my invention has application to the heat-treatment of coils of all compositions, I evolved my invention with particular application to the heat-treatment of the well-known chromium-nickel stainless steels. Usually, the materials undergoing treatment within my new furnace at any one operation or run, are coils of the same composition. Typically, these may be the 18-8 chromium-nickel grade of stainless steel, in which case the temperature of treatment is maintained at from about 2050° F. The coils are caused to follow each other sequentially through the furnace.

It is worthy of note that where the coils are formed of heavy wire, say $\frac{3}{8}$'s of an inch or more in diameter, I find it desirable to maintain the temperature in the first stage or section of the furnace somewhat higher than in the final section. This temperature increase is particularly desirable in the treatment of heavy wire in order to bring the steel to the annealing temperature as promptly as possible.

In a three-stage process, as illustratively disclosed in Figs. 1 and 2, the first stage is maintained at a high temperature of about 2500° F. for the treatment of the 18-8 chromium-nickel grade, the second stage at a temperature of about 2300° F., and the third stage at a temperature in the neighborhood of 2100° F. Where another material is being treated, for example stainless steel of the 25-20 chromium-nickel grade, higher annealing temperatures may be required, in which case the third stage is operated at a temperature of say 2300° F. Of course the temperatures of the several stages of the furnace are closely adjusted according to the analysis of the wire undergoing treatment. And it may be stated as a general rule, that the higher the alloy content of the wire product, the higher the annealing temperature that is required.

The furnace of my invention, preferably is divided into several temperature zones and I prefer to operate the first zone, i.e., the zone nearest the entrance portal of the furnace, at the highest temperature, the next zone at intermediate temperature, and the zone nearest the exit at the lowest temperature. When these several zones are provided in the furnace, thin dividing walls depend vertically from the top of the furnace on the interior thereof, extending to a point just short of where the coils pass therebeneath. In this manner, the heat is retained within each furnace zone with substantial thermal isolation between contiguous zones, so that proper operating temperature is maintained within each furnace section. Such depending walls are shown at 16A and 16B in Fig. 3. This construction facilitates holding the temperatures in the several zones at say, the temperatures heretofore referred to, namely, 2500°, 2300° and 2100° F., respectively, for the three zones.

Thus it will be seen that I provide a method and apparatus in which the various objects hereinbefore set forth are successfully achieved. In the practice of the method according to my invention the individual coils are pushed in zig-zag path along the furnace floor, without dragging or abrasion on the floor. Requisite anti-friction qualities are imparted to the floor through the use of the Carbofrax blocks.

While I illustrate a furnace of three heating stages, it will be understood that the furnace may have 4, 5, 6 or, in fact, any number of stages. Unlike the prior art where the length of furnace is limited by the length of conveyor chain or by the buckling of conveying trays under the stress necessary to push an array of trays through a furnace, there is no limitation on the length of

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furnace of my invention because the coils being treated are handled individually.

And, it is not required of any coil that it push or pull another coil. Thus minimum forces are employed and all likelihood of distortion of coils while they are in relatively softened condition is brought to a minimum. It is also a matter of practical importance that in the practice of my invention the coils lie flat on the floor of the furnace. Because of this, the coils are substantially free of all tendency to droop or sag while passing through the furnace at elevated temperatures. Since no coil contacts another during the passage through the furnace, there is uniform distribution of heat at all times, and no tendency is exhibited towards localized overheating.

The zig-zag furnace of my invention with its tortuous path provided thereby permits individual handling of coils with requisite heat-treatment in rapid manner, all without detrimental change in wire size or dimensions or geometry of the coils themselves. Scaling and oxidation is maintained at a minimum with damage to the furnace itself kept to a minimum. Substantial unit volume is made possible, all with minimum investment in size, cost and operation of the furnace.

The mode of operating my furnace is direct and certain in its results. Close control exists at all times. Coils are properly annealed, without change in shape or dimensions, wire size remains unchanged, little scaling or oxidation is observed. Refractory loss or damage is low. The total quantity of heat required during furnace operation is maintained within comparatively low limits, all with high capacity per thermal unit. The detrimental and unpredictable heating such as is evident where trays are employed, serving as secondary sources of heat application and with localized overheating is avoided.

While I preferably operate the furnace of my invention to give continuous passage therethrough of a series of coils, I find certain advantages in arresting the operation and giving prolonged heating (soaking) as from 2 to 20 hours at 1000° to 1800° F. for some of the straight chromium grades of stainless steel and the resuming operation of the pushing mechanism to discharge the coils one after another.

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It is apparent from the foregoing that, once the broad aspects of my invention are disclosed, many modifications of the disclosed embodiment will readily suggest themselves to those skilled in the art, also many embodiments of the general idea, all falling within the scope of my disclosure. Accordingly, I intend the foregoing description to be considered as merely illustrative and not as comprising limitations.

I claim as my invention:

- 10 An annealing furnace for the treatment of the chromium-nickel and straight chromium grades of stainless steel, comprising an elongated furnace shell of labyrinthal and tortuous configuration along its length, and having a work entrance portal end and a work exit portal end, said shell being divided along its length into separate heat-treating zones; means for heating said heat-treating zones to required temperature; means sealed to the exterior, for separately pushing the work to be annealed through each said zone; at least one further compartment disposed laterally of said furnace shell and connected into the labyrinthal path at a point intermediate the length of said shell and providing a high temperature holding chamber for receiving work product requiring prolonged heat-treatment; and means sealed to the exterior for pushing said work into said further compartment for treatment and pushing the same out of said compartment and back into said labyrinthal path after treatment for discharge at the exit portal of said furnace shell.

References Cited in the file of this patent

UNITED STATES PATENTS

704,286	Allis -----	July 8, 1902
1,776,823	Summey -----	Sept. 30, 1930
2,223,603	Darrah -----	Dec. 3, 1940
2,845,260	Rusciano -----	July 29, 1958

OTHER REFERENCES

- 40 The Book of Stainless Steels, 2nd edition, by E. E. Thum, published by The American Society for Metals, Cleveland, Ohio, January 1935, pages 117-119 and 163, 164.