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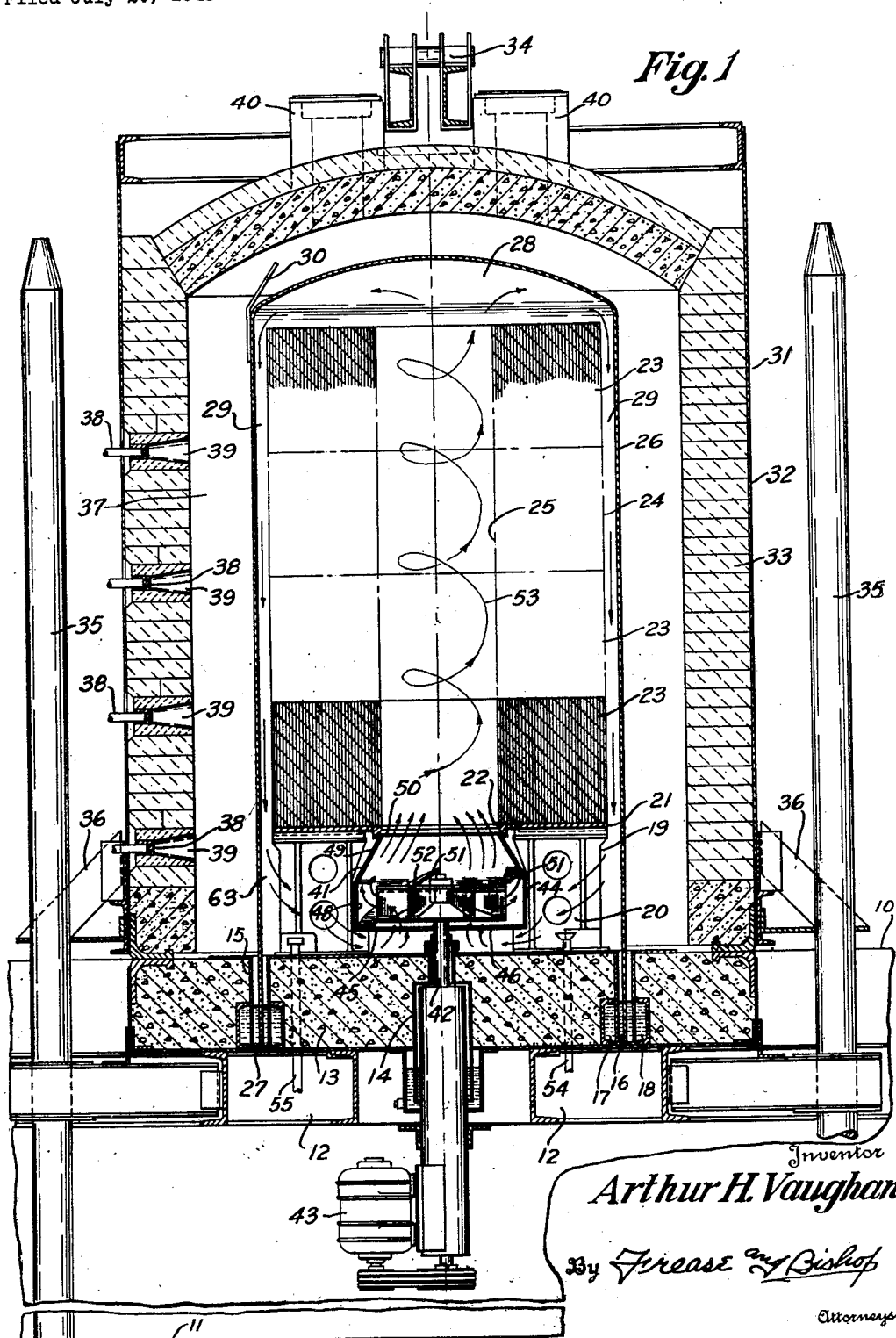
A. H. VAUGHAN

2,463,222

HEAT-TREATING APPARATUS

Filed July 20, 1943

2 Sheets-Sheet 1



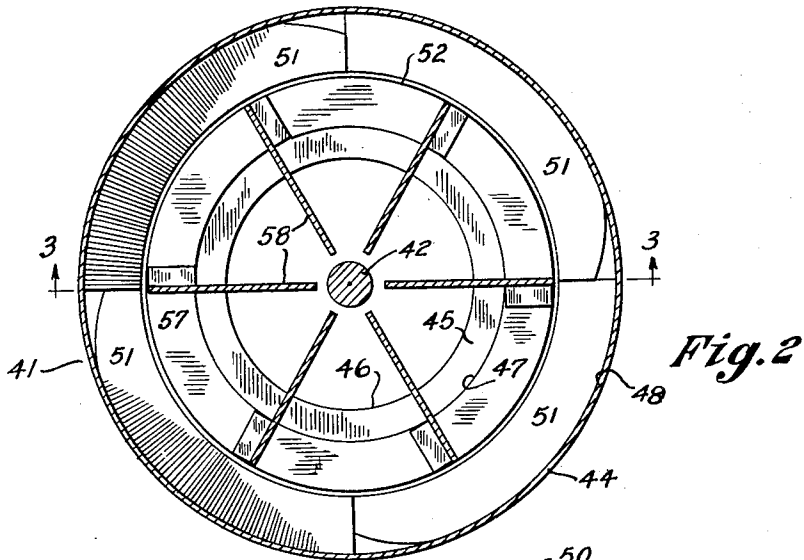
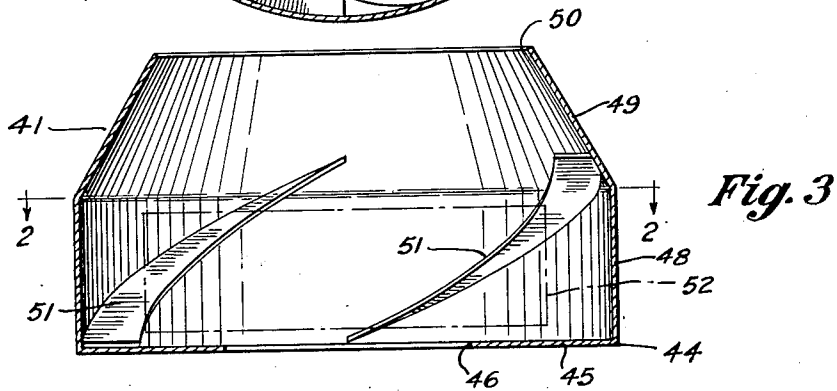
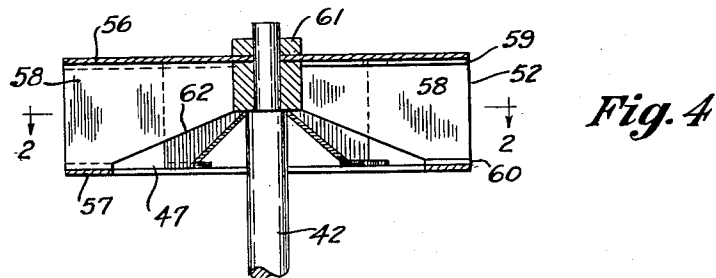
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2 Sheets-Sheet 2



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HEAT-TREATING APPARATUS

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4 Claims. (Cl. 263—40)

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The invention relates generally to heat treating apparatus and more particularly to a furnace known in the art as a bell type furnace. This type of furnace is used extensively for annealing coils of cold rolled strip steel of various widths, gauges and weights.

In the present practice of making cold rolled strips and stripsheets continuously in extremely long coils by initial hot rolling and further cold rolling to extremely thin gauges, it is necessary to anneal the cold rolled material between cold rolling operations, or after finish rolling, and it is preferable to anneal the material in coils and it is also preferable to maintain a special or controlled atmosphere about the coiled material during the annealing operation in order to prevent oxidation or discoloration which would require pickling.

Moreover, in order to obtain a uniform product, it is essential that the desired annealing cycle be precisely carried out with uniform time and temperature conditions so as to obtain uniformity in the annealed product.

A bell type furnace from many standpoints has proven extremely satisfactory for carrying out such a heat treating operation, and such a furnace consists essentially in a base including a work support, upon which the material to be treated is stacked, a removable inner cover and a removable outer refractory lined bell or furnace proper.

In such a furnace, the coils are placed on the work support, edge on edge, so as to form a cylindrical stack of work, over which the inner cover, usually formed of light plate material, is disposed, so that a special or controlled atmosphere may be maintained within the cover and around the material to be treated, if desired.

The furnace bell is formed of a metal shell enclosing refractory walls through which fuel burners extend to heat the interior of the furnace, and this furnace is adapted to be removably disposed over the inner cover.

Unfortunately, there are some inherent disadvantages in this type of furnace such as the normal tendency to be hotter at the upper region than at the lower region; and the location of the relatively large cold mass of the base and the work support, which mass must necessarily be heated and which is subject to heat loss from the bottom during any heating operation.

These factors combine with others to effect a much more rapid and higher heating of the upper region of the work space than of the lower region thereof. Thus, in such a furnace the material may not be uniformly heated, and if the material is heated for a sufficient length of time to bring the lower region of the charge up to the required temperature for the required length of time, the material in the upper region of the

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charge may be heated to too high a temperature, or may be heated at a high temperature for too long a time.

Circulating fans have been used for circulating the gases within the inner hood in an attempt to overcome these difficulties, but this has not solved the problem because the only available place or location for such a fan is at the bottom of the furnace with the fan impeller beneath or within the work support, in order that the fan shaft may extend through the base to a place where the bearings and motive power for the fan shaft may be maintained cool enough for proper operation. It is obviously impossible to locate a fan impeller and a motor for the fan, which can be maintained cool, at the upper end of the removable cover within the removable furnace bell and at the same time provide for removal of the inner cover and furnace bell.

Unfortunately, there are only two general types of fans available, namely, a propeller type fan and a centrifugal type fan. The propeller type fan has the desirable characteristics of being reversible and of normally discharging the gases moved thereby, axially of the fan impeller. However, propeller type fans in smaller diameters, or in the regions thereof near the fan hub are ineffectual and are not capable of producing sufficient useful pressure within the space and fan location limitations of a bell type furnace.

A centrifugal type fan has the desirable characteristic of producing useful pressures at relatively low speeds; but also has the undesirable characteristic of discharging the gases moved thereby, radially of the fan impeller. Thus, with the fan location limitation of a bell type furnace, a centrifugal fan causes the gases to circulate outward at the bottom of the charge, upward within the inner cover around the charge, across the top of the charge and downward through the core of the charge to the fan intake.

This characteristic, however, tends to increase rather than to decrease the non-uniformity of heating of the charge, because the circulating gases become hotter as they move up along the outside of the charge within the inner cover, until they are hottest at the top region of the cover, and they become cooler as they pass down the center or core of the charge until they are coolest at the intake of the fan.

A propeller type fan would normally move the gases in the opposite or desired direction, but in order to attempt to approach the performance of a centrifugal fan, a propeller type fan must be operated at a much higher speed, requiring much greater shaft strength and size, and a consequent greater bearing capacity for the fan shaft. These factors manifoldly increase the problem of keeping the fan shaft and driving means cool; and in

any event, a propeller type fan cannot be effectually operated to produce the necessary pressures required.

I have discovered that these difficulties may be overcome and the problem solved by using a centrifugal type fan in which the fan intake is located on the bottom side of the fan, and in which the centrifugal impeller is located within and surrounded by a housing preferably having an inwardly flaring conical discharge opening arranged within the work support with the said discharge opening located substantially at and in register with the central opening or core of the charge of material being treated, at the bottom thereof.

The function of the fan housing is to turn the moving gases discharged under pressure from the centrifugal impeller from a radially moving direction into an axially moving direction so as to approach the directional discharge characteristic of the propeller type fan.

Moreover, it is preferable to provide the fan casing or hood with vanes or louvers so as to impart a swirling longitudinal motion to the gases discharged under pressure from the fan casing, because it is known that the heat transfer from heated gases moving in a swirling or spiral or helical path in a bell type furnace is much more efficient than from gases moving in a unidirectional path.

By these means, the gases being circulated within the inner cover will become hotter and hotter as they move downward along the outside of the charge of material being treated within the inner cover until they reach the bottom of the inner cover, where they are hottest just as they move to the fan intake. Thus, the gases are hottest as they are discharged from the fan and fan casing, and as they move upwardly in a swirling path they become cooler by giving up their heat to the material to be treated until they become coolest as they reach the top of the inner cover where they again commence to become heated.

This arrangement therefore supplies the most heat where the charge of material is hardest to heat, namely at the bottom inner region of the charge; and supplies the least heat to the material where the material is easiest to heat, namely at the top of the charge. As a result, in actual operation, the new arrangement provides for very uniform heating throughout the entire charge of material being heated, with maximum temperature variations throughout the entire coil stack of only about 25 degrees Fahrenheit.

Moreover, actual operation of the new arrangement has decreased the time in which an annealing cycle can be carried out with satisfactory accuracy and uniform heating by as much as 25 per cent.

It is therefore an object of the present invention to provide a forced circulation bell type heat treating furnace in which the material being treated may be uniformly heated throughout its mass during the heat treating cycle.

It is a further object of the present invention to provide a forced circulation bell type furnace with a centrifugal fan construction which discharges the gases moved thereby under pressure in a swirling longitudinal direction generally axially of the fan impeller.

It is also an object of the present invention to provide a forced circulation bell type furnace with a centrifugal fan construction located at the bottom of the work chamber, which circulates

gases moved thereby under pressure upward along the core or center of the work chamber, outward at the top of the work chamber, downward at the periphery of the work chamber, and inward at the bottom of the work chamber.

It is also an object of the present invention to provide a forced circulation bell type furnace with a centrifugal fan and housing construction which discharges gases with swirling longitudinal motion under pressure axially of the fan impeller.

Also it is an object of the present invention to provide a bell type furnace with a centrifugal fan construction, which circulates gases within the work chamber thereof to uniformly heat coiled strip material placed to form a cylindrical stack therein.

Moreover, it is an object of the present invention to materially reduce the time and materially increase the uniformity of heating for carrying out a heat treating, preferably annealing, cycle in a bell type heat treating furnace.

These and other objects may be obtained, the stated results achieved, and the described difficulties overcome by the devices, constructions, arrangements, combinations, parts, elements and apparatus which comprise the present invention, the nature of which is set forth in the following general statements, a preferred embodiment of which is set forth in the following description, and is shown in the drawings, and which are particularly and distinctly pointed out and set forth in the appended claims forming part hereof.

The nature of the improved apparatus of the present invention may be stated in general terms as preferably including in a bell type heat treating furnace, a base; a work support on the base; a dome-like or bell-like inner cover removably supported by the base, and enclosing the work support and the material to be treated carried thereby; means for sealing the joint between the inner cover and base; an outer refractory lined bell or furnace proper removably supported on the base surrounding the inner cover and forming a chamber between the furnace and inner cover; means for heating said chamber; a centrifugal impeller fan located within the inner cover above the base and below the material to be treated, a fan shaft for the impeller extending through the base, means for driving the fan shaft located at the other end thereof beyond the base, a fan casing surrounding the centrifugal impeller preferably provided with an inwardly conically flaring mouth forming a discharge opening located adjacent the bottom region of the material to be treated, and gas flow directing louvers arranged within the fan casing; the fan impeller, casing, and louvers being so constructed and arranged as to discharge gases moved by the fan under pressure in a swirling longitudinal direction generally axially of the fan.

By way of example, a preferred embodiment of the improved apparatus is illustrated in the accompanying drawings forming part hereof, in which

Figure 1 is an axial sectional view of a bell type heat treating furnace equipped with the present improvements;

Fig. 2 is a plan section view of the fan and casing shown in Fig. 1, taken on the line 2-2 of Figs. 3 and 4;

Fig. 3 is a section through the fan casing taken on the line 3-3, Fig. 2; and

Fig. 4 is a section through the fan impeller taken on the line 3-3, Fig. 2.

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

In Figure 1 the normal floor level is indicated at 10, which may be a grating over an under passage having a sub-floor level 11 serving a number of similar bell type furnaces, one of which is shown.

The desired or required number of structural members 12, tied together and to the foundation at either side of the under pass, form a support on which base 13 is mounted, which is preferably circular having a central opening 14 and a circular groove 15, sealed with oil indicated at 16, and water jacketed at 17 and 18.

A work support generally indicated at 19 is mounted on the base comprising any desired number of circumferentially spaced piers 20 having an annular top plate 21 provided with a central opening 22, upon which coils of strip material diagrammatically indicated at 23, are stacked, edge on edge, to form a cylindrical stack of work generally indicated at 24 having a central core or opening 25.

An inner cover 26 formed of heat resisting preferably plate metal, is removably telescoped over the work 24, with its lower edge 27 seated at the bottom of base groove 15 within the oil seal 16 so as to form a work chamber including an upper chamber 28 within the cover 26 above the work 24, and an outer annular chamber 29 around the work 24 within the cover 26. The cover is provided with usual eye members 30 for being engaged by a crane for placing or removing the cover.

An outer preferably circular furnace bell generally indicated at 31, is formed by a metal shell 32 and refractory walls 33. A top yoke 34 is provided for being engaged by a crane to place or remove the furnace bell in position on the base 13, as shown.

Centering posts 35 extending from the foundation, and guides 36 mounted on the furnace 31 are provided in the usual manner for centering and guiding the furnace 31 as it is placed in or removed from the position shown.

The furnace 31 when placed around inner cover 26 form a heating chamber 37, which may be heated in any desired or usual manner as by any desired or required number of circumferentially and vertically spaced fuel burners 38 firing into burner openings 39 in the furnace 31. Vents or flues 40 may be provided for the furnace.

A circulating fan including a centrifugal impeller 52 is generally indicated at 41, having a fan shaft 42 extending through the central opening 14 of the base to the bottom or underside of the base 13, where a drive motor 43 is mounted on the structural members 12, the shaft 42 being also mounted on bearings, not shown, supported by the structural members 12 below the base 13.

A fan casing 44, preferably mounted on support piers 20, surrounds the centrifugal impeller 52 and preferably comprises a bottom plate 45 having a central axial inlet opening 46 in register with the axial intake 47 of the centrifugal impeller 52; preferably cylindrical side walls 48 surrounding the periphery of the impeller 52 and an upper inwardly flaring conical portion 49 above the top of the impeller 52 forming a discharge opening 50 for the casing 44, which opening 50 is preferably in substantial register with the central opening 22 of work support top plate 21 and with the lower end of the core 25 of material being treated.

Directing vanes or louvers 51 are formed sur-

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rounding the impeller 52 within the fan casing 44, preferably along the cylindrical portion 48 thereof and along a part of the conical portion 49 for directing the gases moved or discharged by the centrifugal impeller 52. The louvers 51 are preferably arranged generally helically of the casing 44 so as to impart a combined longitudinal and swirling motion to the gases discharged under pressure from the casing opening 50, as indicated by the helical arrow 53 within the core 25 of the charge 24 of material being treated. The additional arrows shown on the drawings illustrate the circulation of gases within the inner cover 26 and around the material 24 being treated.

If it is desired to maintain a special or controlled atmosphere within the inner cover 26 and around the material 24 being treated, the same may be provided through one or more inlet pipes 54 and outlet pipes 55.

Referring to Figs. 2, 3 and 4, four directing vanes or louvers 51 are shown within the casing 44, but any desired number and shape of louvers may be provided for imparting a swirling and longitudinal motion to the gases discharged from the casing through the opening 50. The centrifugal impeller 52 may have any usual construction, as by being formed of a top plate 56, a bottom plate 57, and blades 58.

The blades 58 may be provided with angle members 59 and 60 at the top and bottom for being welded respectively to the top and bottom plates 56 and 57; and the impeller 52 may be mounted in any desired manner on the hub 61 secured to fan shaft 42. The blades 58 are cut away at 62 at their bottom inner regions to form the intake of the impeller; the location of the impeller being indicated in dot-dash lines in Fig. 3, with respect to the casing 44.

As shown in the drawings, the circulating fan 41 is located at the only possible location for the same in a bell type furnace, namely, at the bottom of the furnace, so that the shaft thereof may be extended through the base to the exterior for mounting the motor and the shaft bearings under temperature conditions which will permit proper operation.

Also, as shown in the drawings, the fan casing 44 is preferably mounted within the confines of the work support; it being understood that the particular structure of the work support shown is not necessary, but may be varied so long as sufficient passages are available to permit the gases to pass to the intake of the fan at the underside thereof, from the chamber 29 formed around the material being treated within the cover 26; and to permit the gases moved by the fan to be discharged under pressure axially of the centrifugal fan impeller 52.

In operation, the desired number of coils of strip material are placed on work support 19. The cover 26 is then placed over the work, as shown. The furnace 31 is then telescoped over the inner cover 26. The desired special atmosphere is introduced into the chamber within the inner cover 26 and the burners 38 are turned on to commence the heating cycle. The centrifugal circulating fan 41 is also started.

The heating operation will proceed until the desired temperature is reached, which may be around 1400° F. for annealing cold rolled strip steel. As the heating progresses, the circulating fan 41 discharges gas under pressure in a swirling longitudinal path axially of the core 25 of the material being treated, where heat is given up

from the gases progressively from the bottom to the top of the charge of material 23; and the gases then circulate across the top in chamber 28, as shown by the arrows, then down the outside of the material along annular chamber 29. In passing down annular chamber 29, the gases are heated by contact with the cover 26 from the heat supplied to the furnace chamber by burners 38, so that the circulated gases are hottest at the region 63 as they pass in and around the piers 19 of the work support and to the intake 47 of the fan.

Normally, the material being treated is hardest to heat at the bottom region thereof, and particularly at the bottom region adjacent the core of the mass; and this difficulty is increased by the heat which is carried away from the material to be treated, per se, by the mass of the base 13, which has poor insulating characteristics, and which must also be heated and dissipates heat during the heating operation.

However, the improved arrangement provides the hottest circulating gases at the places or regions where the most heat is required, so that the heating operation progresses by uniformly heating the charge of material 23 throughout its mass until the desired annealing temperature is reached. Thereafter the material may be cooled in any desired or usual manner, ordinarily by removing the furnace bell and operating the circulating fan while the inner cover is still in place.

Actual tests have shown that the temperature variation, during heating, throughout the entire mass of material being heated with the present improvements is never greater than about 25° to 30° F., and is usually much less; and because of this uniformity of heating, the time within which a heating cycle can be carried out with satisfactory accuracy is reduced as much as 25 per cent.

The ultimate result is that a very uniformly annealed product is obtained and the holding of part of the charge at annealing temperature for too long a time in order to bring the remainder of the charge up to temperature, which is objectionable, is avoided.

The embodiment of the present improvements illustrated and described herein is by way of example, and the scope of the present invention is not limited to the exact details of construction of the various parts. Moreover, the invention is not limited to apparatus for heat treating strip steel in coiled form, although it is specially adapted for that purpose, because it is clear that materials to be heat treated other than strip steel in coil form, may be satisfactorily and uniformly heat treated by using the improved apparatus.

When the term "strip" is used herein and in the appended claims, that term is intended to include strips, strip-sheets and the like, or other material to be heat treated.

Having now described the features of the invention, the construction, operation and use of a preferred embodiment thereof, and the advantageous new results attained by the improved construction; the new and useful parts, elements, combinations, constructions and devices, and reasonable mechanical equivalents thereof obvious to those skilled in the art, are set forth in the appended claims.

I claim:

1. In a bell-type heat treating furnace having a vertical work chamber provided with a base; annular work support means in the chamber including a top plate provided with a central opening and spaced piers mounted on the base

and supporting the top plate; a centrifugal circulating fan impeller located in said chamber above the base and below said top plate having a top member, a bottom member having a central axial intake opening, and blades between said members; a vertical impeller shaft mounting the impeller extending through said base axially of said openings; a fan casing surrounding said impeller mounted within the confines of the support means including a bottom plate spaced above said base, and side walls terminating in an upper outlet opening registering with the top plate opening; said casing bottom plate having a central axial inlet opening registering with the intake opening of the impeller; and said casing side walls deflecting gases received radially from the impeller and discharging the same into the chamber through said outlet and top plate openings and receiving at its inlet opening gases circulated downwardly around the outer periphery of said top plate.

2. In a bell-type heat treating furnace having a vertical work chamber provided with a base; annular work support means in the chamber including a top plate provided with a central opening and spaced piers mounted on the base and supporting the top plate; a centrifugal circulating fan impeller located in said chamber above the base and below said top plate having a top member, a bottom member having a central axial intake opening, and blades between said members; a vertical impeller shaft mounting the impeller extending through said base axially of said openings; a fan casing surrounding said impeller mounted within the confines of the support means including a bottom plate spaced above said base, and side walls terminating in an upper outlet opening registering with the top plate opening; said casing bottom plate having a central axial inlet opening registering with the intake opening of the impeller; and said casing side walls deflecting gases received radially from the impeller and discharging the same into the chamber through said outlet and top plate openings and receiving at its inlet opening gases circulated downwardly around the outer periphery of said top plate; and means projecting inward of said casing side walls for imparting a swirling axial motion to the gases discharged through said outlet and top plate openings.

3. In a bell-type heat treating furnace having a vertical work chamber provided with a base; annular work support means in the chamber including a top plate provided with a central opening and spaced piers mounted on the base and supporting the top plate; a centrifugal circulating fan impeller located in said chamber above the base and below said top plate having a top member, a bottom member having a central axial intake opening, and blades between said members; a vertical impeller shaft mounting the impeller extending through said base axially of said openings; a fan casing surrounding said impeller mounted within the confines of the support means including a bottom plate spaced above said base, and side walls terminating in an upper outlet opening registering with the top plate opening; said casing bottom plate having a central axial inlet opening registering with the intake opening of the impeller; and said casing side walls deflecting gases received radially from the impeller and discharging the same into the chamber through said outlet and top plate openings and receiving at its inlet opening gases circulated downwardly around the outer periphery

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of said top plate; and helical vanes projecting inward of said casing side walls for imparting a swirling axial motion to the gases discharged through said outlet and top plate openings.

4. In a bell-type heat treating furnace having a vertical work chamber provided with a base; annular work support means in the chamber including a top plate provided with a central opening and spaced pliers mounted on the base and supporting the top plate; a centrifugal circulating fan impeller located in said chamber above the base and below said top plate having a top member, a bottom member having a central axial intake opening, and blades between said members; a vertical impeller shaft mounting the impeller extending through said base axially of said openings; a fan casing surrounding said impeller mounted within the confines of the support means including a bottom plate spaced above said base, and side walls having an inwardly extending conical portion above the impeller terminating in an upper outlet opening registering with the top plate opening; said casing bottom plate having a central axial inlet opening registering with the intake opening of the impeller; and said casing side walls deflecting gases received radially from the impeller and discharg-

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ing the same into the chamber through said outlet and top plate openings and receiving at its inlet opening gases circulated downwardly around the outer periphery of said top plate; and helical vanes projecting inward of said casing side walls for imparting a swirling axial motion to the gases discharged through said outlet and top plate openings.

ARTHUR H. VAUGHAN.

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