

July 14, 1964

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3,140,743

HEAT TREATING APPARATUS

Filed Feb. 1, 1963

3 Sheets-Sheet 1

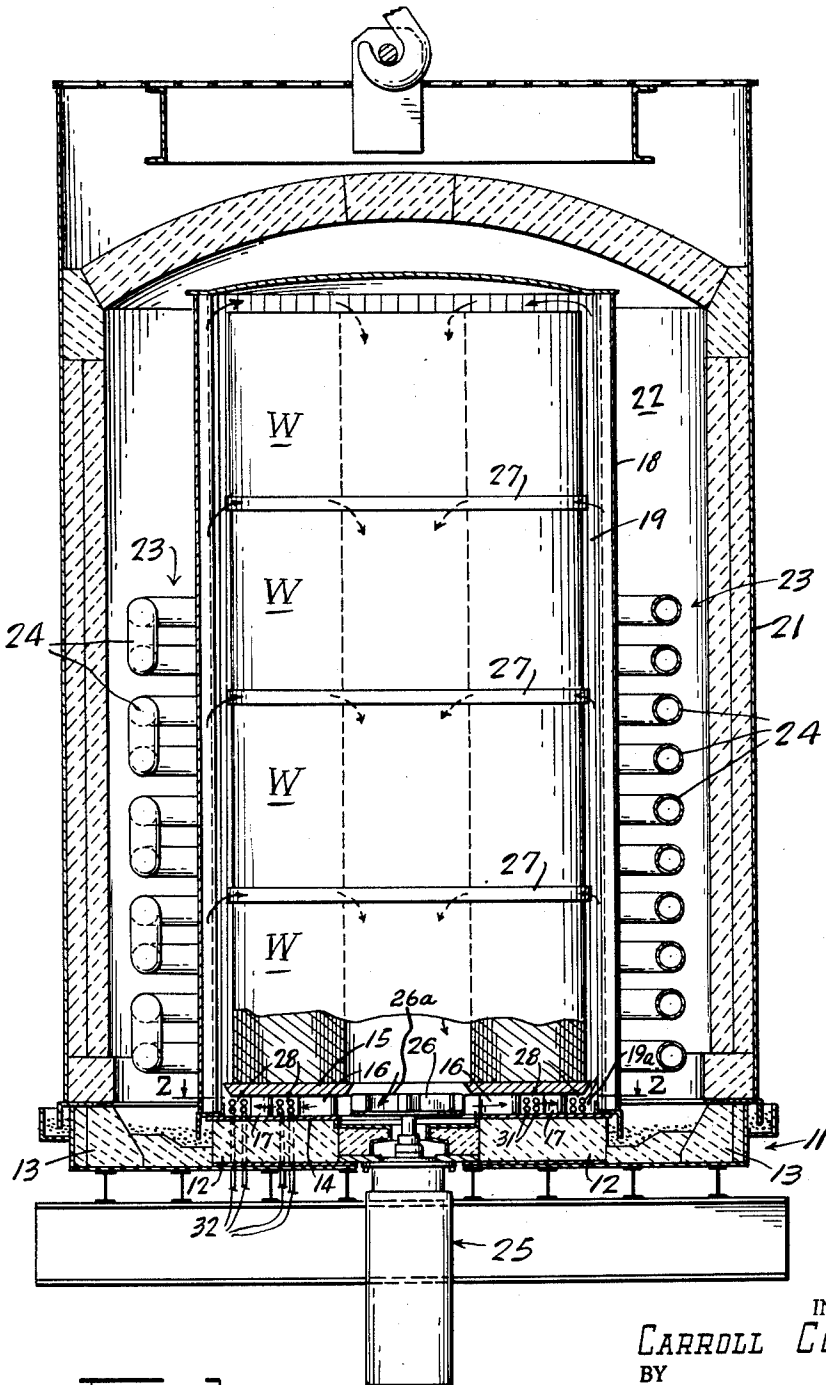


FIG-1-

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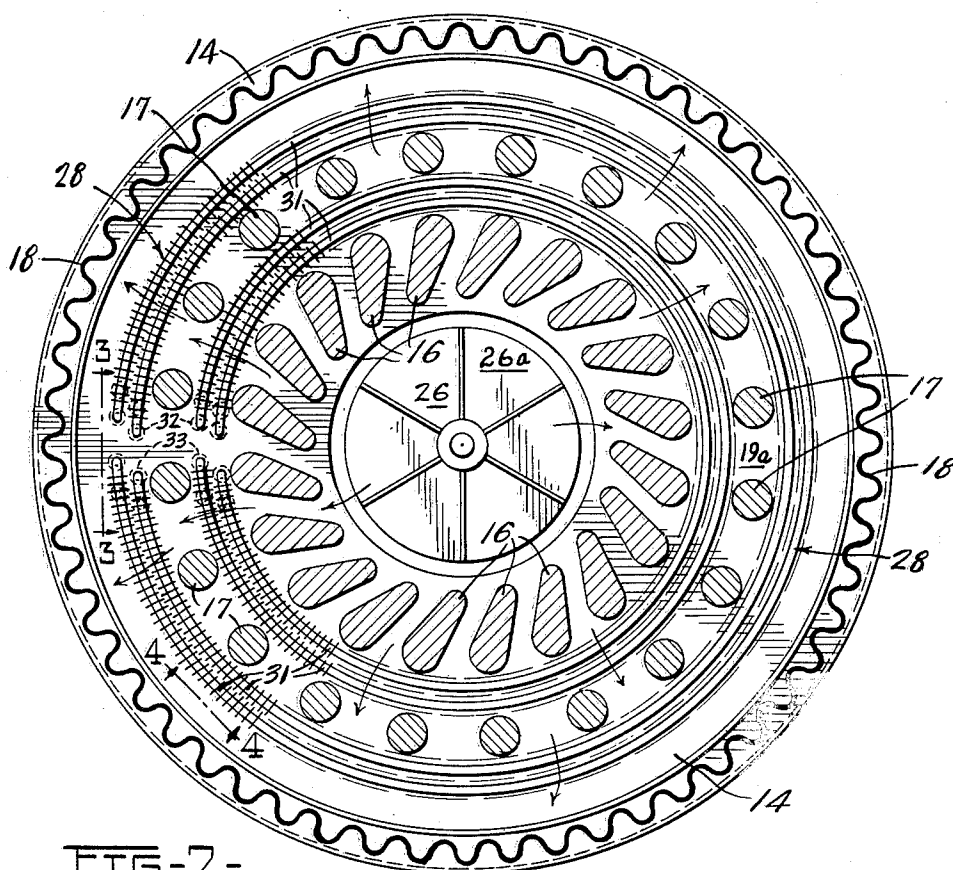


FIG-2-

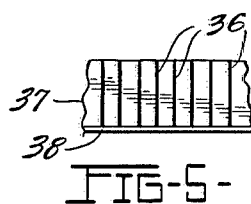


FIG-5-

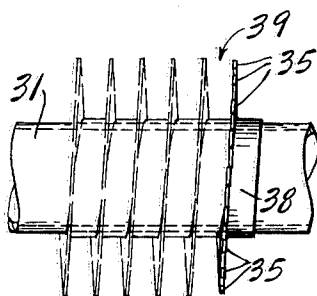


FIG-4-

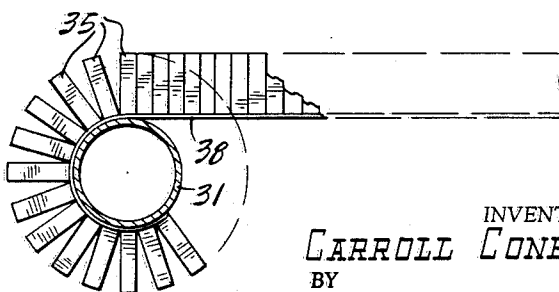


FIG-6-

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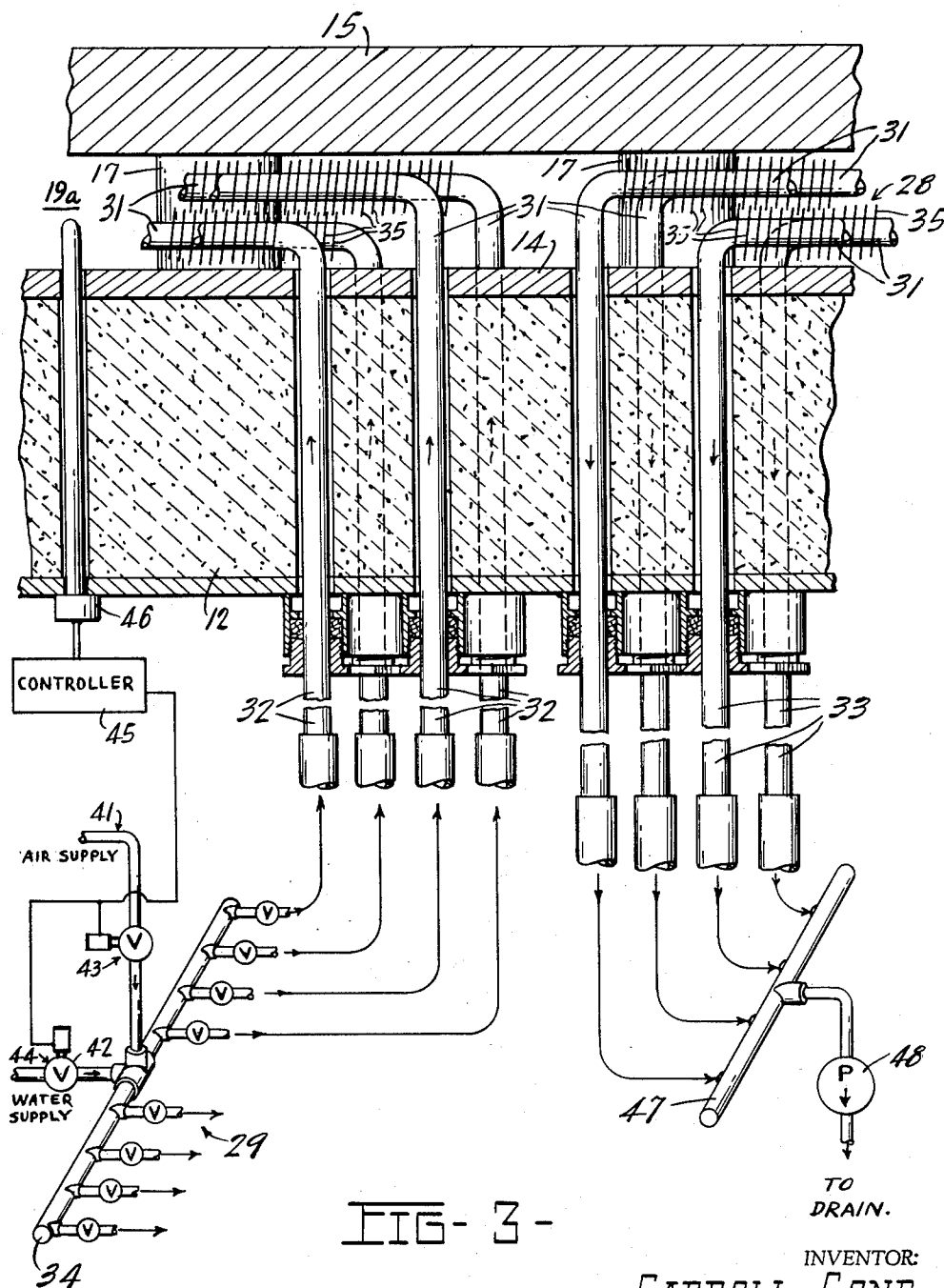
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3 Sheets-Sheet 3



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3,140,743

HEAT TREATING APPARATUS

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7 Claims. (Cl. 165—61)

This invention relates to an improvement in batch-type heat treating furnaces of the type adapted to sequentially heat and cool the work being treated. More particularly, the invention relates to means for more rapidly cooling the work during the cooling phase of the heat treating cycle. The invention is particularly applicable in bell-type furnaces which are used to heat treat one or more vertical stacks of annular coils of sheet metal.

In my U.S. Patent 2,600,094 there is described a bell-type furnace for heat treating one or more stacks of annular coils of sheet metal. According to the teachings of this patent, the coils are stacked upon a base, and an inner cover is superimposed over the stack of coils. Heat is transferred to the coils, indirectly by way of the inner cover, from a heating cover which is superimposed over the inner cover during the heating and soaking portions of the cycle. The coils are thence cooled by removing the heating cover thereby allowing for heat transfer, indirectly by way of the inner cover, from the coils to the surroundings by way of radiation and convection. The inherent slowness of this cooling process, which, illustratively, may require a period of time of the order of 50 hours for a stack of steel coils, acts as a limiting factor on the processing capacity of each installation. Prior artisans have recognized that this limitation exists and have devised a number of special cooling techniques in an attempt to reduce the cooling portion of such a cycle. However, for various practical reasons, none of these cooling techniques has gained widespread acceptance.

It is, therefore, an object of this invention to provide improved means for cooling work in batch-type furnaces. It is a further object of the invention to provide a heat exchanger of a satisfactory design to give good service life under the conditions prevalent in the treating chamber of a batch-type heat treating chamber.

For a further understanding of the invention attention is directed to the following portion of the specification, the drawing, and the appended claims.

In the drawing:

FIG. 1 is a vertical sectional view of a heat-treating furnace, of otherwise conventional design, which incorporates the present invention;

FIG. 2 is a plan sectional view taken on line 2—2 of FIG. 1;

FIG. 3 is a sectional view taken on line 3—3 of FIG. 2;

FIG. 4 is a fragmentary sectional view taken on line 4—4 of FIG. 3;

FIG. 5 is a fragmentary frontal view of a strip of finning prior to being assembled into the heat exchanger of FIG. 4;

FIG. 6 is a view showing a step in the process of assembling the ribbon of finning of FIG. 5 into the heat exchanger of FIG. 4.

Turning now to FIG. 1, the furnace illustrated there comprises a base, illustrated generally at 11, which, in turn, comprises an inner base 12 and an outer base 13. Inner base 12 is provided with a lower base plate 14 and an upper base plate 15, which is disposed somewhat above lower base plate 14. Upper base plate 15 is supported above lower base plate 14 by means of supports comprising an inner ring of generally tear-drop shaped supports 16 and an outer ring of cylindrical-shaped supports 17. Disposed upon upper base plate 15 in a vertical stack are a number of annular coils of sheet metal W.

An inner cover 18 is disposed over inner base 12, as

in the manner explained in my U.S. Patent 2,854,226, and forms, therewith, a treating chamber 19 encompassing coils W. During the heating and soaking portions of the heat treating cycle inner cover 18 is encompassed by a refractory lined outer cover, which is placed upon outer base 13, and which forms a heating chamber 22 with inner cover 21 and outer base 13. Heat is added to heating chamber 22 by heating means 23 carried by outer cover 21. For purposes of illustration heating means 23 are shown as hairpin type tubes 24 disposed on a horizontal arc. Tubes 24 are of the type which are customarily internally fuel fired. It may also be noted that heat may be added to heating chamber 22 by means, such as direct fired burners, located in outer base 13. This construction is shown in U.S. Patent 3,024,015 to Huebler et al.

Due to the fact that inner cover 18 is in place over the stack of coils W during all of the heating cycle and all, or virtually all, of the cooling cycle, it is important to attain very high rates of heat transfer between inner cover 18 and coils W. A substantial improvement in heat transfer rates over those theretofore prevalent can be obtained by providing high rates of atmosphere recirculation within treating chamber 19 in the manner described in my aforementioned U.S. Patent 2,600,094. Consequently, a furnace according to the preferred form of the invention is provided with fan means 25 comprising an impeller 26 extending upwardly through inner base 12 into treating chamber 19. Bladed portion 26a of impeller 26, illustrated as being of the radial flow type, is so positioned as to discharge atmosphere into the atmosphere circulating space 19a between lower base plate 14 and upper base plate 15. In such an arrangement tear-drop shaped supports 17, which are inclined slightly from a radial position, serve also as a flow diffuser of an efficient design for the flow of atmosphere from impeller 26. It is also to be noted that upper base plate 15 is provided with an internal aperture to re-admit spent atmosphere from the core of coils W to impeller 26. To obtain maximum benefit from the atmosphere recirculation provided by fan means 25 it is desirable to provide a convector plate 27 between each of successive coils W to allow for atmosphere flow past the ends of the coils. It is also frequently desirable to construct inner cover 18 with a corrugated wall.

Furnaces as thus far described have been very popular in recent years with producers of both ferrous and non-ferrous metals. However, it is now proposed to further improve the capabilities of such furnaces by incorporating heat exchanger means 28 within treating chamber 19 and by providing means 29, for passing coolant through heat exchanger means 28 during the cooling portion of the cooling cycle. With this construction it is possible to forcibly cool the recirculating atmosphere and thereby withdraw heat from the coils W at a rate considerably faster than that afforded only by convection and radiation from inner cover 18 when outer cover 21 is removed.

To provide satisfactory service life in the environment of the treating chamber of a coil annealing furnace heat exchanger means 28 must be protected from damage by the impact of coils W, or convector plates 27; it must be capable of withstanding repeated thermal cycling; and it be capable of operating under large temperature differences without developing high stress levels. To meet these objectives heat exchanger means is designed in the form of one or more individual arcuate externally finned tubes 31. Tubes 31 are protected from the impact of work coils W by placing them in the space intermediate upper base plate 15 and lower base plate 14, preferably in the recess intermediate inner row of supports 16 and outer row of supports 17. If it is desired to use more tubes 31 than be accommodated in this recess additional tubes 31 can be placed in the recess immediately external to outer

ring of supports 16. An additional advantage in locating tubes 31 intermediate the upper and lower base plates is that all of the atmosphere recirculated by impeller 26 passes therebetween during one portion of each recirculating cycle thereby insuring uniformity in the cooling of the atmosphere.

As is shown most clearly in FIG. 3, each of tubes 31 is provided with an inlet leg portion 32 and an outlet leg portion 33 which depends from tube 31 and pass outwardly from treating chamber 19 through inner base 12. The aforementioned means 29 for passing coolant through heat exchanger means 28 comprises a header 34 to which the inlet leg 32 of each tube 31 is connected. In the preferred embodiment, air supply means 41 and water supply means 42 comprising, respectively, flow control valves 43 and 44, are provided to selectively deliver air or water to heat exchanger 28. During the initial portion of the annealing cycle, from an annealing temperature of about 1300-1400° F., down to a predetermined intermediate temperature, say to about 800° F., the water supply to header 34 would be turned off and the air supply only would be turned on. Consequently, during this portion of the cooling cycle heat exchanger means 28 serves as an air-cooled heat exchanger and the danger of forming steam pockets inherent in the operation of a water-cooled heat exchanger at such temperatures is avoided. At such time when the predetermined intermediate temperature is reached the air supply to header 34 is turned off and the water supply is turned on. During this latter portion of the cooling cycle heat exchanger means 28 serves as a water cooled heat exchanger. This mode of operation can be accomplished automatically by providing a controller 45, sensitive to a condition indicative of temperature within treating chamber 19 as detected by a thermocouple 46 extending upwardly through inner base 12, and by providing valves sensitive to the control signal from controller 45 at 43 and 44. In such an arrangement valve 44 will be closed when the treating chamber temperature is above a predetermined value and valve 43 will be closed when the temperature is less than a predetermined value. It is to be noted that the predetermined temperature above which valve 44 is closed may, under certain circumstances, be greater than the predetermined temperature below which valve 43 is closed. This would be the case if means, not shown, were provided to pass a third cooling fluid, e.g., a mist of atomized water, through heat exchanger means during an intermediate portion of the cooling cycle.

In the operation of the foregoing apparatus it may be desired to maintain a subatmospheric pressure in heat exchanger means 28 to prevent the escape of coolant into the heating chamber in the event that a leak should develop in one of tubes 31. This may be accomplished by connecting the outlet leg 33 of each of tubes 31 to a header 47 and by connecting header 47 to the suction side of a pump of a type satisfactory to pump liquids, gases, and mixtures thereof.

As to the construction of heat exchanger means 28, per se, it is preferred that tubes 31 be externally finned to attain high rates of heat transfer from the atmosphere gas to the tubes. It is important that the type of finned tubing utilized in an annealing furnace application be capable of withstanding temperature differences up to 1000° F. or so across the fins without developing dangerously high stress levels. A design which has been found satisfactory from this standpoint comprises an axial series of sets of narrow fins 35 extending generally radially from heat exchanger tube 31 with the fins in a set being disposed in a generally circumferential pattern. According to this design there is no circumferential restraint on the outer tip of each of fins 35 and therefore no stress is imparted to the tube by virtue of a difference in temperature from the tips to the roots of the fins in a set.

A way which I have found satisfactory for manufacturing tubing finned in the foregoing manner, as is shown in

FIGS. 5 and 6, comprises making a series of parallel cuts 36 in one leg of an elongate ribbon of sheet metal angle 37. The depth of each cut is as nearly equal to the depth of the leg in which it is placed as can be attained without cutting the other leg 38 of the angle 37. When the angle 37 has been so cut its uncut leg 38 is continually tightly wrapped around the outside of tube 31 in the pattern of a helix. In this wrapping process the back edge of one revolution of uncut leg 38 preferably abuts against the front edge of the previous revolution. Thus, the width of the uncut leg 38, which is disposed axially of tube 31, when assembled, determines the angle of the helix formed by the individual fins 35 with respect to tube 31. As thus assembled, uncut leg 38 of angle 37 forms a sleeve 39, circumposing tube 31 and it is preferably secured thereto by spot welding or brazing. Due to the fact that there is no appreciable thermal stress at the roots of fins 35, as previously explained, sleeve 39 will remain tightly wound to tube 31 thereby maintaining good conductive heat transfer therebetween.

As will be evident to those skilled in the art, various modifications can be made to the illustrated embodiment of the invention without departing from the spirit or scope of the invention as claimed hereinafter.

I claim:

1. Heat treating apparatus comprising, in combination: a furnace base comprising a lower base plate and an apertured upper base plate spaced above the lower base plate and forming an atmosphere circulating space thereabove; an inner cover disposed over the base and forming a treating chamber therewith; a fan extending upwardly through the base into the chamber and having an impeller with a bladed portion generally axially aligned with the aperture of the upper base plate and generally horizontally aligned with said space for circulating atmosphere within the treating chamber in a circuit from the portion of the treating chamber above the upper base plate through the aperture to the atmosphere circulating space and thence generally radially outwardly through said space and back to said portion of the treating chamber; an outer cover removably circumposing the inner cover and forming a heating chamber therewith; heating means for adding heat to the heating chamber; generally horizontally disposed arcuate tubular heat exchanger means disposed within said atmosphere circulating space in a generally circular configuration surrounding the bladed portion of the impeller and generally concentrically therewith; and means for passing coolant through the heat exchanger means when the outer cover is removed.

2. Apparatus according to claim 1 and further comprising fin means external to the tubular heat exchanger means and in conductive heat transfer relationship therewith.

3. Apparatus according to claim 2 wherein the fin means comprises a plurality of individual fins attached to the tubular heat exchanger means and extending generally radially outwardly therefrom and arranged in sets disposed generally axially of the tubular heat exchanger means with the fins in each set being disposed generally circumferentially of the tubular heat exchanger means.

4. Apparatus according to claim 3 wherein the individual fins are disposed in a helix circumposing the tubular heat exchanger means.

5. Heat treating apparatus comprising, in combination: a furnace base comprising a lower base plate and a centrally apertured upper base plate spaced above the lower base plate and forming an atmosphere circulating space thereabove; an inner cover disposed over the base and forming a treating chamber therewith; a fan extending upwardly through the base into the chamber and having a radial flow impeller with a bladed portion generally axially aligned with the central aperture of the upper base plate and generally aligned with said space for circulating atmosphere within the treating chamber in a circuit from the treating chamber through the central

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aperture to the atmosphere circulating space and thence generally radially outwardly through said space and back to the treating chamber; an outer cover removably circumposing the inner cover and forming a heating chamber therewith; heating means for adding heat to the heating chamber; heat exchanger means comprising a generally horizontally disposed tube of generally circular configuration disposed within the space surrounding the bladed portion impeller and generally concentrically therewith; and means for passing coolant through the heat exchanger means when the outer cover is removed.

6. Heat treating apparatus comprising, in combination: a furnace base comprising a lower base plate and an upper base plate spaced above the lower base plate and forming an atmosphere circulating space thereabove; an inner cover disposed over the base and forming a treating chamber therewith; a fan extending upwardly through the base into the chamber and having an impeller with a bladed portion generally aligned with said space and adapted to circulate atmosphere within the treating chamber in a circuit comprising said atmosphere circulating space; an outer cover removably circumposing the inner cover and forming a heating chamber therewith; heating means for adding heat to the heating chamber; heat exchanger means comprising a generally horizontally disposed tube within said space; means for passing coolant

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through the heat exchanger when the outer cover is removed comprising means for passing a gas through the heat exchanger and means for passing a liquid through the heat exchanger; sensing means for sensing temperature within the treating chamber; and control means responsive to a signal from the sensing means for throttling the flow of liquid through the heat exchanger when the temperature is more than a predetermined value and for throttling the flow of gas when the temperature is less than a predetermined value.

7. Apparatus according to claim 5 and further comprising a plurality of individual fins attached to the tube in conductive heat transfer relationship, said fins extending generally radially outwardly from the tube and being disposed in a helix circumposing the tube.

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