

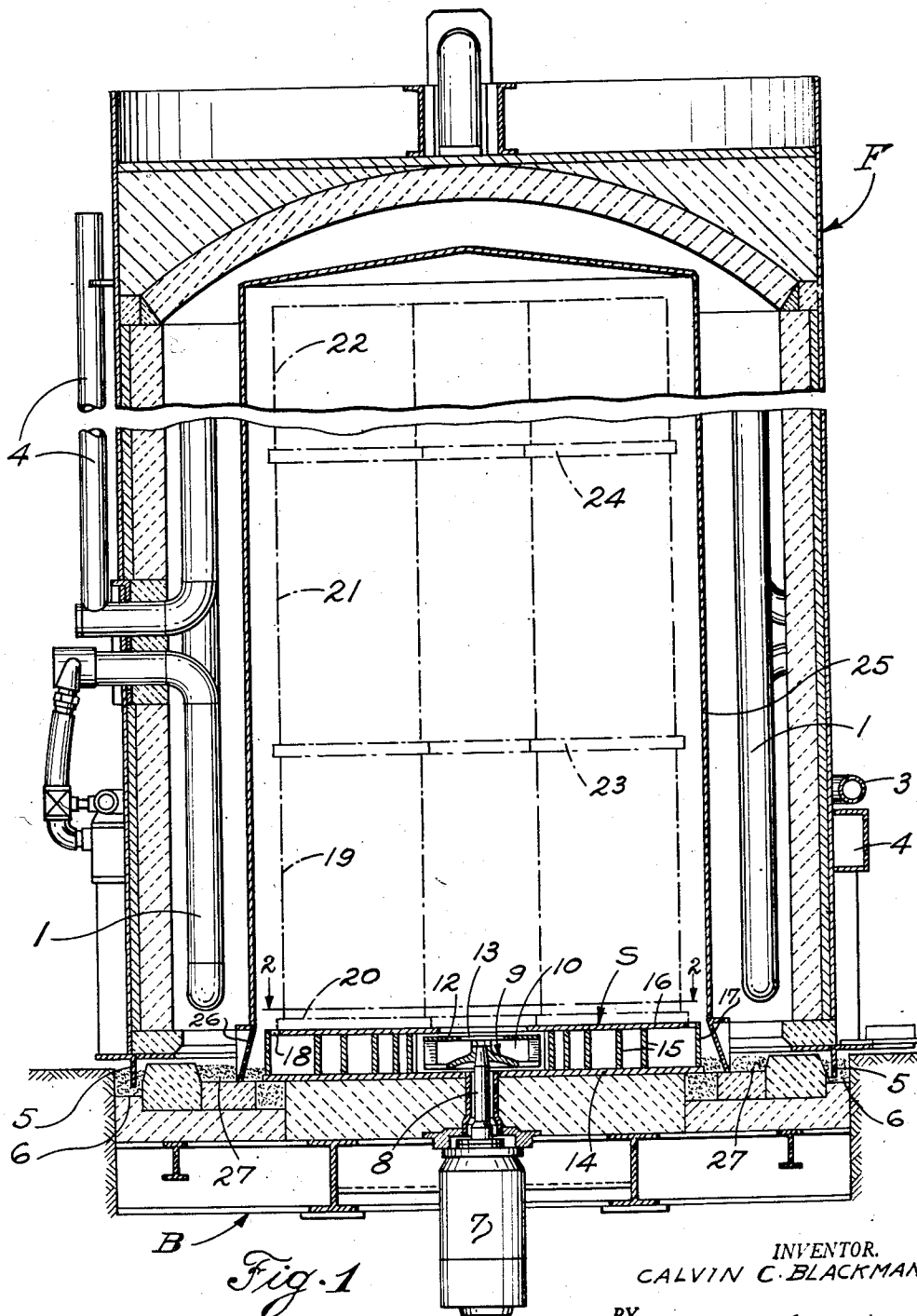
April 23, 1957

C. C. BLACKMAN
METHOD OF AND APPARATUS FOR CONTROLLING
CIRCULATION OF FURNACE ATMOSPHERE

2,789,808

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4 Sheets-Sheet 1



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4 Sheets-Sheet 2

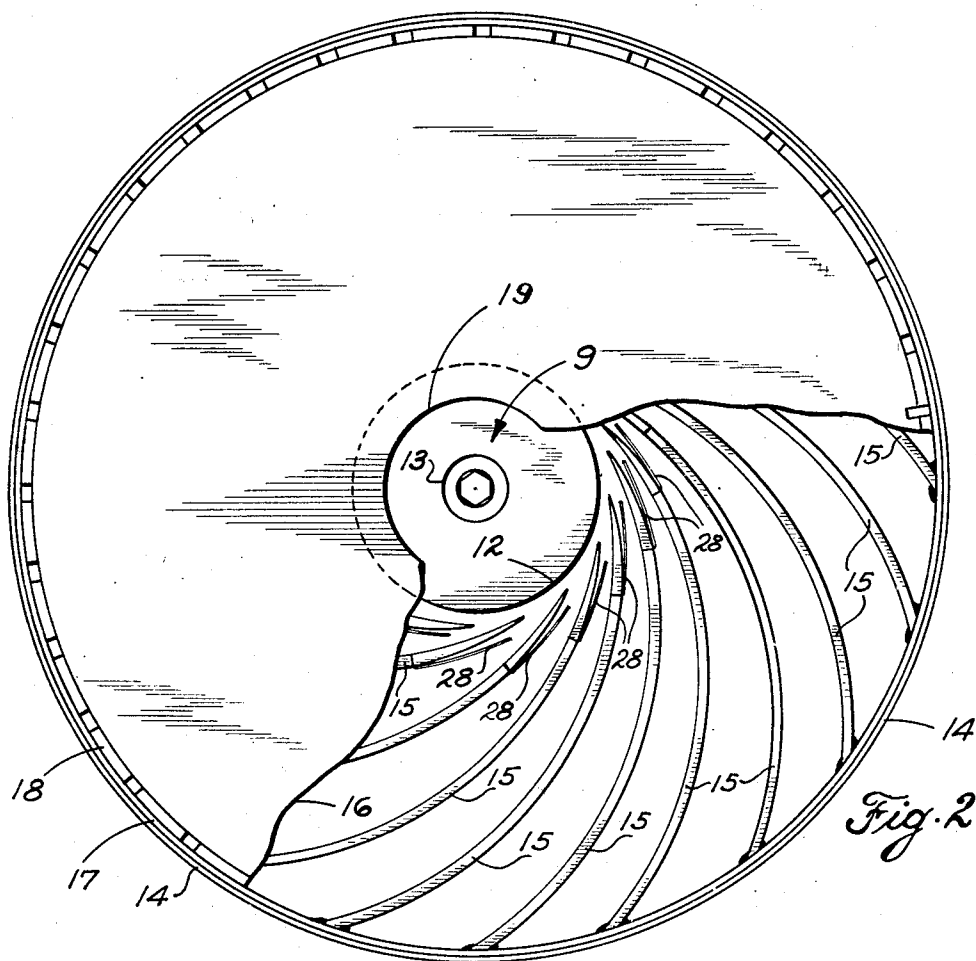


Fig. 2

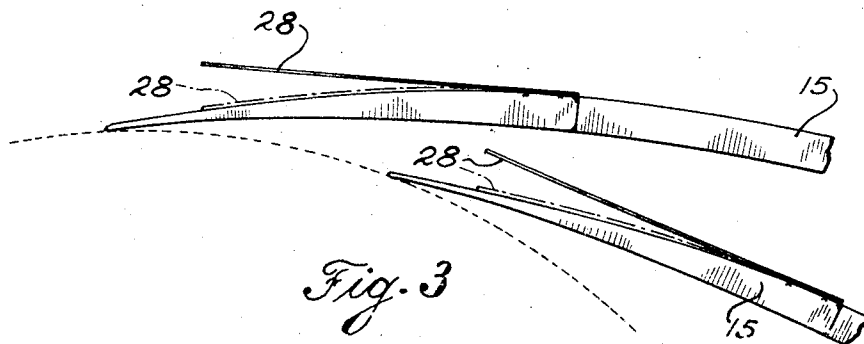


Fig. 3

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4 Sheets-Sheet 3

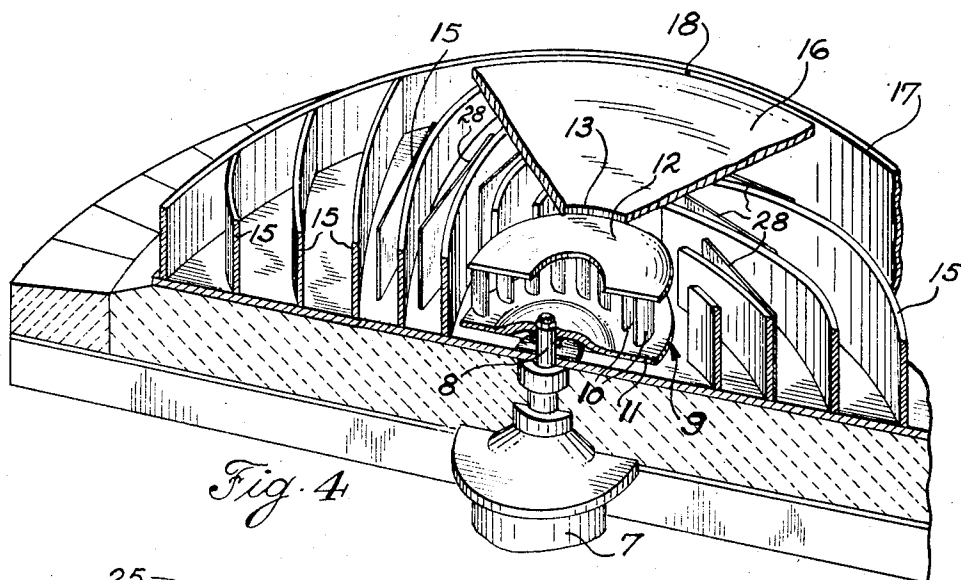


Fig. 4

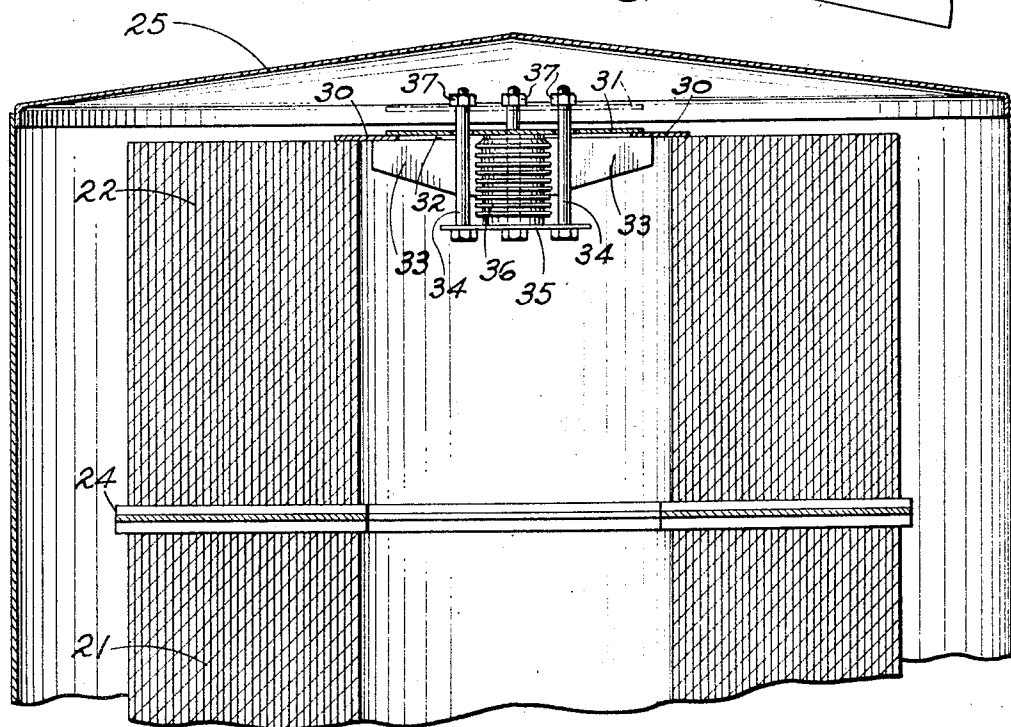


Fig. 5

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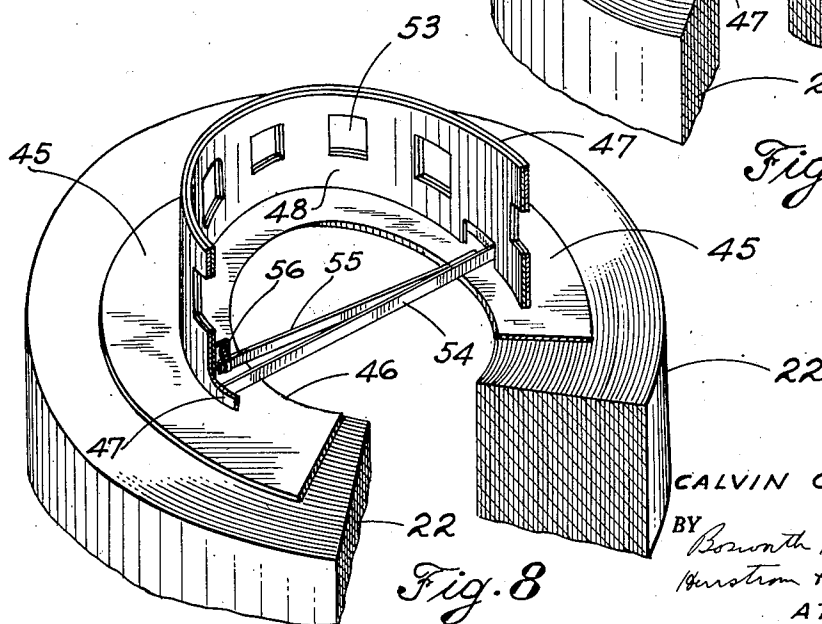
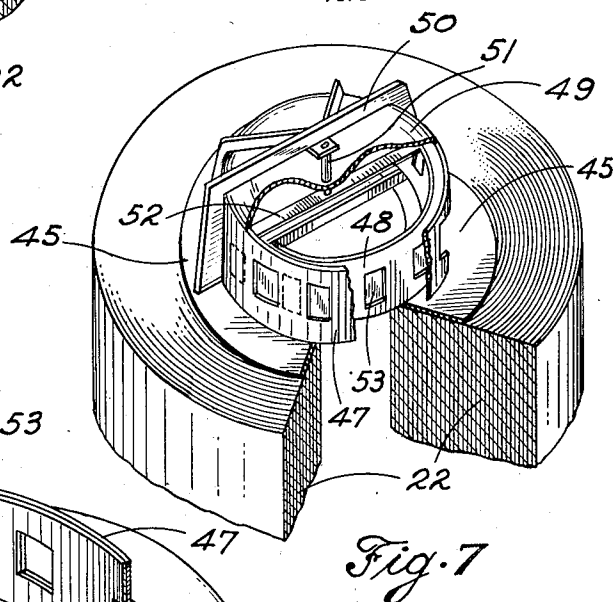
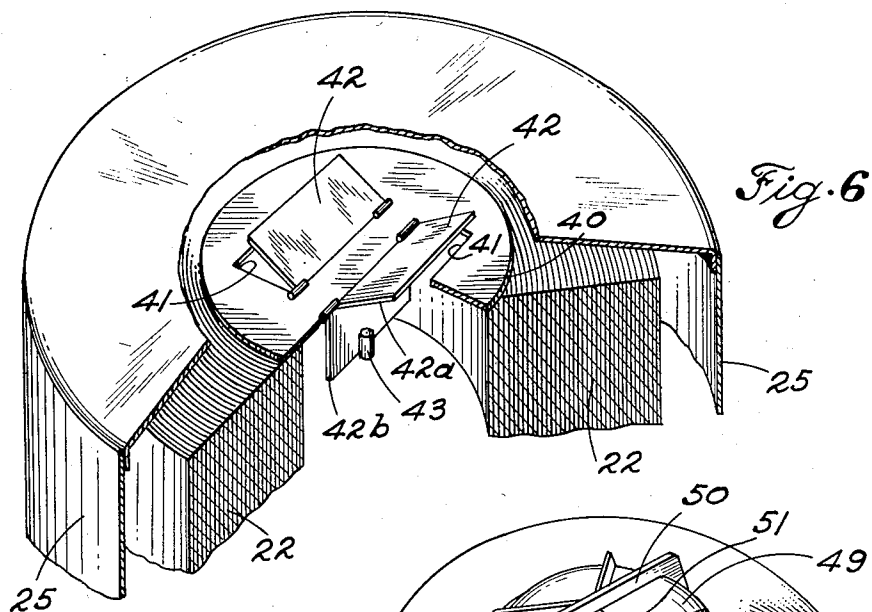
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4 Sheets-Sheet 4



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2,789,808

METHOD OF AND APPARATUS FOR CONTROLLING CIRCULATION OF FURNACE ATMOSPHERE

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18 Claims. (Cl. 263—40)

This invention relates to the heating of a charge in a furnace or the like and more particularly to heat treating of metals such as the annealing of steel, copper, copper alloys, aluminum, etc., in the form of coiled strip or wire.

In carrying out annealing or other heat treating operations on large coils of strip steel bell-type furnaces are commonly employed. In this procedure the coils are stacked one upon the other with spacers therebetween and the furnace bell placed over the stack and heated. Usually an inner cover is placed over the coils within the furnace bell and an atmosphere of non-oxidizing gas maintained within the inner cover. In order to improve the efficiency of the convection transfer of heat to the coils the atmosphere in the enclosure surrounding the coils may be circulated. Fans or blowers are commonly disposed in the furnace base to effect this circulation. Coils of strip of the non-ferrous metals are heat treated in the same manner, also coiled bundles of wire, disposed on a supporting structure. In some instances an inner cover is not required, the bell furnace being the sole container of the atmosphere surrounding the charge being heat treated. The charge may also be composed of a single stack of coils or single stand of wire or it may be composed of multiple stacks of coils or stands of wire.

In the normal operation of such a furnace the fan or blower is started when the furnace bell is placed in position and heat supplied thereto. When the furnace charge is cold and the furnace atmosphere is at a relatively low temperature and high density a certain amount of power is necessary to drive the fan motor at its rated speed. However, when the furnace atmosphere becomes heated to annealing temperature (for example 1200° F.) its density is materially reduced and, as the volume remains constant and the pressure of the atmosphere around the charge remains substantially atmospheric, the power required to drive the blower at its rated speed is very substantially lower than that required when the operation is started and the atmosphere is relatively dense at room temperature.

Prior to the present invention it has been necessary that the blower motor (assuming this motor to be of the constant speed type commonly used) have sufficient capacity to take care of the high power required during the initial warming up period of the heating cycle, although, during the annealing period which is normally considerably longer than the warming up period, the motor operates at only a fraction of its rated capacity. For example it might be necessary in the operation of this type of furnace, as commonly carried out prior to my invention, to install a 15 H. P. fan motor in order to furnish the power necessary to circulate the cold and relatively heavy or dense atmosphere at the start of the operation, although this 15 H. P. motor would need to deliver an output of only 7½ H. P. to effect the same rate of flow or circulation when the atmosphere is heated to annealing temperature and is relatively light.

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It is among the objects of my invention, therefore, to provide a method of and apparatus for controlling the circulation of atmosphere about a charge being heated whereby the fan or blower motor will operate at substantially its full rated power output both when the atmosphere being circulated is cold and heavy during the warm-up period and thereafter when the atmosphere is at high temperature and low density during the heating period.

Other objects of my invention include the provision of means for automatically limiting the load on, and output of, an atmosphere circulating blower motor to a value not greater than normal or rated value at low furnace atmosphere temperatures when the density is relatively high, and automatically permitting the blower motor to operate at substantially its normal or rated load and output at high temperature low density furnace atmosphere conditions; the provision of effective means for increasing the efficiency of a heating installation of the type described and reducing its first cost; and the provision of effective, rugged, and trouble-free means for controlling the output of an atmosphere circulating fan or blower automatically and in relation to the temperature of the atmosphere being circulated, whereby a relatively low rate of flow will be maintained at low temperatures and a relatively high rate at high temperatures.

The above and other objects of my invention will appear from the following description, reference being had to the accompanying drawings in which:

Figure 1 is a vertical cross-sectional view through a conventional bell-type annealing furnace for coils of strip steel having the usual motor driven fan or blower mounted in the base thereof for circulating the atmosphere within the inner cover.

Figure 2 is a fragmentary plan view, taken substantially on line 2—2 of Figure 1, illustrating the furnace base or charge support, a portion of the top plate thereof being broken away to show one form of apparatus for automatically controlling the output of the blower and the rate of circulation through the inner cover in accordance with the temperature of the atmosphere within the inner cover.

Figure 3 is an enlarged illustrative view of two adjacent vanes of the charge support shown in Figure 1 with the bi-metal control strips in their cold or full throttling positions.

Figure 4 is an illustrative fragmentary perspective view of the furnace base and circulation control means shown in Figures 2 and 3, the bi-metal elements being shown in cold or throttling positions.

Figure 5 is a vertical cross-sectional view of an inner cover and the upper coils in a furnace of the type shown in Figure 1 and showing another atmosphere circulation control device disposed on the top of the upper coil and covering the central opening therein, the device being seen in its cold or full-throttling position.

Figure 6 illustrates a modified form of device adapted to perform the same function and disposed in the same location as the device of Figure 5, the parts however being in their open or high temperature positions.

Figure 7 is a detached perspective view of the upper end of the top coil of a stack with still another form of circulation control apparatus disposed therein, the parts being shown in their cold or full-throttling positions.

Figure 8 is a view generally similar to Figure 7 and showing the same apparatus with certain elements omitted for clearness of illustration, the parts being seen in their high temperature or full-flow positions.

A typical bell type furnace for annealing coils of strip metal is illustrated in Figure 1. This includes the furnace bell F which is adapted to be positioned over the charge on the furnace base B. As illustrated, the furnace

bell F consists of a cylindrical, open bottomed structure which carries a series of combustion heating tubes 1 disposed around its inner wall. These tubes are suitably supplied with fuel and air from circular manifolds 3 and 4 respectively and the products of combustion are discharged through exhaust pipes 4. As is well understood, the bell B is provided with a downwardly projecting sealing flange at its lower edge which projects into a groove or trough 6 in the base B when the bell is in heating position. Sand or other suitable sealing material in the trough 6 provides a seal to prevent undesired entry of room atmosphere into the bell.

A charge support and diffuser unit, generally indicated at S, is carried by the base B which also supports the fan motor 7. The vertical shaft 8 of motor 7 extends upwardly through the base B and carries the fan or blower 9 at its upper end. This fan is of the usual centrifugal type having a plurality of blades or vanes 10, a bottom plate 11 and a top plate 12. An inlet opening 13 is formed in the top plate and when the fan is operating gas is drawn inwardly through the opening 13 and discharged outwardly from the periphery of the fan blades.

As is clearly seen in Figures 1 and 2, the charge support and diffuser S includes a base plate 14, a plurality of spirally extending diffuser vanes 15 and a top plate 16. An outer rim 17 extends around the support S at the outer ends of the vanes 15 and it will be seen from Figure 2 that the diameter of the top plate 16 is smaller than the inside diameter of the rim 17, thus providing an annular discharge aperture 18 for the gas which is forced outwardly through the diffuser vanes 15 by the fan 9. A central opening 19 in the top plate 16 is provided to permit gas to enter the fan 9.

The coils to be heat treated are illustrated in phantom lines in Figure 1. Three coils are shown, the bottom coil 19 being supported on the top plate 16 of the charge support S and a spacer or convector 20 being preferably interposed between the bottom of coil 19 and the plate 16. Coils 21 and 22 are superimposed on coil 19 and are spaced from the adjacent coils by convectors or separators which are indicated at 23 and 24. These separators may take any desired form and are such as to provide a passage for the flow of gas across the end faces of the coils from the outside into the inner opening in the coils, thus greatly facilitating the transfer of heat to the coils.

Disposed over the entire charge is the usual relatively thin sheet metal inner cover 25 which is closed at its upper end and provided with a flange portion 26 at its open lower end. When in operating position this flange 26 extends into a body of sand in an annular trough 27 in the base B. Means (not shown) are provided for maintaining the desired atmosphere around the charge by directing gas (usually a non-oxidizing gas) into the space within the inner cover 25 and an outlet for such gas is also provided. As is well understood, the space within the inner cover 25 is purged of air before the heating operation is started and a non-oxidizing atmosphere is maintained during the annealing cycle.

As has been noted above, the atmosphere within the inner cover 25 is relatively dense and heavy when the apparatus is at room temperature before heat is applied by the combustion tubes 1. In order to facilitate the transfer of heat to the coils 19, 21, and 22 the fan 9 is operated throughout the entire heating cycle. The circulation of atmosphere within the inner cover 25 is downwardly through the central openings in the coils into the fan 9, outwardly through the diffuser unit S, and upwardly through the annular discharge 18 into the space between the outside of the coils and the inside of the inner cover 25. Part of the gas discharged through the opening 18 passes through the convectors 20, 23 and 24 into the central opening in the coils while another part moves up and across the top of top coil 22 and downwardly into the central opening thereof.

The fan motor 7 is of the constant speed type (for

example an alternating current induction motor). It operates substantially at rated speed at all times and when the unit is cold it circulates the atmosphere at a certain rate and handles a certain number of cubic feet of atmosphere per minute. This requires an amount of electrical energy which depends upon the density or weight of the gas being handled. As the furnace approaches annealing temperature the atmosphere within the inner cover 25 is similarly heated and, as the annealing temperature may be in the range of 1200-1400° F., the density and weight per cubic foot of the atmosphere being circulated becomes substantially less. The volume and pressure of the gas within the inner cover 25 however remain substantially constant during heating as the sand seals and the gas outlet opening are such as to prevent any build-up of pressure within the cover 25.

Thus when the furnace reaches operating temperature the fan 9 is handling a much lighter gas and accordingly it is working under only a fraction of the load that it is subjected to when the atmosphere is cold.

In order to prevent overloading the fan motor during the warm-up period of operation (or to eliminate the necessity for a motor of much larger capacity than is required for the heating portion of the cycle) I propose to provide means for automatically throttling or reducing the volumetric output of the fan 9 when the furnace is in a cold state and automatically increasing the output as the temperature increases. The result of such automatic atmosphere flow control is that the load on the fan motor when the atmosphere is relatively cold, and during the heating-up period, may be held down to a value not substantially greater than the load required to give the desired circulation of hot gas at annealing temperature.

In Figures 2, 3, and 4 I have illustrated an atmosphere flow control apparatus which consists of a plurality of bi-metal flexible auxiliary vane ends 28 which are secured, as by welding adjacent their outer ends, to all or part of the diffuser vanes 15. As seen in Figure 2 the bi-metal elements 28 are in their cold or throttling positions. These elements are preferably of the same vertical width as the vanes 15 and when they are in their extended or cold positions (Figure 2) they project out into the space between the inner ends of adjacent diffuser vanes 15 and thus reduce the effective discharge outlet area of the fan 9. When the bi-metal auxiliary vane ends 28 are heated they bend inwardly (due to their bi-metallic construction and in well known manner) about their points of attachment to the vanes 15 until, when annealing temperature has been reached they are close to the vanes 15 as is indicated in phantom lines in Figure 3. When this occurs the maximum discharge opening for the fan 9 is provided and maximum rate of flow or circulation of atmosphere within the inner cover 25 will be secured. This occurs without undesirable change in the power output of the fan motor 7 as, with the same power consumption, the motor can handle a greater volume of hot relatively light atmosphere than cold relatively dense atmosphere.

As noted above the bi-metal automatic atmosphere flow control members 28 are illustrated as being mounted on each of the vanes 15 of the diffuser unit. However in some cases it may be necessary to employ the bi-metal elements only on part of the vanes.

The apparatus illustrated in Figures 2, 3, and 4 controls the atmosphere circulation by throttling the flow at the throat section of the diffuser vanes 15 where a minimum movement of the throttling members 28 will produce the greatest throttling of the atmosphere circulating within the system. However, the same results in increased fan efficiency and reduction of required fan capacity may be obtained by locating throttling means at other points in the flow of atmosphere within the inner cover 25. Thus throttling means might be provided at the outlet 18 from the diffuser S, in the passageway between the inner cover and the outside of the coils, in the passageway

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ways through the convector plates 20, 23 and 24, or in the central passageway through the stack of coils.

As the latter location is particularly convenient and practical I have illustrated several embodiments of apparatus for automatically controlling the circulation of atmosphere by controlling the flow at the upper end of the central opening in the coils being heat treated. In Figure 5 this apparatus includes a metallic disc 30 slightly larger in diameter than the central opening in top coil 22 and resting thereon and a movable cover plate 31 of slightly larger diameter than an opening 32 in the disc 30. Webs or flanges 33 are secured to the disc 30 and extend inwardly of the central opening 32 therein and carry at their inner ends vertical guide members in the form of bolts 34. The bottom heads of bolts 34 support a plate 35 which carries a bellows type expansible thermo-responsive unit 36 to the upper end of which the cover plate 31 is secured. When the apparatus is cold the bellows unit 36 is contracted and the cover plate 31 seats on the disc 30, thus completely closing the upper end of the central passage through the coils. However, when the temperature reaches a certain pre-determined degree the bellows 36 expands and lifts the cover plate 31 up into the phantom line position of Figure 5 which opens the passage through the coils and permits the desired increased flow of low-density hot atmosphere. Cover plate 31 is provided with holes loosely fitting the bolts 34 to permit vertical movement of plate 31 and stop nuts 37 are preferably provided on the upper ends of bolts 34 to limit the opening movement of cover plate 31. It will be observed that although the flow of atmosphere within the inner cover 35 is throttled at a different point than that shown in Figures 2, 3, and 4, the same advantages are obtained.

Figure 6 illustrates a somewhat different means for throttling the flow of atmosphere within the inner cover of a bell type furnace while the temperature is low and the density high and automatically opening up the passageways to permit increased flow when the temperature becomes higher and the density less. This consists of a plate or disc 40 disposed over and of somewhat larger diameter than the inner opening in the top coil 22. This disc is provided with a pair of rectangular openings 41 to the inner edges of which angle throttle members 42 are hinged. These throttle members 42 each consist of an upper section 42^a and a lower section 42^b disposed at an angle somewhat greater than 90° to each other. The bottom portion 42^b may be weighted as at 43 so that the bottom portion normally hangs vertically downwardly thus holding the upper portion 42^a in an upwardly sloping position whereby the holes 41 are open. This is illustrated in Figure 6 and is the position of the parts when the apparatus is cold and the fan 9 is not operating. As soon as the fan 9 is started, the apparatus being cold and the atmosphere relatively dense, the pressure differential between the top of the disc 40 and the inside of the passage in the coils will be such as to cause the angle throttle members 42 to swing on their hinges until the upper portions 42^a thereof seat upon the disc 40 and close the holes 41, thus throttling the flow of atmosphere and reducing the load on the fan motor 7. When the atmosphere within the inner cover 25 reaches annealing temperature and its density is substantially diminished the pressure differential between the inside of the coils and the outside thereof becomes less, permitting the weights 43 to swing the throttle members 42 into open position thus permitting an increased circulation of atmosphere but without increased load on the motor because of the reduced density of the hot atmosphere.

Still another apparatus for automatically throttling the flow of atmosphere through the interior of the coils is shown in Figures 7 and 8. In this embodiment of my invention an annular disc member 45 is disposed on the top of the upper coil 22 over the central opening there-

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in. Disc 45 is provided with a central opening 46 and has mounted thereon a vertical double wall member consisting of a stationary outer wall 47 and a movable inner wall 48. A top or cover member 49 (Figure 7) is secured at its edge to the top edge of outer vertical wall 47.

Supported by a suitable bracket 50, which is mounted on plate 45, is a vertical shaft 51 which extends downwardly through the top of cover 49 and has a transverse support bar 52 secured at its lower end. The outer ends of this transverse bar 52 are secured to the inner movable vertical wall member 48 and provide a support for the wall member 48 during rotary movement within the stationary outer wall 47. In each of the walls 47 and 48 are a plurality of circumferentially spaced openings 53. The spaces between these openings are slightly greater than the width of the openings so that when the wall portions 47 and 48 are in closed position (seen in Figure 7) the openings 53 in one wall portion will be out of register with those in the other wall portion and there will be no passageway through the vertical wall. This is the position the parts assume when the apparatus is cold and thus the maximum throttling of the flow of atmosphere is obtained.

As seen in Figure 8 a fixed bar 54 extends diametrically across and is secured at its ends to the lower portion of the outer fixed vertical wall 47. Secured near one end of bar 54 is a bi-metal thermostatic element or arm 55 having its other end attached to a flange 56 projecting inwardly from the inner vertical movable wall 48. The bi-metal element 55 is so designed that when it is cold it will lie relatively close to the stationary bar 54 and the inner wall 48 will be disposed in the position seen in Figure 7 in which its holes 53 are out of register with the corresponding holes in the outer wall. As the temperature of the atmosphere is increased however the bi-metal element 55 bends away from bar 54 under the action of heat and rotates the pivotally mounted inner wall member 48 into position wherein the holes 53 in members 47 and 48 are in register (see Figure 8) thus opening the atmosphere passage and permitting the desired increased rate of flow of the lighter heated atmosphere.

From the above description of my method and several embodiments of apparatus adapted to carry same it will be understood that substantial savings in the first cost of the fan motor, increased heating efficiency, and automatic trouble-free circulation control are obtained. Although I have described the illustrated embodiments of my invention in considerable detail it will be understood that variations and modifications may be made in the specific apparatus employed to carry out my method of automatic throttling in accordance with the temperature of the atmosphere being circulated and accordingly I do not wish to be limited to the particular arrangements herein illustrated but claim as my invention all embodiments thereof coming within the scope of the appended claims.

I claim:

1. The method of heating a charge in an enclosure which includes the steps of applying heat to the atmosphere and charge in said enclosure, forcefully circulating the atmosphere in the enclosure to facilitate transfer of heat to said charge, maintaining said atmosphere under substantially constant volume and pressure conditions during said heat application, and increasing the rate of flow of said atmosphere as the temperature of said atmosphere and charge is increased.

2. The method of heating a charge in an enclosure which includes the steps of applying heat to the atmosphere and charge in said enclosure, forcefully circulating the atmosphere in the enclosure to facilitate transfer of heat to said charge, maintaining said atmosphere under substantially constant volume and pressure conditions during said heat application, and varying the cross-sectional area of the path of said atmosphere in relation to the temperature thereof whereby the rate of flow of said

atmosphere will be increased upon a predetermined increase of atmosphere temperature without increase in the force applied to cause said circulation.

3. The method of heat treating coils of strip metal or the like which includes the steps of enclosing a stack of coils and maintaining a non-oxidizing atmosphere there-around, circulating said atmosphere around said coils, applying heat to said atmosphere and said coils, maintaining said atmosphere under substantially constant volume and pressure conditions while applying said heat, and increasing the rate of flow of said atmosphere around said coils as the temperature of said atmosphere and coils is increased by said application of heat.

4. The method of heat treating coils of strip metal or the like which includes the steps of enclosing a stack of coils and maintaining a non-oxidizing atmosphere there-around, forcefully circulating said atmosphere around said coils, applying heat to said atmosphere and said coils, maintaining said atmosphere under substantially constant volume and pressure conditions while applying said heat, and varying the cross-sectional area of the path of said atmosphere in relation to the temperature thereof whereby the rate of flow of said atmosphere will be increased upon a predetermined increase of atmosphere temperature without increase in the force applied to cause said circulation.

5. In heat treating apparatus the combination of a charge support, a cover for a charge disposed on said charge support, power operated means for circulating atmosphere within said cover around said charge, and means responsive to the temperature of the atmosphere being circulated within said cover for throttling the flow passage of said atmosphere whereby maximum throttling is obtained under cold conditions and minimum throttling under hot conditions.

6. In heat treating apparatus the combination of a charge support, a cover for a charge disposed on said charge support, fan means for circulating atmosphere within said cover around said charge, substantially constant speed electric motor means for driving said fan means, and means responsive to the temperature of the atmosphere being circulated within said cover for throttling the flow passage of said atmosphere whereby maximum throttling is obtained under cold conditions and minimum throttling under hot conditions.

7. In heat treating apparatus the combination of a charge support, a cover for a charge disposed on said charge support, power operated means for circulating atmosphere within said cover around said charge, means for maintaining the atmosphere within said cover at substantially constant pressure, and means responsive to the temperature of the atmosphere being circulated within said cover for throttling the flow passage of said atmosphere whereby maximum throttling is obtained under cold conditions and minimum throttling under hot conditions.

8. In heat treating apparatus the combination of a charge support, a cover for a charge disposed on said charge support, fan means for circulating atmosphere within said cover around said charge, substantially constant speed electric motor means for driving said fan means, means for maintaining the atmosphere within said cover at substantially constant pressure, and means responsive to the temperature of the atmosphere being circulated within said cover for throttling the flow passage of said atmosphere whereby maximum throttling is obtained under cold conditions and minimum throttling under hot conditions.

9. In heat treating apparatus, a charge support, a cover for a charge disposed on said support, fan means for circulating atmosphere within said cover around said charge, means for heating said charge and atmosphere, means for varying the cross-sectional area of the flow path of said circulating atmosphere, and thermoresponsive means for actuating said cross-section varying means

to increase said cross-sectional area when the atmosphere temperature is increased.

10. In heat treating apparatus, a charge support, a cover for a charge disposed on said support, fan means for circulating atmosphere within said cover around said charge, means for heating said charge and atmosphere, means for maintaining the atmosphere within said cover at substantially constant pressure, means for varying the cross-sectional area of the flow path of said circulating atmosphere, thermo-responsive means for actuating said cross-section varying means to increase said cross-sectional area when the atmosphere temperature is increased, and substantially constant speed electric motor means for driving said fan means.

11. In heat treating apparatus, a charge support, a cover for a charge disposed on said support, fan means for circulating atmosphere within said cover around said charge, means for heating said charge and atmosphere, means for maintaining the atmosphere within said cover at substantially constant pressure, means for varying the cross-sectional area of the flow path of said circulating atmosphere, and thermo-responsive means for actuating said cross-section varying means to increase said cross-sectional area when the atmosphere temperature is increased.

12. In heat treating apparatus, a charge support, a cover for a charge disposed on said support, fan means for circulating atmosphere within said cover around said charge, means for heating said charge and atmosphere, means for maintaining the atmosphere within said cover at substantially constant pressure, means for varying the cross-sectional area of the flow path of said circulating atmosphere, thermo-responsive means for actuating said cross-section varying means to increase said cross-sectional area when the atmosphere temperature is increased, and substantially constant speed electric motor means for driving said fan means.

13. In heat treating apparatus, a charge support, a cover for a charge disposed on said support, fan means for circulating atmosphere within said cover around said charge, substantially constant speed electric motor means for driving said fan, means for heating said charge and atmosphere, a diffuser for said fan having a plurality of outwardly diverging vanes, and bi-metal thermo-responsive throttling members disposed in the paths between at least some adjacent pairs of said vanes, said throttling members being adapted to extend into said paths and when at relatively low temperature to offer maximum resistance to flow through said paths and when at relatively high temperature to offer less resistance to said flow.

14. In heat treating apparatus including a charge support, a cover for a charge disposed on said support, fan means for circulating atmosphere within said cover around said charge, substantially constant speed electric motor means for driving said fan and means for heating said charge and atmosphere, a diffuser for said fan comprising a base plate, a plurality of outwardly diverging vanes on said base plate, a top plate supported on the top edges of said vanes, and bi-metal thermo-responsive throttling members secured to at least some of said vanes, said throttling members extending into the paths between adjacent pairs of vanes when the atmosphere is at relatively low temperature to offer maximum resistance to flow through said paths and being retracted when the atmosphere is at relatively high temperature to offer less resistance to said flow.

15. Apparatus for controlling the flow of atmosphere around a centrally apertured coil of strip metal being heat treated within a cover comprising, a plate member adapted to be disposed on the top face of said coil over the central aperture therein, said plate member having an opening, and thermo-responsive means for closing said opening when the temperature of the surrounding

atmosphere is below a predetermined value and opening said opening as said temperature rises.

16. Apparatus for controlling the flow of atmosphere through the central opening in a coil of strip metal or the like while being heat treated within a cover member comprising, a plate member adapted to be disposed on the top of said coil over the central opening therein, said plate member having an opening therethrough, means carried by said plate member for throttling the flow of atmosphere through said opening in said plate member, and thermo-responsive means for closing said throttling means when the atmosphere temperature is low and opening said throttling means when the atmosphere temperature is increased.

17. Apparatus for controlling the flow of atmosphere through the central opening in a coil of strip metal or the like within a cover member during heat treating comprising, a plate member adapted to be positioned on top of said coil over said central opening therein, an opening in said plate member, pivotally mounted closure means for said opening in said plate member, said pivotally mounted closure means including a weighted portion adapted to hold said closure means open when the

pressure differential between opposite sides of said plate member is relatively small and to permit said closure means to be closed by a predetermined increase in said pressure differential.

18. In heat treating apparatus the combination of a charge support, a cover for a charge disposed on said charge support, power operated means for circulating atmosphere within said cover around said charge, and throttling means responsive to the pressure differential on opposite sides of said throttling means for controlling the flow passage of said atmosphere whereby maximum throttling is obtained when said pressure differential is maximum and minimum throttling is obtained when said pressure differential is minimum.

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