

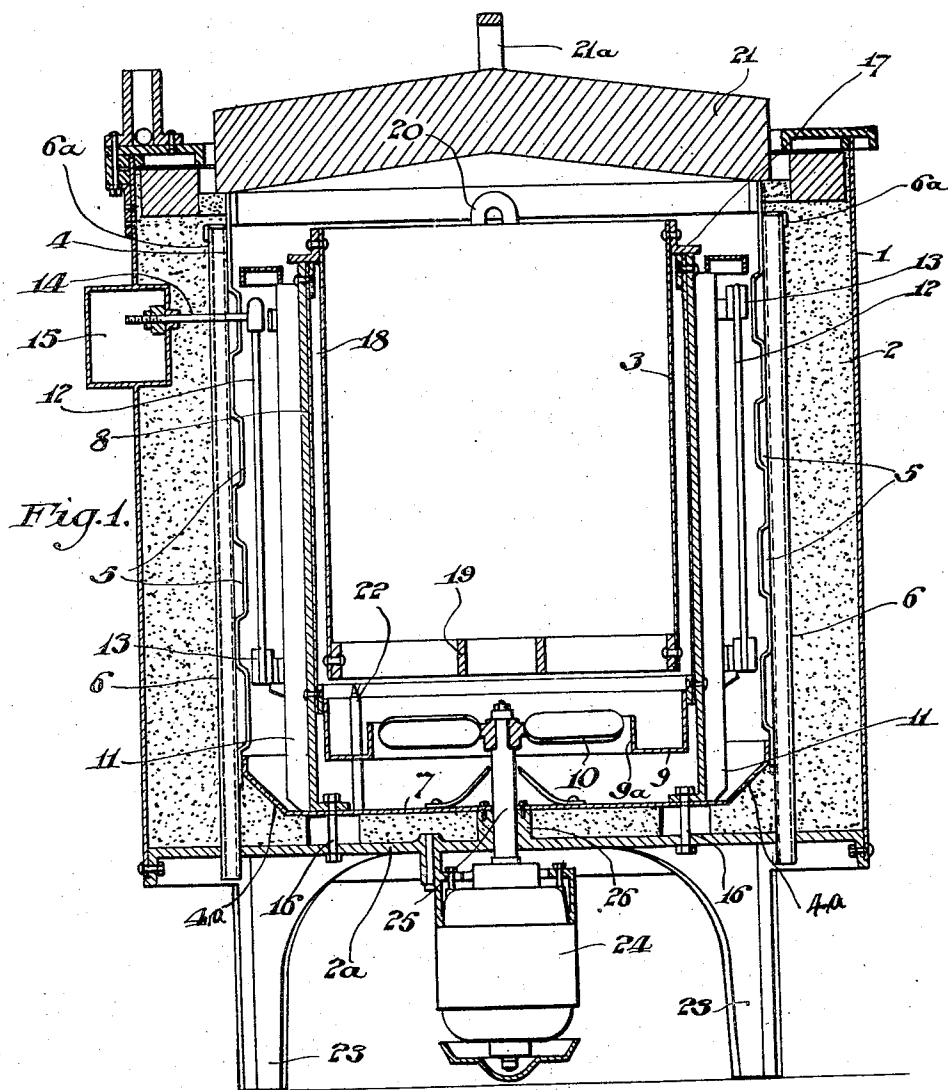
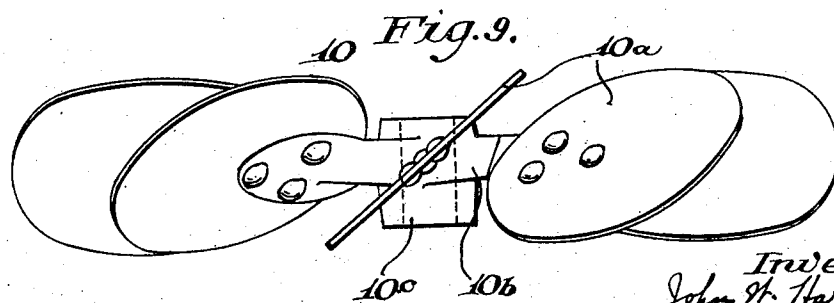
Dec. 26, 1933.

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1,940,948

HEAT TREATING SYSTEM

Original Filed June 27, 1929 4 Sheets-Sheet 1



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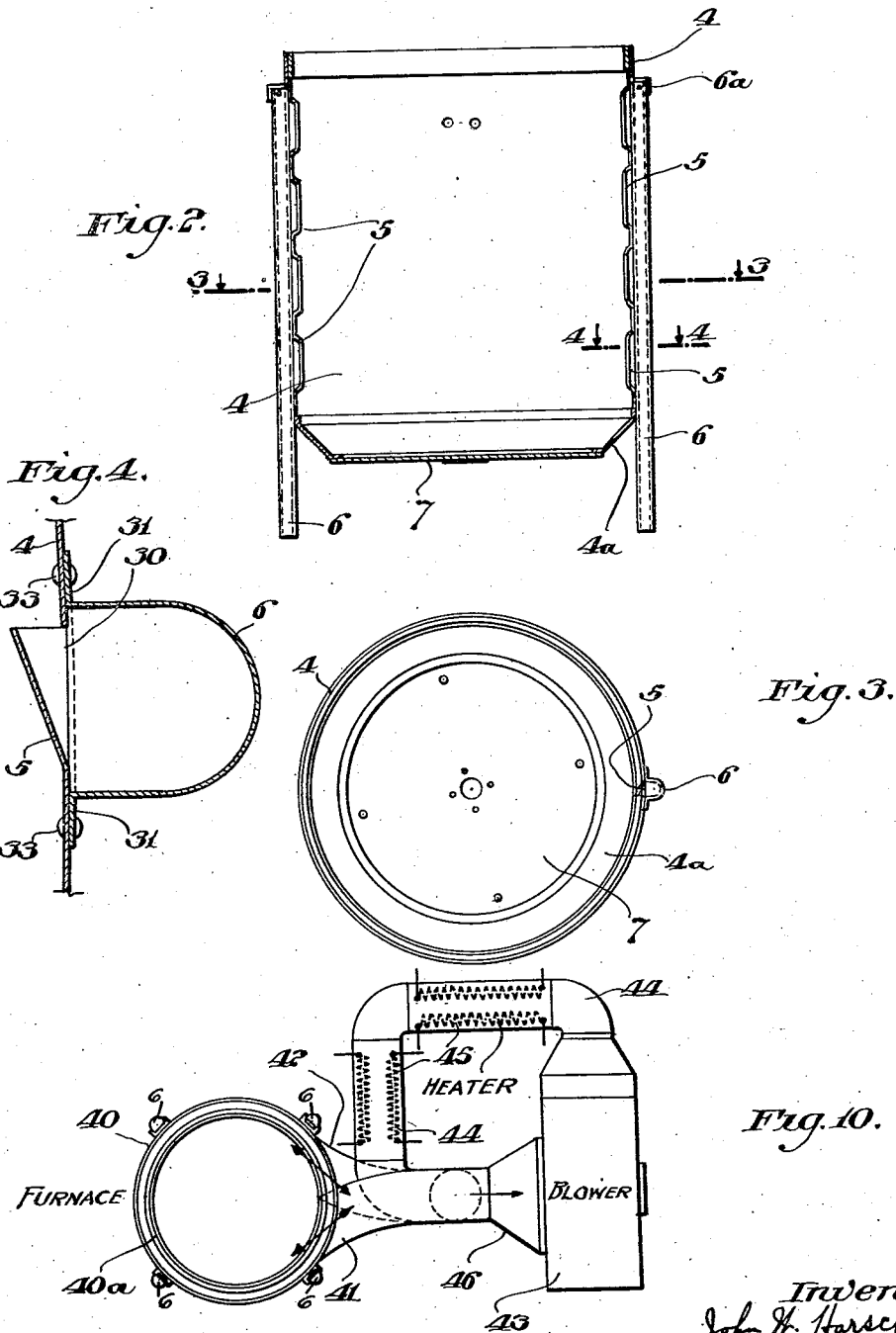
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HEAT TREATING SYSTEM

Original Filed June 27, 1929

4 Sheets-Sheet 2



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HEAT TREATING SYSTEM

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Fig. 5.

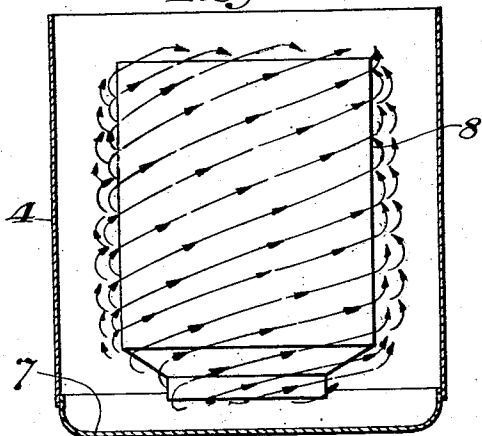


Fig. 6.

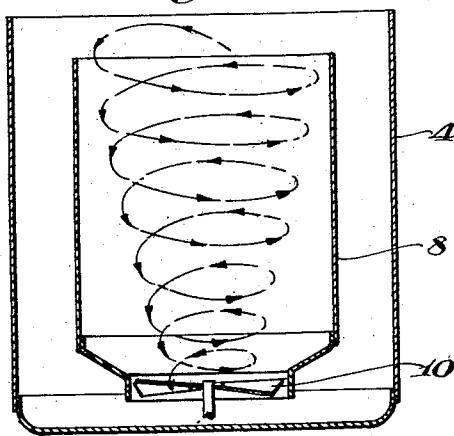


Fig. 7.

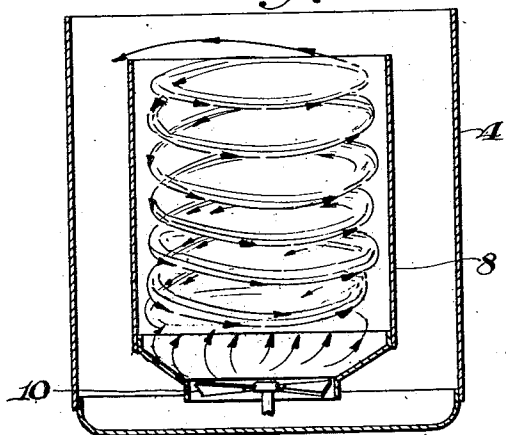


Fig. 8.

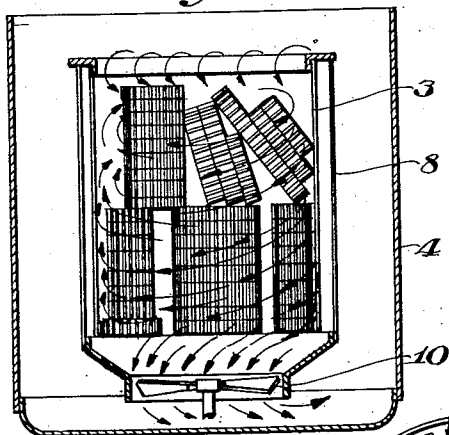
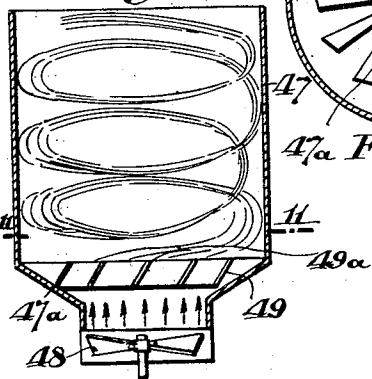
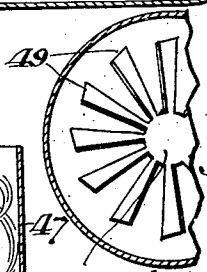
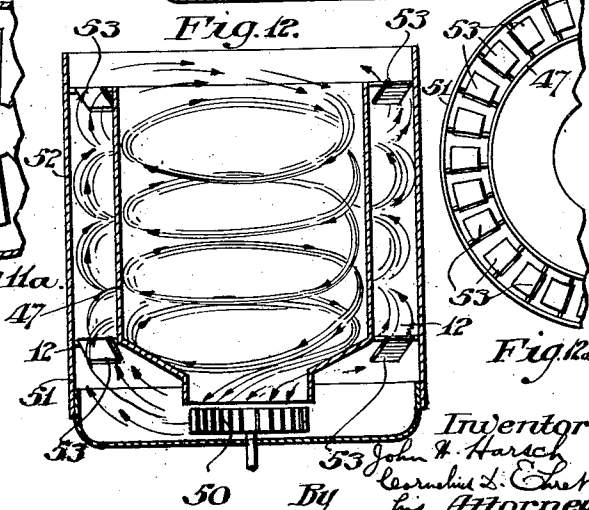


Fig. 11.



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HEAT TREATING SYSTEM

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Fig. 13.

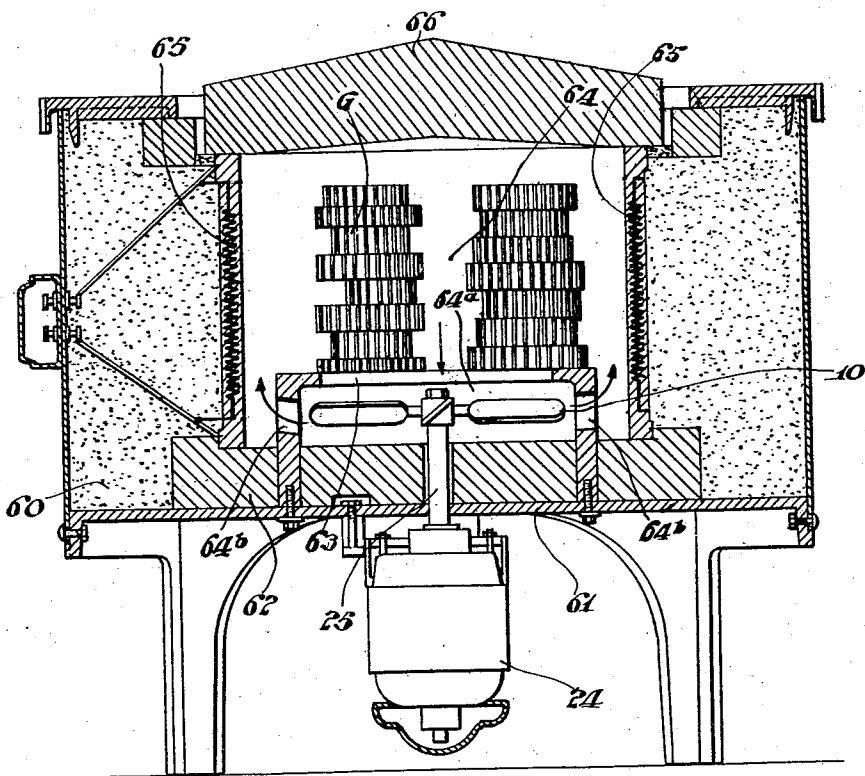
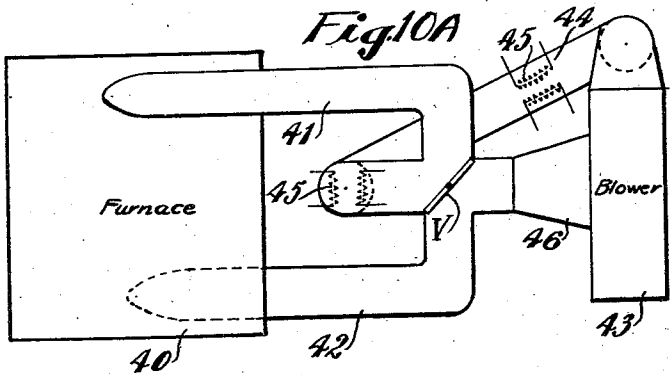


Fig. 10A



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UNITED STATES PATENT OFFICE

1,940,948

HEAT TREATING SYSTEM

John W. Harsch, Gwynedd, Pa., assignor to
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a corporation of Pennsylvania

Application June 27, 1929. Serial No. 374,034
Renewed January 19, 1933

10 Claims. (Cl. 263—2)

My invention relates to a method of applying heat in furnaces, ovens and the like and to the structure of furnaces, ovens and the like, utilized for applying heat to any material, as for drying or baking it, and particularly for heat treatment of metals, for hardening, annealing, normalizing, tempering, nitriding, gas carburizing and the like.

In accordance with my invention, in a furnace, oven, substantially closed circulatory system, or equivalent structure, a fluid, utilized as a vehicle for transferring heat to the work or material to be heat treated, is forcibly circulated in a closed system and during circulation is caused to partake of a movement having as components motion of translation and motion of rotation, the ratio of the latter to the former preferably being relatively great, effecting a motion which may be characterized as helical or swirling, for the purpose of enhancing uniformity of application of heat to the work, for causing the fluid to reach all parts of the work, and in some cases to prevent channeling, and for other purposes.

More particularly in accordance with my invention, the heat transferring fluid partakes of the swirling movement through different zones or chambers within the furnace oven or equivalent structure, absorbing heat from a source of heat in one of the chambers and delivering it to the work in another of the chambers; and more particularly said chambers are so related that they are in substantially immediate communication with each other or coupled or connected by passages which are relatively short and preferably shorter than the length of the chambers.

More particularly in accordance with my invention, the direction of movement of the heat transferring fluid is from time to time reversed, and in both directions of movement is caused to partake of the swirl aforesaid.

The swirl may be imparted to the heat transferring fluid upon any suitable principle; preferably however, the swirling movement is effected by imparting suitable shape to the blades of a fluid impelling fan-like structure, and particularly by utilizing blades having both centrifugal blower blade and propeller blade characteristics.

Under ordinary circumstances the heat transporting vehicle is air, though under some circumstances the heat transferring medium may be another gas or vapor; for nitriding, the vehicle may be ammonia gas; and for bright annealing it may be hydrogen, nitrogen or equivalent.

Under some circumstances the circulating medium, whether or not swirling movement is imparted thereto, picks up and transports from

the work, or other structures or materials within the system, solid particles, scale or the like which may be deposited and accumulate within the system, or be deposited upon electrical insulating material of and for electrical elements, such as heating resistors when such are used; in accordance with a further feature of my invention structure is provide which will cause the transport of the particles, scale and the like to a suitable destination, particularly external to the system.

My invention resides in a method and apparatus of the character hereinafter described and claimed.

For an understanding of my invention, reference is had to the accompanying drawings, in which:

Fig. 1 is an elevational cross-sectional view of a furnace embodying my invention.

Fig. 2 is an elevational cross-sectional view of part of the furnace structure shown in Fig. 1.

Fig. 3 is a sectional plan view taken along line 3—3 of Fig. 2.

Fig. 4 is an enlarged view taken along line 4—4 of Fig. 2.

Figs. 5 and 6 are diagrammatic illustrations of air flow within a furnace.

Fig. 7 is a diagram illustrative of air flow within a furnace wherein the impelling force is reversed as compared with Figs. 5 and 6.

Fig. 8 is a diagrammatic illustration of air flow within a charged work chamber of a furnace.

Fig. 9 is a detailed view of an impeller or fan for imparting a swirling motion to a heat vehicle.

Fig. 10 is a plan view, partly in section, of apparatus for effecting a swirling motion to a heat vehicle traversing furnace structure.

Fig. 10a is a side elevational view of the arrangement of Fig. 10.

Fig. 11 is an elevational cross-sectional view of furnace structure showing other means for imparting a swirling motion to a heat vehicle.

Fig. 11a is a cross-sectional plan view taken along the line 11—11 of Fig. 11.

Fig. 12 is an elevational cross-sectional view of modified furnace structure.

Fig. 12a is a plan cross-sectional view taken along the line 12—12 of Fig. 12.

Fig. 13 is an elevational sectional view of furnace structure.

Referring to Fig. 1, a furnace 1 comprises side and bottom insulating walls 2 and 2a respectively enclosing a work-containing structure 3. A cylindrical structure 4 adjoins the inner side of insulating wall 2 forming a lining for the furnace,

and comprises sides of sheet-like material, as sheet metal, open at the top and having a tapering section 4a closed by a bottom portion 7 as illustrated in Fig. 2. The sides of structure 4 are provided with louvres 5, or the like, opening into said structure and formed therein, as by a pressing or punching operation, for example, the said louvres extending vertically along the sides of member 4 and communicating with tubular structure 6 through openings 30, Fig. 4, for a purpose hereinafter described. Tubular structure 6 may be secured to member 4 in any suitable manner, as by flanges 31 riveted at 33 to the side of said member. Disposed concentrically within cylindrical structure 4 is another cylindrical member 8 having sheet-like metal sides. As shown in Fig. 1, the top of member 8 is open and the bottom has secured thereto an annular channel-like receptacle 9 open at its upper side and comprising a circular inner wall 9a cooperating with a fan 10.

Referring to Fig. 9, the fan or impeller comprises a plurality of blades or vanes 10a mounted in any suitable manner, as by riveting, to arms 10b secured to a central hub member 10c. In the present instance, referring to the center blade, it will be noted that the pitch angle or inclination of the blades is approximately 40 degrees. This value, however, is simply by way of example, since I have found that appreciable latitude is permissible in determining the blade pitch. For example, the pitch angle may range from approximately 30 degrees to 40 degrees or more, depending upon the desired ratio of motion of rotation to motion of translation of the air stream impelled by the fan. In order that a constant relation between the blade angle and the tip or peripheral speed of the fan be maintained, the blade angle may be varied from the tip of the blade towards the axis of rotation.

It has been the previous practice in furnace systems using forced convection to employ a fan or impeller having a relatively flat or low blade angle in order that the motion of the air flow shall be substantially translational. Such translational motion of the air has also been characteristic of previous furnace structures using separate blower systems or the like, either incorporated within or mounted externally of the furnace proper. For example, fans of the aforesaid type in practice impart such a small component of rotation to the air stream that but one complete rotation is effected for approximately 30' or more of translation. As will be hereinafter described, such air flow is for all practical purposes parallel flow, and the results so obtained when air or equivalent is utilized as a heat vehicle in heating systems are substantially different from those obtained when the blade angle of the impeller is such that the ratio of the motion of rotation of the air stream to its motion of translation is appreciable.

Member 8, Fig. 1, is supported at points spaced around its circumference by vertically extending flanged members 11, which also support a plurality of heater elements 12. Heater elements 12 are of the resistor type and are mounted on insulating supports 13 carried by members 11, the current for the resistors being supplied and controlled through terminal box 15 and conductor cable 14. Members 11 are secured to the base 2a by bolts 16, which also hold lining 4 in position.

The work-containing structure 3 fits within member 8, which serves to shield structure 3

from radiant heat of the resistors or other source of heat, and is spaced therefrom to form an annular dead space 18. The work-containing structure comprises a cylindrical container having sheet-like metallic sides, open at the top, and partially closed at the bottom by a metallic spider or grid 19. An annular shoulder 17 secured to the top edge of the container seats upon the tops of uprights 11, thereby supporting the container. Eyes 20, or equivalent, are secured at diametrically opposite points to the top edges of container 3 for permitting raising and lowering of the heat-treated or untreated metal into and from the furnace. Cover structure 21 rests on furnace wall 2 and may be raised or lowered into position by suitable lever or other means (not shown) connected to eye-bolt 21a.

A thermo-element, as a thermo-couple 22, is disposed adjacent the bottom of the work-containing chamber and cooperates with other apparatus, not shown, for indicating the temperature of the metal under treatment.

The bottom wall 2a of furnace 1, which rests on supporting structure 23, has mounted on its lower side a motor 24 having a shaft 25 extending through a retaining collar 26 in wall 2a. Fan or impeller 10 is secured to shaft 25 and is rotated thereby for effecting circulation of air through the furnace in a swirling manner, the extent of the swirl depending, as previously noted, upon the fan or impeller design. When fan 10, which is preferably close to the work within container 3, is rotated by motor 24 in such direction that the air is impelled upwardly, the air or other fluid medium passes in a swirling motion through the open spider structure 19 forming the bottom of the work-container, upwardly in a helical or spiral-like course through the work within container 3 to the space underneath cover 21, downwardly through the heating chamber comprising the annular space between lining 4 and cylindrical structure 8 in which resistors 12 are disposed, and into the space below fan 10, so that the above cycle is repeated. When the direction of rotation of fan 10 is reversed, as described in my Patent #1,578,027 of March 23, 1926, air is drawn through the work in the same swirling motion and passes through the heating chamber so that the work in the upper part of the container is first in contact with the air or heat vehicle at its highest temperature.

Referring to Figs. 5 and 6, the course of the heat vehicle in passing upwardly through the heating chamber containing the source of heat, (not shown) and downwardly through the work or treating chamber is diagrammatically illustrated. In Fig. 5, the flow through the outer chamber is generally in the direction indicated by the arrows, the fan or impeller in the present instance drawing the heat vehicle downwardly through the central or work chamber. It will be noted that the heat vehicle takes a substantially helical course in passing upwardly through the outer chamber, the pitch of the helix being small as compared with the length of the furnace.

Referring now to Fig. 6, the heat vehicle is diagrammatically illustrated as passing from the upper part of the outer chamber into and downwardly through the inner chamber formed by shell 8. As in the previous instance, the heat vehicle passes downwardly through the work chamber in a swirling or spiral-like path, the heat vehicle completing a number of revolutions in passing through the work chamber to

fan 10 which again impels it through the above described cycle.

Fig. 7 diagrammatically illustrates the course of the heat vehicle when the direction of rotation of fan 10 has been reversed, so that the heat vehicle is impelled upwardly through the central or work chamber and downwardly past the source of heat (not shown) to again be impelled by the fan through the work chamber. It will be noted in the above instance that the heat vehicle flows to substantially all parts of the work chamber, and particularly to all parts of the lower half of the chamber, as contrasted with the flow in Fig. 6, wherein the upper half of the work chamber is most effectively reached. Accordingly, when the work chamber is substantially filled with material to be uniformly heated, it will be apparent that periodical reversal of the impeller 10 will in effect produce two approximately conical heat zones in inverted relation with respect to each other such that a uniform heat zone may be maintained throughout the entire length of the work chamber.

In Fig. 8 there is illustrated a work container 3 charged with material to be heat treated, such as stacks of gears for example. Since in practice it is essential that the furnace be capable of quantity as well as quality production the gears or other articles to be treated are stacked or piled within the work container in any desired manner, such as for example, in the manner illustrated in Fig. 8. As the impeller 10 draws the heat vehicle from the outer heating chamber downwardly through the work container, it passes through and around the individual stacks or piles of articles to be treated in a winding tortuous course considerably longer than the length of the work-containing structure itself. Expressed in another way, the heat vehicle is subjected to a stirring action which causes it to penetrate to all parts of the work container. Accordingly, the heat vehicle is brought into direct contact with substantially the entire exposed surface of the material to be treated, thereby uniformly heating the batch instead of causing one part to be more highly heated than another, as would be the case where dead or stagnant spaces existed in certain parts of the batch. By way of further example, let it be assumed that the impeller was of the old type and impelled substantially parallel air currents through the work chamber. In such an event, it is obvious that the air currents would take the paths of least resistance, and where a parallel passage, or one with comparatively little obstruction existed in the batch, the air would tend to traverse that passage to the exclusion of other more restricted passages, thereby producing what may be described as "channeling", or nonuniform heating of the batch. By imparting an appreciable rotational component to the heat vehicle, "channeling" is substantially reduced or eliminated and the heat vehicle in its swirling motion tends to traverse all spaces within the work container not actually occupied by the work itself, and to accordingly effect uniform and simultaneous distribution of heat throughout the entire batch of material in the work chamber.

Figure 10 illustrates apparatus of a different form for imparting a swirling motion to the heat vehicle as it traverses the furnace structure. A furnace or heating chamber 40, which may be generally similar in character to the structure previously described, is provided with conduits

or pipes 41 and 42 which open into the top and bottom of the furnace interior respectively. Conduits 41 and 42 are disposed substantially tangential to the inner circumference of the furnace for a purpose hereinafter described. A fluid impeller 43, as a centrifugal blower or the like, is connected at its outlet to a conduit 44 within which are disposed sources of heat as for example electrical resistors 45. The intake of the blower comprises a conduit 46 adapted to be interconnected by valve mechanism V (Fig. 10a) with either conduit 41 or 42. Conduit 44 comprising the source of heat is also adapted to be interconnected with either conduit 42 or conduit 41 by the same valve mechanism. In other words, when the intake of the blower is connected to conduit 41 the heating conduit 44 is connected to the lower conduit 42. With the valve in its alternative position, the above described connections are reversed. Accordingly, assuming conduit 44 to be in communication with conduit 42, actuation of blower 43 forces a current of air or the like through conduit 44 where it is heated by resistors 45, and into the lower part of the furnace through conduit 42. Since the heat vehicle enters the furnace tangentially with respect to the treating chamber, it will circulate around the chamber in a swirling manner, gradually passing to the top of the furnace from where it is exhausted through conduit 41 in communication with the intake of the blower. The work-containing structure 40a when filled with a batch of material to be treated will be traversed by the swirling heat vehicle in substantially the same manner as that previously described.

In lieu of a fan or impeller designed for the purpose, or structure such as shown in Fig. 9 for initially imparting a swirling motion to the heat vehicle as it is introduced into the furnace, structure such as illustrated in Figs. 11 and 11a may be utilized wherein the means for imparting a swirl to the heat vehicle is incorporated with the furnace proper and is independent of the impeller which may be of any suitable type.

Referring to Fig. 11, shell 47 has disposed at its lower end a fan or impeller 48 of the type for effecting substantially parallel flow of an air stream. Disposed above fan 48 and mounted in the funnel like structure 47a of shell 47 are a plurality of vanes 49 inclined with respect to the direction of air flow from fan 48 and radially disposed with respect to a center portion 49a. The radially disposed vanes 49 are suitably angularly spaced with respect to each other and have the same inclination and direction of inclination with respect to the air stream. In effect, vanes 49 comprise a stationary fan-like structure mounted with respect to the shell 47. Accordingly, it will be observed that the substantially parallel flow of air from fan 48 will be deflected while passing through the vane structure, and due to the radial disposition thereof, a helical or swirling motion will be imparted to the air stream as it passes upwardly through shell 47. It will be apparent that the number of vanes and the inclination of the same with respect to the air stream may be varied to suit the particular requirements of the furnace.

Fig. 12 illustrates another modification of the above form wherein the impeller used comprises a blower 50 of the centrifugal type. Outer shell 51, comprising the inner lining of the furnace, is spaced in the usual manner from shell 47, thereby providing the outer heating chamber 52

within which are mounted blades or vanes 53. In the present instance, the centrifugal blower 50 is illustrated as drawing the air downwardly through the center of shell 47 and impelling it upwardly through the outer chamber 52. As the air flows upwardly through chamber 52, it is deflected by the annularly disposed vanes 53, Fig. 12a, which are uniformly inclined in the same direction with respect to the air stream, such that the air stream or heat vehicle is rotated in a swirling motion through chamber 52 as it passes therefrom into shell 47, which comprises the treating chamber. As illustrated in Fig. 12, the heat vehicle emerging from chamber 52 passes in a swirling, substantially helical motion downwardly through shell 47 to be again impelled by blower 50 through the same cycle. The air stream in the above instance uniformly traverses the entire length of shell 47, thereby producing a uniform heating zone throughout the chamber, as compared with the more or less conical heating zone illustrated in connection with Fig. 6.

For certain kinds of heat treatment, as in hardening for example, the means illustrated in Fig. 1 for shielding the work from the radiant heat of the resistors may be omitted, and the relation between the heat imparted to the work by radiation and convection so balanced by means hereinafter described that uniformity of heating is substantially attained. To this end, structure illustrated in Fig. 13 may be utilized comprising a circular insulating wall 60 having a bottom plate 61 with respect to which is mounted a member 62 forming the bottom of a heating chamber, and a grate-like structure 63 extending within an inner circular treating chamber 64. Disposed within and around the periphery of chamber 64 are sources of heat, diagrammatically illustrated by electrical resistors 65. An impeller or fan 10 of the character previously described is mounted beneath grate 63 within the chamber 64a, having openings 64b, and is rotated by motor 24. Chamber 64 is charged in the usual manner by removing cover 66 and piling the material to be treated, which in the present instance comprises gears G, upon the grate 63. As illustrated, those surfaces of the gears directly facing the resistors are exposed to the radiant heat therefrom, while the gear surfaces within the batch proper receive heat only from the circulating heat vehicle. However, due to the swirling motion imparted to the heat vehicle by impeller 10, the central portion of the batch has heat transmitted thereto at such a rate that the effect of radiant heat upon the outer stacks of gears does not overheat those stacks with respect to the inner ones. In other words, the temperature gradient throughout the work is substantially reduced or eliminated.

Previously, it was generally necessary to shield the work from radiant heat in order to prevent non-uniformity of heating. By utilizing the radiant heat of the source, while at the same time maintaining uniformity of heating, I am enabled by my invention to increase the furnace efficiency.

In the above-described systems of heating, the heat vehicle has generally been referred to as a fluid, particularly gaseous in character. It will be apparent that for different processes and treatment the heat vehicle may, and generally will, vary in character and composition. For example, where material is to be nitrided, ammonia gas may be employed in the manner described in my copending application Serial No. 336,065,

filed January 30, 1929; and if the process requires bright annealing, the heat vehicle may be hydrogen, nitrogen or equivalent, the treating chamber being sealed with respect to the atmosphere to prevent admission of air.

Referring again to the structure illustrated in Figs. 1 to 4, the apparatus therein disclosed, while providing a closed system of circulation for the heat vehicle, is not sealed with respect to the atmosphere, and accordingly, where such apparatus may be used, the swirling movement of the heat vehicle may be employed to produce an additional result other than uniform heating of the work. Since there will generally be to a greater or lesser extent metallic particles, as scale or oxide, or other foreign material, on the metal which is loosened during handling, or which is formed and loosened during the heating of the metal, the air stream, having appreciable velocity, will pick up these particles which are loose within the container 17, and which fall through spider 19 to bottom lining 7. Again, assuming direction of rotation of fan 10 so that air is circulated downwardly through the work chamber, fan 10 will impart to the air or other fluid a swirling motion as it is forced upwardly through the heating chamber, so that it takes a substantially helical course. Due to this swirling curvilinear motion, or due to any other abrupt change in direction of the air stream, there is exerted on the metallic or foreign particles, which are heavier than air, centrifugal forces which tend to throw them to the outer wall of the heating chamber, i. e., against lining 7. As the particles are thrown against lining 7, louvres 5, which open in a direction opposite to that of the air stream, catch and collect the same. As the particles pass through the louvres, they enter tube 6 through which they fall to the exterior of the furnace.

Due to the fact that some of the scale or foreign particles will probably pass through the heating chamber and back to the fan, the annular receptacle 9 is disposed so that these particles when propelled upwardly by fan 10, tend to rebound from the lower side of spider 19 towards the periphery of the fan and fall into said receptacle. Furthermore, receptacle 9 is effective for collecting heavier particles dropping down through the work-chamber which would not be carried through the furnace by the air stream.

I have found that a considerable quantity of metallic scale introduced at once into a furnace of the above type embodying my invention is readily removed from the same during normal operation thereof within a very short time, usually within a minute or so.

It will be apparent that a plurality of rows of louvres may be used if desired, although for usual operation, a single row opening in the direction opposite to that of air flow is generally sufficient to maintain the furnace substantially free of scale, etc. at all times. A row of louvres and a co-operating tube 6 may also be provided for effecting removal of particles from the air stream when the direction of air flow has been reversed. In this case, the louvres will open in the opposite direction, as viewed in Fig. 2.

A very obvious advantage of my scale separating structure is that attendance of the furnace is not necessary to observe when the metallic scale and oxide has accumulated to such degree that the efficiency of the furnace is reduced. Furthermore, the furnace is maintained productive by keeping the resistors and insulators

free and clean of conducting particles which would cause short-circuiting of them.

It shall be understood for the purpose of brevity that the term "air" as used in the above specification and following claims is not limited to the usually accepted definition, but includes any suitable gas or vapor which is adapted to conduct heat in the manner above described, i. e., to serve as a heat vehicle in transmitting heat from a source of heat to a heat-receiving material.

It shall further be understood that any suitable source of heat, other than the electrical resistors specifically described and illustrated, may be employed in connection with the heat vehicle, and, by way of example, the furnace or heating chamber may be of the gas fired type.

What I claim is:

1. In the operation of a heat treating furnace, the method of uniformly heating a batch of material which comprises passing in a gaseous medium into heat transfer relation with a source of heat, and imparting a swirling motion to said heat-bearing medium and passing it through, and into direct heat transfer relation with, the said batch of material, said gaseous medium completing at least a revolution of its swirl while passing through said batch.

2. In the operation of a heat treating furnace comprising a treating chamber and a source of heat disposed therein, the method of uniformly heating work within said chamber which comprises exposing the work to radiant heat from said source, and imparting a swirling motion to a gaseous heat vehicle passing through the work to substantially reduce or eliminate by said stirring action of said swirling heat vehicle temperature gradients existing in the work.

3. The combination with a furnace comprising a substantially circular heating chamber, a work-containing structure disposed therein, and impeller means for effecting circulation of air in a swirling manner through and around said chamber and structure, of means for removing solid particles from the air stream comprising louvres opening in the direction opposite to that of air flow, said louvres being disposed in the outer wall of said heating chamber against which said particles are projected due to changing direction of said air stream.

4. The combination with a furnace comprising a heating chamber, and impeller means for effecting circulation of air in a swirling manner through and around said chamber, of means for removing solid particles from the air stream due to change in direction thereof comprising louvres formed in a wall of said chamber opening in the direction opposite to that of air flow.

5. A heat treating system comprising a treating chamber for receiving a batch of metallic objects, a heating chamber, a duct connecting said heating chamber to one end of said treating chamber and extending tangentially of said treating chamber, a second duct extending from the other end of said treating chamber, means for forcing gas heated in said heating chamber through said tangential duct into said treating chamber, the gas swirling as it advances through said batch axially of said chamber for exit through said other duct.

6. A heat treating system comprising a treating chamber for receiving a batch of metallic objects, a heating chamber, ducts connecting opposite ends of said chambers to form a closed path and extending tangentially of said treating chamber, means forcibly circulating a gas in said path, the gas swirling within said treating chamber as it advances axially thereof through said batch, and means for reversing the connections of said ducts to reverse the direction of swirl and axial movement of said gas through said treating chamber.

7. A heat treating system comprising a treating chamber for receiving a batch of metallic objects, a heating chamber forming with said treating chamber a closed path, means for forcibly circulating a gas in said path, and vane structure in said path for imparting substantial swirling movement to said gas as it passes through said treating chamber.

8. A heat treating system comprising a treating chamber for receiving a batch of metallic objects, a heating chamber forming with said treating chamber a closed path, a blower fan for forcibly circulating a gas in said path, and vane structure in said path for imparting swirling movement to said gas as it passes through said treating chamber.

9. A heat treating system comprising a treating chamber for receiving a batch of metallic objects, a heating chamber forming with said treating chamber a closed path, a blower fan for forcibly circulating a gas in said path, and vane structure disposed in said path adjacent the entrances to said chambers for imparting swirling movement to said gas as it passes into said chambers.

10. A heat treating furnace comprising a treating chamber, a heating chamber surrounding said treating chamber, and means including a fan for forcibly circulating gas through said chambers and for swirling the gas as it advances longitudinally of said chambers.

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