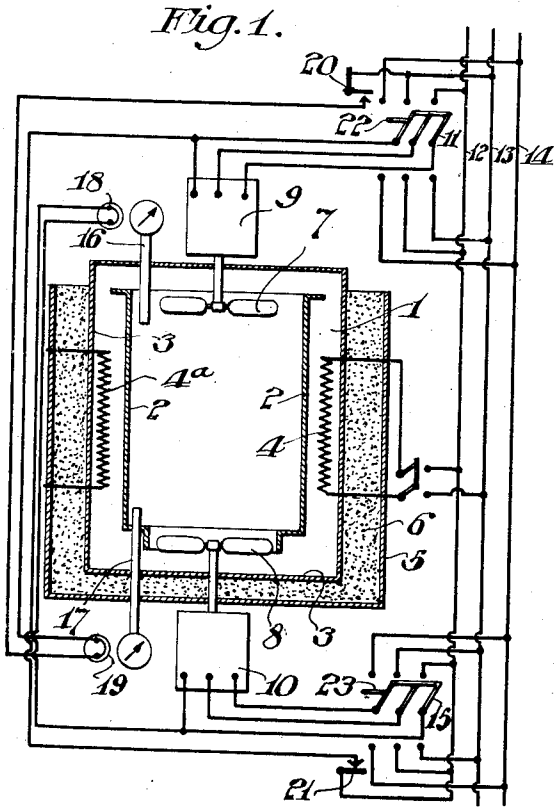
Aug. 22, 1933. J. W. HARSCH 1,923,145

METHOD AND APPARATUS FOR HEAT TREATING

Original Filed Jan. 28, 1931 3 Sheets-Sheet 1

Fig. 1.



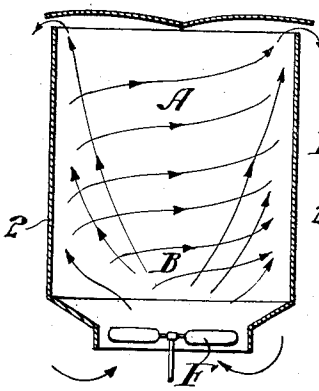


Fig. 2.

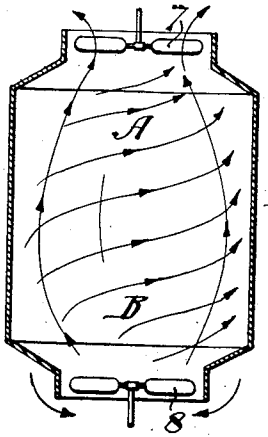


Fig. 3.

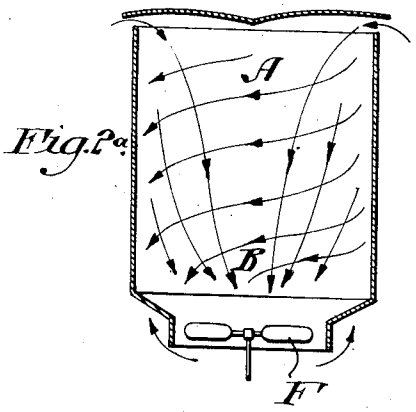


Fig. 2a.

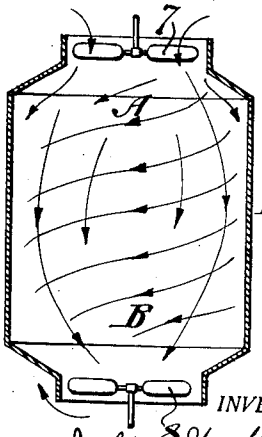


Fig. 3a.

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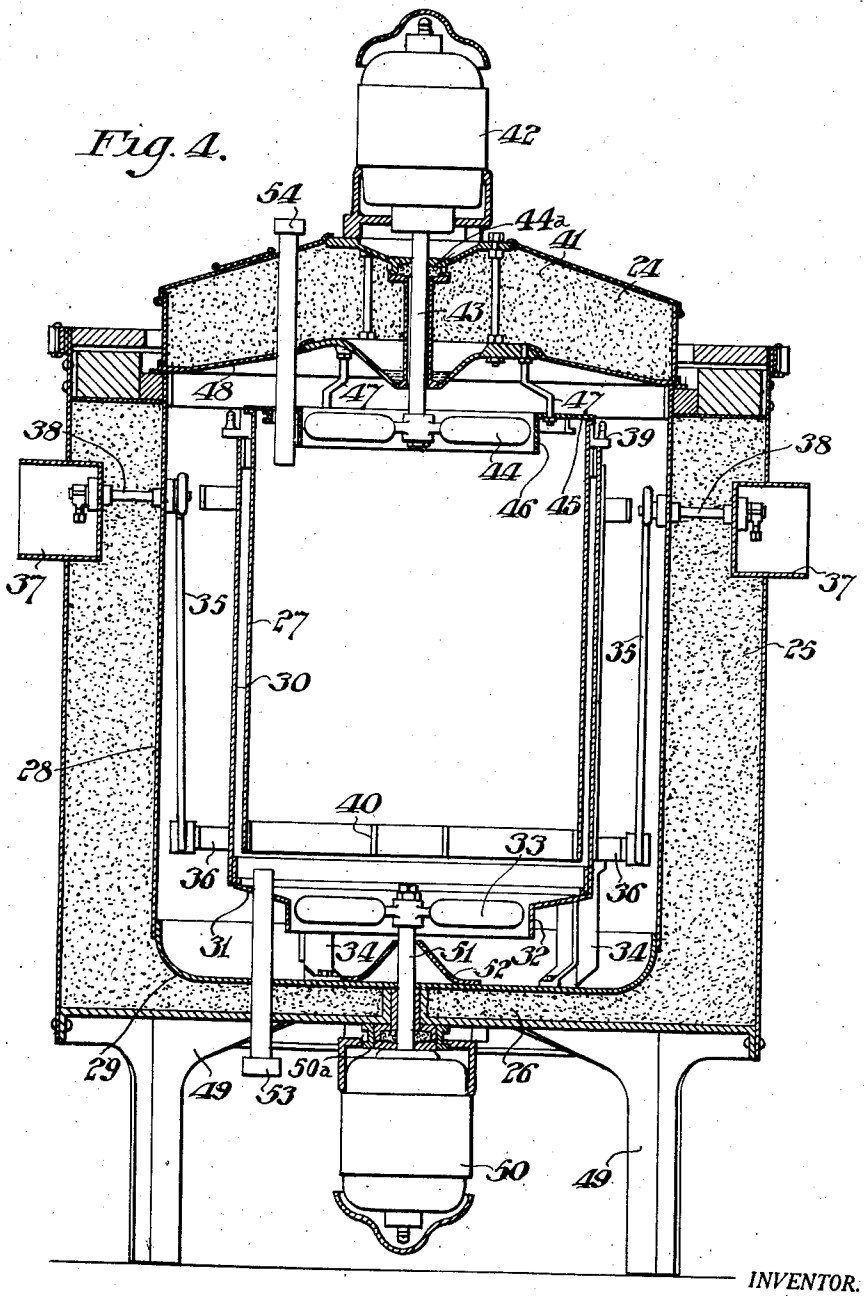
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Fig. 4.



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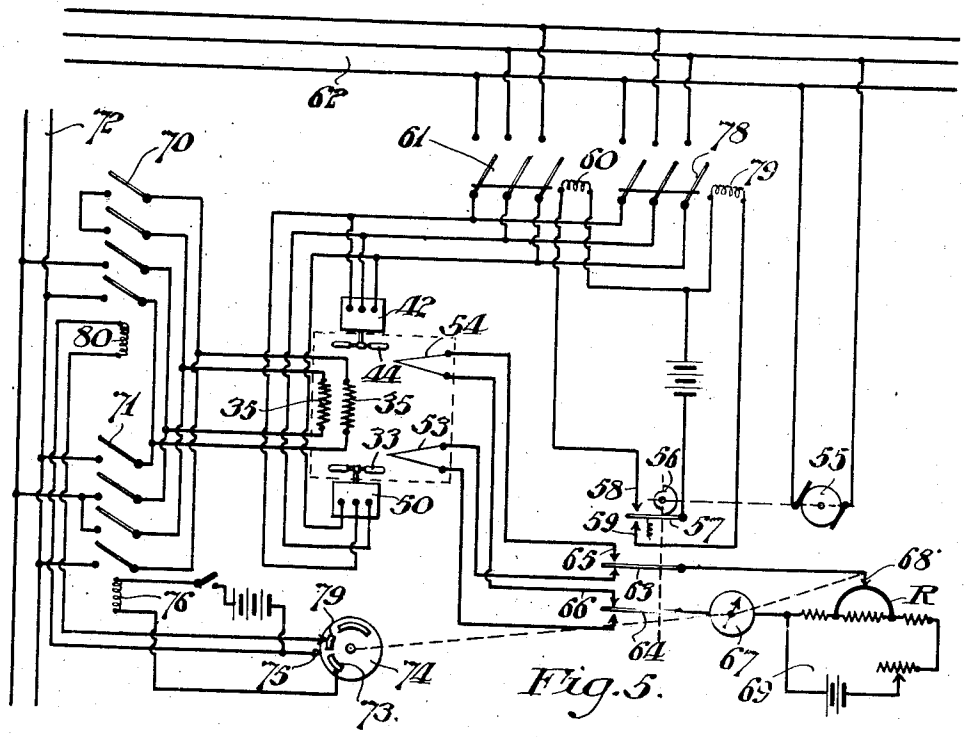


Fig. 5.

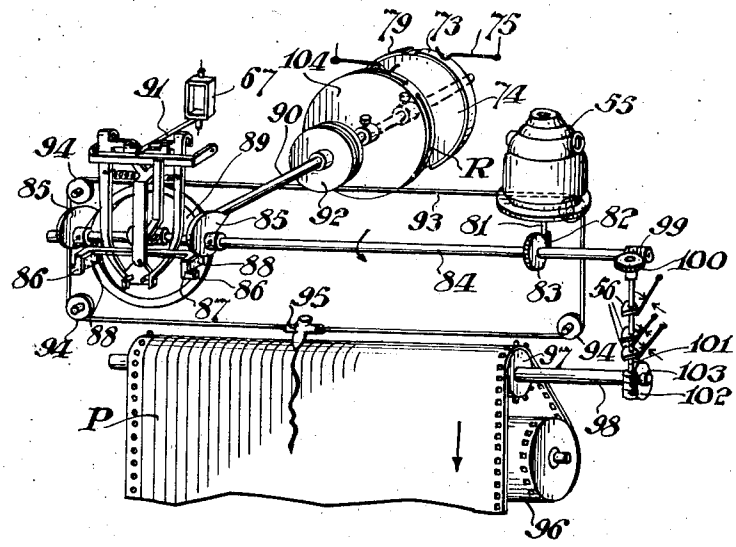


Fig. 6.

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Patented Aug. 22, 1933 1,923,145

UNITED STATES PATENT OFFICE

1,923,145

METHOD AND APPARATUS FOR HEAT TREATING

John W. Harsch, Gwynedd, Pa., assignor to Leeds & Northrup Company, Philadelphia, Pa., a Corporation of Pennsylvania

Application January 28, 1931, Serial No. 511,693
Renewed December 6, 1932

30 Claims. (Cl. 266—5)

My invention relates to method of and apparatus for applying heat to material or objects under treatment by forced movement or circulation of a heat medium or vehicle into transfer relation therewith; and more particularly for heat treatment of metals, as hardening, annealing, tempering, nitriding, normalizing, gas carburizing, and the like.

In accordance with my invention, the material or objects generically termed load, is disposed in a path of the heat medium, as in the work chamber of a furnace, between fans which operate alternately, or preferably simultaneously and cumulatively to effect thorough penetration of the load by the heat vehicle to ensure uniform temperature; more particularly, the heat medium is circulated in a closed path and is drawn, as distinguished from blown, through the load alternately in different or opposite directions by alternate or successive operation of the fans as suction fans; preferably, the fans are of the reversible, or propeller type, and while one is functioning as a suction fan to draw heated gas through the load, the other is assisting in the circulation and diffusion of the gas by operating as a blower.

Further in accordance with my invention, the drawn and forced gases are caused to swirl through the work or heating chamber in which the load is disposed in helical paths generating oppositely converging cones differing somewhat in size, the cones interchanging position upon reversal of the fans to ensure high degree of uniformity of temperature throughout the load.

Also in accordance with my invention, the source of heat for the gas or other transfer medium for both directions of its circulation is regulated to effect or maintain a predetermined temperature of the gas entering the work chamber; specifically, upon reversal of direction of circulation of the gas, which is preferably effected automatically at relatively short intervals, a thermo-couple or other temperature responsive device in the path of gas traveling from the heat source to the load is operatively associated with a temperature-indicating, recording or controlling system.

My invention also resides in the methods, systems, and apparatus hereinafter described and claimed.

For an understanding of my invention and of some of the forms my systems and apparatus may take, reference may be had to the accompanying drawings in which:

Fig. 1 illustrates diagrammatically a furnace, circulating fans and associated circuits.

Figs. 2, 2*a*, 3 and 3*a* are explanatory diagrams.

Fig. 4 discloses in section, the front elevation of a furnace constructed in accordance with my invention.

Fig. 5 is a diagram of an automatic furnace control system.

Fig. 6 in perspective illustrates automatic controlling and recording mechanism.

Referring to Fig. 1, the furnace 1 comprises a work chamber, adapted to contain material or objects under treatment, defined by the wall structure 2, and a heating chamber between wall structure 2 and the wall 3 containing for example, the electrical resistors 4, 4*a*, although heat may be developed by any suitable method, as by combustion of gas or oil. Between the outer casing 5 of the furnace and the wall 3 may be disposed a mass 6 of suitably low heat conductivity to increase the efficiency by reducing heat losses. The fans 7 and 8 disposed at the opposite, open ends of the work chamber are driven by motors 9 and 10 respectively.

Heretofore circulation of heated gas has been effected between the work chamber and a source of heat by a single fan, as disclosed in my Patent 1,578,027, granted March 23, 1926, which was reversed intermittently or periodically to effect more uniform temperature of material or objects within the work chamber than before realized. However, it was found that the temperature of the work chamber remote from the circulating fan was consistently less than in regions nearer the fan. This difference in temperature existed even when the gas was caused to swirl through the furnace, by using for example, fan blades of high pitch, as described in my pending application Serial No. 374,034, filed June 27, 1929.

Referring to Fig. 2, which illustrates diagrammatically, a furnace of that type, when the fan F is rotating in such direction as to effect blowing of gas through the work chamber as indicated by the arrows, there was formed or generated a heat zone, simulating in form a cone whose apex is presented to or which converges toward the fan, with the result that the temperature in the region A of the work chamber is less than that of region B, which is nearer the fan. Upon reversal of rotation, Fig. 2*a*, the fan operates to draw the heated gases through the work chamber, and there is formed another heat zone, also simulating a cone in shape, converging toward the fan with the result that the temperature in the region A is again less than that of region B.

The cones formed, as indicated generally in the drawings, are generally of such shape and size that if existing simultaneously they would nest. The reversal of the single fan does not equalize the temperature in the regions A and B.

Further and particularly when the load in the work chamber is dense, as closely stacked gears, for example, blowing of the heated gases through the load is less effectual than drawing the gases through the load, with resultant further increased difference in temperature between regions A and B.

By providing two fans, as shown in Fig. 1, which may be alternately operated, preferably to draw the gas through the work chamber, the heat cone, Fig. 2*a*, is inverted for each reversal with the result that the temperatures in the regions A and B over a period of time corresponding to several reversals, are substantially identical. For example, an operator may throw the switch 11 upwardly to energize the motor 9 from the conductors 12, 13 and 14, and effect rotation of the fan 7 to draw gases within the furnace through the heating chamber and upwardly through the work chamber. After a suitable interval, which is relatively short compared to the time required for the load to attain its desired temperature, the switch 11 may be opened and switch 15 thrown upwardly to energize motor 10 and drive the fan 8 to effect reversal of circulation of gas within the furnace, and specifically to draw the heated air or gas downwardly through the work chamber. For this mode of operation, the fans may be of the centrifugal type in which direction of rotation is more or less immaterial, the fans operating always as suction fans.

However, the fans are preferably of the propeller type, of which it is characteristic that direction of rotation determines whether the fan operates as a blower or as a suction type and the switches 11 and 15 may be operated to reverse direction of rotation of the fans at will. When the load is first put in the furnace, to rapidly raise its temperature, both fans may be operated as blowers, which can be effected by throwing switch 11 downwardly and switch 15 upwardly in the system indicated. The thorough agitation of the heated gas by both fans ensures substantially uniform distribution of the heated gases through the work chamber and at least approximate equalization of temperature of the load. As the load approaches its desired temperature and while it is maintained at that temperature to effect desired treatment, it is preferable to effect circulation of the heated gases from the heating chamber through the work chamber; for example, one of the fans may be shut off, or reversed to give uni-directional circulation; or as previously stated, the fans may alternately operate as suction fans, or less desirably alternately as blowers, to give circulation first in one direction and then in an opposite direction.

Great nicety of temperature equalization is effected by operating the fans alternately as suction fans, the other fan simultaneously operating as a blower.

When fan 7, for example, is operating as a suction fan, and fan 8 is operating as a blower, switches 11 and 15 being in their upper position, the circulation of air through the furnace and the heat zone formed thereby is substantially as indicated in Fig. 3, the zones formed being a composite of Figs. 2 and 2*a*, that is, two cones whose apexes extend oppositely. The fans, whose construction is more specifically hereinafter described, cooperate in producing swirling of the heated gas within the work chamber in counter-clockwise direction as viewed from the top of the furnace. Upon reversal of both motors as effected by throwing both switches 11 and 15 downwardly, the lower fan 8 operates to draw the gas through the load while the upper fan 7 is blowing it through the work chamber. The resulting circulation and distribution of gases is substantially as indicated in Fig. 3*a*, the cones of drawn and forced gases being interchanged with respect to Fig. 3, and swirling in clockwise direction. At each end of the furnace, by reversal, there are successively produced the cones of Figs. 2 and 2*a*, which if existing simultaneously would nest or telescope. By so operating the fans, and as is apparent from Figs. 3 and 3*a*, the temperature of all parts of the load, irrespective of their position in the work chamber, is the same, and substantially independent of the load density.

Temperature responsive devices 16 and 17, of any suitable type, are disposed at opposite sides of the work chamber to assist an operator in controlling supply of heat. In Fig. 1 shown, the resistors 4, 4*a* may, by proper switching mechanism, not shown, be connected individually, in parallel, or in shunt, to the source of supply to effect different rates of heat supply. If the source of heat is a gas burner, the heat is regulated by proportioning the components of the combustion. As it is preferable to regulate the heat to maintain a desired temperature of the air or other heat vehicle moving from the source of heat to the furnace load, suitable indicating means are provided to indicate to the operator which of the temperature responsive devices 16 and 17 is in the path of gases moving toward the work chamber from the heating chamber. For example, the signal light 18 adjacent the temperature indicating instrument 16 at the upper end of the furnace, is energized when switch 15 is thrown to its lower position effecting operation of fan 8 as a suction fan. The operator reading the temperature of the instrument 16 regulates, if necessary, the supply of heat to the furnace to maintain the desired temperature of air entering the work chamber at the top or upper end. Similarly, when the switch 11 is in its upper position to effect operation of upper fan 7 as a suction fan, the signal light 19 adjacent an indicating instrument 17 at the lower end of the furnace is lit to indicate to the operator that the regulation of heat should be made if necessary to maintain a certain reading of indicating instrument 17.

The pilot lights 18 and 19 are controlled respectively by the switches 20 and 21 adapted to be closed by the arms 22 and 23 carried by the movable structure of switches 11 and 15 respectively. The selection of the proper temperature responsive device may be effected in other ways and by different means without departing from my invention.

A preferred furnace construction is shown in section in Fig. 4, the furnace 24 comprising the side and bottom insulating walls 25 and 26 enclosing the work container 27. A cylindrical structure 28 adjoins the inner face of insulating wall 25, forming a lining for the furnace, open at the top and closed by a bottom portion 29. The sheet metal cylinder 30, open at the top and to the bottom of which is secured an annular channel like pan 31 having a flange 32 sur-

rounding the fan 33, is disposed concentrically with the cylindrical structure 28. Partition member 30 is supported at points spaced around its circumferences by the vertically extending members 34, which may also support a plurality of heating elements 35, which are of the resistor type and are mounted on insulator supports 36 carried by the members 34, the current for the resistors being supplied through terminal boxes 37 and conductor cables 38.

The work container structure 27 or basket, is provided with a flange 39 adjacent its upper end which rests on the top of the partition 30 which serves to shield the basket 3, and its contents, the load, from radiant heat of the resistors or other source of heat, and is spaced from the partition to form an annular dead air space. The bottom of the basket is partially closed by metallic spider or grid 40 which supports objects under treatment within the basket and permits circulation of heated gases therethrough.

Eyes, or equivalent, as shown in Fig. 4, may be secured at suitable points adjacent the top of the container to permit raising and lowering of the container and its contents into and from the furnace.

The cover structure 41 rests on the top of furnace wall 2 and may be raised or lowered into position by suitable lever or other means not shown. A motor 42 is mounted on the top of the cover, its shaft 43 extending downwardly therethrough and having at its lower end a propeller or fan 44, which when the cover is in position, is within the work container 27 above the load. A ring or plate 45 having a depending flange 46 encircling the fan 44 is supported from the under side of the cover by a plurality of bolts 47, the outer edge of the ring resting upon the top of the work basket to define a communicating passage from the heat chamber between the partition 30 and wall 28 to the work chamber, defined by the interior of container 27, through the opening or passage provided by the flange 46 and within which the fan 44 rotates. The cover 41 or top, may be of the same low heat conductivity material as the sides 25 and bottom 26 of the furnace. The under side of the cover which is dished and has a depending conical protuberance through which the shaft 43 extends, is preferably covered with sheet metal lining 48. A stuffing box 44*a* or equivalent prevents induction of cool air when the fan 44 is blowing through the load which would otherwise result in a more or less localized cool spot in the load.

The bottom wall 26 of the furnace which may rest upon the supporting structure 49, has mounted on its lower or under side, a motor 50 having a shaft 51 extending through a collar in wall 26, the cone 52 which projects upwardly from the bottom lining member 29, and a stuffing box 50*a*. The fan 33 secured to shaft 52 rotates as previously described within the area defined by flange 32.

Preferably the pitch or inclination of blades of fans 33 and 34 is suitably high, for example, 40 to 45 degrees. As a result the heated gases swirl or take a substantially helical course when traveling through the work chamber, the ratio of motion of rotation of the stream to its motion of translation being appreciable, as is more fully set forth in my aforesaid application.

The thermo-couple 53 extends upwardly through the bottom of the furnace into the space between the grill 40 at the bottom of the work basket 27 and the fan 33. The thermo-couple 54 extends downwardly through the cover 41 and through the ring 45 into the work container 27 below the upper fan 44. The furnace in Fig. 4 is fundamentally the same as that diagrammatically shown in Fig. 1 and may be similarly operated. The control of current to the resistors 35 may be effected manually as the result of the observed readings of indicating instruments associated with thermo-couples 53 and 54. Preferably, however, the reversal of the motors and the control of the source of heat is effected automatically.

Referring to Fig. 6 the motor 55, through suitable reduction gearing, drives a cam 56 periodically to effect alternate engagement of switch arm 57 with fixed contacts 58 and 59. The circuit of the solenoid 60 is completed when switch arm 57 is in its upper position in engagement with contact 58, to effect closure of switch 61 which simultaneously connects motors 42 and 50 to the power supply main 62. The motors are so connected that fan 33 is operating as a suction fan and fan 44 operating as a blower. The contact arms 63, 64 operated simultaneously with contact arm 57 are in their upper position in engagement with contacts 65 and 66 to include the upper thermo-couple 54 in circuit with the galvanometer 67 and the slide wire contact 68 of a potentiometer network 69, or equivalent. The movable element of the galvanometer is mechanically connected as indicated by the dash lines to the slide wire contact 68 to effect its movement upon deflection of the needle in such direction and to such extent as to effect balance between the thermocouple potential and that of the potentiometer, the position of contact 68 with respect to the slide wire directly or indirectly indicating the temperature of heated gases entering the work container, or through the load toward the suction fan.

The resistors 35, 35 are connected to a switching mechanism 70 adapted to connect them in series, and to a switching mechanism 71 adapted to connect them in parallel with respect to the line conductors 72. When the furnace is cold, the temperature to which thermo-couple 54 is subjected is much less than the desired temperature and a contact 73 carried by a control disk 74 mechanically associated with the movable element of galvanometer 67 is in engagement with the fixed contact 75, completing a circuit through the solenoid 76 to effect closure of switch mechanism 71 connecting the resistors 35 in parallel to effect high rate of generation of heat. Considerable time will elapse before the furnace and its load are heated to the desired temperature and in this interval cam 56 has rotated several times. When the high part of the cam depresses the switch arms 57, 63 and 64, the circuit of solenoid 60 is broken and that of solenoid 77 established to close switch 78, reversing the connection of motors 42 and 50 to the line 62 and thereby their direction of rotation, so that fan 44 operates as a suction fan and 33 as a blower; simultaneously, thermo-couple 54 is disconnected from the measuring circuit and thermocouple 53 substituted.

Assuming that the temperature, as measured by either of thermo-couples 53 or 54, has reached the desired value, the control disk 74 has been moved to such position by the galvanometer 67 that the fixed contact 75 now engages contact 79 of the control disk to energize actuating solenoid 80 of the switch 70 which connects the resistors 35 in series and thereby effects reduc-

tion in the rate of heat supplied to the circulating medium of the furnace. If, for any reason, the temperature thereafter exceeds the desired value, the control disk 74 is moved still further in clockwise direction as viewed in Fig. 5, to break the circuit of solenoid 80. Upon the resulting cessation of current, the furnace temperature will drop, and when it again reaches the desired magnitude the supply circuit will be re-established by engagement between contacts 75 and 79 in response to position of the galvanometer needle to connect the resistors in series by re-energization of solenoid 80.

Briefly, by automatic means, the direction of circulation of the heat vehicle is reversed periodically while the furnace is being heated to the desired temperature, and while that temperature is maintained, the thermocouples being alternately and automatically brought into circuit in order that the control of heat may be in accordance with the temperature of gas entering the work chamber. With the exception of the last feature, the control of the resistors is substantially similar to that of my Patent 1,578,027, granted March 23, 1926.

The actuating mechanism between the galvanometer, the slide wire contact 68, and a control disk 74, may, for example, be of the type shown in Fig. 6, illustrating a mechanism of the character disclosed in prior Leeds Patent #1,125,699 or more specifically, a modification of this mechanism substantially corresponding to Fig. 4 of my aforesaid patent. The motor 55 rotates at substantially constant speed the shaft 81 upon which is secured the worm 82 meshing with gear 83 secured upon shaft 84 to which are attached the cams 85, 85 co-acting with the ears or lugs 86, 86 upon the pivoted lever 87 which carries the friction shoes 88, 88 co-acting with disk 89 secured upon shaft 90 for rotating it in one direction or the other, depending upon direction of deflection of the needle or pointer 91 of galvanometer 67. The magnitudes of the increments of rotation of shaft 90 are further determined by the extent of deflection of needle 91 from its normal or mid position illustrated, all in accordance with the mode of operation of apparatus of this character, as described in the aforesaid Leeds patent. Secured upon the shaft 90 is a wheel or pulley 92 around which is wrapped the cord 93, passing over the idler rolls 94 and secured to the pen or marker 95 which draws upon the record sheet P a time temperature curve. The paper chart P is fed from the roller 96 by the roll 97 whose teeth engage in marginal perforations of the sheet. The roller 97 is mounted upon shaft 98 driven from shaft 84 through the worm 99, gear 100, shaft 101, worm 102 and gear 103.

Upon the shaft 90 is secured the disk 104 upon which is disposed the potentiometer slide wire resistance R, with which co-acts the stationary contact 68. In the event that the thermometer coils are substituted for thermocouples 53 and 54, the network 69 is of the Wheatstone bridge type, and the resistance R is a balancing resistance of the bridge.

Secured upon the shaft 90 is the control disk 74 upon which are secured the arcuate contacts 73 and 79, co-acting with the stationary contact 75 to effect selective energization of the relays 76 and 80 as previously described.

If desired the automatic control of temperature may be dispensed with, an operator manipulating the switches 70 and 71 or equivalent if necessary subsequent to an observation of the chart P, for example, which continuously indicates temperature of gases flowing to or entering the work chamber, the switches 63, 64 connecting the proper thermo-couple in circuit as the motors 42 and 50 are reversed.

Insofar as some of the aspects of my invention are concerned, the control whether automatic or manual may be in accordance with the measurement of a single thermo-couple, as in my aforesaid patent.

The nature or composition of the circulated medium and the temperature at which it is maintained is determined by the treatment desired. For example in nitriding, ammonia gas is introduced into the furnace and during the process serves both as a heat vehicle and a chemical agent; in bright annealing, hydrogen is heated and circulated. In all heat-treatments including those mentioned and others as hardening, normalizing, carburizing, more satisfactory and uniform results are attained by the practice of my invention.

What I claim is:

1. In heat treating by apparatus having a work chamber, the method which comprises effecting thorough penetration of the load within said chamber by positive and independent agitation of the heat vehicle on different sides of the load.

2. In heat treating by apparatus having a work chamber, the method which comprises effecting thorough penetration of the load within said chamber by positive and independent agitation of the heat vehicle alternately on different sides of the load.

3. In a heat treating system employing a work chamber, the method which comprises drawing a heat vehicle through said chamber alternately and directly in opposite directions.

4. In the art of heating materials in a work chamber, the method which comprises circulating a heat vehicle through the chamber in one direction by suction on one side of the load within the chamber and by blowing on the other side of the load, and reversing the direction of circulation by blowing on said one side of the load and by suction on said other side of the load.

5. In a heat treating system employing a work chamber, the method which comprises directly drawing a heat vehicle through said chamber alternately in opposite directions upon attainment of predetermined temperature conditions.

6. In a heat treating system employing a work chamber, the method which comprises alternately and directly drawing a heat vehicle through the chamber in opposite directions, and, for both directions, measuring the temperature of the heat vehicle as it moves toward material within said chamber.

7. In a heat treating system employing a work chamber, the method which comprises directly drawing a heated gas toward and out of one end of the chamber and simultaneously blowing gas into the chamber from the other end thereof to effect circulation of said gas, reversing the direction of circulation by directly drawing heated gas toward and out of said other end and simultaneously blowing gas within the chamber from said first end, and, for both directions of circulation, measuring the temperature of the heated gas and regulating the supply of heat to said gas in accordance with said measurements.

8. In the art of heating material in a work chamber, the method which comprises circulating a heat vehicle in the chamber to and away

from the material, reversing the circulation, and regulating the quantity of heat supplied to said heat vehicle to effect or maintain desired temperature thereof as it moves toward said material for both directions of circulation.

9. In the art of heating material in a work chamber, the method which comprises drawing heated gas within the chamber toward and out of an end thereof and simultaneously blowing gas from another end of the chamber, and regulating the supply of heat to said gas to effect desired temperature thereof.

10. In a heat treating system having a work chamber, the method which comprises drawing a heated gas toward and out of one end of the chamber, simultaneously blowing gas within the chamber from the other end thereof, measuring the temperature of gas within the chamber adjacent said other end, and regulating the supply of heat to said gas to effect or maintain the desired magnitude of said temperature.

11. In a heat treating system employing a work chamber, the method which comprises swirling a heat vehicle passing through said chamber to generate a substantially conical heat zone, reversing the direction of movement of the heat vehicle through said work chamber, and imparting swirling movement thereto during the reverse movement to generate another substantially conical heat zone inverted with respect to said first conical zone.

12. In a heat treating system employing a work chamber open at opposite ends, the method which comprises drawing a heat vehicle through said chamber to one end thereof, thereby swirling the heat vehicle to generate a substantially conical heat zone converging toward said end, reversing movement of the heat vehicle by drawing it through the chamber to the other end thereof, and thereby swirling the heat vehicle to generate a substantially conical heat zone converging toward said other end.

13. In a heat treating system employing a work chamber, the method which comprises directly drawing a heat vehicle through the chamber, simultaneously blowing the heat vehicle through the chamber, and thereby effecting swirling movement of the heat vehicle as it passes through the chamber.

14. In the art of heating material in a work chamber, the method which comprises effecting circulation of a heat vehicle through the chamber by simultaneously drawing and blowing it toward one end of the chamber, thereby swirling the heat vehicle as it moves through the chamber, reversing the direction of circulation of the heat vehicle by simultaneously drawing and blowing it toward another end of the chamber, and thereby simultaneously reversing the direction of swirl of the vehicle.

15. In the art of heating material in a work chamber, the method which comprises rapidly raising the temperature of the load within said chamber by blowing a heat vehicle into the load simultaneously from different sides thereof, and thereafter effecting circulation of the heat vehicle for equalizing the temperature.

16. A heat treating apparatus comprising a work chamber, a heating chamber, means providing passages connecting said chambers and forming therewith a closed circulatory path, and means for effecting circulation of a heat transfer medium in said path comprising fans on opposite sides of said work chamber.

17. Heat treating apparatus comprising a work chamber, a heating chamber surrounding said work chamber, connecting passages between adjacent ends of said chambers, and a fan structure disposed in each of said passages.

18. A furnace comprising a work chamber adapted to contain material to be heated, a source of heat, and means for agitating air within said chamber heated by said source comprising fans at opposite ends of said chamber.

19. A furnace comprising a work chamber adapted to contain material to be heated, a source of heat, fans at opposite ends of said chamber, and means operable to effect drawing of air heated from said source through said chamber alternately in opposite directions by alternate operation of said fans.

20. A furnace comprising a work chamber adapted to contain material to be heated, a source of heat, propeller fans at opposite ends of said chamber, and means ensuring rotation of the fan structure at one end of said chamber in proper direction to draw air heated from said source through said chamber and simultaneous rotation of fan structure at the other end of said chamber in proper direction to blow air heated from said source through said chamber.

21. A furnace comprising a work chamber adapted to contain material to be heated, a source of heat, propeller fans at opposite ends of said chamber, means ensuring rotation of the fan structure at one end of said chamber in proper direction to draw air heated from said source through said chamber and simultaneous rotation of fan structure at the other end of said chamber in proper direction to blow air heated from said source through said chamber, and means for reversing the direction of circulation of air through said work chamber comprising means for reversing the rotation of said fans.

22. A furnace comprising a heating chamber, a work container therein spaced from the wall thereof and adapted to hold material to be heated, said container at both ends communicating with the space between it and said heating chamber, air propellers disposed adjacent the openings at both ends of said container, motors for driving said propellers, and switching mechanism controlling the energization of said motors.

23. Heat treating apparatus comprising a heating chamber, a work chamber, a passage connecting an end of said work chamber to said heating chamber, a fan disposed within said passage supported by wall structure of said apparatus, a passage connecting another end of said work chamber to said heating chamber, removable wall structure, and a fan mounted upon said removable wall structure for disposition within said second passage.

24. A furnace comprising a heating chamber, a container therein spaced from the wall thereof and adapted to hold material to be heated, a cover for said chamber and container, an apertured plate supported by said cover in spaced relation thereto and adapted to engage an end of said container, and a fan and driving motor therefor mounted upon said cover.

25. A heat treating system comprising a furnace having a work chamber, means for circulating heated air through said chamber alternately in opposite directions, and means for measuring the temperature of air entering said chamber for each direction of circulation.

26. A heat-treating system comprising a fur-

nace having a work chamber, a source of heat, means for circulating air heated by said source through said chamber alternately in opposite directions, means for measuring the temperature of air entering said chamber for each direction of circulation, and means for regulating said source of heat to effect desired temperature conditions.

27. A heat-treating system comprising a furnace having a work chamber, a heating chamber, means for circulating air through said chambers, temperature responsive devices on both sides of said work chamber, and means for reversing the direction of circulation of air in said path and simultaneously selecting that one of said temperature responsive devices which responds to temperature of air moving from said heating chamber.

28. A heat-treating system comprising a furnace having a work chamber, a heating chamber, means for circulating air through a path including said chambers, temperature responsive devices in said path on opposite sides of said work chamber, means for reversing the direction of circulation of air in said path and simultaneously selecting that one of said devices responding to temperature of air moving toward the work chamber, and means for regulating the supply of energy to said heating chamber by the selected temperature responsive device.

29. A heat treating system comprising a work chamber, means for forcibly circulating gas through said chamber, temperature responsive devices at opposite ends of said chamber, a heat source for heating said gas, and means for regulating the supply of heat by said source and controlled by said temperature responsive devices.

30. A heat treating system comprising a work chamber, means for forcibly circulating gas through said chamber, means for reversing the direction of circulation of said gas, means for indicating the temperatures at opposite ends of said chamber, and means controlling by said reversing means cooperating with said temperature indicating means to distinguish between the temperatures of gas entering and leaving said chamber.

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