Oct. 17, 1939. C. Z. ROSECRANS 2,176,473

SYSTEM FOR HEAT TREATMENT

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Fig. 1.

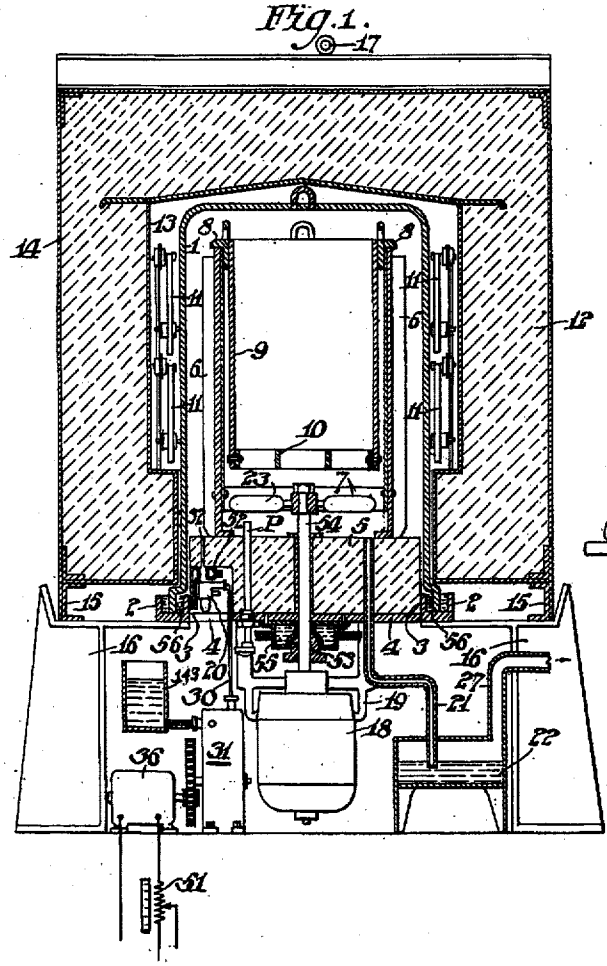


Fig. 7.

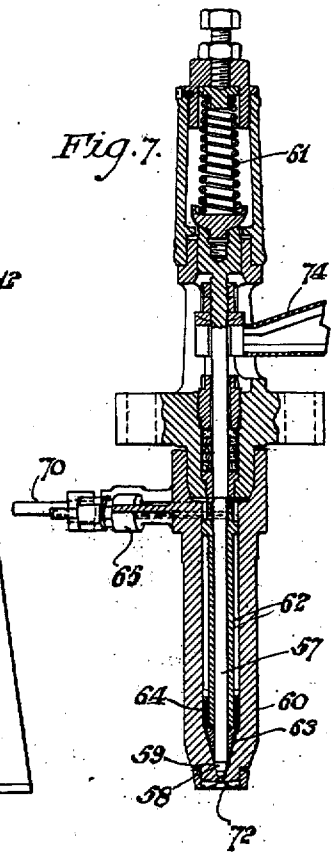


Fig. 2.

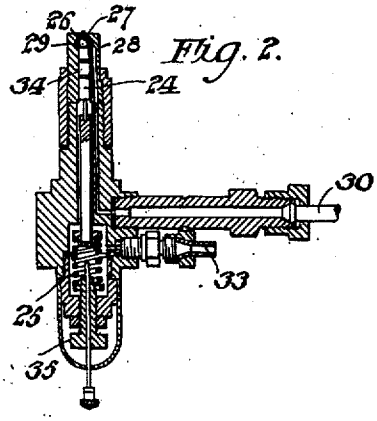
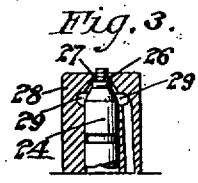


Fig. 3.



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Fig. 4.

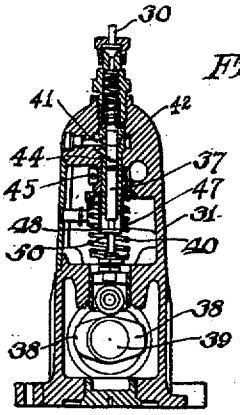


Fig. 5a.

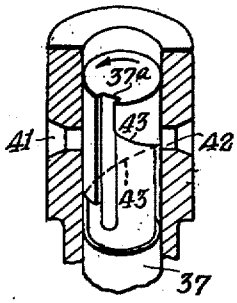


Fig. 5.

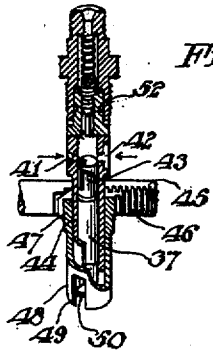
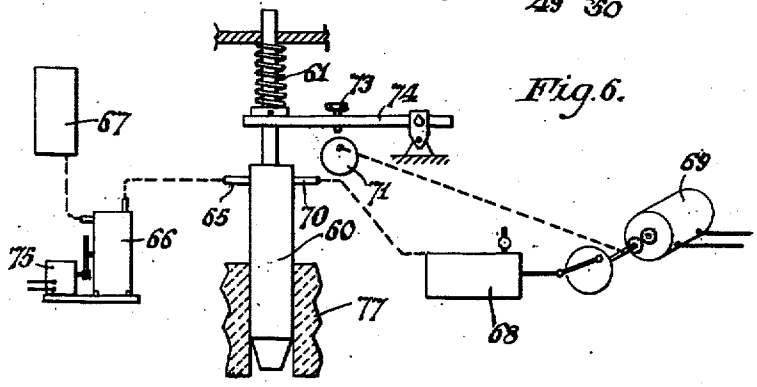


Fig. 6.



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SYSTEM FOR HEAT TREATMENT

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Fig. 8.

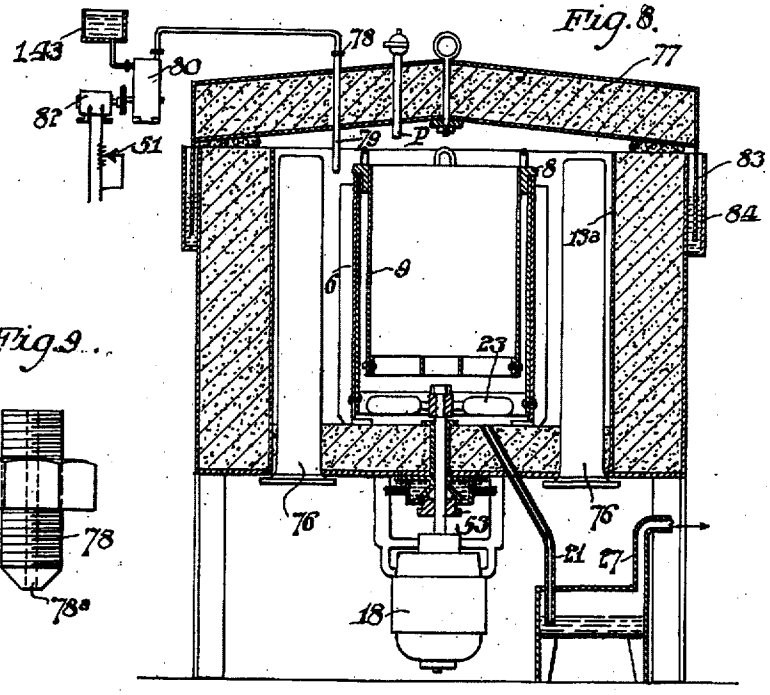
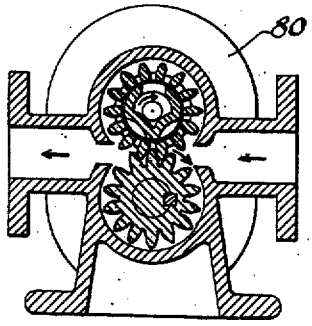


Fig. 9.

Fig. 10.



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SYSTEM FOR HEAT TREATMENT

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Fig. 11.

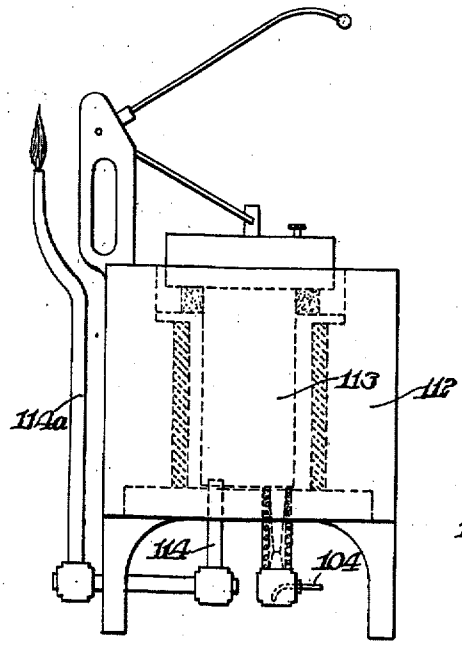
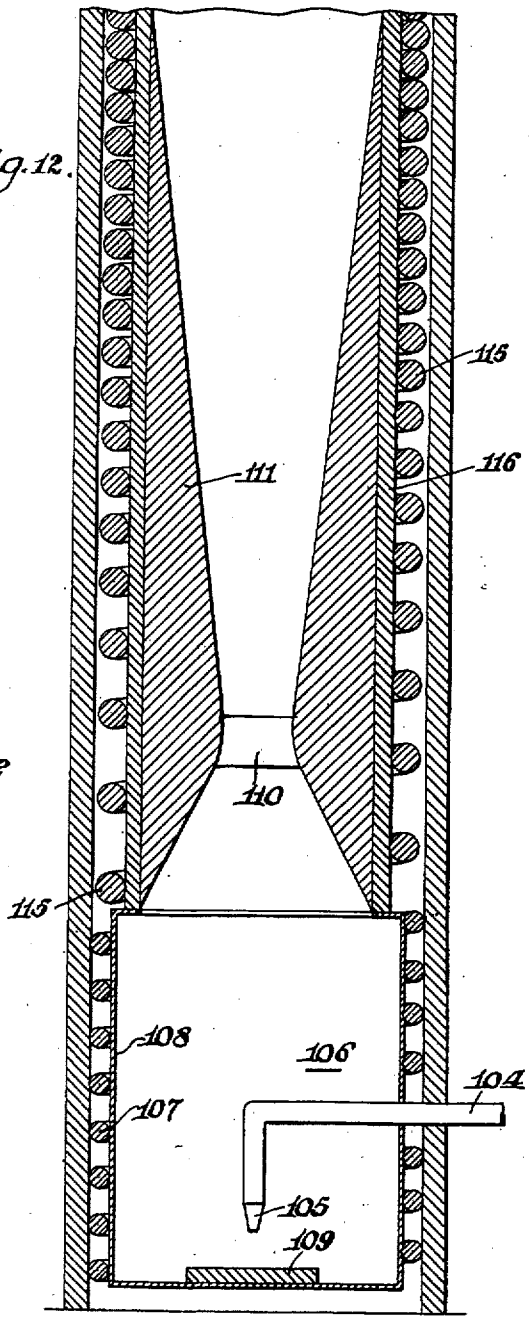


Fig. 12.



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Patented Oct. 17, 1939

2,176,473

UNITED STATES PATENT OFFICE

2,176,473

SYSTEM FOR HEAT TREATMENT

Crandall Z. Rosecrans, Philadelphia, Pa., assignor to Leeds & Northrup Company, Philadelphia, Pa., a corporation of Pennsylvania

Application July 22, 1936, Serial No. 91,855

3 Claims. (Cl. 266—5)

My invention relates to systems for treatment of metal objects in furnace atmospheres, and more particularly to the treatment of metal objects in chemically active, specifically carbonaceous atmospheres, to form a diffusion alloy case or to prevent loss of carbon during hardening.

In accordance with my invention, a treating or processing fluid of definite chemical composition is positively fed at metered rate to the furnace atmosphere and is therein dissociated to maintain or form a processing or treating atmosphere of definite reproducible composition; more particularly, the metered agent is intermittently or continuously injected into the furnace atmosphere at high velocity to preclude pyrolytic breakdown or dissociation of the agent at or adjacent the point or points of injection, to avoid clogging of the one or more injection nozzles or orifices; the forcible injection of the agent also acts to effect turbulence of the furnace atmosphere to enhance uniformity of reaction temperature and uniformity in characteristics imparted to the objects treated.

In certain forms of my invention, the fluid agent is fed to the injection nozzle by a positive displacement pump; the rate of feed of the agent may be varied, as by adjustment of the pump speed, or the timing of a valve in the pump, to obtain the desired reactive state of furnace atmosphere.

My invention further resides in the apparatus having the features of novelty hereinafter described and claimed.

Application Serial No. 696,020, as originally filed October 31, 1933, (now Patent No. 2,056,175, Oct. 6, 1936), by applicant and another, disclosed and described subject matter herein specifically claimed as applicant's sole invention.

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

Fig. 1, with parts in section, illustrates a furnace and a system for injecting a treating agent;

Fig. 2, on enlarged scale, is a sectional view of the injection nozzle of Fig. 1;

Fig. 3, on further enlarged scale, is a detail view in section of the tip of the nozzle of Fig. 2;

Fig. 4 is a cross-section on enlarged scale of the feed-pump shown in Fig. 1;

Fig. 5, on further enlarged scale, is a sectional view of the plunger mechanism of Fig. 4;

Fig. 5a is a detail view showing the plunger of Fig. 5 in another operating position;

Fig. 6 illustrates diagrammatically a modified feed system;

Fig. 7 is a sectional view on enlarged scale of the nozzle of Fig. 6;

Fig. 8, with parts in section, illustrates another furnace and feed system therefor;

Fig. 9 is a detail view on enlarged scale of the injection nozzle of Fig. 8;

Fig. 10 illustrates, in section, the feed pump of Fig. 8;

Fig. 11 illustrates another form of furnace and mode of injecting a treating agent;

Fig. 12, on enlarged scale, is a sectional view of the injection nozzle of Fig. 11.

Referring to Fig. 1, the lower edge of the retort 1 rests within a peripheral groove, defined by the flanges 2, 3 of plate 4, which is filled with a suitable sealing material, such as oil or an oxide, such as hematite. The groove also serves to center the retort with respect to the base member 5 of suitable heat-insulating material. Upwardly from the upper face of the base member 5 extends a series of circumferentially spaced supports 6 connected by ring 7 and whose upper ends receive the flanged member 8 from which depends the work container or basket 9. The bottom of the basket is provided with a grating or grid 10 which supports the work while allowing for circulation of the treating gases hereinafter described.

The electric heaters 11 are supported in spaced relation around retort 1 by the housing member 12 having an inner shell 13 and an outer shell 14, the space between which is filled with material of suitably high heat-resisting and insulating properties as "Sil-o-cel."

Other methods, such as gas-firing, may be used instead of heaters 11, but the electrical method is preferred because affording better temperature control.

The weight of the housing assembly is carried by the structure 15 which, in turn, is mounted upon the main frame 16 of the furnace. The housing or heating bell 12 is removable from the position shown by lifting it upwardly and to that end, one or more eyes 17 or the like, are provided to facilitate attachment of suitable lifting chains.

Assuming that the parts are in the position shown and that heaters 11 are energized, the fan 23, which may be of the propeller type, or of the blower type, or of the propeller type with high blade angle to obtain centrifugal or blower action, is rotated at suitably high speed, for example, 1800 revolutions per minute, by motor 18 supported by bracket 19 from plate 4. The gas within the retort, which initially may be air, is

circulated in the closed path through the work basket 9 and the space between the retort 1 and the work basket, (in the sequence named when fan 23 is of the centrifugal type, and in either sequence when fan 23 is of the propeller type), uniformly to heat the articles or objects, such as gears, shafts, roller-bearing races, or the like, within the basket.

When the fan is of the centrifugal blower type, the air or gas always flows downwardly through the work basket irrespective of the direction of rotation of the fan; when the fan is of the propeller type, the direction of circulation may be reversed by reversing the direction of rotation of the fan.

To use the furnace for carburizing, a carburizing agent, preferably fusel oil, carbitol, or other compound of the character specified in the aforesaid Patent No. 2,056,175, is discharged from the atomizer 20 in the form of a jet of fine mist or spray into the space between the basket 9 and retort 1 where it is quickly vaporized by contact with the circulating gas and/or the wall structure of retort 1 or the external wall structure of basket 9. The vaporized agent shortly thereafter contacts the articles within basket 9. The carburizing liquid is preferably not injected until after the preliminary heating period during which air, or a substantially inert gas, as nitrogen, has been circulated to raise the work to carburizing temperature. The atmosphere within the retort, within a short time after injection has begun, consists substantially solely of the products of the pyrolytic breakdown of the carburizing agent, principally carbon monoxide, methane and hydrogen, the air or the gas previously in the retort having been forced out through the bleeder 21 which discharges to atmosphere, in the particular arrangement of Fig. 1, through the liquid seal 22.

The reaction between the articles and the treating atmosphere forms at and near the surface of the articles a diffusion alloy case, specifically a carburized case.

Preferably for carburizing the agent is of the character claimed in the aforesaid Patent No. 2,056,175, for example, fusel oil, diethyleneglycol, or diethyleneglycolmonoethylether, since for these compounds the time of pyrolytic breakdown is suitably short so that the gas or vapor is in suitably active state or some of its components, as carbon, are nascent by the time it reaches the work. It is also characteristic of use of such compounds that there is substantial freedom from hard or tarry deposits on the work and furnace parts within the retort.

The pyrometer P measures the temperature of the circulating carburizing agent and may be utilized to actuate or control temperature recording and/or controlling apparatus during carburization of the work.

At the end of a run, the heating bell 12 is lifted from the position shown and may be lowered in position to heat a similar set-up which, in the meantime, has been loaded; i. e., the installation may include a set-up similar to that shown in Fig. 1, except for heating bell 12 which may be used alternately to heat the retorts and work therein.

After removal of heating bell 12, a forcible circulation by fan 23 or equivalent may be continued more quickly to bring the temperature of the work to a desired lower magnitude, whereupon the retort 1 may be lifted off, allowing the basket 9 and its contents to be lifted from the furnace.

With the construction shown in Fig. 1, there is no need to disconnect any of the pipes communicating with the interior of the retort to allow removal of either the retort 1 or the heating bell 12.

The atomizer nozzle structure 20 may be similar to that used for fuel injection in Diesel engines, Figs. 2 and 3. The plunger 24 is forced by spring 25 to seat its valve surface 26 against the face 27 of the body member 28 of the nozzle. When the pressure of the liquid carburizing agent within the chamber 29, which is supplied through pipe 30 from pump 31, attains a pressure high enough to overcome spring 25, the liquid is forced through the nozzle into the passage 32 in the base 5; the valve surfaces 26, 27 remain slightly separated until the liquid pressure, in the cycle of operation of pump 31, falls below the value for which spring 25 is set or adjusted. The pipe 33 drains off any of the liquid which may pass between the plunger 24 and the side walls of the guide chamber 34 therefor.

The positive feed pump 31 as appears from Figs. 4 and 5 comprises a piston 37 which is periodically lifted by cams 38 on the motor-driven pump shaft 39 against the action of the return spring 40. When the top of the piston is below the two inlet ports 41, 42, interconnected by an annular channel in the pump body, Fig. 4, the carburizing liquid flows from the container 143 through ports 41, 42 into the cylinder space above the piston. As the piston continues to rise, the pressure attains a value sufficient to overcome the bias of spring 25 in the nozzle, whereupon the fluid is ejected from the nozzle into the furnace at high velocity until the piston reaches such position that the helical edge 43 is above port 42 (Fig. 5a) allowing fluid above the piston to flow down through slot 37a in the piston and thence out of port 42, and whereupon the pressure on the fluid abruptly falls and the nozzle valve 24 is seated by its spring 25.

To vary the amount of carburizing agent injected for each cycle, the piston 37 is rotatable in its barrel or cylinder 44 by movement of the control rod 45 which is provided with a rack 46 engaging the toothed quadrant 47 of the control sleeve 48 which, at its lower end, is provided with a guide slot 49 which receives the cross piece 50 secured to and extending from the piston 37. Adjustment of piston 37 in the direction of the arrow, Fig. 5a, reduces the output because the helical edge 43 passes port 42 earlier in the cycle; conversely, adjustment of piston 37 in reverse direction increases the amount of carburizing agent fed by the nozzle for each cycle of the pump.

The rate of feed of the carburizing agent may also be adjusted by changing the speed of the pump, for example, by changing the setting of the rheostat 51 in circuit with the pump motor 36.

The pump 31 is a positive displacement pump, consequently the amount of carburizing liquid fed within any given time is definitely fixed by either of the adjustments above described.

The carburizing atmosphere within the retort is of definite reproducible composition because the rate of feed of the agent is definitely metered, because the proportions of carbon monoxide, methane and hydrogen are definitely fixed by the stoichiometric composition of the agent, cracked or dissociated, and because the temperature is definitely known and controllable.

The pressure at which the liquid is ejected is suitably high, for example, of the order of 2500 pounds per square inch. The agent therefor, as it issues from the nozzle into the furnace atmosphere, is in the form of a jet of fine mist or spray moving at very high velocity. The temperature within the retort is so high, of the order of 1700° F., that vaporization of the jet is practically instantaneous upon contact with the furnace atmosphere and, in addition, the jet velocity is so high there is no tendency for liquid to flow back and clog the passage 32 or the nozzle orifice. Moreover, the velocity is so high there is no opportunity for the agent to crack while in the passage 32 and cause deposits therein.

Preferably, as shown in Fig. 1, the atomizing nozzle may be provided with a jacket 52 through which water or other suitable cooling fluid is circulated to maintain it at a temperature low enough to insure proper working of the nozzle mechanism and suitably below the cracking temperature of the carburizing agent. In actual practice, the nozzle temperature has been maintained below about 550° F.

The bushing 53 for the fan shaft 54 may be provided with a cooling jacket 55 and, if desired, the seal for the retort 1 may be provided with a cooling coil 56.

The following is given as an example, illustrative of the practice of the invention.

The furnace, similar to Fig. 1, was provided with a cylindrical work basket 9, fourteen inches in diameter, containing 150 pounds of cylindrical specimens of S. A. E. 1020 steel, ⅞ inch in diameter and six inches long, positioned haphazard with respect to the basket and each other, filling the basket to about three-fourths of its capacity. Fan 23 was of the propeller type, diameter 13½ inches, four blades, pitch 21°, rotated by motor 18 at a speed of 1800 revolutions per minute. The carburizing agent was fusel oil and was fed at the rate of 450 cubic centimeters per hour throughout the run which was of two hours' duration, after raising the temperature of the furnace, during circulation of nitrogen therein, for a preliminary period of about fifty minutes. The temperature as measured by the thermocouple pyrometer P was maintained at 1700° F. throughout the run. The results were as follows:

Case	Depth in inches
Hyper-eutectoid	0.012
Eutectoid	0.009
Hypo-eutectoid	0.009
Total	0.030

The magnitudes in the above table are in each case the average for specimens located in various places in the container. The variation from each of these average magnitudes for the different specimens was insubstantial and within the error of observation by microscope of a cross-section of the case, showing substantial uniformity of case on all specimens.

On removal of the work there was no uncombined carbon or soot or other deposits adherent to or caked upon any of the pieces; the carbon upon the work was slight in quantity, non-adherent to the work and easily blown or brushed therefrom.

This furnace may also be used to practice the method of hardening described and claimed in Harsch Patent No. 2,103,848, of which it is characteristic that the furnace atmosphere, during heating of the work, such as dies, of high carbon or other tool steels, to quenching temperature, is maintained in a slightly carburizing state to preclude loss of carbon from the steel.

When the source of the carburizing component of the agent introduced into the furnace atmosphere, for example kerosene, is deficient in oxygen, and so requires admixture of its dissociation products with air, or other source of oxygen, the arrangement diagrammatically shown in Fig. 6 and using the nozzle shown in detail in Fig. 7 may be used to obtain a carburizing atmosphere of definite reproducible composition.

The spindle 57, Fig. 7, of the nozzle is provided with its tapered end 58 biased against the lower end of the seat 59 in the casing 60 by the spring 61. Immediately surrounding the spindle 57 is the sleeve 62 which rests on the cone 65 engaging the upper part of seat 59 and fluted to permit passage of air and carburizing liquid. Above the cone 63 are a plurality of small perforated discs 64 through which the air and carburizing liquid is forced, as hereinafter described.

The carburizing liquid is fed to the space above the discs 64 through pipe 65 in communication therewith by the pump 66 whose inlet is connected to a suitable reservoir 67 of carburizing liquid. An air compressor 68, driven by motor 69, or equivalent, is connected by pipe 70 to the space above the discs 64; a reservoir or air-storage tank may be connected to the line from the compressor to the nozzle. Alternatively, pipe 70 may connect the nozzle to any suitable source of air, or oxygen, under high, constant pressure.

The cam 71 driven by motor 69 at suitable speed, for example, 250 revolutions per minute, periodically lifts the spindle 57 against spring 61, as viewed in Fig. 7, whereupon the compressed air, which is at high pressure, for example, of the order of 2000 pounds per square inch, flows through the nozzle orifice 72 at high velocity carrying with it the charge of carburizing fluid above the discs. The movement of the air and liquid at high velocity through the small perforations of the disc causes the liquid and air to be mixed and issue from the nozzle as a fine spray or jet travelling at high speed into the furnace atmosphere.

The amount of air entering the furnace through the nozzle for each injection may be varied by changing the length of the portion of each cycle during which the spindle valve is away from its seat 58; for example, as appears from Fig. 6, the proportion of the cycle during which cam 71 is effective to hold the valve from its seat may be varied by adjustment of the screw 73 supported by the rocker arm 74.

The amount of carburizing liquid entering the furnace for each injection may be predetermined, for example, by varying the time of cut-off, as described in connection with the pump of Figs. 4 and 5. If desired, the rate of feed of the carburizing liquid may be controlled by varying the speed of the pump motor 75. In either event, change in the rate of feed of carburizing liquid varies the amount of liquid in the nozzle above the discs 64 for each cycle of the valve spindle 57.

This type nozzle is not, without modification, suited for a bottom-injection furnace such as shown in Fig. 1; it is used with a top-injection furnace such as shown in Fig. 8, having the nozzle in the position shown in Figs. 6 and 7 with its orifice at the lower end of the nozzle structure. The type nozzle shown in Fig. 2 may be used with the top-injection furnace of Fig. 8.

The modification shown in Fig. 8, is characterized by absence of a retort such as retort 1 of Fig. 1. The work basket 9 rests upon the upper ends of the vertical supports 6, the inner wall of the basket defining what may be considered a work chamber. The space between the outer wall of the basket and the inside face of the shell 13a is the chamber in which the carburizing gas or furnace atmosphere is heated by transfer of heat from the heater units 76.

Since it would not be practical or desirable to expose the heating resistors to direct contact with the carburizing gas, the heating resistance is divided into a plurality of encased units 76 circumferentially spaced within the shell 13a. Each unit may comprise resistance wire helically wound and supported in U-form by a refractory cement. The assembly is encased by the housing of the unit which is nichrome, or other metal substantially unaffected by the high temperature and the carburizing atmosphere. The space within the unit housing is filled with material, for example, Austrian furnace magnesite, having high electrical resistance and high thermal-conductivity.

As in the modification of Fig. 1, the carburizing gas is forcibly circulated by a fan 23 through the work and heating chambers.

When the carburizing agent is injected into the furnace atmosphere by a nozzle structure, such as shown in Fig. 2 or 7, the tip of the nozzle preferably does not extend into the furnace chamber, but is in communication with a passage in the cover 77 corresponding to passage 32 of Fig. 1. As in the modification of Fig. 1, the carburizing agent, in metered quantity, is forcibly injected into the furnace as a fine spray which is immediately vaporized, the high velocity of the jet precluding clogging of the jet orifice and premature cracking of the carburizing agent which would tend to cause deposits fouling the orifice and the jet passage.

In lieu of the valved nozzles of Figs. 2 and 7, there may be used a simple nozzle, such as an open ended tube 78, Fig. 9, having one or more small openings 78a at its lower end. The discharge end of the nozzle enters the pipe 79 which is directed or extends into the heating chamber of the furnace and which serves the same general purpose as passage 32 of Fig. 1. Pipe 79 may be omitted and the nozzle 78 fitted into the passage through the cover 77.

The pump 80 is a positive displacement pump; it may be of the type shown in Figs. 4 and 5 having a variable cut-off for adjustment of the rate of feed of the carburizing agent to nozzle 78 from the reservoir 143, or it may be a gear pump 80, as shown in Fig. 10. In either case, the speed of the pump may be controllable, as by rheostat 51 in circuit with the pump motor 82 to permit variation in the rate of feed of the carburizing liquid.

The carburizing agent issues from the nozzle in jet form, the jet travelling at high velocity through pipe 79 into the furnace where it is substantially immediately vaporized. Clogging of the nozzle cannot arise because of the capability of the pump to develop, in event of stoppage, high pressure which blows out or away any obstruction tending to close the orifice. Moreover, the time required for the agent to traverse tube 79 is so short that premature cracking therein does not occur thus avoiding deposits within the tube.

The cover 77 is provided with a deep flange 83 received by channel 84 containing suitable sealing liquid or material.

The operating procedure is readily understandable from the previous description of Fig. 1. The metering of the carburizing agent and the control of the furnace temperature provide for definite, controllable and reproducible composition of the furnace atmosphere insuring consistently good and uniform results for different runs. The forcible circulation or stirring of the carburizing atmosphere by fan 23 insures uniformity of the reaction temperature and of the composition of the furnace atmosphere throughout the furnace load, with resultant uniformity of characteristics of the product.

The velocity of circulation of the carburizing agent is preferably high, and preferably such that the pyrolytic breakdown or dissociation process beginning almost immediately the agent is injected into the furnace atmosphere is well under way or has reached a stage by the time the freshly injected treating agent reaches the work so that nascent carbon resulting from the breakdown or dissociation immediately combines with or enters into the metal to be carburized.

In the modification of my invention shown in Figs. 11 and 12, a carburizing liquid, as carbitol, is fed at metered rate, as by a positive displacement pump, to pipe 104 which terminates in a nozzle 105 in a vaporizing chamber 106 suitably heated to a temperature high enough to vaporize the liquid but well below the cracking temperature of the liquid; for example, the temperature to which the chamber is heated as by heater coil 107 may be of the order of 350° F.

The wall 108 of the vaporizing chamber and the target 109 may be of nichrome or other suitably resistant material.

The vaporized carburizing agent enters the throat 110 of the nozzle 111 and expands through the throat to the point where it enters the bottom of the furnace 112. Because of the pressure developed in the vaporizing chamber and the expanding passage of the nozzle, the vapor or gas issues from the nozzle at high velocity, for example, of the order of 400 feet per minute. The turbulence created by the high-velocity jet in the work chamber 113 of the furnace, which specifically is a small hardening furnace, procures substantial uniformity of the composition of the gaseous atmosphere in the furnace which is preferably slightly carburizing.

The opening for the outlet pipe 114 is preferably disposed as shown, in the bottom of the furnace at a region remote from, as diametrically opposite, the mouth of the nozzle 111.

Preferably, a second heating coil 115 is wound lengthwise of the nozzle, as upon the tube 116 of "Rezistal" or other suitable metal which encases nozzle 111. The temperature of the vapor is thus increased during its passage through the nozzle, consequently its rate of expansion is increased materially to increase the velocity of the vapor as it emerges from the nozzle. The heater 115 also avoids any great temperature gradients along the nozzle which would tend to cause deposits of carbon. The heaters are preferably so designed that the vapor is almost at furnace temperature by the time it leaves the nozzle. The throat and divergent portion of the nozzle are designed to provide maximum possible velocity of the gases issuing from the nozzle to promote a maximum turbulence in the work chamber.

Since the jet is substantially at furnace temperature, it causes no localized cold spot in the furnace near its region of entry.

The furnace 112 is provided with resistors, not shown, for maintaining or obtaining the desired

temperature of the work and the furnace atmosphere. The temperature may be measured and/or controlled by a pyrometer, not shown. The waste gases escape to atmosphere from pipe 114a connected to the conduit 114 and are burned as a matter of safety to the operator.

In all modifications, since the rate at which the carburizing fluid is fed to the furnace is definitely controllable, and the composition of the fluid is determined stoichiometrically, or by chemical law of combination, the composition of the treating atmosphere is definite and reproducible, insuring consistent results for different carburizing or hardening runs. Moreover, because the carburizing liquid is fed to the nozzle or pipe by a positive displacement pump capable of producing high pressure, clogging of the nozzle, by products of cracking of the carburizing liquid or agent, is precluded and feed of the liquid at predetermined, metered rate is ensured.

While I have illustrated and specifically described preferred forms of apparatus, it is to be understood my invention is not limited thereto but is coextensive in scope with the appended claims.

What I claim is:

1. A system for heat-treatment of metal objects comprising a furnace including a chamber for said objects, means providing a passage for discharge into said chamber of a treating liquid, unmixed with gas, which by pyrolytic breakdown forms the atmosphere in which said objects are treated, and feeding means for the liquid comprising a positive displacement pump for exerting upon the liquid a pulsating pressure which increases upon increase of resistance to flow of the liquid through said passage to ensure feed of a constant metered amount of said liquid per unit of time irrespective of greater or lesser obstruction of said passage as by said breakdown products of said liquid.

2. A system for heat-treatment of metal objects comprising a furnace including a chamber for said objects, a nozzle for discharging a treating liquid into said chamber, a high pressure pump having a reciprocating piston for feeding a predetermined amount of said liquid to said nozzle for each reciprocation of said piston, valve means in said nozzle for controlling the discharge from said pump, and means for opening and closing said valve means at predetermined times in the cycle of reciprocation of said piston.

3. A system for heat-treatment of metal objects comprising a furnace including a chamber for said objects, a nozzle for discharging a treating liquid into said chamber, a high pressure pump having a reciprocating piston for feeding a predetermined amount of said liquid to said nozzle for each reciprocation of said piston, valve means in said nozzle for controlling the discharge from said pump, and means for opening said valve when the pulsating pressure exerted on said liquid by said piston exceeds a predetermined magnitude and for closing said valve when the pressure is less than a predetermined magnitude.

CRANDALL Z. ROSECRANS.

CERTIFICATE OF CORRECTION.

Patent No. 2,176,473. October 17, 1939.

CRANDALL Z. ROSECRANS.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, first column, lines 3, 4 and 5, strike out "(in the sequence named when fan 23 is of the centrifugal type, and in either sequence when fan 23 is of the propeller type),--; and second column, line 30, after "42" strike out the comma; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 1st day of October, A. D. 1940.

Henry Van Arsdale,
Acting Commissioner of Patents.

(Seal)

temperature of the work and the furnace atmosphere. The temperature may be measured and/or controlled by a pyrometer, not shown. The waste gases escape to atmosphere from pipe 114a connected to the conduit 114 and are burned as a matter of safety to the operator.

In all modifications, since the rate at which the carburizing fluid is fed to the furnace is definitely controllable, and the composition of the fluid is determined stoichiometrically, or by chemical law of combination, the composition of the treating atmosphere is definite and reproducible, insuring consistent results for different carburizing or hardening runs. Moreover, because the carburizing liquid is fed to the nozzle or pipe by a positive displacement pump capable of producing high pressure, clogging of the nozzle, by products of cracking of the carburizing liquid or agent, is precluded and feed of the liquid at predetermined, metered rate is ensured.

While I have illustrated and specifically described preferred forms of apparatus, it is to be understood my invention is not limited thereto but is coextensive in scope with the appended claims.

What I claim is:

1. A system for heat-treatment of metal objects comprising a furnace including a chamber for said objects, means providing a passage for discharge into said chamber of a treating liquid, unmixed with gas, which by pyrolytic breakdown forms the atmosphere in which said objects are treated, and feeding means for the liquid comprising a positive displacement pump for exerting upon the liquid a pulsating pressure which increases upon increase of resistance to flow of the liquid through said passage to ensure feed of a constant metered amount of said liquid per unit of time irrespective of greater or lesser obstruction of said passage as by said breakdown products of said liquid.

2. A system for heat-treatment of metal objects comprising a furnace including a chamber for said objects, a nozzle for discharging a treating liquid into said chamber, a high pressure pump having a reciprocating piston for feeding a predetermined amount of said liquid to said nozzle for each reciprocation of said piston, valve means in said nozzle for controlling the discharge from said pump, and means for opening and closing said valve means at predetermined times in the cycle of reciprocation of said piston.

3. A system for heat-treatment of metal objects comprising a furnace including a chamber for said objects, a nozzle for discharging a treating liquid into said chamber, a high pressure pump having a reciprocating piston for feeding a predetermined amount of said liquid to said nozzle for each reciprocation of said piston, valve means in said nozzle for controlling the discharge from said pump, and means for opening said valve when the pulsating pressure exerted on said liquid by said piston exceeds a predetermined magnitude and for closing said valve when the pressure is less than a predetermined magnitude.

CRANDALL Z. ROSECRANS.

CERTIFICATE OF CORRECTION.

Patent No. 2,176,473. October 17, 1939.

CRANDALL Z. ROSECRANS.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, first column, lines 3, 4 and 5, strike out "(in the sequence named when fan 23 is of the centrifugal type, and in either sequence when fan 23 is of the propeller type),--; and second column, line 30, after "42" strike out the comma; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 1st day of October, A. D. 1940.

Henry Van Arsdale,
Acting Commissioner of Patents.

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