April 19, 1949. F. O. HESS 2,467,746

HEAT-TREATING APPARATUS

Filed April 12, 1943 2 Sheets-Sheet 1

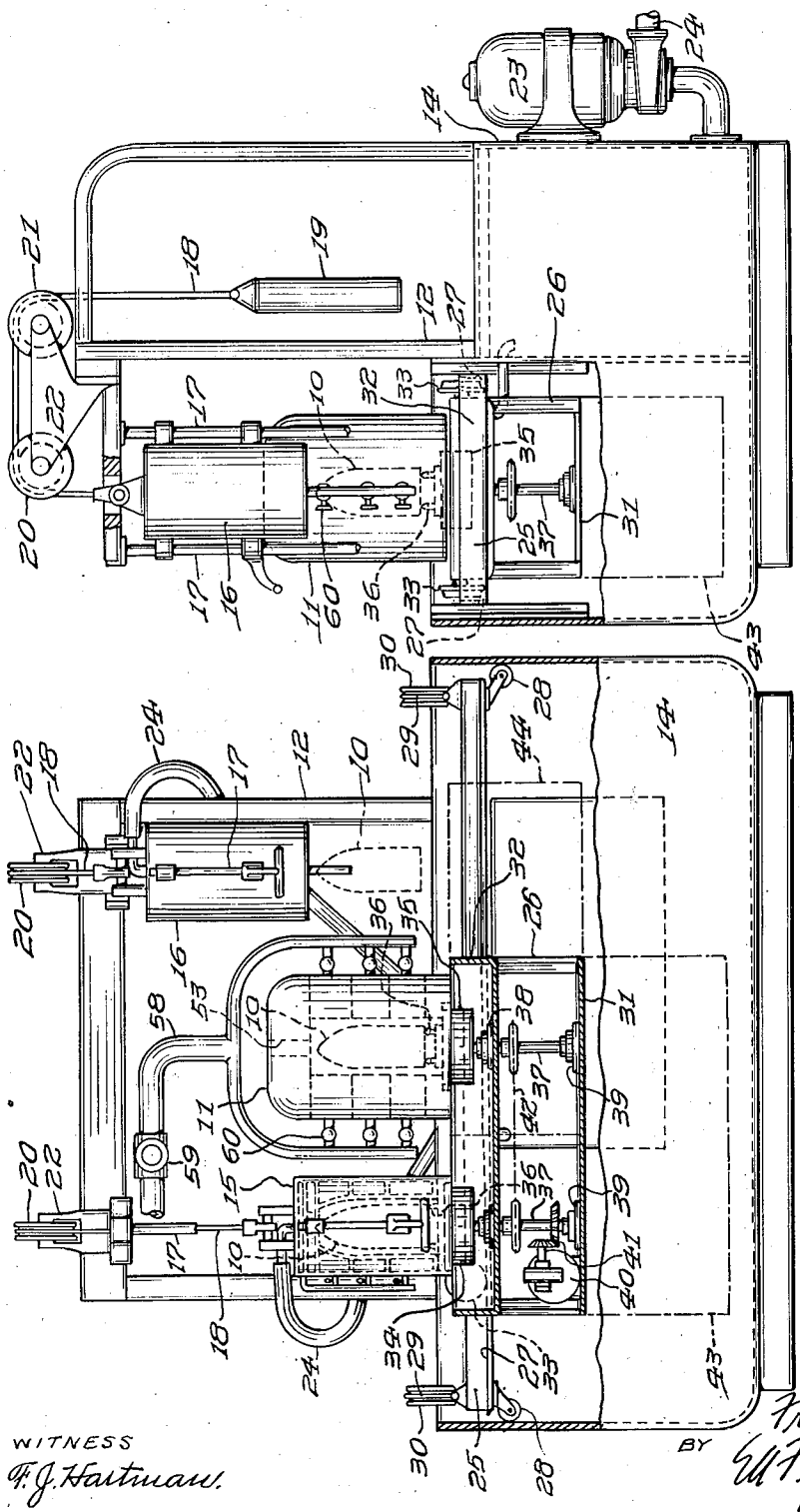

Fig. 2.



Fig. 1.

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HEAT-TREATING APPARATUS

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Fig. 3.

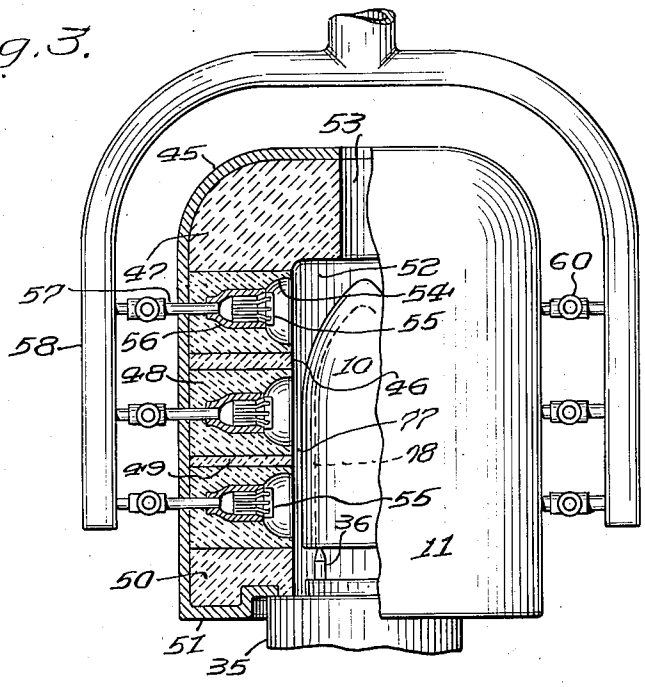
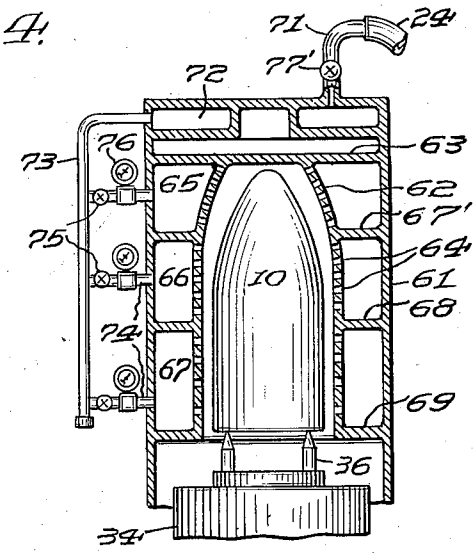



Fig. 4.

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Patented Apr. 19, 1949 2,467,746

# UNITED STATES PATENT OFFICE

2,467,746

## HEAT-TREATING APPARATUS

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Original application April 12, 1943, Serial No. 482,697. Divided and this application December 14, 1944, Serial No. 568,150

5 Claims. (Cl. 266—4)

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My invention relates to heat treating metallic bodies, and is concerned with an improvement for heating metallic bodies rapidly to an elevated temperature in a bell type heating unit and effecting such heating of a number of the bodies in rapid succession.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the claims. The invention, both as to organization and method, together with the objects and advantages thereof, will be better understood by reference to the following description taken in connection with the accompanying drawings forming a part of this specification, and of which:

Fig. 1 is a view in elevation, partly broken away and in section, of apparatus for heating metallic bodies in accordance with the invention;

Fig. 2 is a view in elevation, partly broken away and in section, taken at right angles to Fig. 1;

Fig. 3 is an enlarged fragmentary view, partly broken away and in section, of the heating unit embodied in the apparatus of Figs. 1 and 2; and

Fig. 4 is an enlarged vertical sectional view of one of the quenching units embodied in the apparatus of Figs. 1 and 2.

Referring to the drawings, apparatus embodying the invention is shown for heat treating and hardening work pieces 10. As best shown in Figs. 1 and 2, the apparatus comprises a stationary heating unit 11 of the bell type which is closed at its upper end and open at the bottom. The heating unit 11 is mounted on a frame 12 formed of angle members which is fixed to and extends upwardly from a tank or vessel 14. At opposite sides of the heating unit 11 are located vertically movable quenching units 15 and 16. The quenching units 15 and 16 are also of the bell type and move vertically along guide rods 17 which extend downwardly from an overhanging part of frame 12, as shown most clearly in Fig. 2.

Each quenching unit is movable between the positions of quenching units 15 and 16, as shown in Fig. 1, and the vertical movement of each of these units may be accomplished with the aid of a cable 18 which is connected at one end to one of the quenching units and at the opposite end to a counterweight 19. The cables 18 pass over and are guided by pulleys 20 and 21 which are journaled in brackets 22 at the top of frame 12. A pump 23 is connected to the bottom of tank 14 to raise the cooling liquid employed for quenching, such as water, for example, through flexible conduits 24 which are connected at their upper ends to the quenching units 15 and 16.

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Within the tank 14 is provided a vertically movable platform 25 upon which moves a carriage 26. The platform includes a pair of parallel rails or tracks 27 extending lengthwise of the tank 14 and terminating at the sides thereof. The platform 25 is provided with a wheel 28 at each corner which extends beyond the ends of the platform and engages a side wall of the tank 14, so that the platform will fit snugly between the ends of the tank and can freely move up and down therein. Vertical movement of the platform 25 may be accomplished with the aid of cables 29 which are connected at one end to the ends of the platform and pass over pulleys 30 mounted on the frame 12. The opposite ends of the cables 29 may be connected to suitable counterweights (not shown) which are similar to the counterweights 19.

The carriage 26 is provided with a solid bottom floor 31 and a shallow vessel 32 at the upper portion which is spaced from the floor 31. The carriage 26 is provided with wheels 33 which are journaled at the side of vessel 31 and adapted to move along the rails 27 of platform 25. Two work support members 34 and 35 are mounted on the carriage 26 and located in the shallow vessel 32. The support members 34 and 35 extend above the sides of vessel 32 and are provided with a number of pins 36 at their upper faces for supporting the work pieces 10 to be heat treated and hardened.

The members 34 and 35 are fixed to the upper ends of rotatable spindles 37 which extend vertically downward through the bottom of the vessel 32 to the floor 31, and are provided with suitable bearings 38 and 39, respectively. Rotating movement is imparted to the spindles 37 and work support members 34 and 35 fixed thereto by an electric motor 40 which is mounted on the floor 31 of carriage 26. The motor 40 is connected by gearing 41 to the left-hand spindle in Fig. 1, and this spindle in turn is connected by an endless belt or sprocket chain 42 to the right-hand spindle.

The work supporting members 34 and 35 are spaced apart the same distance as the quenching units 15 and 16 are spaced from the stationary heating unit 11. Thus, when carriage 26 is in the position shown in Fig. 1, the work support member 34 is in alignment with the quenching unit 15 and the work support member 35 is in alignment with the heating unit 11, whereby one of the work pieces 10 may be heat treated at the same time that another work piece is being quenched following heat treatment.

Since the length of time required for cooling the work piece 10 in quenching unit 15 usually is less than that required for heat treating the work piece in heating unit 11, the quenching unit 15 may be raised to the same elevation as quenching unit 16 immediately after the desired quenching of the work piece is accomplished. This will permit the quenched work piece to be removed from the support 34 and a new work piece to be placed on that support while heat treatment of the work piece in heating unit 11 is being completed.

When heat treatment of the work piece 10 in heating unit 11 is completed, the platform 25 is then lowered so that the carriage 26 will be moved downwardly to the position indicated in dotted lines 43 in Figs. 1 and 2. In this lower position of carriage 26 the work piece 10 is brought out of the heating unit 11 and sufficient clearance is provided between the open bottom of the heating unit and the upper ends of the work pieces on support members 34 and 35 to permit horizontal movement of the carriage 26.

The carriage 26 is moved toward the right in Fig. 1 until the work support member 34 is in vertical alignment with the heating unit 11 and the work support member 35 is in alignment with the quenching unit 16; and in this position of carriage 26 the platform 25 is moved upwardly so that the work pieces 10 on the support members will move into the heating unit 11 and quenching unit 16 through the open bottoms thereof. This new position of carriage 26 is indicated by dotted lines 44 in Fig. 1, and, before the carriage 26 is moved to this position, the quenching unit 16 is moved downwardly to the same elevation as the quenching unit 15 shown in Fig. 1, so that heating of the new work piece can now be effected in heating unit 11 and quenching of the work piece just removed from the heating unit may be accomplished at the same time in quenching unit 16. After cooling of the work piece 10 in quenching unit 16 is completed, the latter is moved upwardly and a new work piece 10, indicated in dotted lines in Fig. 1, is placed on the support member. Hence, when heating of the work piece in heating unit 11 is completed, the carriage 26 may be moved back from the dotted line position 44 to the position shown in solid lines in Fig. 1. In this way the carriage 26 may be moved back and forth in the manner just described to effect heating and quenching of a number of work pieces 10 in rapid succession.

As shown most clearly in Fig. 3, the heating unit 11 comprises an outer shell 45 within which is provided a circular refractory lining 46. The refractory wall surface or lining 46 is formed by a number of ceramic blocks 47, 48, 49 and 50 of different sizes which are in abutting relation within the outer shell 45. The shell 45 is formed with an inwardly extending flange 51 at its lower open end adjacent the lowermost blocks 50, and it is against this flange that the work support members bear when moved upwardly to position a work piece 10 in heating chamber 52 to effect heat treatment of the work piece. Thus, the lower open end of the heating chamber 52 is closed by the work support members, and a narrow vent opening 53 is provided at the upper closed end of the heating unit 11 through which the spent products of combustion are discharged.

Each of the blocks 47 includes a parabolic radiator 54 at the refractory lining 46, a distributor cap 55, and a nipple connection 56 which is secured at its rear end to a pipe 57. The pipes 57 are connected to branch conduits of a manifold 58 in which is provided a main control valve 59 and to which a suitable heat producing medium, such as a gas mixture is delivered from a source of supply. In Fig. 3 is shown one group of three radiators 54, and another similar group is provided at the opposite side of the heating unit, as diagrammatically indicated in dotted lines in Fig. 1. A control valve 60 is provided in each of the pipes 57 for independently regulating the supply of the gas mixture to the radiators 54.



The quenching units 15 and 16 are alike and shown most clearly in Fig. 4. Each quenching unit comprises an outer shell 61 and a cylindrical vertical wall 62 of smaller diameter which extends downwardly from a horizontal partition 63 to the bottom open end of the quenching unit. A plurality of openings or apertures 64 are provided in the wall 62, and a number of annular compartments 65, 66 and 67 are formed one above the other about the wall 62 by the partition 63 and wall members 67' 68 and 69.

The upper ends of flexible conduits 24, through which cooling liquid is raised from tank 14, are connected to pipes 71 each of which communicates with a chamber 72 formed in the upper part of the quenching units. From chamber 72 cooling liquid passes through a conduit 73 to which are connected a number of branch conduits 74 for supplying the cooling liquid to the compartments 65, 66 and 67. A control valve 75 and suitable pressure gauge 76 are provided in each branch conduit 74, and a main control valve 77' is connected in the pipe 71.

During operation, the gas mixture is supplied under pressure from the source of supply to the radiators 54 in each of which a plurality of gas streams are produced by the caps 55. Combustion of the small gas streams is effected at the caps 55 to produce a number of gas flames, and the heat developed by such combustion heats the radiators 55 to a highly radiant condition.

The gas mixture is preferably supplied to the radiators 54 so that the heated gases, which are developed by combustion of the gas mixture, are produced in such volumes that the chamber 52 is filled with the heated gases at a pressure above that of atmosphere by reason of the narrow vent or opening 53 through which the spent products of combustion are discharged. In the embodiment being described, the work pieces 10 are shown as projectiles including a heavy straight-sided bottom portion and a tapered top portion forming the nose of the work piece. In such case, at least the two bottom radiators 54 of each group are so positioned with respect to the lining 46 that, due to the narrow gap or kerf-like space therebetween, the outward flow of the heated gases through the gap 77 is restricted and the gap is filled with gases at a pressure above that of atmospheric which is slightly higher than that in the upper part of the chamber 52.

In order to maintain the heated gases at a pressure above that of atmospheric in the gap 77 adjacent the more massive bottom portion of the work piece 10, as well as to keep the heated gases in the upper part of chamber 52 at a slightly lower pressure which is still above that of atmospheric, the rate of supply of the gas mixture to the radiators 54 is adjusted so that combustion may be accomplished in the radiators at a correspondingly higher pressure. This intensifies the combustion reaction to produce intense regions of heat because the rate of combustion is

accelerated and the temperature at which combustion is accomplished is increased. Any increase in temperature at which combustion is accomplished increases the temperatures of the radiators **54** and the highly radiant condition thereof.

Since the rate at which radiant heat flows is proportional to the difference of the absolute temperatures of the radiators and the opposing surface of the work piece **10** raised to the fourth power, the heating of the radiators **54** to the highest degree of incandescence possible contributes to the rapid rate of heat input to the work. By reason of the fast rate at which heating is accomplished and the high heat penetration produced by heating the work by the radiators **54**, it is possible to employ fuel mixtures of air and ordinary gas, such as city gas and natural gas, for example, to effect heating of work pieces in the heating unit **11**.

When a combustible mixture of air and city gas, having a rating of about 500 B. t. u. per cubic foot, is employed, for example, the heated gases developed by combustion of the mixture may be produced at such a rate that the gap or kerf-like space **77** between the refractory lining and the work piece is filled with heated gases at a pressure above that of atmospheric by an amount which is in the neighborhood of 1 inch of water column. In such case the gap **77** between the two bottom radiators **54** and the work piece may be in the neighborhood of ⅜ to 1 inch, and a surface layer of the projectile can be heated to the critical hardening temperature of 1550° F. to 1650° F. in a heating period of several minutes. Under these conditions the combustion reaction in the radiators **54** is intensified to heat the refractory wall surfaces thereof to an average temperature of about 2700° F. and in a temperature range not below 2650° F. and as much as 2850° F. or higher.

The control valves **59** and **60** may be adjusted so that all surface portions to a predetermined depth are brought up to the critical hardening temperature at substantially the same rate and at the same time, as indicated by the dotted line **78** in Fig. 3; or, if it is desired to produce a definite graduation in hardness or effect selective heat treatment of the work pieces, the supply of the gas mixture to the radiators **54** may be regulated accordingly. During the heat treatment of each work piece **10**, the latter is being continuously rotated by one of the spindles **37** whereby the desired heating is accomplished at all surface portions of the work piece.

After being heat treated, the work pieces are removed from the heating unit **11** and carried to one of the quenching units **15** or **16** in the manner explained above. Cooling liquid is discharged through the openings **64** in wall **62** to cool the heated projectiles rapidly from the critical hardening temperature. The valves **75** may be readily adjusted to control the rate of flow of cooling liquid to each compartment **65**, **66** and **67**, so that definite surface portions may be cooled at substantially the same rate whereby the desired hardening of the work pieces is produced at all surface portions thereof. In certain instances, it may be desirable to employ different cooling liquids for different parts of the work pieces. For example, cooling water, brine and oil may be simultaneously discharged from the several compartments **65**, **66** and **67** at regulated rates, and, since these cooling liquids have different rates of heat absorption, the desired rate of cooling may be accomplished at different surface portions of the work pieces.



In the illustrated embodiment, the cooling liquid passes from the quenching units **15** and **16** into the shallow vessel **32** of carriage **26** and overflows from this vessel into the tank **14**. From tank **14** the cooling liquid is raised by the pump **23** through the flexible conduits **24** back to the quenching units, as explained above.

In view of the foregoing, it will now be understood that an improvement has been provided for heating metallic bodies in rapid succession by radiant heat in a bell type heating unit. In view of the relatively short heating times required and the fact that many heat treating operations can be accomplished with gas mixtures of air and ordinary gas, like city gas and natural gas, for example, considerable economy is effected in heating work pieces to elevated temperatures in accordance with the invention. While some convection heating of the work is effected by the heated gases developed by combustion of the gas mixture in the radiators **54**, the heating of the work pieces is accomplished predominantly by radiant heat projected from the radiators which are maintained at high incandescent temperatures. Substantially complete combustion of a gas mixture is accomplished at the radiators without flame impingement on the work, and the heated gases produced form a high temperature gas blanket over the entire surface of the work piece through which the radiant heat waves project. Since the time required to heat work pieces to an elevated temperature is reduced considerably when compared to prior practices employing combustible fuel mixtures, and the work pieces are enveloped by the high temperature heated products of combustion while heat treating is being effected, the formation of objectionable scale is practically eliminated.

Although the movements of the quenching units **15** and **16**, the platform **25** and carriage **26** are manually effected in the embodiment just described, it is to be understood that hydraulically operated cylinders or other suitable mechanism may be employed to accomplish movement of these parts. Further, it will be understood that in apparatus of the kind shown, it is usually desirable in practice to provide automatic arrangements for timing and regulating the heating and quenching operations and that such automatic controls and devices may readily be incorporated in the illustrated embodiment.

This application is a division of my copending application Serial No. 482,697, filed April 12, 1943, entitled "Heat treatment," now abandoned, which in turn is a continuation-in-part of my copending application Serial No. 459,680, filed September 25, 1942, entitled "Method of and apparatus for heating metallic bodies," now abandoned.

While a single embodiment of the invention has been shown and described, it will be apparent that modifications and changes may be made without departing from the spirit and scope of the invention, as pointed out in the following claims.

What is claimed is:

1. Apparatus for heat treating work pieces comprising a bell type heating unit having a chamber formed with a refractory lining and open at the bottom, a number of radiators at said lining, a rotatable work support member adapted to be positioned beneath the open end of

the chamber, said member and heating unit being vertically movable with respect to each other whereby a work piece adapted to be supported on said member may enter said chamber at the open end thereof and be removed therefrom, means for heating said radiators to a highly radiant condition by a heat producing medium, and means for rotating said member whereby the work piece supported thereon may be rotated while being heated to an elevated temperature in said chamber by radiant heat waves projected from said radiators.

2. Apparatus for heat treating work pieces comprising a bell type heating unit having a chamber formed with an inner refractory lining and open at the bottom, a number of radiators at said lining, a rotatable work support member adapted to be positioned beneath the open end of said chamber, said member and heating unit being vertically movable with respect to each other whereby a work piece adapted to be supported on said member may enter said chamber at the open end thereof and be removed therefrom, said chamber being of such size that, when the work piece is positioned therein, a narrow gap is formed between the work piece and said radiators, means for supplying a fuel mixture to said radiators to heat the latter to a highly radiant condition by combustion of the mixture at the vicinity of said radiators, and means for rotating said member whereby the work piece supported thereon may be rotated while being heated to an elevated temperature in said chamber by radiant heat waves projected from said radiators, said heating unit having a vent at the upper part thereof through which products of combustion are discharged from the chamber.

3. Apparatus for heat treating work pieces comprising a bell type heating unit having a chamber formed with an inner refractory lining and open at the bottom, a number of radiators at said lining, a rotatable work support member adapted to be positioned beneath the open end of said chamber, said member and heating unit being vertically movable with respect to each other whereby a work piece adapted to be supported on said member may enter said chamber at the open end thereof and be removed therefrom, said chamber being of such size that, when the work piece is positioned therein, a narrow gap is formed between the work piece and said radiators, means for heating said radiators to a highly radiant condition by a gaseous heat producing medium whereby the work piece positioned in said chamber may be heated to an elevated temperature by radiant heat waves projected from said radiators while the surface areas being so heated are enveloped by the gaseous heating medium, and means for adjusting the heating of said radiators by said gaseous heating medium and hence the heating of the work piece by the radiant heat waves projected from said radiators at close range thereto.



4. Apparatus for heat treating work pieces comprising a bell type heating unit having a chamber formed with an inner refractory lining and open at the bottom, a number of refractory radiators at said lining, a vertically movable platform, a carriage horizontally movable on said platform, a number of rotatable work support members on said carriage, said platform being vertically movable so that a work piece adapted to be supported on any of said members may be raised from a position beneath said heating unit into said chamber at the open end thereof and lowered from said chamber, means for heating said radiators to a highly radiant condition by a heat producing medium, and means including an electric motor carried by said carriage for rotating said members whereby the work pieces may be rotated while being heated to an elevated temperature in said chamber by radiant heat waves projected from said radiators.

5. Apparatus for heat treating work pieces comprising a bell type heating unit having a chamber formed with an inner refractory lining and open at the bottom, a number of radiators at said lining, a pair of bell type quenching units at opposite sides of and equidistant from said heating unit, a vertically movable platform beneath said heating and quenching units, a horizontally movable carriage on said platform, a pair of rotatable work support members on said carriage, said members being spaced apart substantially the same distance as said quenching units are spaced from said heating unit, each of said quenching units being movable between a quenching position and work removing position, means for supplying a cooling liquid to said quenching units for cooling a heat treated work piece, means for heating said radiators to a highly radiant condition by a heat producing medium, and means including an electric motor carried by said carriage for rotating said members so that work pieces supported thereon may be rotated while being heated to an elevated temperature in said chamber by radiant heat waves projected from said radiators and while being cooled in the quenching units.

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