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BRIGHT-FINISH METAL-TREATING FURNACE

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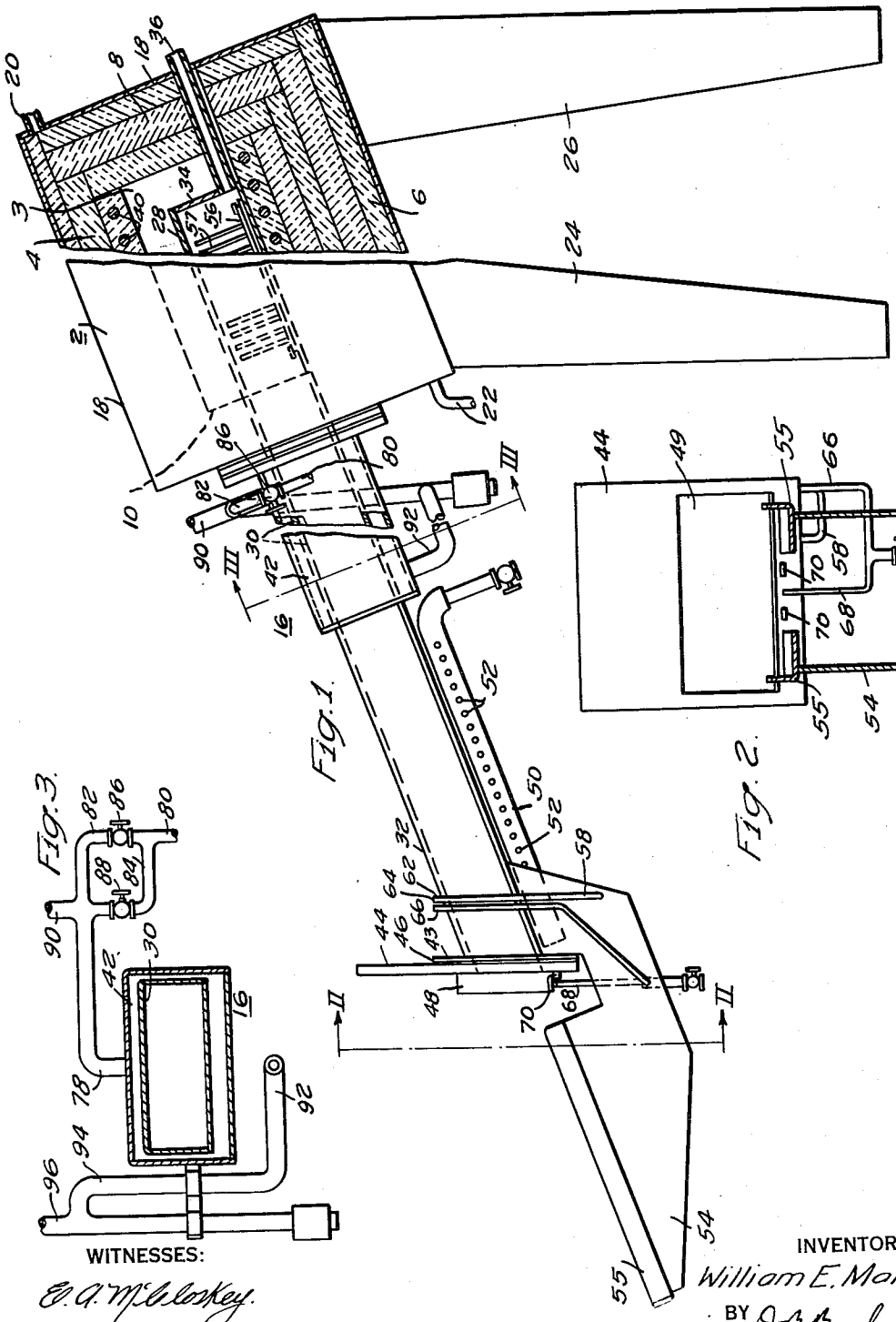


FIG. 1.

FIG. 2.

FIG. 3.

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BRIGHT-FINISH METAL-TREATING FURNACE

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10 Claims. (Cl. 266—5)

My invention relates generally to electrical heat-treating furnaces, and is more specifically in the nature of an improvement on the heat-treating furnaces disclosed and claimed in the J. R. Gier, Jr., patent applications, Serial Nos. 296,586 and 296,587, filed September 26, 1939, which describe furnaces adapted especially for damage-free bright-hardening of "air hardening" tool steels.

Application Serial No. 296,587 discloses and claims a muffle-type furnace comprising an inclined elongated tube-like two-section metal muffle having its upper end closed and its lower end open, but closable by a movable door, to provide a work-opening through which a charge-tray, having a charge of work thereon, can be inserted into the muffle, the charge-tray being moved to different positions inside the muffle during the heat-treating process and then withdrawn through the work-opening. The upper portion of the muffle, which is surrounded by furnace walls and heated, and the lower portion of the muffle, which extends outwardly from the furnace walls and is cooled by a surrounding water-jacket, provide the necessary heat-treating zones in which the steels can be treated for hardening while enveloped by a suitable controlled atmosphere which is introduced into the muffle at its upper end and taken from the muffle at its lower end to provide a generally downward flow of the atmosphere through the muffle.

In the operation of this tilted-muffle furnace, the muffle door is opened and a charge-tray upon which the work to be heat-treated has been placed, is pushed into the lower muffle-section. The muffle door is then closed and the controlled atmosphere is passed through the muffle, at an increased rate of flow, if desired, in order to purge the inside of the muffle. After completion of a purging period, the charge-tray is pushed into the upper muffle-section, preferably by means of a push-pull rod passing through a small closable hole in the door, where the work is heated to the proper temperature for the necessary time, after which it is pulled back into the lower muffle-section where it is "atmosphere quenched," or cooled, by the action of the water-jacket about the lower muffle-section. After the charge has cooled to a temperature at which it may be safely handled without damage, the muffle door is again opened and the charge-tray removed. The furnace is then ready for heat-treating another charge. The controlled atmosphere envelops the charge-tray during the heat-treating process, and because the atmosphere used, which is mostly dissociated ammonia containing 75% hydrogen, is lighter than air and flows slowly generally downward through the muffle, the atmosphere about the charge is kept clean and pure so that a suitable charge can be hardened without damage. Further details as to the operation of the furnace and its construction may be obtained by reference to the aforesaid applications, and the description of the furnace of this invention is more or less limited to the improvements of my invention thereover.

A tilted-muffle furnace of the type described has proved very practical and satisfactory for the bright-hardening of "air-hardening" tool steels; and many tools, dies and similar working implements have been hardened without damage and ready for use without further grinding or removal of surface metal after a heat-treatment in the furnace. A furnace of the type described has the further advantage that it can be operated for bright-hardening of tool steels with a comparatively simple technique. However, when the furnace was used for hardening steels of readily oxidizable alloys, such as stainless steels having in the neighborhood of 12%, or more, chromium, and particularly after the furnace had been in operation for some time, the product on many occasions came out of the furnace with a gray or blue oxide surface film which usually could not be completely removed by a subsequent passivating treatment for one-half hour in a 30% nitric acid solution at room temperature.

It is accordingly an object of my invention to provide an improved inclined muffle-furnace in which a metal having a relatively high proportion or percentage of a readily oxidizable constituent, can be processed by hardening to obtain a more perfect bright finish on its surface, which processing requires no specialized technique and can be carried out by an operator of ordinary ability.

It is my belief that the inconsistent results in the bright-hardening of readily oxidizable alloys in the prior tilted-muffle furnace are due to the infiltration of oxygen-bearing gases, particularly water-vapor, into the cooling section of the muffle. It is well known that high-chromium stainless steels, when hot, are very sensitive to even minute amounts of oxidizing gas. When the metal muffle-door of the described prior furnace is opened for the insertion or removal of a charge, the controlled atmosphere, which is dissociated ammonia containing combustible hydrogen gas, burns with a flame which extends along a zone bounded on the top by a substantially horizontal

plane intersecting the bottom edge of the open door. The zone extends into the cooling section of the muffle to a point where the aforesaid plane intersects the bottom of the muffle. The flame water-vapor which is condensed on, or absorbed by, the inner cool walls of the cooling-section of the muffle, which are kept below the boiling point of water by the circulation of water through its water-jacket. When a later heated charge is drawn into the cooling-jacket, the condensed water is turned into water-vapor, or absorbed water-vapor is freed, producing an oxygen-containing gas which reacts with the stainless steels to form the objectionable surface film.

Consequently, it is a further object of my invention to provide a muffle-furnace of the type described in which the atmosphere in the heat-treating sections of the muffle can always be kept at a high degree of purity, with very little possibility of contamination from outside sources.

It is another object of my invention to provide a tilted-muffle furnace of the type described in which significant damaging water, in any of its physical phases or states, formed by the products of combustion between the combustible controlled atmosphere and air when the muffle door is open, is prevented from entering the heat-treating zones of the muffle, the water being kept in a vapor or gaseous form so that it can be easily purged out of the muffle by the flow of controlled atmosphere through the muffle.

In a general way, it is an object of my invention to provide a furnace in which repeated charges of high-chromium stainless steels can be consistently bright-hardened, without requiring a highly skillful operator or involved technique for operating the furnace.

Other features, objects, methods and innovations of my invention, some of which parallel those of the aforesaid patent application Serial No. 296,587, will be suggested or apparent from the following description thereof, which is to be taken in conjunction with the accompanying drawing, in which some details are omitted for reasons of clarity or because they are shown in the application; and in which:

Figure 1 is a vertical view, partly in cross-section, of the improved furnace; and

Figs. 2 and 3 are vertical sectional views of the furnace of Fig. 1, taken on the lines II—II and III—III thereof with parts omitted for clarity.

The furnace of the preferred embodiment of my invention comprises a furnace proper **2** having refractory and insulating walls defining a heating chamber **3**. The walls are constructed of firebrick and refractory tile, and perhaps other heat-insulating material, in any customary manner and include a top wall **4**, a bottom wall **6**, suitable side walls, a closed rear end wall **8** and a front end wall **10** provided with an opening through which the muffle, indicated in its entirety by the reference numeral **16**, passes.

The furnace is generally rectangular in any transverse cross-section and the walls are suitably encased in a metallic shell or casing **18** which completely encases the furnace proper **2** except for such openings as are necessary for terminal and other appurtenances that go with a furnace of the general type described. A suitable gas inlet **20** at the top of the furnace walls and a gas outlet **22** at the bottom of the furnace walls may be provided so that the interior of the furnace proper, about the muffle, can be permeated with a suitable controlled atmosphere for the protection of the muffle and heating elements, and for reducing the possibility of contaminating gases getting inside of the muffle by diffusion through the walls of the heated portion of the muffle, or otherwise. The furnace proper **2** is supported on front legs **24** which are shorter than rear legs **26** so that the muffle will assume an inclined position which is preferably about 15° to 20° to the horizontal for a muffle having a charge-heating muffle-portion and a charge-cooling muffle-portion of the dimensions described in the pertinent Gier patent application.

The muffle **16** is made of metal and comprises three muffle-portions, these muffle-portions consisting of a section **28** inside the heating chamber **3**, a second muffle-section **30** extending outwardly from the furnace walls, and, in accordance with my invention, a third section **32** extending outwardly from the muffle-section **30**. The muffle-sections **28**, **30** and **32** are, in effect, continuous and have their abutting ends gas-tightly arranged, although a single tube-like construction may be used, either for all three sections or for any two adjacent sections. In the particular embodiment shown a single tube is used for the sections **30** and **32**. However, it is preferred that the upper muffle-section **28**, in which the charge-heating zone is provided, be made of a high nickel content alloy or other heat resisting metal, and in order to decrease the cost of the muffle, the two muffle-sections **30** and **32** may be made of a single piece of a high-grade steel.

The upper portion or section **28** of the muffle is disposed in the furnace proper, and is provided with a closed end **34** so that the upper end of the muffle **16** is substantially gas-tight, with respect to extraneous gases. The upper end of the muffle-section **28** is provided with a suitable gas-inlet pipe **36** through which controlled atmosphere is delivered to the inside of the muffle at the upper portion thereof. Suitable temperature-responsive means should also be provided for controlling the heating of the muffle-section **28**. The upper muffle-section, except for the part which connects to the intermediate muffle-section **30**, is completely surrounded by the furnace walls and is heated by any suitable heating means, preferably electrical heating means **40** inside the heating chamber of the furnace.

The second, or intermediate, portion or section **30** of the muffle has its exterior, for substantially its full length in the preferred embodiment, surrounded by a water-jacket **42** which provides a charge-cooling zone inside this muffle-section.

The lower, or third, portion or section **32** of the muffle has an open end provided with an outer peripheral flange **43** gas-tightly secured thereto. A door-plate **44** is secured to the flange **43** in a gas-tight manner, a gasket **46** being interposed between the two. The door-plate **44** has an opening substantially aligned with the lower open end of the muffle-section **32**, and this opening in the door-plate **44** is closable by a raised door **48**, snugly slidable on the door-plate **44** and operated by any suitable door-operating means. The door **48** may be forced pressed against the door plate **44** to reduce gas-leakage around the door **48** in closed position. A work-opening **49** is thereby provided at the lower end of the muffle; the top of this work-opening being generally determined by the height to which the door **44** is raised; the lower edge of the door defining the top of the work-opening unless the door is raised above the top of the end opening of the muffle, which then defines the top of the work-opening.

An elongated gas burner **50** is provided cen-

trally below the muffle-section 32 for heating the muffle-section 32 to temperatures somewhat above the boiling point of water, in the neighborhood of 250° F. to 500° F. although these are not limiting values. The gas burner has a plurality of gas-discharge holes 52 on each lateral side so that the muffle-section can be uniformly heated throughout its length.

A suitable apron-table 54 is secured to the lower outside of the muffle-section 32 and extends axially outwardly therefrom, being provided with charge-supporting guides 55 for supporting a charge which is to be inserted into or withdrawn from the furnace; the guides having flat portions aligned with the bottom of the muffle.

The three muffle-sections 28, 30 and 32 are aligned and their inside dimensions are substantially the same, so that the muffle, including the charge-supporting floor thereof, is, in effect, elongated and continuous, the charge-heating muffle-section 28 and the charge-cooling muffle-section 30 being each of a length sufficient to accommodate a charge-tray 56 on which the work to be hardened may be supported. Preferably, the tray is somewhat smaller than each charge-treating zone of the muffle-sections. Details of the charge-tray may be obtained by reference to the aforesaid Gier applications. Briefly, the charge-tray comprises a plurality of spaced parallel bars carrying at their ends a plurality of spaced nickel sheets 57 which loosely fit the muffle, and act as heat-barriers. An open screen on the bars supports the work to be hardened. The nickel sheets 57 favor temperature uniformity over the extent of the tray and the work thereon, and make unnecessary, for a uniform temperature distribution along the tray, any appreciable protruding of the heating chamber or the cooling chamber beyond the ends of the tray, which would be necessary if the heat-barrier shields were eliminated.

The lower muffle-section 32 is also preferably of a length to accommodate the charge-tray, but may be more or less than this length to some extent. It is desirable to have the length of the muffle-section 32 such that the top of the work-opening 49 with the door in maximum raised position is on a lower level than any part of the charge-cooling zone in the intermediate muffle-section 30, and in a preferred embodiment of my invention in which very satisfactory results have been obtained, a horizontal line from the top of the work-opening intersected the bottom of the muffle 16 at a point below the junction of the muffle-sections 30 and 32.

The lower muffle-section 32 is provided at its lowermost end with a gas-outlet pipe 58 comprising a U-shaped pipe having a leg 62 turned upwardly to provide a gas-discharge tip 64 at the top open end of the leg, although the leg 62 may be omitted, in which case the gas-discharge opening would be below the muffle. Controlled atmosphere continuously admitted to the muffle through the gas-inlet pipe 36 flows generally downwardly through the muffle, permeating the interior of the muffle and enveloping the charge-tray and then flowing out of the muffle through the gas-outlet pipe 58. Outflowing controlled atmosphere is ignited by a flame continuously burning at the tip of a gas-pipe 66, the tip being arranged near the gas-discharge opening 64. One or more gas-pipes 68 may provide a continuously burning flame or flames near the abutting surfaces of the door 48, in closed position, and the door-plate 44, for igniting any controlled atmosphere that might leak through crevices between the door and the door-plate, but, more importantly, for igniting the controlled atmosphere when the door 48 is raised. The lower position of the door is determined by one or more door-stops 70.

As shown in Figs. 1 and 3, the water-inlet pipe 78 to the water-jacket 42 of the muffle-section 30 is connected to a water supply pipe 80 through two branch passages 82 and 84, the branch passage 82 being controlled by an adjustable globe valve 86 which in fully opened position permits a large quantity of water to flow to the water-jacket, and the branch passage 84 being controlled by a globe needle valve 88 which, in fully opened position, permits only a relatively small quantity of water to flow to the water-jacket. Inasmuch as the water inlet is at the upper end of the water-jacket, it is desirable to provide a standpipe 90 connected to the water inlet, the standpipe having an upper open end. A water-outlet pipe 92 is provided at the lower end of the water-jacket, the pipe 92 having an inverted U-bend 94, the top of which is above the top of the water-jacket so that the water-jacket will always be full of cooling liquid when the water-jacket is supplied with cooling liquid, which is generally tap-water. A standpipe 96, having an upper open end, is connected to the water outlet.

In the operation of the furnace, a charge to be heat-treated is inserted into the muffle and preferably kept in the lowermost section 32 of the muffle, while the muffle is purged with the door 48 closed. The charge is then moved into the charge-heating section 28 of the muffle, and heated to the proper temperatures which may be as high as 2100° F., or somewhat more. After the required heating, which for stainless steels should preferably be ten minutes or more, depending on the character of the steel and the shape of the work being heat-treated, the charge is drawn into the charge-cooling muffle-section 30 for cooling. After cooling, which is continued until the work is brought down below its air-tarnishing temperature, the door 48 is opened and the charge drawn through the lower muffle-section 32, onto the apron-table 54.

For moving the charge between the different muffle-sections, the door 48 may be provided with a small closable opening through which a push-pull rod passes for engaging the charge-tray. In loading or unloading the furnace, it is preferable to operate in such a manner that the door 48 is not kept in open position for any time longer than is necessary for such loading or unloading.

Upon opening the door 48 and while the door remains open, either when a treated charge is withdrawn from the muffle or a new charge is inserted into the muffle, the hot dissociated ammonia which flows downwardly through the muffle ignites and a flame is visible inside the muffle, in a substantially horizontal plane substantially level with the top of the work-opening 49. The resultant products of combustion of this flame will contain water in some form, and with the use of other controlled atmospheres, other additional forms of oxidizing gases might be formed. Water-vapor or other oxidizing impurities on the inner walls of the charge-cooling zone would be harmful to the surface brightness of a heated charge brought into the charge-cooling zone from the charge-heating zone.

In a muffle not provided with the additional muffle-section 32, these impurities may be deposited, in some manner or manners, on the inner walls of the cooling muffle-section 30. Once oxidizing impurities have been deposited by conden-

sation, absorption or adsorption, in the cooling muffle-section **30**, they can only be driven off by heating. A hot charge in the charge-cooling zone will gasify any impurities that might be on the inner walls of the muffle-section **30** to produce an oxidizing gas which may contact the hot charge while it is cooling through the temperature range in which it is very susceptible to oxidation or surface tarnish. Consequently, to avoid oxidation, it is important to remove the impurities from the charge-cooling zone before the hot charge, which would gasify the impurities, is brought down for cooling. This may be done by completely shutting off water flow through valve **86**, allowing only a small trickle of water to run through valve **88** for safety reasons, which permits a heating-up of the inner walls of the muffle-section **30** by transfer of heat from the muffle-section **28**, causing evaporation or freeing of moisture or other impurities that may be on the walls of the muffle-section **30**, so that such impurities, now in a vapor or gaseous state, can be flushed out through the lower end of the muffle by the downward flow of the controlled atmosphere. This purifying operation may be carried out while the charge is being subjected to its heating cycle in the muffle-section **28**, and full water flow through the cooling jacket **42** for cooling purposes can be restored when the hot charge is pulled down into the charge-cooling zone.

If the muffle-section **32** were omitted from the furnace then the described contamination of the atmosphere in the charge-cooling muffle-section **30** would occur whenever the furnace door is opened for charging or discharging the furnace, necessitating the described purifying operation of muffle-section **30**. With the improved furnace, the purifying operation need be carried out only at the beginning of each furnace operating-period, irrespective of the numbers of charges heat-treated during the operating-period of the furnace, because any significant production of impurities in the charge-cooling muffle-section occurs only when the controlled atmosphere is initially admitted to the furnace, at which time the downwardly flowing dissociated ammonia is burned partly to water by the air present in the muffle.

The heated muffle-section **32** provides a region in which, during normal loading and unloading operations of the furnace, the dissociated ammonia may burn while the door is open, without causing a significant deposit of moisture or oxidizing impurities by either liquid condensation or gas adsorption or absorption on the interior muffle walls, which later could, if permitted to deposit on the walls, contaminate the controlled atmosphere when a hot charge is withdrawn from the charge-heating zone of the muffle-section **28**, causing volatilization into the charge-cooling zone of the moisture or other oxidizing impurities, producing oxidizing conditions while the work is hot. By maintaining the lower muffle-section **32** at a temperature somewhat above the boiling point of water, the water or other impurities tend to be kept in a gaseous state and are purged from the muffle by the downwardly flowing controlled atmosphere, and, therefore, are removed from the muffle before the heated charge is drawn from the charge-heating muffle-section **28** into the charge-cooling muffle-section **30**.

A furnace without the extended muffle-section **32** requires purifying operations in the heat-treatment of each charge, but the addition of the muffle-section **32** not only improves the quality of the finished heat-treated product, but also makes unnecessary frequently repeated purifying operations.

Another advantage resulting from reduction of the periodic moisture condensation in the cooling section of the muffle of a furnace of the type described, is that the tendency for the inner cooling-section walls to rust is greatly reduced and substantially eliminated. A rust layer is very porous and absorbent and is capable of retaining moisture and other oxidizing impurities so strongly that they cannot be driven off to satisfactory degrees in any heating period of reasonable length. Without a muffle-section such as the muffle-section **32**, rust formations on the cooling-section walls of the muffle may be relatively very rapid, and require frequent removal.

The reduction in the flushing or purging operations has the further advantage of reducing the injurious effects of repeated heating and cooling on the charge-cooling muffle-section, which, being usually a double-walled, welded-steel structure, is susceptible to warpage by thermal shocks.

A furnace in accordance with my invention has been used to harden a considerable number of charges of readily oxidizable stainless steel, with resultant bright surfaces. Only rarely has a charge been found to have a surface tarnish and in such instances the tarnish layer was so thin that during subsequent passivating treatment, as previously described, complete brightness was restored. In a furnace of the character described, processes for the bright carburizing of stainless steels, such as described in the patent application of John R. Gier, Jr., Serial No. 413,625, filed October 4, 1941, can also be successfully carried out by the addition of a small amount of carburizing gas to a controlled atmosphere of dissociated ammonia.

While I have described my invention in a form which I now believe to embody the preferred construction, it is obvious that many changes can be made thereto and equivalent forms used. Thus, for example, I have shown the upper muffle-section **28** as having the same internal dimensions as the other muffle-sections, but in the Gier application Serial No. 296,587, an equivalent construction is obtained by using an upper muffle-section which is somewhat higher in order to accommodate a non-metallic refractory floor plate. Obviously, either construction, and others, can be used.

I claim as my invention:

1. A bright-finish metal-treating electric furnace comprising an elongated continuous tube-like metallic-refractory muffle, said muffle being inclined to the horizontal, the upper end of said muffle being closed and the lower end being provided with a work-opening, movable closure means for said work-opening, said muffle comprising a plurality of inclined portions including an upper charge-heating portion at the upper end of said muffle, a lower portion at the lower end of said muffle, and an intermediate portion between said charge-heating portion and said lower portion, each of said portions of said muffle being of sufficient length to accommodate a charge-tray, insulating walls about said upper portion of said muffle, heating means for providing a charge-heating zone in said upper portion of said muffle, cooling means for providing a charge-cooling zone in said intermediate portion

of said muffle, and means for causing said muffle to be permeated with a generally downwardly flowing controlled atmosphere.

2. A bright-finish metal-treating electric furnace comprising an elongated continuous tube-like metallic-refractory muffle, said muffle being inclined to the horizontal, the upper end of said muffle being closed and the lower end being provided with a work-opening, movable closure means for said work-opening, said muffle comprising a plurality of portions including an upper charge-heating portion at the upper end of said muffle, a lower portion at the lower end of said muffle, and an intermediate charge-cooling portion between said charge-heating portion and said lower portion, insulating walls about said upper portion of said muffle, heating means for providing a charge-heating zone in said upper portion of said muffle, cooling means for providing a charge-cooling zone in said intermediate portion of said muffle, heating means for heating said lower portion of said muffle, whereby any water in the lower portion of said muffle tends to exist as a water-vapor, means for causing said muffle to be permeated by a controlled atmosphere having a combustible constituent, igniting means for igniting such combustible component and air at said work-opening, and means comprising vent means in the said lower portion of said muffle, for venting gases, including the said water-vapor, from said muffle.

3. A bright-finish metal-treating electric furnace comprising an elongated continuous tube-like metallic-refractory muffle, said muffle being inclined to the horizontal, the upper end of said muffle being closed and the lower end being provided with a work-opening, movable closure means for said work-opening, said muffle comprising a plurality of inclined portions including an upper charge-heating portion at the upper end of said muffle, a lower portion at the lower end of said muffle, and an intermediate portion between said charge-heating portion and said lower portion, insulating walls about said upper portion of said muffle, heating means for providing a charge-heating zone in said upper portion of said muffle, cooling means for providing a charge-cooling zone in said intermediate portion of said muffle, the incline of said muffle being such that the exposed top of the work-opening when said movable closure means is moved to open position, is horizontally below said charge-cooling zone, and means for causing said muffle to be permeated with a generally downwardly-flowing controlled atmosphere.

4. Furnace means for bright-hardening steels containing a readily oxidizable alloy-constituent, comprising an inclined metal muffle having a closed upper end and a lower end provided with a lower work-opening for the insertion and withdrawal of a charge; movable closure means for said work-opening; means for heating the charge in the upper heating part of said muffle; means for cooling the charge in a cooling part of said muffle, which is lower than said upper heating part of said muffle; means for causing said muffle to be permeated with a generally downwardly flowing controlled atmosphere having a combustible constituent; means comprising heating means for maintaining products of combustion inside said muffle, caused by the burning of the combustible constituent of the controlled atmosphere with air upon opening of said movable closure means, in a gaseous form; and means for venting such products of combustion from said muffle before they can precipitate to any significant extent in the cooling part of said muffle.

5. Furnace means for bright-hardening, comprising a continuous tube-like muffle provided with a work-opening at one end and fixed means for closing the other end gas-tight with respect to extraneous gases, movable closure means for said work-opening, means for heating charges in one zone of said muffle, water-cooled means for cooling the charge in a second zone of said muffle, which is juxtaposed to the said one zone, means for heating a third zone of said muffle to temperatures above the boiling point of water, means for permeating said muffle with a controlled atmosphere which flows generally through said one zone, said second zone and said third zone in that order, said second and third zones of said muffle being between said work-opening and said first zone of said muffle, the last said means comprising a gas-inlet means at said one zone.

6. A bright-hardening furnace comprising an inclined elongated tube-like refractory muffle having a substantially continuous bottom for supporting a charge in different portions of said muffle, said muffle having its upper end closed and its other end provided with a work-opening, movable closure means for said work-opening, said muffle providing a charge-heating zone at its closed end, refractory and insulating furnace walls about said charge-heating zone of said muffle, means for heating said charge-heating zone, said muffle providing a charge-cooling zone adjacent to said charge-heating zone, means for cooling said charge-cooling zone, said muffle providing a charge-passage zone between said charge-cooling zone and said work-opening, means for heating said charge-passage zone to a temperature above the boiling point of water, and means for causing a generally downward flow of controlled atmosphere through said charge-heating and charge-cooling zones of said muffle.

7. A bright-hardening furnace comprising an inclined elongated tube-like refractory muffle having a substantially continuous bottom for supporting a charge in different portions of said muffle, said muffle having its upper end closed and its other end provided with a work-opening, movable closure means for closing said work-opening, said muffle providing a charge-heating zone at its closed end, metal encased refractory and insulating furnace walls about said charge-heating zone of said muffle, means between the said walls and said muffle for heating said charge-heating zone, said muffle providing a charge-cooling zone adjacent to said charge-heating zone, cooling means for said charge-cooling zone, said muffle providing a charge-passage zone between said charge-cooling zone and said work-opening, means for heating said charge-passage zone to a temperature above the boiling point of water, means for causing a generally downward flow of controlled atmosphere through the said zones of said muffle, and means for permeating the interior of said furnace, which is outside of said heating zone of said muffle, with a controlled atmosphere.

8. A bright-finish metal-treating furnace of the type described, comprising an elongated tube-like metal muffle having one end closed and its other end provided with a work-opening, movable closure means for said work-opening, said muffle providing successively from said closed end; a charge-heating zone, a charge-cooling zone and a charge-passage zone; means for supporting said muffle at an incline with the charge-

heating zone higher than the charge-cooling zone and the charge-cooling zone higher than the charge-passage zone of the muffle, the top of said work-opening being below said charge-heating zone, means for heating said charge-heating zone for heat-treating a charge therein, means for cooling said charge-cooling zone for cooling a charge which has been heat-treated in said charge-heating zone, means for heating said charge-passage zone to a temperature above the boiling point of water, said muffle including gas-inlet means for a combustible atmosphere, at its upper end and gas-venting means at its lower end, and igniting means for igniting combustible atmosphere and air at said work-opening.

9. A bright-finish metal-treating controlled-atmosphere permeated furnace of the type described, comprising an elongated tube-like metal muffle having one end closed and its other end provided with a work-opening, movable closure means for said work-opening, said muffle providing in consecutive order from said closed end; a charge-heating section, a charge-cooling section and a charge-passage section in open communication; means for supporting said muffle at an incline with the charge-heating section higher than the charge-cooling section and the charge-cooling section higher than the charge-passage section of the muffle, the top of said work-opening being below said charge-cooling section, means for heating said charge-heating section for heat-treating a charge therein, means for cooling said charge-cooling section for cooling a charge which has been heat-treated in said charge-heating section, means for heating said charge-passage section to a temperature above the boiling point of water, and means for purging products of combustion from said muffle, which products of combustion are formed by the burning, in said muffle, of air and a combustible constituent of the controlled atmosphere in said muffle.

10. A bright-hardening furnace comprising an inclined elongated tube-like refractory muffle having a substantially continuous bottom for supporting a charge in different portions of said muffle, said muffle having its upper end closed and its other end provided with a work-opening, movable closure means for said work-opening, said muffle providing a charge-heating zone at its closed end, refractory and insulating furnace walls about said charge-heating zone of said muffle, means for heating said charge-heating zone, said muffle providing a charge-cooling zone adjacent to said charge-heating zone, means for cooling said charge-cooling zone, said muffle providing a charge-passage zone between said charge-cooling zone and said work-opening, means for heating said charge-passage zone to a temperature above the boiling point of water, and means for permeating said muffle with a moving controlled atmosphere, the controlled atmosphere flowing generally downward in said charge-cooling zone of said muffle.

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