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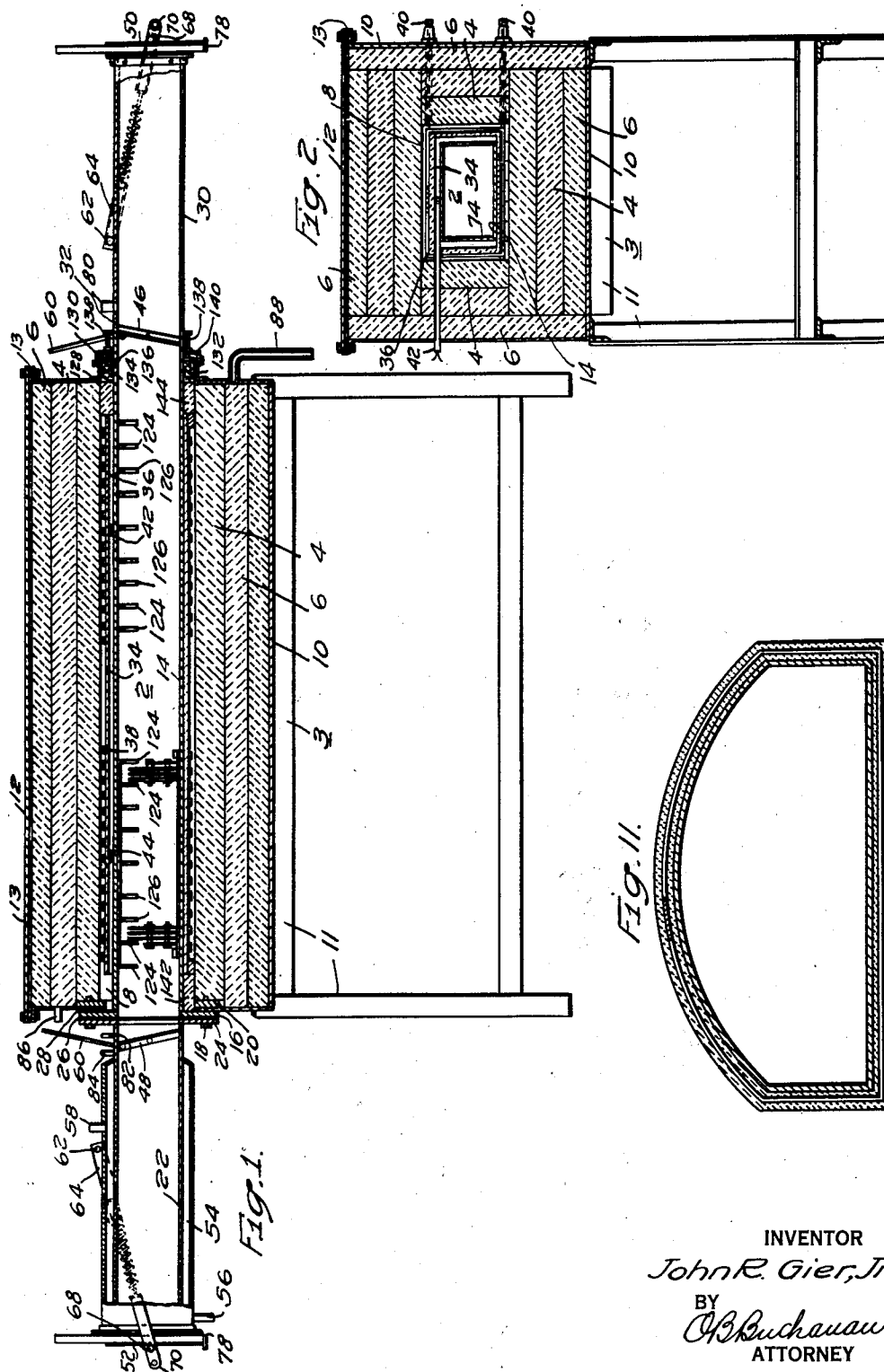
J. R. GIER, JR

2,290,551

HEAT TREATING FURNACE

Filed Sept. 26, 1939

3 Sheets-Sheet 1



July 21, 1942.

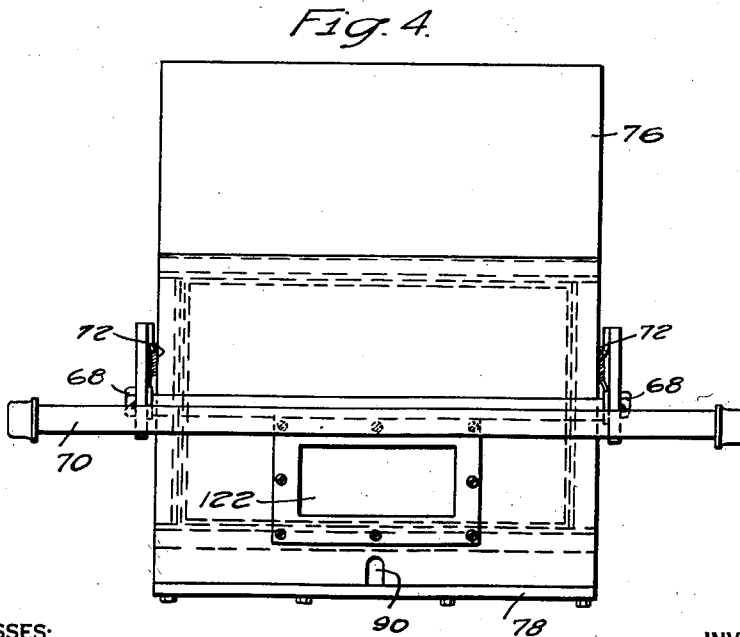
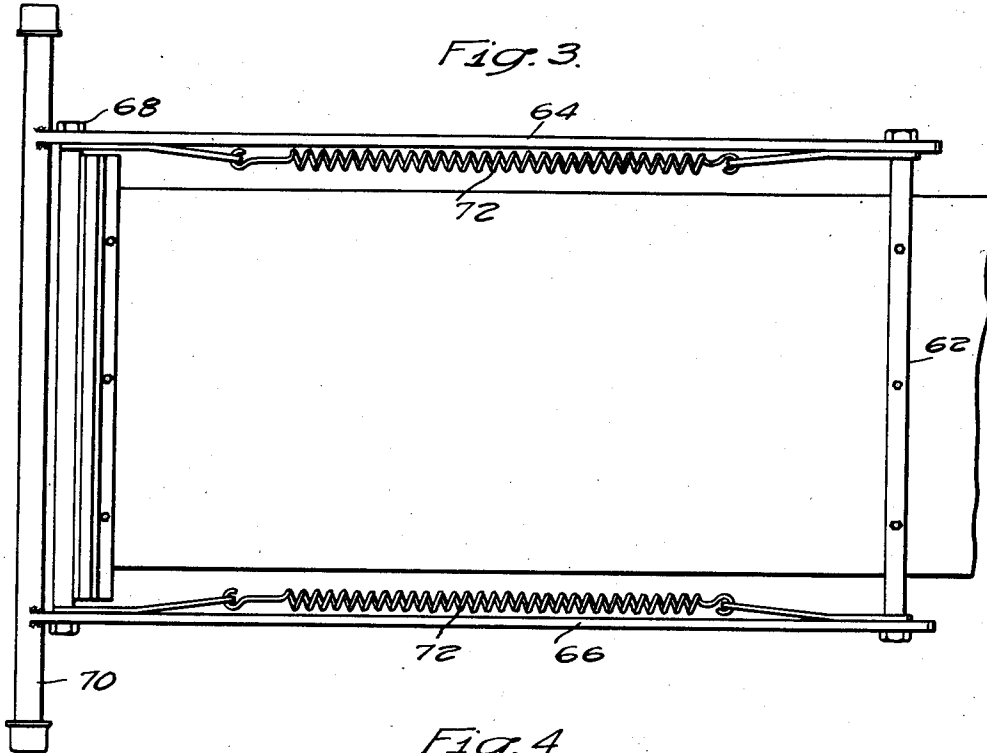
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HEAT TREATING FURNACE

Filed Sept. 26, 1939

3 Sheets-Sheet 2



WITNESSES:

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HEAT TREATING FURNACE

Filed Sept. 26, 1939

3 Sheets-Sheet 3

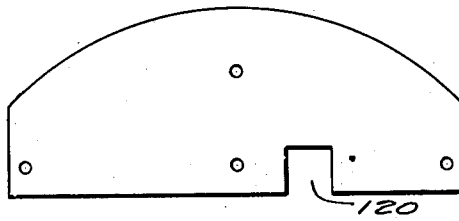
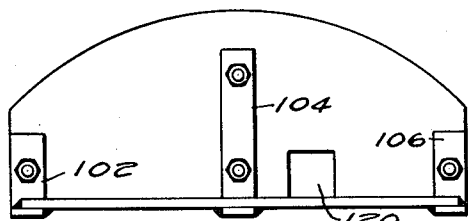
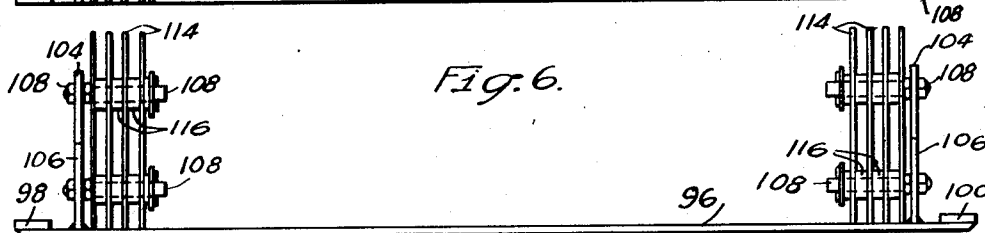
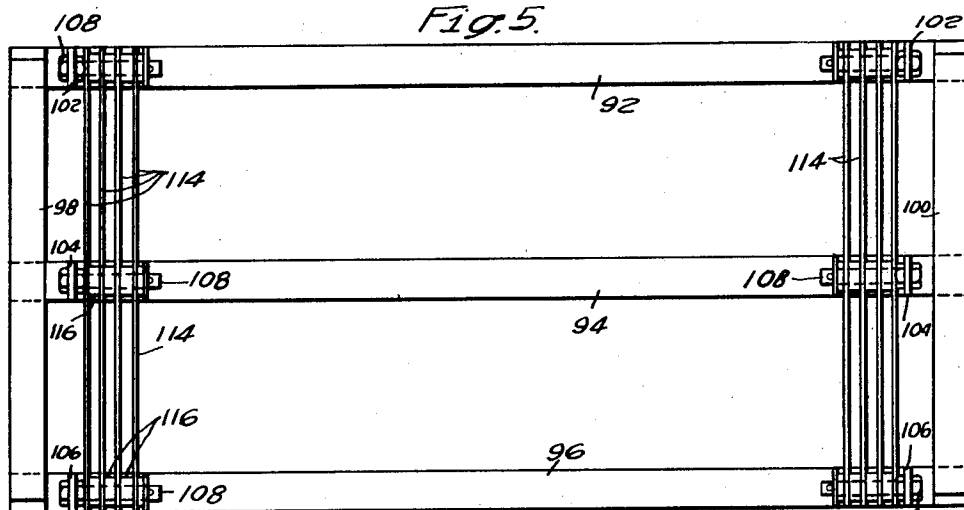


Fig. 9.

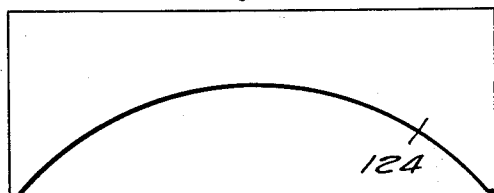
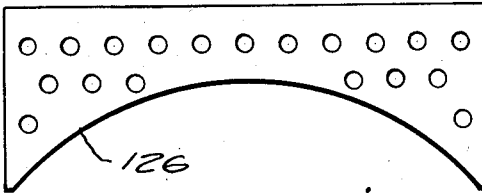


Fig. 10.



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UNITED STATES PATENT OFFICE

2,290,551

HEAT TREATING FURNACE

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Application September 26, 1939, Serial No. 296,586

6 Claims. (Cl. 266—5)

My invention relates generally to electric furnaces, and more particularly to electric furnaces especially useful in the heat treatment of tool steels in the form of tools, dies, and the like, while enveloped by an inert or protective atmosphere for the purpose of uniformly hardening the article heat-treated.

One of the primary purposes of my invention is to provide a furnace in which tool steel articles, including those of high-speed tool steels, may be hardened free from any of the types of damage heretofore usually experienced, the more important of which are oxidation, decarburization, distortion, and cracking.

Oxidation and decarburization are caused by chemical reaction of elements in the steel with certain elements in the furnace atmosphere at high temperatures. Oxidation produces an undesirable surface scale, and decarburization produces a soft surface layer, the metal thereof being deficient in carbon. Through the use of certain protective reducing gas atmospheres, steels are now commonly prevented from scaling, but these atmospheres do not ordinarily prevent decarburization.

To prevent both oxidation and changes in surface carbon content on all types of tool steel during heat treatment requires a highly reducing atmosphere, such as a mixture of hydrogen and nitrogen, although if carburization is desired the mixture may have a carburizing constituent added which may contain CH₄ up to 2% and not more than traces of CO₂ and H₂O. Ordinary controlled atmosphere hardening furnaces are incapable of maintaining a protective atmosphere of the necessary purity and exactness of composition.

It is a purpose of this invention to provide a furnace in which protective atmospheres of high purity and accurately controlled composition may be maintained to prevent both oxidation and decarburization of all tool steels during heat treatment. In the widely used and more expensive tool steels which must be heated up to temperatures in the range of 1700° F. to 2300° F., more or less, for hardening, decarburization can be extremely rapid due more to the high temperatures required for carbide solution than to any direct effect of alloy content. Heretofore, it has been the practice to allow for surface damage, as well as for distortion, by leaving extra stock on the tool which had to be removed after hardening by one or more finishing operations, such as grinding and hand stoning for fine interior

contours, all of which add greatly to the cost of the tools and dies.

It is accordingly an object of my invention to provide a furnace for the heat treatment of tool steels, especially at elevated temperatures in the range of 1700° F. and higher, from which oxidizing agents can be effectively purged and kept out of contact with the charge, whether such agents come from the air, or are occluded gases contained in the charge, or in the firebrick of the furnace, or come from other sources.

Damage by distortion includes the irregular or unpredictable changes in dimensions or contour of the tool in excess of the normal and determinable increase in specific volume which always accompanies the hardening of steel with the production of martensite. Both distortion and cracking can be easily avoided by cooling the tool or die in air for hardening, or, following my procedure, by cooling in an appropriate controlled gaseous atmosphere. So cooling for hardening, of course, restricts the number of steels which can be treated in a furnace having provisions for hardening the tool steels which include the step of cooling in air (gas). This restriction, however, is not at all serious or objectionable since it parallels the previous requirement, namely, that the steels considered are those requiring temperatures in the neighborhood of 1700° F., or even higher, for the hardening process. Such steels, in practically all cases, are capable of, and preferably are, hardened while enveloped by a protective gas, and can be successfully hardened without damage in block sizes up to 2 inches thick, and even more, and in lengths up to the capacity of the furnace.

Accordingly, it is a further object of my invention to provide a furnace for the heat treatment of tool steels at temperatures in the neighborhood of 1700° F. and above, in which the charge can be completely enveloped by a non-oxidizing, non-decarburizing gas, which furnace has provisions for permitting the cooling of the charge in the same or another controlled, protective atmosphere in a manner to prevent distortion and cracking.

The furnace of my invention has several basic features and innovations which enabled me to harden tool steels of the character aforesaid without surface contamination, with dimensional changes confined to these which are predictable, and without decarburization. In other words, I have devised a furnace in which I can harden tool steels with clean and fully hardened surfaces having the wanted dimensions and free from

cracks, warpage and high internal stresses, so that the article can be used immediately with the minimum of further grinding or stoning or other finishing treatment, and in most cases without the need of any finishing treatment.

In accordance with one embodiment of my invention, a furnace adapted to achieve the heat-treatment of tool steels without damage should have provisions for heating and cooling the work within a controlled atmosphere, and for moving the work through the different heat-treatment zones of the furnace without harmful contamination of that atmosphere, as might occur, for example, with the opening of outside doors. In use, a satisfactory atmosphere must be delivered to the furnace, and particularly to its main heating chamber, and must remain innocuous to the hot work while in contact with it.

Additionally, the work must be so supported so as to heat and cool uniformly and freely, but without distortion from sagging under its own weight. And since the furnace is for use in commercial fields, it must be low in initial cost and long of life, low in upkeep cost, easy of manipulation, and simple in operation. Broadly, therefore, it is among the objects of my invention to devise a simple means, in the form of a commercially-acceptable furnace, for heating and cooling tool steels in a special gas so that the steels will be hardened without damage.

It is an object of my invention to provide a furnace in which the widely used and more expensive tool steels can be heat-treated whereby the necessity for machining, grinding, or stoning after the heat-treatment is kept to a minimum, and, in most cases, entirely eliminated.

In one embodiment of my invention for the purpose, I provide a metallic muffle for the heating chamber of the furnace, the muffle being capable of withstanding the high temperatures specified for long periods without appreciable deterioration, and further having the requisite strength at the temperatures involved. I prefer to make the muffle in the high temperature zone of commercially-pure nickel or, in some cases, nickel alloyed with a non-carburizing metal, such as copper. The interior of the muffle is in contact with a non-oxidizing protective gas, and will, therefore, be protected against oxidation. To further protect the muffle on the outside, and also particular kinds of electric heating units about the muffle, I may encase the furnace in a metallic shell into which is introduced the same or a similar protective gas.

I specify commercially-pure nickel as the material from which I prefer to construct that part of the muffle exposed to the high temperatures, for I have found by experiment, in which the deflections of cantilever bars of identical size but of different materials were measured, that one of nickel deflected considerably less than chromium-alloyed nickel at temperatures about 2100° F., and while enveloped by a non-oxidizing atmosphere, more particularly, pure, dried, hydrogen. Additionally, experiments in a carburizing atmosphere, specifically, dried, dissociated ammonia containing about 1% of methane, indicated that nickel and copper-alloyed nickel did not embrittle when heated for four hours at the aforesaid temperature, while various chrome-nickel alloys, with and without iron, apparently absorbed carbon from the carburizing gas to the extent of becoming brittle or having their melting point lowered, or both. Accordingly, for a long-life, high-temperature furnace muffle for

use in a non-oxidizing atmosphere which may or may not include carbon-containing gases, these experiments indicate that a nickel muffle or nickel-copper alloy muffle should be used.

The muffle itself extends beyond the end of the refractory brickwork of the furnace to provide a chamber or section in which the charge may be initially placed. Protective gases are admitted to this section so that it may be purged of obnoxious gases before the charge is introduced into the heating zone. After heat-treatment, the charge may, if desired, be returned to the first purging chamber where it may remain while enveloped by the protective atmosphere until cooled to the proper degree. However, to permit work to be continually moved through the furnace and thereby increase its capacity, I prefer to have the muffle extend from both sides of the furnace proper so that one section may be employed as a charging and purging chamber, and the other section as a cooling and discharging chamber, it being understood, of course, that the various sections of the muffle, including the section in the heating zone, will be separated by manipulatable doors inside the muffle.

In building a furnace in accordance with my invention, I necessarily have in mind that the furnace must be as efficient as possible in order to be commercially attractive. Accordingly, I incorporate into my furnace certain features which not only increase its efficiency with respect to consumption of power, but also enable the heat-treating process to be carried out more effectively. Among these features is the confining of the heating zone to definite limits substantially determined by a tray which carries the work. This tray is specially constructed for supporting the work and, in addition, has end shields which fit the roof of the muffle in contour so that the section between the end shields is in effect the heating chamber for the work, the end shields further acting to confine the radiant energy between them.

Other details, features, elements, and combinations of my invention will be apparent from the following description thereof, taken in connection with the drawings, in which:

Figure 1 is a vertical view, mostly in longitudinal section and partially in elevation, of a furnace built in accordance with the teachings of my invention, and showing a charge-carrying tray in one of its heating zones;

Fig. 2 is a transverse cross-sectional view of the furnace of Fig. 1;

Fig. 3 is an enlarged plan view of an end of my furnace to show the outside door and its operating means;

Fig. 4 is an end view of the structure of Fig. 3;

Fig. 5 is an enlarged plan view of a work-carrying tray adapted for use in my furnace;

Figs. 6 and 7 are elevational and end views, respectively, of the tray of Fig. 5;

Fig. 8 is an elevational view of one of the shields secured to the end of the tray of Fig. 5;

Figs. 9 and 10 are enlarged elevational views of end and intermediate baffles, respectively, which depend from the roof of one embodiment of a muffle and which have lower contours substantially following the lines of the upper contour of the shields of the work-carrying tray; and

Fig. 11 is an enlarged, sectional view of a modified form of muffle and heating means.

The furnace of my invention is of the so-called muffle type and comprises a muffle, indicated in its entirety by the reference numeral 2, of suffi-

cient length to provide a plurality of different heat-treatment zones or sections therein, and projecting from both sides of the furnace proper 3. The furnace proper comprises the usual wall structure, such as refractory tile 4, backed by heat-insulating firebrick 6 or the equivalent. The refractory tile and firebrick are suitably assembled in the furnace to provide a central opening or heating space 8 in which the muffle 2 is located. The entire furnace proper is encased in a metallic shell 10 except, of course, for such openings as are necessary to accommodate the muffle and pipes and other elements to be later described, all of which are secured gas-tight to the shell so that it is, in effect, completely gas-tight. The furnace may be supported on any suitable under-structure, such as framework 11, and may have a removable top 12, bolted to the body of the furnace with a gasket 13 interposed to make the closure gas-tight.

The muffle 2 comprises a central tube or section 14 disposed within the furnace proper. In order to secure this tube removably in the furnace, one of its ends is provided with an integral outwardly-directed flange 16 which can be secured to the shell through the medium of bolt and nut means 18. As shown more particularly in Fig. 1, a backing ring 20, welded to the shell, reinforces the shell at points opposite the flange 16, and the parts are suitably apertured so that the bolt and nut means may extend therethrough.

A second section 22 of the muffle, which is the cooling and discharging section, is also provided with a flange 24 mating the flange 16 of the central tube of the muffle. By means of the bolt and nut devices 18, the flanges 16 and 24 are clamped to the shell and backing ring 20, with gaskets 26 and 28 properly interposed to assure a gas-tight joint.

The muffle also comprises a third section 30, which is the charging chamber in which charges to be heat-treated are placed preliminary to their entrance into the furnace proper. This section also serves as a purging chamber for purging the undesirable gases which might find their way into the muffle with the admission of a charge.

In this particular embodiment, the muffle is substantially rectangular in cross-section, and the central section 14 is preferably made of nickel for reasons aforesaid. As already stated, it has been found that in processes that require carburizing atmospheres for enveloping the charge, such as, for example, the hardening of high-speed tool steels, a nickel muffle does not absorb carbon, and consequently does not embrittle, nor is its melting point lowered, so that its life is considerably longer than muffles which might contain chromium or iron or both. For an all-purpose muffle, I have found that a central section of commercially-pure nickel has exceptionally long life, and does not affect the heating process.

The outer or cooling chamber 22 of the muffle is exposed to the outside atmosphere and insulated from the heat of the furnace proper so that a cheaper metal such as hot-rolled steel may be employed in the fabrication of this part of the muffle. The same holds true for the third section 30 of the muffle which is welded, as indicated at 32, to the nickel muffle. The three sections together comprise the muffle 2.

In one very satisfactory embodiment of my invention, I have used a muffle having a base width of approximately 10½ inches, and a height of approximately 6½ inches with the central heat-

ing section having a length of approximately 65 inches and the outer sections having lengths in the neighborhood of 32 inches.

As the heating means for the furnace, I provide a non-metallic refractory tube or shell 34 slightly larger than the central tube 14 of the muffle, and also disposed in the central opening 8 of the furnace. This shell 34 is preferably formed of alumina with a suitable clay binder, and is employed because of its availability at low prices, its low coefficient of thermal expansion, and its highly refractory character. Additionally, it is a relatively good conductor of heat while being an electrical insulator, and is chemically inert to electrical high temperature resistors.

The shell 34 is relatively thin and has wound about it electrical resistor ribbons in helical form to which energy may be supplied for raising the temperature of the furnace.

In the embodiment shown in Fig. 1, the heating resistors are divided into two zones arranged so that more energy can be supplied at one zone than the other zone. By this construction, I arrange within the central muffle section 14 two heat zones, one of which may be designated as the preheat zone, which is employed to bring the charges up slowly to a temperature of about 1300° F., and the other as the high heat zone, in which the charges are soaked at higher temperatures. The preheat zone comprises the resistor unit 36 wound on the alumina shell 34 at one side of the section 14, and the high heat zone comprises the resistors 38 similarly wound on the shell 34 at the other side of the section. Suitable gas-tight terminals 40 for each of the resistors convey their ends outside of the furnace for connection to an electrical source of power, preferably through control means under the control of temperature-responsive means 42 for the preheat zone, and 44 for the high heat zone. The temperature-responsive means may include thermocouples and suitably control, through well-known apparatus, the application of the power to the different resistors in the furnace so that its temperature may be regulated as desired.

The muffle structure is completed by suitable appurtenances which are preferably removably mounted thereon. These appurtenances include a door 46 separating the muffle into a charging and purging chamber comprising the section 30 and a central heating chamber comprising the section 14, and a door 48 separating the heating chamber of the muffle from the cooling chamber. Additional doors 50 and 52 close the ends of the charging and cooling chambers, respectively. The cooling chamber is further provided with a water jacket 54 having a water inlet 56 and a water outlet 58 so that the rate of cooling of any charge disposed in the cooling section 22 may be suitably controlled.

The doors 46 and 48 are preferably top-hinged inside the muffle, the shafts upon which they rotate extending through one side of the muffle through gas-tight glands, and can be manually operated by levers 60.

The exterior door structures and operating mechanism therefor are more particularly shown in Figs. 3 and 4, and each comprises a bar 62 secured transversely across the top of the muffle. Rotatably mounted on the ends of the bar 62 are connecting bars 64 and 66 which are secured to the door by means of bolts 68 and project somewhat beyond so that a door operating handle 70 may be fastened thereto.

The bars 64 and 66 are spaced somewhat from the exterior sides of the muffle, and in each of these spaces is disposed a tension spring 72 having one end hooked to the bar 62 and the other end hooked to the door. A door frame or jamb having a suitable opening fitting the interior of the muffle is secured to the muffle and includes a flat upwardly-projecting portion 76. As shown in Fig. 1, the bars 64 and 66 extend somewhat downwardly from their pivot point to about the center of the door, so that a toggle arrangement is provided for the door. In its lower closing position, the springs maintain the door against the door frame, while in the upper portion the tension of the springs 72 maintains it by friction in raised position, although a latch may be added if desired. A door rest 78 at the bottom of the door frame determines the disposition of the door in closing position and supports it.

Since the heat-treating process which is to be carried out in this furnace requires a protective atmosphere about the work, gas inlets 80, 82, and 84 are provided which convey a controlled atmosphere to the interior of the muffle. In the preferred process which I have briefly mentioned for the heat-treatment for the higher grades of tool steel, I prefer to employ a protective atmosphere of dissociated ammonia which has been dried to at least a dew point in the neighborhood of -35° F. or even lower; and for high-speed tool steels a small amount of carburizing gas may be added, in which case the dissociated ammonia need not be dried so thoroughly.

Since it is also desirable to envelope with a suitable protective gas the nickel muffle of the heating chamber, a protective gas is fed into the furnace proper through a gas inlet 86 and discharged from a gas outlet pipe 88. Inasmuch as ordinary firebrick and refractory are porous to some extent, it is manifest that the gas will permeate through these and flow into the central opening 8 of the furnace enveloping the muffle and resistor ribbons, finally flowing out through the gas outlet pipe 88. It should, of course, be understood that the expansion joints customarily provided in the assembly of the refractory and insulating lining of the furnace further facilitate the flow of protective atmosphere there-through.

It may be observed that the gas outlet pipe 88 is bent downwardly to have its discharge end somewhat below the bottom of the furnace proper, and by igniting the out-flowing gas the flame is an indication of the satisfactory operation of the gas supply means. In this connection, a gas outlet pipe may also be provided for the muffle.

In the operation of the furnace just described, a charge is first placed in the charging section 30 of the muffle where it remains until the air is flushed out by the flow of the pure dissociated ammonia. After this chamber has been thoroughly purged and flushed, the inner door 46 between it and the heating chamber may be opened and the work moved into the preheat zone without the admission of air. The work is pushed through the medium of a rod inserted through suitably-located openings 90 in the end doors and door frame which are covered preferably by small swinging closures in a customary manner. However, it should be understood that the pressure of the protective atmosphere within the muffle is maintained sufficiently great so that no air can enter the chamber, that is, a plenum system exists in the muffle whereby the flow of gas is outwardly from the muffle to the outside at-

mosphere through small openings and crevices rather than vice versa. It is only when the outer doors are open that any appreciable amount of air can find its way into the muffle. In such case, the intermediate doors 46 and 48 aid in preventing air flowing into the heating zones.

After the charge has been treated by preheating in the preheat zone, it may be pushed into the high heat zone where it is permitted to soak for a required length of time, and then it is drawn into the cooling section 22 of the muffle for cooling treatment.

In order to convey the charge through the muffle and at the same time further increase the efficiency of the furnace, I provide a special tray having many advantages for the particular use to which my furnace is put. One of these trays is shown more particularly in Figs. 5, 6, 7, and 8, and comprises three relatively narrow longitudinal skid bars 92, 94, and 96 having a length slightly less than that of the helical resistor 36 and the helical resistor 38, the lengths of both of the latter being substantially equal. Across the ends of the bars 92 and 94, and on top surfaces thereof, are welded two transverse end bars 98 and 100, so that a rigid skeleton under-structure is provided for the tray. By securing the end bars on top of the longitudinal bars, the tray can be readily slid along the bottom of the muffle, and additionally the raised end bars permit a pusher rod to readily engage them on one side, or a puller hook to engage an opposite side for pulling, rather than for pushing, the tray. In operation, a charge-carrying member or means in the form of a wire mesh screen or netting or even a wire basket may be placed on the top of the skid bars and the particular articles being heat-treated suitably arranged on this mesh to be carried along with the tray.

The tray is completed by a plurality of shields at each of its ends. To secure these shields to the under-structure, small upright bars or angles 102, 104, and 106 are welded to the longitudinal bars 92, 94 and 96, respectively, somewhat inward of the end bars 98 and 100. Bolts 108 are suitably secured in these upright bars, extending inwardly of the tray, and suitably-apertured shields 114 fit over the bolts. Each of these shielding plates preferably comprises a thin nickel sheet and four are used in this embodiment at each end of the tray, maintained in spaced relation by spacers 116 on the bolts 108, and held in position by any suitable means, such as cotter pins and washers. It is to be understood, of course, that the dimensions of the spacers 116 and the thicknesses of the shielding plates 114 are chosen so that the shields are suitably spaced and will be maintained in spaced relation during the heat-treating process. I have found that one-quarter to one-half inch spacing between the individual shields is quite satisfactory.

The shields are further provided with small aligned windows 120 in the event that it is desired to observe the work during the heat-treating process, a closed window 122 being provided in each of the end doors aligned with the windows 120 so that it is only necessary to swing an intermediate door partially open for a direct line of vision to the work in the heating chambers.

The tray shields are preferably so dimensioned as to occupy the full available cross-sectional area within the muffle. However, in this particular embodiment, I prefer to reinforce the muffle

section in the heating zones by means of upper baffles secured at different intervals along the top of the muffle and to the upper parts of its sides. In this instance, the end baffles 124 are formed solid, while the intermediate baffles 126 are formed with a plurality of apertures so that the heat will be better distributed through the different heating sources, although very satisfactory heat distribution obtains with solid intermediate baffles. The baffles are preferably nickel and occupy but a small fraction of the space within the muffle. The bottom contours are curved for strength, and to increase the useable heating space in the furnace. It follows, therefore, that the upper ends of the shields are also curved in a line similar to the curvature of the lower periphery of the baffles so that the tray may be moved in and out of the muffle without interference. Manifestly, the shields and baffles will cooperate to form a confined heating zone between the ends of the tray.

To facilitate the repair of the heating means and to permit expansion and contraction of the muffle which is anchored to the shell by the flange 16, a gas-tight stuffing box is provided at the end of the muffle away from the flanges 16 and 24, this closure comprising an angle frame 128 welded to the shell, as shown, and a second angle frame 130 bolted to a horizontal leg 132 of the angle frame 128. The leg 132 is spaced from the muffle and an asbestos backing 134 may be compressed by a movable plate frame 136 moved by means of bolts 138 threaded in suitable apertures in a depending leg 140 of the angle frame 130 in an obvious manner.

In the assembly of the heating means, the end closure just described is to be assumed completely loose so that the shell 34 may be slid into position until it abuts a suitable refractory brick 142 at the other end of the furnace proper. A second brick 144 may then be placed against the end of the shell 34 so that the full length of the furnace is substantially occupied by the two bricks 142 and 144, and the shell 34. This structure not only positions the shell 34 and the heating means wound on it, but, by tightening the packing after the insertion of the shell, a gas-tight seal is obtained.

It may thus be observed that I have provided a furnace having a charging chamber outside of the furnace proper and two heating sections which may be independently controlled within the furnace proper, each occupying approximately half the length of the full space available for heating. The zone adjacent the entry chamber is the preheat zone and is adapted to preheat the charge to temperatures in the neighborhood of 1200-1400° F., and a tray may be disposed in this zone while a second tray is disposed in the other zone, which is the heating zone, the baffles of the muffle and the shields of the trays serving to fully define the two zones. By admitting a protective atmosphere into the outer shell of the furnace proper, the heating ribbons and the outside surface of the heating section of the muffle are protected from oxidation, and, consequently, I may use electric resistors capable of attaining higher temperatures than the customary alloys which must be made resistant against oxidation. Thus, the resistors might be nickel or even molybdenum.

The protective gas is fed into the muffle at three places, although with sufficient pressure one only would be sufficient. In such case, it would be preferred to have the gas inlet admit the gas di-

rectly into the heating section of the muffle. In the event the end doors and frames fit quite tightly and do not permit a slow continuous flow of atmosphere between the crevices of their joints, adjustable vents may be provided in the ends of the muffle and the out-flowing gas may be burned in a flame. The inner doors fit loose enough to allow the free flow of gas between sections of the muffle, but prevent air getting into the heating section of the muffle during the short period when the end doors are opened, the air being purged through the venting means.

My tray, cooperating with the baffles of the muffle, aids in defining the different heating zones, and, moreover, is conducive to a uniform temperature within the tray length which is the charge-treating zone, while reducing the heat losses out of the end of the muffle. Without the shields, which act as a heat-barrier or heat-confining means, the heating source would have to be considerably longer to get the same length of uniform temperature within the charge-treating zone and, consequently, the furnace would have to be longer.

At extremely high temperatures, there may be a tendency for the trays to weld to the floor of the muffle due to the clean surfaces. Where such sticking might occur, and also to make the trays slide more freely, a thin coating of refractory sand, such as zircon sand, may be scattered on the muffle floor.

In Fig. 11, I show a second form of muffle and heating means combined. In this case, the muffle, rather than being squared in cross-section, as is the muffle of Fig. 2, follows the contour of that of the tray so that baffles need not be added to the muffle, the arch curvature of the muffle serving as a strengthening means at high temperatures. The muffle of Fig. 11 is further different from the prior described device in that the heating means is made unitary therewith by first applying a layer of electrically-insulating refractory cement outside of the muffle and then drying it. The heating ribbon may then be wound directly on the resulting tube, and thereafter a second layer of the insulating refractory cement may be applied so that the resistor is fully embedded in the unit. Manifestly, the tray of Figs. 5 to 8 can be used with a muffle such as shown in Fig. 11.

While I have shown my invention in a form which I now believe to be very suitable to my purposes and objects, it is obvious that many modifications may be made and other equivalents employed, especially in the manner by which the furnace is heated, and in a copending application Serial No. 296,587, filed currently herewith, entitled Heat-treating furnaces, and assigned to Westinghouse Electric & Manufacturing Company, I described another preferred form of my invention. In that application I also describe in greater detail the methods of operation, accomplishments and results that I can obtain in that embodiment. These can be duplicated in this furnace, the essential differences being that in this furnace a separate preheat zone is provided, and in this furnace continuous operation is possible.

In the appended claims I employ the term "muffle" generically to include only the central section of the described embodiment or additional sections depending on the context of the particular claim, and the term "tool" generically to include tools, dies, and similar working implements. I claim as my invention:

1. An electric furnace, adapted especially for

the heat-treatment, at elevated temperatures, and hardening of the higher grades of tool steels and the like while enveloped by a protective atmosphere, comprising a plurality of refractory and insulating walls defining a heating space, a metallic muffle-section in said heating space, a metallic shell for gas tightly encasing said walls, said shell having an opening through which an end of said muffle-section protrudes, said end having an outwardly-extending peripheral flange, a second muffle-section aligned with the first said muffle-section, said second muffle-section having a peripheral flange, and means for gas tightly securing said flanges together and to said shell, the first said muffle-section being passable through said opening.

2. A bright-finishing metal-treating electric furnace adapted for substantially damage-free hardening heat-treatment in a controlled atmosphere of the higher grades of tool steels and the like, said furnace comprising non-metallic refractory walls defining a heating space, an elongated tube-like metallic muffle including a first muffle-portion in said heating space and a cooling muffle-portion, heating means in said heating space outside of said first muffle-portion for providing a heated zone therein for heating a charge, cooling means for said cooling muffle-portion for providing a cooling zone therein for cooling a charge, a metallic charge tray means movable in said muffle, each of said muffle-portions being of a length to accommodate said tray means, said tray means comprising a bottom for supporting articles to be heat-treated, a pair of metallic heat-confining means, one at each end of said charge-supporting bottom, each of said heat-confining means comprising a plurality of adjacent relatively closely spaced upwardly directed metallic sheet-like members, said pluralities of members of said heat-confining means fitting the interior of said muffle in which the tray means is movable with only a slight clearance sufficient to permit the tray means to be moved between said muffle-portions and to permit flow of controlled atmosphere between said heating and cooling zones, closing means for one end of said muffle, and closing means comprising a force-pressed closure for the other end of said muffle.

3. A bright-hardening metal-treating muffle-furnace of the type described, said furnace comprising an elongated metallic-refractory muffle having means whereby the inside of the muffle may be permeated with a flowing controlled atmosphere, heating means for heating a first portion of said muffle for providing a heating zone, said first portion of said muffle being in open communication with a second portion of said muffle, means for providing a treating zone in said second portion of said muffle, which is of lower temperature characteristics than said heating zone, a metallic charge-tray movable inside said muffle into said heating zone and said treating zone, said charge-tray comprising an article-carrying means, metal heat-confining means carried by said charge-tray at each end of said article-carrying means for thermally delimiting, in conjunction with said muffle, the ends of a charge-treating zone, said heat-confining means being conducive to uniform temperatures along said article-carrying means, and permitting said controlled atmosphere to flow between said heating zone and said treating zone.

4. A bright-finishing metal-treating furnace of the type described adapted for the hardening

heat-treatment in a controlled atmosphere of the higher grades of tool steels and the like, said furnace comprising an elongated tube-like metallic muffle having means whereby its tube-like interior may be permeated with a flowing controlled atmosphere, said muffle comprising two muffle-portions in open communication and in contiguous relation, means for affecting the temperature in one of said muffle-portions to provide a treating zone therein, means for heating the other of said muffle-portions to provide a heated zone therein of higher temperature characteristics than said treating zone, said heated zone and said treating zone being also in open communication, means disposable in said muffle between said heated zone and said treating zone for thermally separating the two zones, said thermal separating means comprising a plurality of adjacent relatively closely spaced sheet-like metallic members loosely, but relatively closely, fitting the interior of said muffle, whereby controlled atmosphere may flow between edges of said plurality of sheet-like members and the muffle, and closing means for the ends of said muffle.

5. A bright-finishing metal-treating furnace adapted for substantially damage-free hardening heat-treatment in a controlled atmosphere of the higher grades of tool steels and the like, said furnace comprising non-metallic refractory and insulating walls defining a heating space, an elongated tube-like metallic muffle having means whereby the inside of the muffle may be permeated with a flowing controlled atmosphere, said muffle including a first muffle-portion in said heating space, and a second muffle-portion extending outwardly from said walls, heating means for said first muffle-portion, cooling means for said second muffle-portion, an article-supporting tray means axially movable in said muffle, each of said muffle-portions having metal-treating zones of a length to accommodate said tray means, said tray means comprising a gas-pervious article-supporting member and lower supporting means for said article-supporting member, said supporting means being provided with spaces through which controlled atmosphere may flow to the lower side of said article-supporting member, said tray means further comprising heat-confining means comprising a plurality of relatively closely-spaced upwardly-directed sheet-like metal members carried by said supporting members above the bottom of said muffle, said plurality of sheet-like metal members closely, but loosely, fitting the interior of said muffle to permit the flow of controlled atmosphere between the muffle and the edges of said plurality of sheet-like metal members.

6. As an article of manufacture, a heat-resistant tray for conveying articles to be heat-treated in a controlled atmosphere, comprising a gas-pervious metallic article-carrying means, and a pair of spaced metallic heat-confining means carried by said article-carrying means, the spacing between said heat-confining means providing an article-receiving portion on said article-carrying means, each of said heat-confining means comprising a plurality of relatively closely-spaced adjacent metallic sheet-like members, said members extending for substantially the width of the said article-carrying means, and being upwardly disposed with respect to a horizontal position of said article-carrying means.