March 24, 1942. S. N. LEVY ET AL 2,277,595

FURNACE

Filed May 15, 1941 3 Sheets-Sheet 1

Fig. 1.

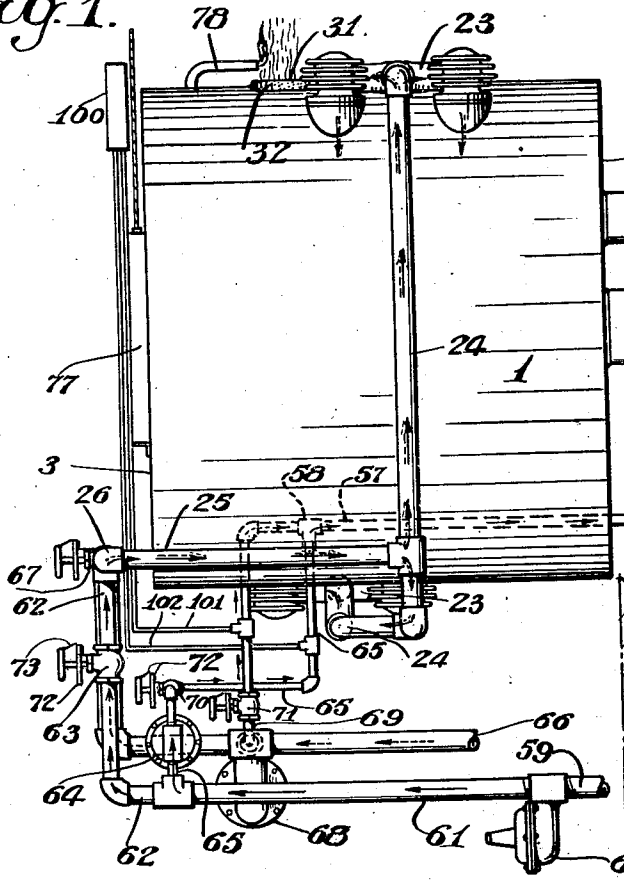



Fig. 7.

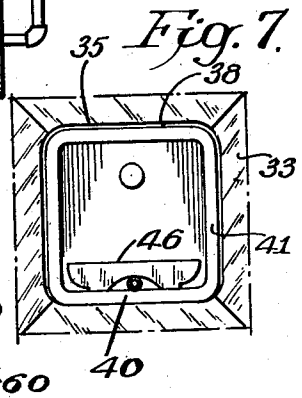
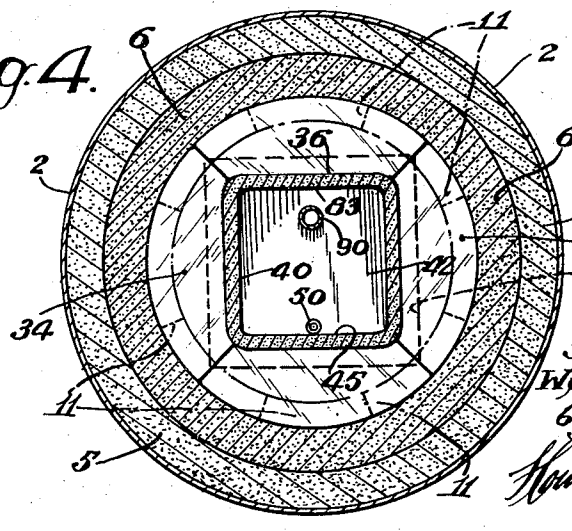



Fig. 4.



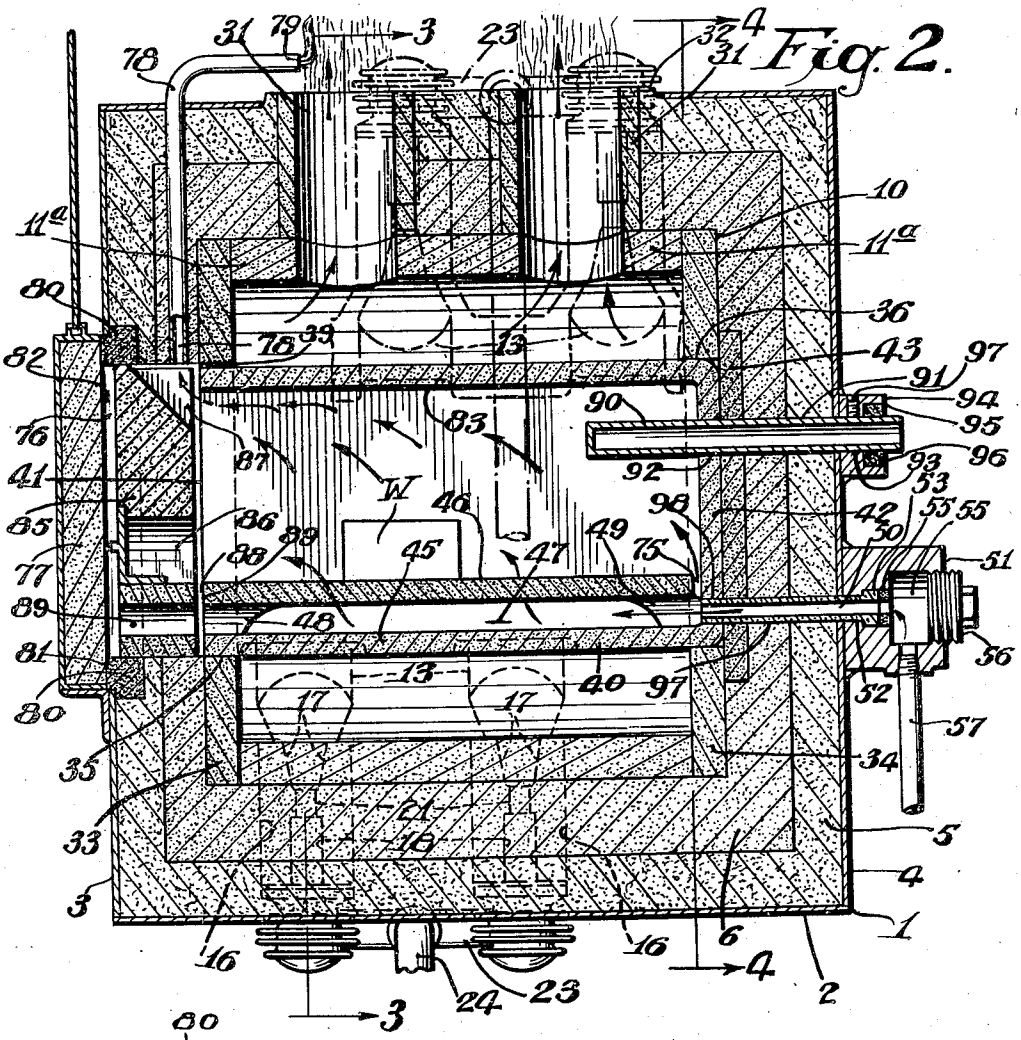

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FURNACE

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Fig. 2.



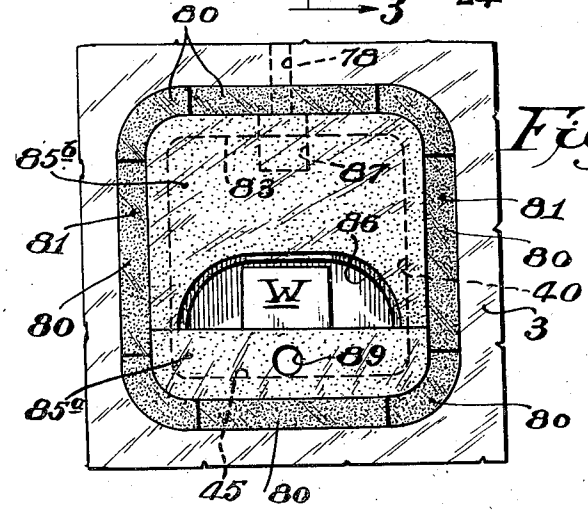
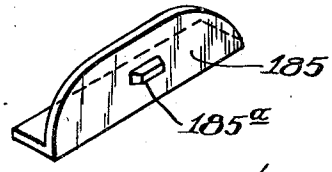




Fig. 5

Fig. 6.



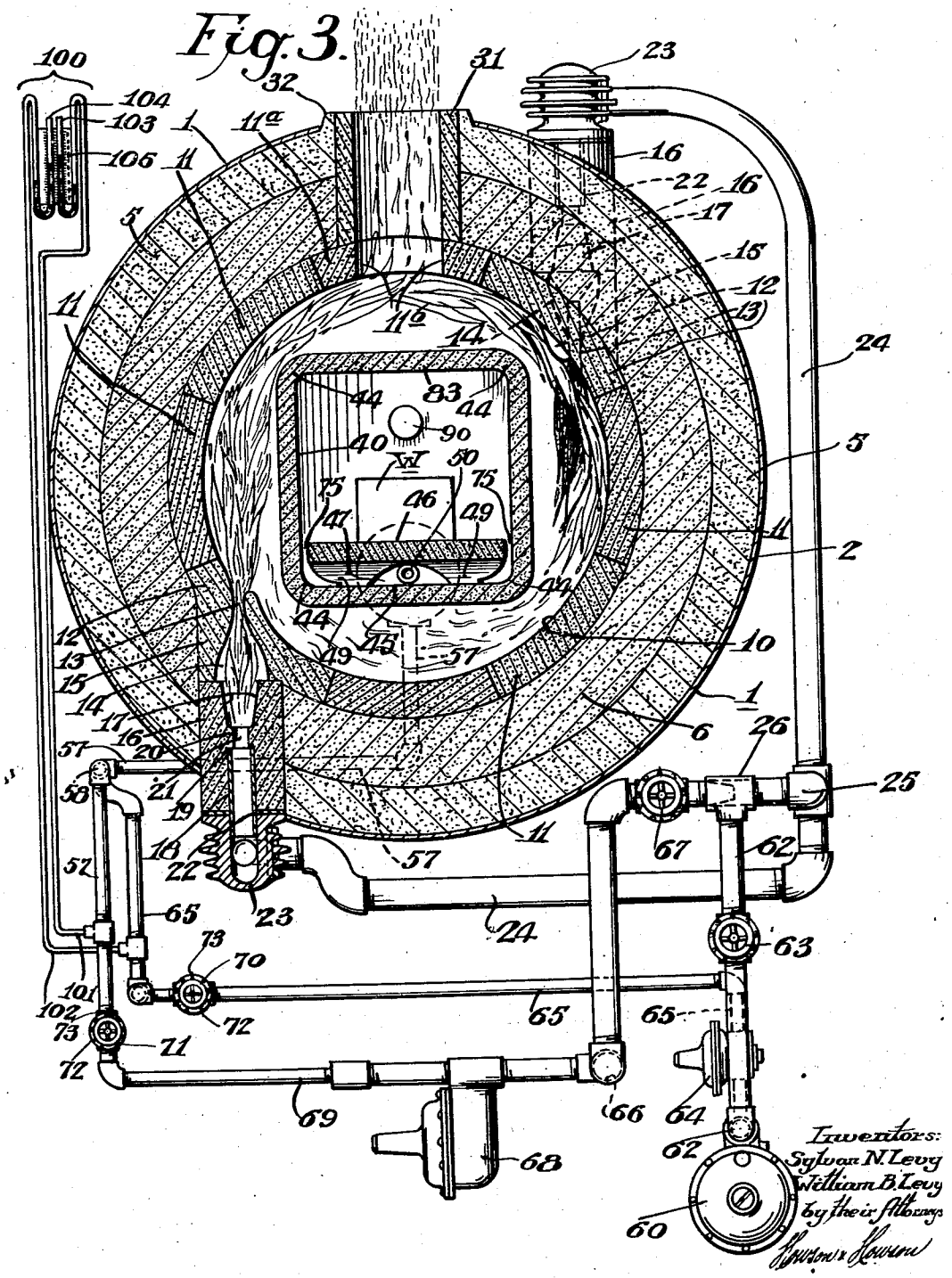

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FURNACE

Filed May 15, 1941 3 Sheets-Sheet 3

Fig. 3.



Patented Mar. 24, 1942

2,277,595

# UNITED STATES PATENT OFFICE

2,277,595

## FURNACE

Sylvan N. Levy and William B. Levy, Arden, Del.

Application May 15, 1941, Serial No. 393,624

22 Claims. (Cl. 263—14)

This invention relates to metal-heating furnaces, and especially to those of the muffle type employed principally for heat-treating trial specimens, tools, machine parts or other articles composed of various grades of steel, or of different base metals, or metal alloys adapted to be heated or treated in such a furnace.

One object of the present invention is to provide a heat-treating furnace which can be brought up to a high operating temperature in a minimum amount of time.

Another object of the invention is to construct the furnace and the muffle in such a maner that the muffle will heat uniformly in all parts thereof, simultaneously, and hold such uniformity throughout the operation of the furnace, thereby eliminating localized "hot spots" and increasing the operating efficiency of the furnace.

Another object of the invention is to construct and mount the muffle in such a manner that it may readily expand and contract during the heating and cooling thereof without producing destructive strains therein, whereby muffle breakage is reduced to a minimum.

Another object of the invention is to construct the furnace and the muffle in such a manner that replacement or substitution of one muffle for another may be readily accomplished without dismantling major parts of the furnace.

Another object of the invention is to support the muffle solely at its opposite ends, respectively, with the major intermediate portion of the muffle suspended in the clear, within the combustion chamber of the furnace, whereby substantially the full length of the muffle will be available for use to treat work specimens uniformly, at all points throughout substantially the whole length of the muffle.

Another object of the invention is to so form the furnace and to so deliver the heat to the interior of the combustion chamber thereof that the front open end of the muffle may be subjected to a suction action from the interior of the combustion chamber, or, if desired, the interior of the muffle may be completely isolated from communication with the interior of the combustion chamber, whereby, in either case, a predetermined atmosphere may be maintained uniformly in the muffle at all times during the operation of the furnace.

Another object of the invention is to provide independent calibrated controls and individual indicators for the component gases of which the atmosphere within the muffle is composed, whereby the mixture may be accurately controlled and maintained or varied at will to a predetermined extent while the furnace is in operation, and whereby any desired percentages of $CO_2$, $O_2$, or CO may be established and maintained in the muffle without resorting to any time-consuming trial and test method for any desired atmosphere.

Another object of the invention is to provide an inlet tube for the atmospheric gases, which may be readily cleaned out, if necessary, while the furnace is in operation.

Another object of the invention resides in the provision of a mixing chamber for the atmospheric gases, exterior of the furnace, and to provide the chamber with a removable plug or cap providing access to the outer end of the inlet tube, for readily replacing the tube if and when such replacement becomes necessary.

Another object of the invention is to provide the furnace with a readily removable casing for enclosing the thermocouple within the muffle, whereby the aligned openings in the rear walls of the furnace and muffle, respectively, through which the thermo-couple casing projects, may be employed to support one end of a guide bar inserted from the open front end of the furnace to align the rear end of the muffle with a seat therefor in the rear wall of the furnace, in replacing a muffle in the furnace.

Another object of the invention is to provide a work support or hearth tile in the bottom of the muffle, with the ends only of said tile supported at and by the supported ends solely of the muffle, whereby the intermediate portion of the floor of the muffle will be relieved of the weight of the work contained within the muffle, thereby prolonging the life of the muffle.

Another object of the invention is to provide a vent for escape of the atmospheric gases from within the muffle to a point outside the furnace when the interior of the muffle is completely isolated from the combustion chamber; and to position the external outlet of the vent in juxtaposition to an exhaust port for the hot combustion gases coming from the combustion chamber, whereby the escaping atmospheric gases will be lighted by the flaming exhaust from the combustion chamber and constantly consumed, to eliminate accumulation of said atmospheric gases in the vicinity of the furnace.

Another object of the invention resides in providing readily interchangeable closure tiles with various sized openings respectively, for use, singly, in the front opening of the furnace, between the open end of the muffle and the door of the

furnace, to reduce the furnace and muffle opening to a size just large enough for the passage of single pieces of work into and out of the muffle, whereby the area of exposure of the door to the interior of the muffle is reduced to a minimum, thereby effecting a considerable saving in heat losses through and around the door of the furnace; and whereby the temperature of the atmosphere at the open end of the muffle is not materially affected during loading and unloading of the muffle.

Another object of the invention is to provide a removable plate for covering the small work opening in the closure tiles while the work is being treated, to close the muffle completely; to eliminate all possibility of outside air entering the muffle; to keep the front end of the muffle from chilling; and to protect the refractory lining of the furnace door from the muffle heat.

Another object of the invention is to make the muffle of a rectangular cross-section to provide greater work-supporting area within the muffle.

Another object of the invention is to provide a circular combustion chamber around the muffle and to project heating flames into the interior of the combustion chamber substantially tangential to the circular wall thereof, whereby the flame will hug said circular wall and will not impinge upon any local portion of the muffle to create a hot spot therein.

Another object of the invention is to provide a plurality of said tangential flames in laterally overlapping relation, longitudinally of the combustion chamber, whereby uniform heating of the muffle from end to end thereof is accomplished.

In the accompanying drawings:

Fig. 1 is a side elevation of a furnace constructed and adapted to operate in accordance with the principles of the present invention;

Fig. 2 is a longitudinal vertical sectional elevation of the furnace shown in Fig. 1;

Fig. 3 is a transverse sectional elevation taken on the line 3—3, Fig. 2;

Fig. 4 is a transverse sectional elevation taken on the line 4—4, Fig. 2;

Fig. 5 is a fragmentary front elevation of the furnace and muffle, with the door of the furnace removed;

Fig. 6 is a perspective view of the removable closure plate for the muffle closure tiles; and

Fig. 7 is a fragmentary face view of the front wall of the combustion chamber and the front end of the muffle.

As shown in the drawings, the furnace comprises an outer metallic shell 1, of usual construction, including a main cylindrical barrel or body portion 2, a face plate 3, and a back plate 4, all of which are preferably welded together at adjacently disposed edges thereof.

Within the metallic shell 1, the furnace includes an outer insulating shell 5 composed of one type of heat-insulating material, such for example, as an asbestos plaster, etc., and an inner insulating shell 6 composed of a different type of heat-insulating material, such as fire clay. However, the insulating envelopes 5 and 6 may, if desired, be composed of a single body of insulating material of any of the well-known kinds employed for preventing transmission of high temperatures to the outer metal shell of the furnace.

Enclosed within the insulating shell, composed of the combined bodies 5 and 6, is the combustion chamber 10, which in the present instance is formed of premolded units of high test refractory material, such as silicon carbide, sillimanite, or suitable equivalents.

The combustion chamber 10 is of circular cross-section and is preferably formed of a plurality of segmental wall tiles 11, 11 and segmental burner or flame tiles 12, 12 fitted and cemented together to form the cylindrical barrel of the combustion chamber 10, with the flame tiles 12, 12 staggered circumferentially and longitudinally of said chamber, as shown in Figs. 2 and 3.

The flame tiles 12, 12 are of the type disclosed in the prior U. S. patent to Sylvan N. Levy (one of the joint inventors in the present case) No. 2,230,960, dated February 4, 1941.

Each flame tile 12 is provided with a flame outlet 13 which is contracted in the direction of the circumference of the combustion chamber 10 and elongated in the direction of the axis of the combustion chamber 10, to discharge a flat or ribbon type flame against and tangent to the circular inner surface of the combustion chamber 10. The series of flame ports 13, 13, four in number in the present case, are staggered as shown in Fig. 3, whereby the lateral edges of the several flat ribbon-like flames are in laterally abutting or overlapping relation to each other and form a substantially solid cylindrical sheet of flame which is caused to swirl about the axis of the chamber 10, from end to end of said chamber, in contact with and adjacent the inner circular wall of said chamber.

The axially elongated flame ports 13, 13, within the respective flame tiles 12, 12, communicate with circular flame inlets 14, 14 formed in external bosses 15, 15 in the flame tiles 12, 12, respectively. Each flame tile boss 15 is abutted by a cylindrical flame tube 16, composed of refractory material and which extends through the insulating shell 5—6 and outer metallic shell 1, as shown in Fig. 3.

The flame tubes 16 are respectively provided, at one end of each, with an inwardly tapering flame discharge port 17, in direct axial communication with the flame inlet 14 of the flame tile 12. At the opposite end of each flame tube 16 is a circular opening which terminates in an annular shoulder 19 formed by an annular flange 20, in which is a restricted flame passage 21 in axial alignment with the flame port 17. A metal fuel tube 22 fits snugly in the circular opening 18 with its inner end in contact with the shoulder 19.

The flame ignites and burns at, and outwardly from, the base of the tapered port 17 and the overhanging flange 20 protects the inner end of the fuel tube 22 from the heat of the flame, thus considerably prolonging the life of the fuel tube. The outer end of the fuel tube 22 is fixed in a manifold 23, in spaced relation, axially of the furnace, to another of the fuel tubes located at the same side of the furnace.

The manifolds 23, 23 at the opposite sides respectively of the furnace, are connected by a fuel pipe 24, which, in turn is connected by a pipe 25 to a mixing fitting 26.

The products of combustion are permitted to exhaust from the interior of the combustion chamber 10 through a pair of refractory sleeves 31, 31 located and spaced apart in the top of the furnace. The sleeves 31 pass through the outer shell 1 and the insulating shell 5—6, and rest on the tops of the uppermost segmental wall tiles 11a, each of which is provided with an opening 11b affording communication between the

interior of the combustion chamber 10 and the atmosphere outside the furnace, through the refractory sleeve 31.

The insulating material of the insulating shell 5 is formed in a lip or flange 32 around the exterior of the sleeve 31, between said sleeve and the opening in the outer shell 1 through which said sleeve projects, for the purpose of reducing or eliminating transmission of heat from the exhaust sleeve 31 to the metal shell 1. As shown in Fig. 2, there are two exhaust sleeves 31 disposed in staggered relation to the flame ports 13, 13 so that neither of the exhaust sleeves is in direct line with any of the flame ports.

In addition to the segmental wall tiles 11, 11a and 12, the combustion chamber includes a front wall 33 and a back wall 34 composed of refractory material, such as silicon carbide, sillimanite, etc. The front and rear walls 33 and 34 are provided with axially aligned rectangular openings 35 and 36, respectively, for the reception of the muffle 40, which, as shown in Fig. 2, extends the full length of chamber 10, with its open front end 41 substantially flush with the outer face of the front wall 33, and the outer surface of its closed rear end 42 substantially flush with the outer surface of the rear wall 34 of the combustion chamber 10.

The said rear end of the muffle 40 abuts against a plate 43 composed of refractory material and inserted in the body 6 of insulating material, with the marginal edges of the refractory plate 43 in overlapping relation to the edges of the muffle opening 36 in the rear wall 34 of the combustion chamber.

As shown in Figs. 2, 3 and 4, all of the corners of the rectangular muffle 40 are internally filleted and externally rounded where the adjacent walls of the muffle join, in order to reduce breakage of the muffle as a result of expansion and contraction thereof, as shown at 44 in Fig. 3.

The muffle 40 is supported solely by those portions of the floor 45 thereof which are adjacent the opposite ends 41 and 42 thereof and which rest on the front and rear walls 33 and 34, respectively, of the combustion chamber 10, whereby all obstruction to free rotary swirling motion of the sheet of flame projected into the combustion chamber by the flame ports 13, 13 is eliminated.

As shown in Fig. 2, the interior of the muffle 40 is provided with a work-supporting or hearth tile 46. As shown in Figs. 2 and 3, the hearth tile 46 lies parallel to and is spaced above the floor 45 of the muffle 40, with a space 47 therebetween. Adjacent the front and rear ends 41 and 42 of the muffle 40, the hearth tile is provided with laterally spaced feet 48, 48 and 49, 49, respectively, which rest on the floor 45 of the muffle immediately in line with or immediately adjacent those portions of said floor 45 which bear on the front and rear walls 33 and 34 of the combustion chamber 10, whereby the weight of work specimens W resting on and supported by the hearth tile 46 is carried substantially directly by the end walls of the combustion chamber, thus eliminating strains on the floor 45 of the muffle which would normally result from supporting the weight of the load within the muffle. In this manner, the life of the muffle is considerably prolonged.

In the treatment of steel, it is particularly desirable to maintain either a neutral, a reducing, or an oxidizing atmosphere within the muffle, without contamination from or by gases from the combustion chamber. For the purpose of preventing the passage of combustion gases from the interior of the combustion chamber 10 to the interior of the muffle 40, the area of the exterior cross-sectional contour of the muffle is slightly less, but of the same shape as the muffle-supporting opening 35 formed in the front wall of the combustion chamber 10, with sufficient clearance provided to enable the muffle to be readily inserted in or removed from the combustion chamber. When it is desired to isolate the interior of the muffle from the interior of the combustion chamber, to insure sealing of the muffle, the small clearance between the exterior of the muffle and the interior of the opening 35 is closed by fire clay or other refractory material 39, Fig. 2.

As shown in Figs. 2 and 3, the mixed component gases which constitute the atmosphere within the muffle 40 are admitted to the muffle through the rear wall thereof, into the space 47 between the hearth tile 46 and the floor 45 of the muffle, intermediate the rear feet 49, 49 of the hearth tile 46, through an atmosphere tube 50 which projects through an opening formed in the outer rear wall 4 of the furnace, through the insulation shell 5—6, through the closure plate 43 forming part of the rear wall 34 of the combustion chamber, and through the rear wall 42 of the muffle.

Preferably the atmosphere tube 50 is composed of porcelain or its equivalent and is adapted to be readily removable from and replaced in the furnace. For this purpose a block 51 of suitable metal is welded or otherwise secured to the rear wall 4 of the furnace. The block 51 is provided with a counterbored opening 52, for reception of the body of the tube 50. The counterbore 52 provides an annular shoulder against which an annular flange 53 on the outer end of said tube rests. The counterbore 52 communicates with an enlarged cavity 55 formed in the block 51. A ring of sealing compound 55 is provided in the open end of the counterbore 52 between the outer end of the tube 50 and the enlarged cavity 54. The block 51 is drilled and tapped for the reception of a removable plug 56 in axial alignment with the counterbore 52, to provide access to the interior of the cavity 54 and providing for removal of the tube 50, which may be driven out through the block 51 by inserting a rod through the front of the muffle and furnace.

The cavity 54 acts as a chamber for thoroughly and completely mixing the component gases constituting the atmosphere entering the muffle 40 through the tube 50. The primarily mixed component atmospheric gases enter the chamber 54 through a pipe 57 which is connected to a primary mixer fitting 58.

The mixer fittings 58 and 26 for the muffle 40 and combustion chamber 10, respectively, are supplied with gaseous fuel from a supply pipe 59, through an automatic fuel pressure regulator 60, when the furnace is gas fired.

In some instances the furnace may be fired with fuel oil, in which case the fitting 26 would be connected to a suitable source of fuel oil through a suitable pressure pump or gravity feed, while the fitting 58 would be connected to a suitable source of air under pressure through a suitable automatic pressure regulator.

In the present instance, the automatic pressure regulator 60 supplies gaseous fuel, i. e. either natural or manufactured gas, to a pipe 61 at a constant uniform and predetermined pressure.

The pipe 61 is connected to the combustion chamber fuel mixer 26 by a pipe 62, under con-

trol of a hand valve 63, and to the muffle mixer 58 through an auxiliary pressure regulator 64 by a pipe 65.

The auxiliary automatic pressure regulator 64 maintains a constant uniform supply of fuel to the muffle mixer 58 regardless of the manipulations of the valve 63, by which the flow of fuel to the combustion chamber mixer 26 is governed to increase or decrease the operating temperature of the furnace, and the regulator 60 maintains a constant uniform flow of fuel to the furnace as a whole.

Air is supplied to the mixers 26 and 58 from a suitable source under pressure through a pipe 66. The pipe 66 is connected directly to the combustion chamber mixer 26, through a control valve 67, and to the muffle mixer 58, through an automatic pressure regulator 68 and pipe 69.

The gas and air pipes 65 and 69 for the muffle mixer 58 are provided with hand valves 70 and 71, respectively, by which the flow of the air and of the gas to the mixer 58 may be separately and accurately adjusted to admit predetermined proportions of gas and air to the mixer 58 for providing a predetermined neutral, reducing, or oxidizing atmosphere in the muffle 40, and for that purpose each valve body is provided with a dial 72 and the valve stem is provided with a pointer 73 operating over the dial to indicate the extent of flow, or of valve opening.

With the air and gas under definitely known pressures, respectively, and with the flows through the valves 70 and 71, respectively, being definitely known for each degree of rotation of the valve stems, by setting the arrows 73, 73 to definitely calibrated markings on the dials 72, 72, respectively, the relative volumes of gas and air passing into the mixer 58, and consequently the atmosphere passing from the mixer 58 into the muffle 40, are definitely known and controlled, whereby any desired reducing atmosphere or oxidizing atmosphere may be created and maintained in the muffle 40, or a neutral atmosphere may be produced and held in the muffle in lieu of either of the others, by merely setting the pointers to spots on the dials which are known to indicate the proper mixture of gas and air for the atmosphere which is desired.

As a matter of check against variation in the gas or air entering the muffle, from the amounts required according to the dial setting of the valves 70 and 71, as by failure of one or the other of the pressure regulators 64 and 68, or for other reasons beyond the control of the operator, a manometer 100 of any ordinary commercial type is connected by pipes 101 and 102 to the gas and air lines 65 and 69, respectively. This manometer is provided with juxtapositioned sight tubes 103 and 104 adjacent a scale 105 and includes a colored liquid which rises and falls in each tube in accordance with the pressure and/or volume of the gas or air entering the muffle, by which the relationship of the two entering the mixer 58 is at all times clearly visible to the operator of the furnace.

The atmospheric mixture formed in the mixer 58 passes therefrom into the pipe 57 and from the pipe 57 into the chamber 54 where a second or complete mixing of the air and gas is effected, by reason of the pipe 57 entering the chamber from one side thereof, at 90° to the axis of the tube 50 which conducts the mixture from the chamber 54 into the rear end of the muffle 40, below the hearth tile 46.

From the inner end of the tube 50 the atmosphere flows along under the hearth tile 46 and around the marginal edges thereof, through slots 75, 75 formed between said marginal edges of the hearth tile and the vertical walls of the muffle, into the interior of the muffle above the hearth tile and around the work specimens W supported thereby.

As shown in Fig. 2, the front end 41 of the muffle 40 terminates at the outer wall of the front plate 33 of the combustion chamber 10, in inwardly spaced relation to the outer surface of the front plate 3 of the outer casting 1, thereby providing a space 76 between the front end of the muffle and the front of the furnace, which has a shape and area corresponding to the cross-sectional shape of the muffle, which normally is closed only by the door 77 of the furnace. The atmospheric gases normally flow from the open end 41 of the muffle into this space 76.

In furnaces of the prior art, the doors fit the furnace openings rather loosely and the atmospheric gases escape from the furnace between the rear face of the door and the front face of the furnace, around the marginal edges of the door. If a reducing atmosphere is being used, the escaping gas, upon coming into contact with the air outside the furnace, bursts into flame around the edges of the door.

In the present case, when the interior of the muffle is completely isolated from the interior of the combustion chamber, the atmospheric gases are conducted from the space 76, between the door 77 and the front end 41 of the muffle, to a point outside the furnace and remote to said door through and by a vent pipe 78, which, as shown in Fig. 2, passes upwardly from said space through the insulating shell 5—6 and outer shell 1 to a point above the top of the furnace and rearwardly located with respect to the front of the furnace. In the present instance, the outer end 79 of the vent 78 terminates over one of the exhausts 31 for the gases coming from the combustion chamber 10, which are usually flaming or of such heat as to cause the atmospheric gases escaping from the end 79 of the vent to ignite and burn. This structure and arrangement of parts eliminates the undesirable escape, burning, etc., of the atmospheric gases around the door of the furnace.

In some instances the sealing material 39, between the inner surface of the muffle opening 35 in the front wall 33 of the combustion chamber 10 and the exterior surface of the front end 41 of the muffle 40 is eliminated, leaving a space 38, Fig. 7, therebetween, through which the swirling products of combustion in the chamber 10 sets up a suction action and draws the atmospheric gases into the combustion chamber from the front end of the muffle 40. In such cases, the vent pipe 78 may be plugged with fire clay, or eliminated.

In order to eliminate further the escape of the atmospheric gases around the door of the furnace, the opening 76 is framed in premolded units 80 of silicon carbide, sillimanite or the like, and which project to some extent beyond the front face of the front plate 3 of the furnace. The outer faces of the framing units 80, 80 are set in one common plane represented by the surface 81, against which the rear planar face 82 of the door 77 bears and substantially seals the opening 76 against the escape of gas from the muffle. The sealing or frame tiles 80, 80 may be readily replaced when necessary without dis-

mantling the furnace, whereby a practical seal may also be maintained around the furnace opening.

The top or roof 83 of the muffle 40 is disposed a sufficient distance above the top surface of the hearth 46 to accommodate relatively large articles and to provide a sufficient volumetric capacity in the muffle to contain a sufficient quantity of atmosphere for properly treating any and all work placed on the hearth tile 46 which can be inserted through the furnace entrance opening 76.

However, it frequently happens that the furnace is used for heat-treating tools or specimens of small size. The operator of the furnace will frequently raise the door to a greater elevation than is necessary for inserting such small work into the muffle for treatment or in removing the treated specimens from the muffle. This results in excessive losses of heat and atmosphere from the muffle.

In the present case, to avoid such losses, and to avoid heat losses by radiation through the door, an interchangeable baffle wall 85, of high refractory material, is removably placed in the normally open space 76 between the front edge 41 of the muffle and the rear face 82 of the door, and an opening 86 of an area commensurate with the size of the individual pieces of work being treated is formed in the baffle wall 85 for passage of the work pieces therethrough. This reduces the losses of atmosphere when the door is open and reduces the heat losses when the door is closed.

In order to keep the heat of the muffle from impinging against the inside surface of the door 77, while the work W is undergoing treatment, and in order to maintain uniform heat throughout the full length of the muffle clear up to the open end 41 thereof, an auxiliary closure plate 185 (Figs. 2 and 6) is provided to close the work opening 86 in the baffle wall 85. A substantial lug 185a is formed on the closure plate 185 to be gripped by work tongs in setting the closure plate in place and when removing it from the opening 86.

A passage 87 is formed in the rear and top surfaces of the baffle wall 85 to afford communication between the front of the muffle and the inlet end of the vent 78, when the muffle 40 is completely isolated from the interior of the combustion chamber, as noted above.

A slot 88 is also formed between the front edge 89 of the hearth tile 46 and the rear face of the baffle wall 85, which permits the atmospheric gases to flow from the space 47 beneath the hearth tile 46 upwardly across the work opening 86 in the baffle wall 85 in the form of a curtain to shield the muffle against entrance of exterior atmosphere when the door 77 is raised.

The baffle wall 85 is provided with a peep hole 89 in axial alignment with the atmosphere inlet tube 50, whereby the condition of the tube or flame, if a neutral or reducing atmosphere is being used, may be readily observed, or through which a cleaning rod may be inserted into the tube from the front of the furnace while the furnace is in operation.

Preferably, as shown in Fig. 5, the baffle wall is made in two pieces, i. e. a bottom or base piece or section 85a which rests on the bottom wall of the furnace opening 76, extends from side wall to side wall across said opening, and terminates, vertically, in a horizontal plane substantially coincident with the top surface of the hearth tile 46; and a second or upper section 85b which rests on the upper edge of the base section 85a and substantially fills the remaining area of the furnace opening 76, with the exception of the work opening 86 formed in the upper section 85b and which may vary in area in different sections 85b, respectively, in accordance with the sizes of the work pieces to be passed through the work opening 86.

In practice, the base section 85a may, if desired, be permanently installed, as by setting it in a fire-proof cement in the furnace opening 76; and if large numbers of any one size of work piece are to be treated successively in the furnace, the upper section 85b may also be secured in place by fire-proof cement. However, in any case, the baffle wall may be readily removed in whole or in part without serious interruption in the operation of the furnace.

As shown in Fig. 2, a casing 90, in the form of a tube closed at one end and open at its opposite end, is inserted through an opening 91 formed in the rear wall of the furnace, including the back plate 4, insulating shell 5—6, and rear wall plate 43 of the combustion chamber 10, and an opening 92 formed in the rear wall 42 of the muffle 40, for the accommodation of a thermo-couple for indicating the interior temperature of the muffle.

The casing 90 is fixed in a boss 94, welded or otherwise secured to the rear plate 4, with a bore 93 axially aligned with the tube opening 91. A counterbore 95 is formed in the boss 94 at the outer side thereof and is filled with a ring of suitable sealing compound 96. A set screw 97, tapped into the boss 94, bears against the tube 90 and holds the same rigidly in place.

If for any reason it should become necessary to replace the muffle 40, it is only necessary to remove the casing 90 and atmosphere tube 50, through the rear of the furnace; and the baffle 85, if such has been used, through the front opening 76 of the furnace. If the front end 41 of the muffle has been sealed in the opening 35 in the front wall 33 of the combustion chamber 10, the seal 39 between the marginal edges of the open end 41 of the muffle and the adjacent surfaces of the opening 35 in the front wall 33 of the combustion chamber 10 is then broken, whereupon the old muffle may be moved out of the furnace through the front opening 76.

In order to place a new muffle in the furnace, a long rod of metal, or other suitable material, of a diameter substantially equal to the outside diameter of the thermo-couple casing 90 may be inserted, from the rear of the furnace, through the opening 93 therein and through the aligned opening 91 in the rear wall of the furnace. The length of the rod should be sufficient to extend completely through the combustion chamber 10 and out through the front furnace opening 76, with the end of the rod extending outwardly beyond the front wall of the furnace. This exposed end of the rod is then inserted through the opening 92 in the rear wall of the new muffle, whereupon the new muffle is inserted through the front opening 76 of the furnace into the combustion chamber. The rod will function as a means to guide the rear end of the muffle into the opening 36 in the rear wall 34 of the combustion chamber 10.

A similar rod can, if desired, be passed through the opening 97 in the rear wall of the furnace through which the atmosphere tube 50 normally passes.

In following the above procedure, the openings 92 and 98 in the rear wall 42 of the muffle will be assured of axial alignment with the openings 91 and 97 in the rear wall of the furnace through which the thermo-couple casing tube 90 and the atmosphere tube 50, respectively, project. This tube may then be reinserted and secured in place and the seal provided between the marginal edges of the open front end 41 of the muffle and the respectively adjacent walls of the front opening 76 of the furnace and/or the opening 35 in the front wall 33 of the combustion chamber 10.

The foregoing description and the drawings referred to therein includes a number of details of construction which contribute largely to the successful, efficient, economical, and convenient operation and maintenance of the furnace of the present invention as a whole.

We claim:

1. A muffle furnace comprising a combustion chamber consisting of a fabrication of premolded side and end wall units composed of high refractory material, a body of heat-insulating material molded en masse about the combustion chamber, said end walls being respectively provided with axially aligned openings formed therein, and said body of insulating material having a similarly aligned opening extending from the exterior of the furnace to one of said end walls, and a muffle extending from one end wall to the other end wall of said combustion chamber and having its opposite ends respectively seated in said end wall openings, said end walls functioning as the sole means of support for the muffle with the muffle spaced from said side walls completely around the muffle along the length thereof intermediate said end walls.

2. A muffle furnace comprising a combustion chamber consisting of a fabrication of premolded side and end wall units composed of high refractory material, a body of heat-insulating material about the combustion chamber, said end walls being respectively provided with axially aligned openings formed therein, and said body of insulating material having a similarly aligned opening extending from the exterior of the furnace to one of said end walls, and a muffle extending from one end wall to the other end wall of said combustion chamber and having its opposite ends respectively seated in said end wall openings, said end walls functioning as the sole means of support for the muffle with the muffle spaced from said side walls completely around the muffle along the length thereof intermediate said end walls, and a plate of refractory material located in said insulating material adjacent the second of the end walls of the combustion chamber, with the marginal edges of the plate in overlapping relation to the marginal edges of the opening in said second end wall and functioning as a closure therefor.

3. A muffle furnace according to claim 2, and including an end wall of the muffle disposed adjacent the plate, and an atmosphere tube removably projecting through said muffle end wall, said plate, and the insulating material from the exterior of the furnace to the interior of the muffle.

4. A muffle furnace according to claim 2, and including a thermo-couple casing removably projecting from the exterior of the furnace through axially-aligned openings in the insulating material, the plate and an end wall of the muffle adjacent the plate, with said aligned openings being adjacent the top of the muffle.

5. A muffle furnace comprising a combustion chamber consisting of a fabrication of premolded side and end wall units composed of high refractory material, a body of heat-insulating material molded en masse about the combustion chamber with an opening formed in the heat-insulating material adjacent one end wall of the combustion chamber in alignment with a corresponding opening formed in said one wall, said furnace including at least one premolded flame tube, and at least one exhaust conduit, each composed of refractory material, extending through said body of insulating material from the exterior of the furnace to the side wall of the combustion chamber, with a flame passage in said flame tube communicating with a flame-distributing port formed in one of the refractory units of said side wall, and an exhaust passage in said conduit communicating with an exhaust port in another of said side wall units.

6. A muffle furnace comprising an outer shell, including side and end walls, a combustion chamber within said shell and composed of a fabrication of premolded side and end wall units of high refractory material, an intermediate body of heat-insulating material molded en masse around the sides and ends of the combustion chamber within said outer shell, one end wall of the outer shell, the adjacent end wall of the combustion chamber, and the insulating material intermediate these two end walls being provided with aligned openings forming an entrance into the interior of the combustion chamber from the exterior of the furnace, and a frame around said entrance opening composed of premolded high refractory material embedded in the insulating material and projecting outwardly therefrom through the entrance opening in the outer shell.

7. A muffle furnace according to claim 6, wherein the frame units are shouldered to overlap the marginal edges of the entrance opening in the outer shell.

8. A muffle furnace comprising an outer shell, including side and end walls, a combustion chamber within said shell and composed of a fabrication of premolded side and end wall units of high refractory material, an intermediate body of heat-insulating material around the sides and ends of the combustion chamber within said outer shell, one end wall of the outer shell, the adjacent end wall of the combustion chamber and the insulating material intermediate these two end walls being provided with aligned openings forming an entrance into the interior of the combustion chamber from the exterior of the furnace, a muffle within said combustion chamber arranged with an open end thereof disposed in said entrance opening intermediate the end wall of the outer shell and the adjacent end wall of the combustion chamber, and a readily removable baffle of high refractory material located in and substantially closing said entrance opening intermediate said open end of the baffle and the plane of the end wall of the outer shell.

9. A muffle furnace according to claim 8, wherein the removable baffle is provided with a through opening of relatively smaller area than the entrance opening of the furnace for passage of work specimens into the muffle.

10. A muffle furnace according to claim 8, wherein the removable baffle is provided with a through opening of relatively smaller area than the entrance opening of the furnace for passage of work specimens into the muffle, and wherein a readily removable closure plate is provided for

temporarily closing said work passage opening in the baffle while the furnace is in operation.

11. A muffle furnace comprising a horizontal cylindrical combustion chamber including vertical end walls, a muffle coaxially arranged in said chamber with its opposite ends respectively seated in corresponding openings in said end walls which constitutes the sole means of support for the muffle, a plurality of flame ports in the cylindrical wall of said combustion chamber in circumferentially and longitudinally staggered relation to each other with said ports contracted circumferentially and elongated longitudinally of said chamber and directed in substantially tangential relation to said cylindrical wall to produce a substantially continuous sheet of flame from one end wall to the second end wall of said chamber in rotating contact with said cylindrical wall around and out of direct contact with said muffle, and a plurality of exhaust ports in longitudinally spaced relation in the top of said combustion chamber, in staggered relation to said flame ports, to convey products of combustion beyond the exterior of the furnace directly from said chamber.

12. A muffle furnace comprising a horizontal cylindrical combustion chamber including vertical walls at the opposite ends respectively thereof, a muffle of rectangular cross-section located in said chamber with the opposite ends of the muffle resting in openings formed in said end walls respectively of said combustion chamber, said end walls affording the sole means of support for the muffle, and a work plate within the muffle and provided with relatively spaced legs resting on the bottom of the muffle at the places where the ends of the muffle bottom rest on the end walls of the combustion chamber, said legs constituting the sole means of support for the work plate in the muffle.

13. A muffle furnace according to claim 12, wherein the area of the work plate is less than the area of the bottom of the muffle and provides clearance between the marginal edges of the work plate and the respectively adjacent walls of the muffle, and means for injecting gaseous fluid into one end of the muffle intermediate and parallel to the bottom of the muffle and the under side of the work plate to flow longitudinally of the muffle and upwardly around the marginal edges of the work plate around the work on said work plate.

14. A muffle furnace comprising an outer shell, including side and end walls, a combustion chamber within said shell and composed of a fabrication of premolded side and end wall units of high refractory material, an intermediate body of heat-insulating material around the sides and ends of the combustion chamber within said outer shell, one end wall of the outer shell, the adjacent end wall of the combustion chamber and the insulating material intermediate these two end walls being provided with aligned openings forming an entrance into the interior of the combustion chamber from the exterior of the furnace, a muffle within said combustion chamber arranged with an open end thereof disposed in said entrance opening intermediate the end wall of the outer shell and the adjacent end wall of the combustion chamber, means for closing said entrance opening outwardly beyond the open end of the muffle, means for maintaining a predetermined atmosphere within said muffle, independent means for supplying a mixture of flaming combustible fluids to the interior of the combustion chamber around said muffle, means for exhausting resultant hot gases from the interior of the combustion chamber, means affording escape of excess atmosphere from the interior of the muffle through said open end thereof in said entrance opening of the furnace, and means for conducting the atmosphere escaping from the muffle into contact with the flaming gases of the combustion chamber.

15. A muffle furnace according to claim 8, wherein the means conducting the atmosphere escaping from the muffle into contact with the flaming gases from the combustion chamber at a point exterior of the furnace comprises a pipe having one end communicating with the entrance opening of the furnace adjacent the open end of the muffle and its opposite end disposed adjacent the exhaust from the combustion chamber.

16. A muffle furnace comprising an outer shell including end and side walls, an inner combustion chamber including end and side walls respectively spaced from those of the outer shell, a body of heat-insulating material intermediate the walls of the shell and the walls of the combustion chamber, a muffle within the combustion chamber, means for injecting gaseous fluid into the interior of the muffle from the exterior of the furnace comprising a fixture secured to one end wall of the shell of the furnace and having an internal gas chamber, a tube affording communication between the interior of said gas chamber and the interior of the muffle, said tube being removably mounted in aligned openings formed in the adjacent end walls of the shell combustion chamber intermediate insulating material and the muffle and a corresponding aligned opening in one side of said fixture, and a readily removable closure element for the side of said fixture opposite to that through which said tube projects.

17. A muffle furnace comprising an outer shell including end and side walls, a combustion chamber within said shell and including end and side walls respectively spaced from those of said shell, a body of insulating material intermediate said spaced walls, a horizontal opening of predetermined contour formed in the end wall of the shell, the end wall of the combustion chamber, and the intermediate body of insulating material at one end of the furnace and in the second end wall of the combustion chamber at the second end of the furnace, a muffle of corresponding cross-sectional contour insertable through said passage into said combustion chamber with the opposite ends of the muffle resting respectively on the opposite end walls of the combustion chamber, the end of the muffle adjacent said second end of the furnace being closed by an end wall integrally formed with the side walls of the muffle, the opposite end of the muffle being open and in communication with the muffle-receiving opening in the said one end of the furnace, said closed end wall of the muffle and the adjacent end walls of the shell, the combustion chamber, and the intermediate insulating material having aligned openings near the top of the muffle for the purpose of facilitating the seating of the closed end of the muffle in the muffle opening formed in the end wall of the combustion chamber at said second end of the furnace, and a thermo-couple casing normally projecting into the interior of the muffle from the exterior of the furnace through said aligned openings in said second end of the furnace.

18. A muffle furnace comprising an outer shell including end and side walls, a combustion cham-

ber within said shell and including end and side walls respectively spaced from those of said shell, a body of insulating material intermediate said spaced walls, a horizontal opening of predetermined contour formed in the end wall of the shell, the end wall of the combustion chamber, and the intermediate body of insulating material at one end of the furnace and in the second end wall of the combustion chamber at the second end of the furnace, a muffle of corresponding cross-sectional contour insertable through said passage into said combustion chamber with the opposite ends of the muffle resting respectively on the opposite end walls of the combustion chamber, the end of the muffle adjacent said second end of the furnace being closed by an end wall integrally formed with the side walls of the muffle, the opposite end of the muffle being open and in communication with the muffle-receiving opening in the said one end of the furnace, a door normally closing the muffle-receiving opening at the one end of the furnace, and a baffle wall removably mounted in said muffle-receiving opening between the open end of the muffle and said door.

19. A muffle furnace comprising an outer shell including end and side walls, a combustion chamber within said shell and including end and side walls respectively spaced from those of said shell, a body of insulating material intermediate said spaced walls, a horizontal opening of predetermined contour formed in the end wall of the shell, the end wall of the combustion chamber, and the intermediate body of insulating material at one end of the furnace and in the second end wall of the combustion chamber at the second end of the furnace, a muffle of corresponding cross-sectional contour insertable through said passage into said combustion chamber with the opposite ends of the muffle resting respectively on the opposite end walls of the combustion chamber, the end of the muffle adjacent said second end of the furnace being closed by an end wall integrally formed with the side walls of the muffle, the opposite end of the muffle being open and in communication with the muffle-receiving opening in the said one end of the furnace, a door normally closing the muffle-receiving opening at the one end of the furnace, a baffle wall removably mounted in said muffle-receiving opening between the open end of the muffle and said door, means for injecting atmospheric gases into the interior of the muffle remotely with respect to the open end of the muffle, and a vent for excess atmosphere passing upward through the insulating material at the one end of the furnace from the top of the muffle-receiving opening to the exterior of the furnace between the wall of the shell and the wall of the combustion chamber at said one end of the furnace.

20. A muffle furnace comprising an outer shell including end and side walls, a combustion chamber within said shell and including end and side walls respectively spaced from those of said shell, a body of insulating material intermediate said spaced walls, a horizontal opening of predetermined contour formed in the end wall of the shell, the end wall of the combustion chamber, and the intermediate body of insulating material at one end of the furnace and in the second end wall of the combustion chamber at the second end of the furnace, a muffle of corresponding cross-sectional contour insertable through said passage into said combustion chamber with the opposite ends of the muffle resting respectively on the opposite end walls of the combustion chamber, the end of the muffle adjacent said second end of the furnace being closed by an end wall integrally formed with the side walls of the muffle, the opposite end of the muffle being open and in communication with the muffle-receiving opening in the said one end of the furnace, a door normally closing the muffle-receiving opening at the one end of the furnace, a baffle wall removably mounted in said muffle-receiving opening between the open end of the muffle and said door, means for injecting atmospheric gases into the interior of the muffle remotely with respect to the open end of the muffle, and a vent for excess atmosphere passing upward through the insulating material at the one end of the furnace from the top of the muffle-receiving opening to the exterior of the furnace between the wall of the shell and the wall of the combustion chamber at said one end of the furnace above said baffle, said baffle having a recess formed therein to afford communication between said vent and the open end of the muffle, said baffle also being provided with an opening of lesser area than the cross-section of the muffle to afford passage of work specimens to and from the interior of the muffle.

21. A heat-treating furnace having a cylindrical combustion chamber arranged with its axis horizontally disposed, said furnace comprising a front wall of predetermined thickness with an opening extending therethrough from the inner to the outer face thereof, a muffle of rectangular cross-section disposed in said furnace chamber with its longitudinal axis substantially coinciding with that of said chamber and having an open end located in said opening near said outer face and remote to said inner face of said front wall, the outer cross-sectional contour of said end of the muffle being similar to but of slightly lesser area than said opening to provide a clearance therebetween, a series of relatively staggered flame and exhaust ports spaced axially of said chamber and muffle with said flame ports elongated in the direction of said axes to provide laterally abutting ribbons of flame forming a whirling sheet-like current of gaseous fluid around and substantially in contact with the inner circular wall of said furnace chamber along the full length of said muffle and creating a draft current through said clearance for drawing gaseous fluid into the furnace from beyond the open end of the muffle, and means for producing a predetermined atmosphere in said muffle.

22. A heat-treating furnace comprising a front wall of predetermined thickness with an opening extending therethrough from the inner to the outer face thereof, a muffle of rectangular cross-section horizontally disposed in said furnace with an open end thereof located in said opening near said outer face and remote to said inner face of said front wall, the outer cross-sectional contour of said end of the muffle being similar to but of slightly lesser area than said opening to provide a clearance therebetween, means to cause a current of gaseous fluid to flow in said furnace around said muffle externally thereof and create a draft current through said clearance for drawing gaseous fluid into the furnace from beyond the open end of the muffle, a hearth tile in said muffle in vertically spaced relation to the bottom wall of said muffle with the marginal edges of the hearth tile spaced inwardly from the side and back walls of the muffle, the opposite end and the walls intermediate said ends of said muffle being closed

against entrance of said external fluid into said muffle, means for introducing a gaseous fluid into said muffle below said hearth tile comprising a pipe extending through the rear wall of the muffle below and parallel to said hearth tile with an open end of the pipe facing and disposed at a point remote to said open end of the muffle for said gaseous fluid from said pipe to flow under and upwardly around the marginal edges of the hearth tile and through said muffle to said open end thereof to fill said muffle with an atmosphere of predetermined character and whereby escaping excess atmosphere from the muffle will be caught in said draft current and carried into said furnace, and means for closing said opening beyond and in spaced relation to said open end of said muffle and the marginal edge of the hearth tile adjacent thereto.

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