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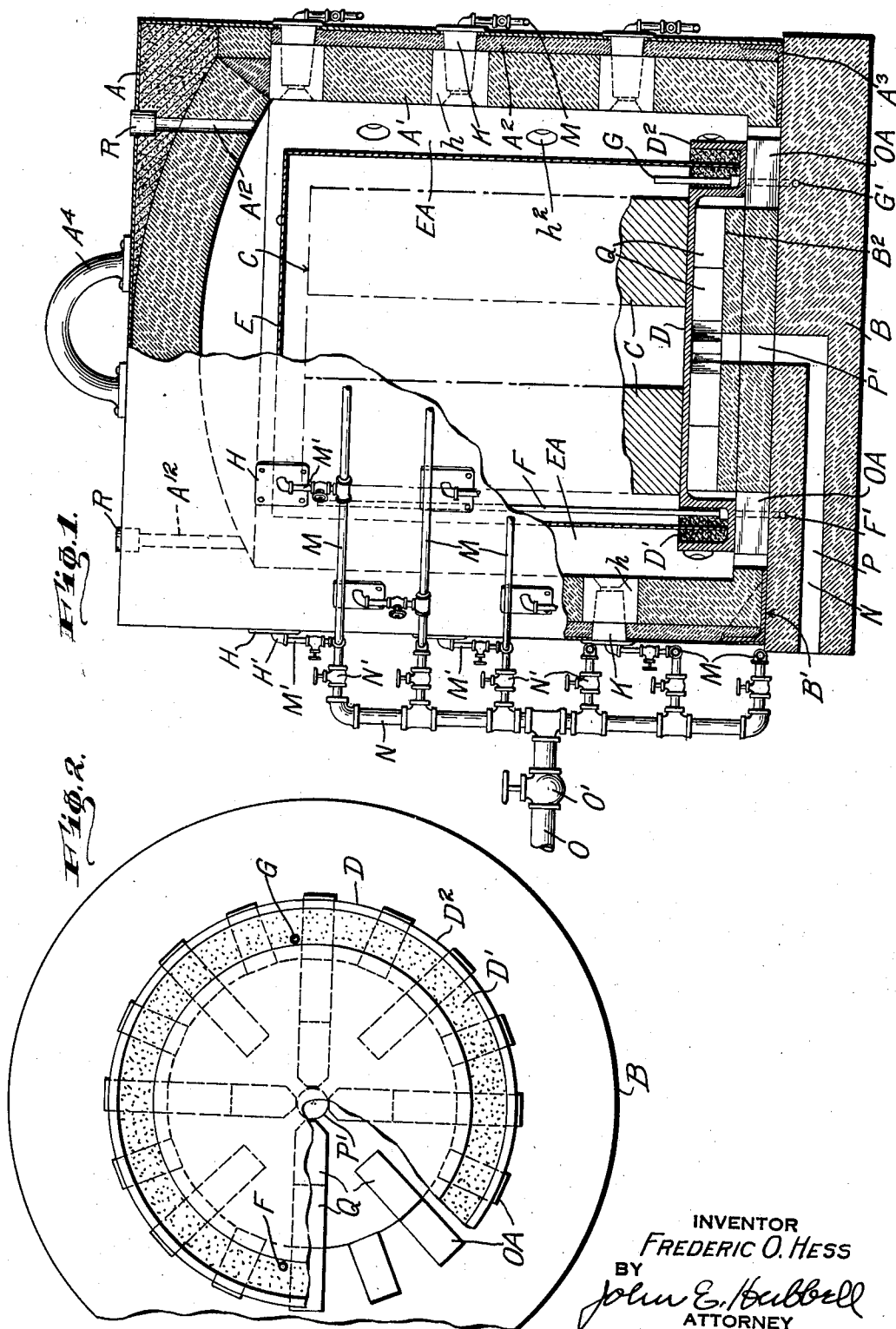
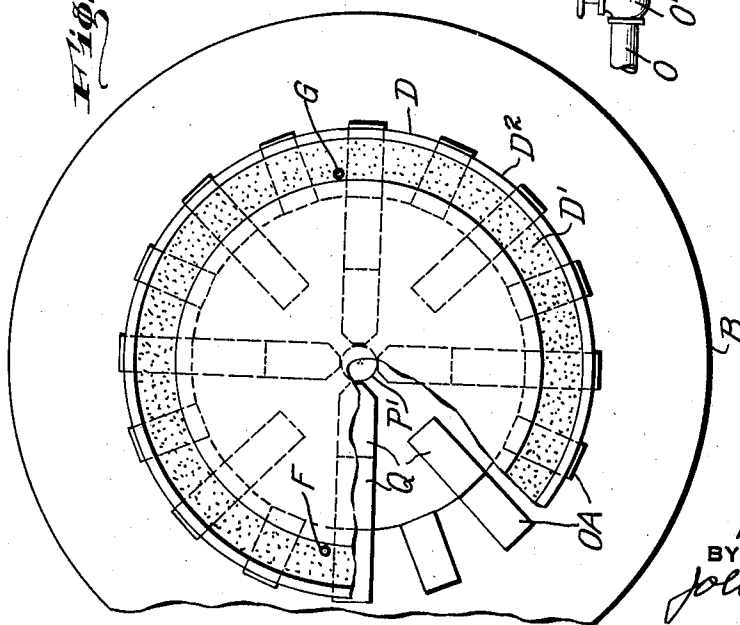
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2,215,081

BELL TYPE FURNACE

Filed Sept. 3, 1937

3 Sheets-Sheet 1



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BELL TYPE FURNACE

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Fig. 4.

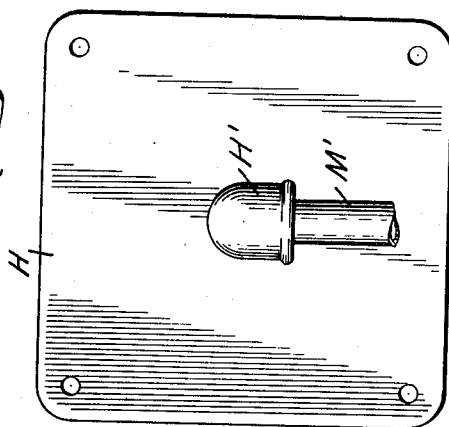
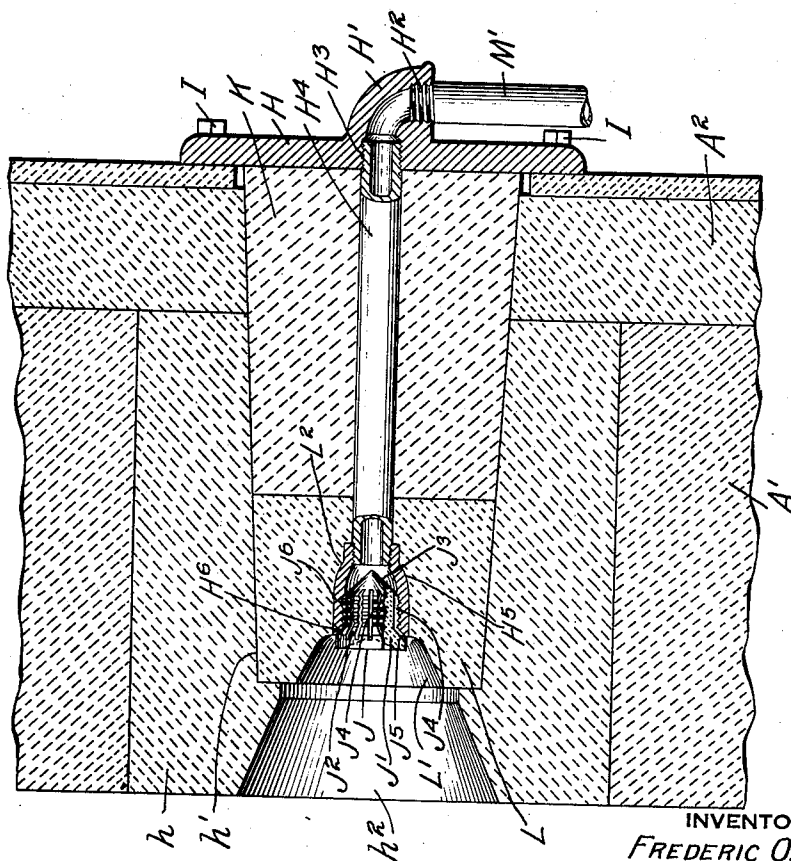


Fig. 3.



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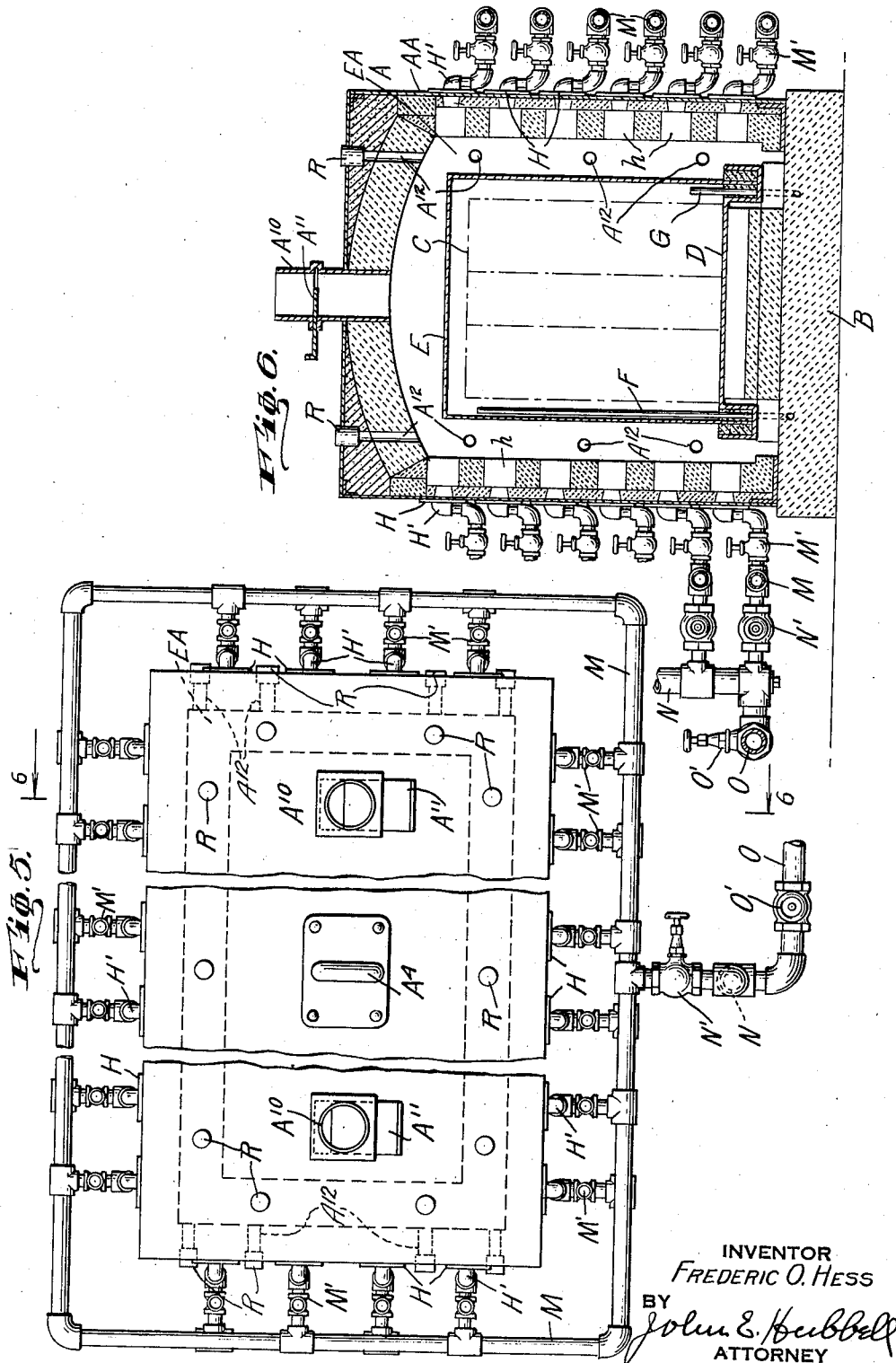
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BELL TYPE FURNACE

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UNITED STATES PATENT OFFICE

2,215,081

BELL TYPE FURNACE

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Application September 3, 1937, Serial No. 162,263

10 Claims. (Cl. 266—5)

The general object of the present invention is to provide an improved furnace of the kind commonly called a bell or dome furnace, in which the side and roof walls of the furnace are formed by a bell or box-like structure open at its lower side and adapted to be removably seated upon a stationary base member, forming a hearth or work support, from which the bell is lifted for the introduction of work into the furnace to be heated, and for the removal of the material which has been heated.

Such bell type furnaces are in extensive use for metal annealing and other heat treatment purposes. For the usual purposes for which such furnaces are employed, it is highly desirable that the heat supplied to the work be distributed thereto in a uniform manner, and be regulated to avoid the risk of overheating either the work or the furnace, while at the same time avoiding unnecessary waste of time in heating the work and furnace up and completing the heat treating operation. For most purposes, for which such furnaces are used, it is also practically essential that the composition of the atmosphere enveloping the work be closely controlled, and in many cases the work is enclosed by an inner hood or work cover, having side and roof walls parallel and spaced away from the inner walls of the outer bell. Such an inner hood also shields the work against contact with atmospheric air, and desirably retards the work cooling rate, when slow cooling is desirable, and, when the outer bell is removed and in use in connection with another base or hearth and inner hood if, as is not unusual, a single outer bell is employed with two or more furnace bases and inner hoods to form two or more successively heated furnaces.

The heating means employed in such a bell furnace must not only satisfy the furnace heat distribution and temperature requirements but must meet the mechanical requirements incidental to the fact that the movable outer bell is a relatively massive structure which may weigh several tons and that it is desirable to minimize the weight of the heating provisions supported by the bell. Formerly all, or practically all, such furnaces in regular commercial use were electrically heated, but, to reduce construction, maintenance and operating costs, many such furnaces now in use, are heated by means of combustion chambers within, and supported by the outer bell, and having metallic walls from which heat is radiated to the work.

The primary specific object of the present invention, is to provide a furnace of the above men-

tioned type, with gas burning means incorporated in its walls and comprising combustion spaces facing and open to the work or the work enclosing hood heat and directly radiating to the work of its enclosing hood, and having said spaces so distributed, and subject to such ready control, as to insure the proper heat distribution and temperature control.

A more specific object of the present invention is to provide burner units adapted for removable mounting in openings formed for the purpose in, and extending through the wall of the outer furnace bell, so that each burner unit can be withdrawn for inspection, repairs or replacement, while the furnace is in operation and without significant disturbance in the furnace operating conditions.

The burner units hereinafter described in detail herein, were especially devised for the purposes of, and comprise a part of the present invention, but in respect to the form and character of their combustion space and the manner in which fuel and air jets are pressed into said spaces, the said units embody the essential features and principles of a burner in commercial use, and commercially known as a Duradant burner, previously devised by me, and disclosed in my prior application Serial No. 88,744, filed July 3, 1936.

A bell type furnace having heating means constructed and arranged in accordance with the present invention, has important practical advantages. With it high combustion efficiency is maintained, and the maximum operating economy of fuel burning furnaces over electrically heated furnaces is obtainable. Burners of the special type mentioned, constructed for efficient operation, with a relatively low rate of fuel combustion per individual furnace, and made with a small heat liberating, or burning capacity, and this coupled with the relatively low cost of constructing the burners and mounting them in the wall of the outer bell, make it practically feasible to employ as many individual burner units in a single furnace, as may be required to effect practically any sort or degree of heat distribution and temperature regulation that may be desired.

Each of the burners distributed over the wall of the outer bell, may be supplied with an individual regulating cock or valve at the outer side of the bell and readily accessible for adjustment. As previously pointed out, the individual burner units are removable for inspection, repairs and replacement without interrupting the furnace operation.

As compared with furnaces heated up combustion chambers having heat radiating metal walls,

the improved furnace is especially characterized by its capacity for a more rapid heating up operation, since there are no metal burner parts to be heated up to heat radiating temperatures; and is characterized by its avoidance of the expense inherent in the use of relative large amounts of heat resisting metallic alloys, and by its avoidance of any such heavy maintenance expense as is inevitable with direct flame impingement against metallic parts at high temperatures.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, however, its advantages, and specific objects attained with its use, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described a preferred embodiment of the invention.

Of the drawings:

Fig. 1 is a vertical section on a diametral plane of a bell type furnace, circular in horizontal cross section;

Fig. 2 is a plan view of a portion of the base member of the furnace shown in Fig. 1;

Fig. 3 is a partial section taken similarly to Fig. 1, but on a larger scale.

Fig. 4 is an end elevation of one of the burner units shown in Figs. 1 and 3;

Fig. 5 is a somewhat diagrammatic plan view of a bell furnace rectangular in horizontal cross section;

Fig. 6 is an elevation, partly in section on the line 6—6 of Fig. 5.

In Figs. 1-4, I have illustrated the use of one form of the present invention in a bell type furnace, circular in horizontal cross section, and which may be, and as shown is, of conventional construction, except in respect to its heating provisions, including the gas burner parts incorporated in the vertical wall of the bell, dome or hood member A of the furnace, and the vent passages formed in the stationary base member B, on which the bell A is removably seated in the operative condition of the furnace. In accordance with the usual practice of the art, the bell member A comprises an outer metallic armor or shell, and a refractory shell lining, which may comprise an inner layer A' of insulating fire brick or like refractory material, and an outer layer of so-called heating insulating refractory material. The shell is supported on a horizontal flange portion A³ of the metallic shell. A metallic bail or eye A⁴ secured to the metallic shell of the bell A, extends upwardly from the center of the top portion of the shell, for engagement by the hoisting hook of a crane, not shown, by which such a bell is customarily lifted or lowered, and shifted horizontally, in opening up the furnace for the removal of treated work, and for the introduction of the work to be treated, and in thereafter restoring the furnace to its operative condition.

As shown, the work C rests upon a metal part D, which may be of alloy steel, and forms the top or hearth portion of the base member B, the portion of the latter below the part D being formed of refractory material. In most cases, and as shown, the work C is normally enclosed by an inner metallic hood or cover member E, supported by the hearth D and having its side and roof walls respectively spaced away from the side and roof walls of the bell A, to provide

a heating space EA between the hood E and bell A. Suitable sealing means are provided to make a gas tight joint between the lower edge of the hood E and the member D. As shown for this sealing purpose, the member D is formed to provide an annular trough D' at the periphery of the member, the trough being open at its top and being formed in what may be regarded as a depending peripheral flange portion D² of the member D. The lower edge of the member E is received in the trough space D' and rests upon the bottom wall of the latter, and the joint between the member D and E is sealed by sand, or the like, in said trough space. It is also customary, though not universal practice, to provide special means for sealing the joint between the lower edge of the bell A and the surface B' of the base B on which the bell A is seated.

In the use of a heat treating furnace of the character shown in Fig. 1, it is usual to provide means for maintaining a special atmosphere within the work cover E. That atmosphere may be formed by an inert gas, or may be a specially manufactured atmosphere, including products of combustion and gases evolved within the work cover E from the work, or as a result of dissociation of other constituents of the gases within the hood E. Regardless of the character of the special atmosphere within the hood E, its maintenance ordinarily requires gas supply and discharge conduits, such as are formed by the vertical metal tubes F and G, respectively, shown in Fig. 1 as extending up through the member D into the space within the hood E, and which in many cases, at least, should be formed of highly resistant metallic alloys. At their lower ends, the pipes or tubes F and G communicate with the channels or pipes F' and G' formed or imbedded in the masonry portion of the base member B, and leading to the exterior of the furnace.

In respect to its features, specifically mentioned above, the furnace shown in Fig. 1 follows the usual practice of the art, and embodies no feature of construction and arrangement which is original with me, but is a typical example of the sort of furnace with which my invention may be used with advantage.

In accordance with the present invention, the furnace collectively shown by Figs. 1-4, is heated by the combustion of a combustible mixture of air and gas in the combustion spaces of burner elements or units incorporated in the vertical wall of the bell A. Each burner element or unit in the form best shown in Figs. 3 and 4, comprises a burner assembly insertable in, and removable from the furnace wall, and a special refractory block h constituting a permanent portion of the inner refractory lining layer A', and formed with an outer conical passage h', into which the corresponding burner assembly extends, and an inner expanding passage h² coaxial, and communicating, with the passage h'.

The burner assembly, as shown, comprises a metal casting H having a rectangular plate-like body portion adapted to overlap the outer metallic shell of the bell A at the margin of the opening A⁵ through which the burner assembly extends. As shown, each part H is secured in place by clamping bolts or screws I threaded into the metallic shell of the bell A. The casting H comprises an outer pipe elbow portion H', having a downwardly facing internally threaded, inlet H², and a horizontal internally threaded outlet H³ opening at the furnace side of the

part H. A horizontal metal pipe H^4 has its outer end threaded into the outlet H^3 , and has its inner end threaded into the outer end of a tubular part H^5 . The inner end portion of the latter is of larger diameter than its outer end portion and is internally threaded for threaded engagement with the externally threaded body of a burner tip element J. The part H^4 may be formed of heat resistant metallic alloy material and the part H^5 may be formed of such material or of refractory ceramic material.

The tube H^4 passes axially through an outer refractory body K in conical frustum form, and into a refractory burner body element L shaped externally to form an extension of said conical frustum. The member L is formed with a cup shaped combustion space or cavity L' extending into it from its inner end coaxial with a passage L^2 , which comprises an inner end portion large enough to snugly receive the metallic burner part H^5 , and an outer end portion of smaller diameter receiving the corresponding portion of the metal pipe H^4 . The parts H^4 and H^5 thus form means for detachably clamping the parts H, K and L together. Advantageously the part K is formed of heat insulating refractory material and the part L of refractory material having a relatively small coefficient of thermal expansion.

The chamber h^2 in the block h is outwardly flared to form a symmetrical extension of the space L' from which a large portion, ordinarily more than one half, of the heat generated by the burner is, radiated to the adjacent portion of the hood E, and from which gaseous products of combustion pass into the space EA.

In the preferred form illustrated, the burner tip member J is of refractory ceramic material, and comprises a main cylindrical portion which extends into the bore of the larger inner end portion of the member H^5 , and an inner end portion J' which is shorter, and of larger diameter, than the first mentioned cylindrical portion, and is external to the member H^5 , and a conical intermediate portion J^2 , engaging the beveled end H^6 of the member H.

A multiplicity of peripheral grooves J^4 are formed in the outer surface of the tip member J. Each groove J^4 comprises a portion parallel to the axis of the tip member and extending for the full length of the main cylindrical portion of the tip, and comprises an inclined discharge end portion J^5 extending alongside the outer surface of the tapered intermediate section J^2 of the tip member, to the periphery of the inner end cylindrical, burner tip portion J' . As is clearly shown in Fig. 3, each groove J^4 thus forms a gas passage or orifice rectangular in cross section, and having three walls formed by the ceramic tip member J, and a fourth wall formed by the adjacent portion of the burner part H^5 . As shown, the tip member J is formed with a screw thread J^6 engaging the internal screw thread formed in the inner end portion of the member H^5 , so that the tip member is firmly anchored in place in the burner assembly.

The portion of the wall of the cavity L' in the refractory part L at the inner side of the inner end of the metallic part H^5 , surrounds and defines a combustion space in which the fuel mixture delivered thereto through the channels J^4 , is wholly or largely burned. That space may be described as cup shaped, and the wall of the cavity L' may be regarded as comprising a circular series of surface portions or sectors alongside the

jets issuing from the respectively adjacent burner channels J^4 . Each of said surface sectors has a portion adjacent the burner body which is inclined away from the axis of the burner at about the same angle as the adjacent burner channel portion J^5 , and which is laterally displaced from the axis of that channel portion. In other words, the said portion of the cavity wall may be regarded as a part of a conical surface with its apex in the axis of the burner, at some distance outward from the point of that axis at which the inclined channel portions J^5 , if extended, would intercept said axis.

The inclination to the burner axis of each such sector portion of the wall of the cavity L' , diminishes as the distance from the discharge-end of the corresponding channel J^4 increases, so that the line of intersection with the cavity wall of a plane radial to the burner axis, is concave toward said axis. The described shaping of the wall of the cavity L' relative to the inclination of the burner orifice discharge J^5 , serves the purpose of so locating the corresponding sector portion relatively to each flame or burning jet formed by the combustion of the fuel mixture supplied by the adjacent orifice J^4 , that said surface will be heated to incandescence and with a desirably close approximation to temperature uniformity of all portions of the wall directly alongside the flames, regardless of the actual length of the latter.

The lengths of the flame jets will depend somewhat upon the composition of the combustible mixture, and with any given fuel composition, will be longer or shorter, accordingly, as the gas pressure in the pipes H^4 , and consequently the rate of combustion and total heating effect are relatively great or relatively small.

The burner construction illustrated, in respect to its use of a burner tip member formed and shaped like the member J, to deliver combustible mixture jets into a combustion space surrounded by a refractory wall, like the wall of the cavity L' , not claimed herein, but is claimed in my said prior application, Serial No. 88,744.

In the intended operation of the form of the invention shown in Figs. 1-4, the combustion of the fuel mixture supplied to each pipe H^4 , is completely effected in the cavity L' , or in that cavity and its extension h^2 . In consequence, the composition of the combustion gases passing into the space EA, will depend upon the composition of the combustible mixture. It is thus possible by varying the mixture composition to control the composition of the atmosphere, and in particular in the space EA to make said atmosphere oxidizing, neutral or reducing, as conditions make desirable. The wall of the cavity L' will be heated to incandescence, at least in the portion thereof respectively adjacent and alongside the different flame jets, so that the conditions are highly favorable to efficient combustion, and to the attainment of high temperatures by the wall of the cavity L' , and of lower, but still high, temperatures by the wall of the conical space h^2 . In consequence, a large portion of the heat liberated is transmitted to the hood E by radiation.

The form and character of the burners shown and described, make it practically feasible to incorporate a relatively large number of closely spaced burners in the wall of the bell A, so as to insure whatever heat distribution, and gradation in the rates at which heat is transmitted to the different unit areas of the work cover or hood E, may be desirable. As shown in Fig. 1

the burner elements are arranged in a number of superposed horizontal rows extending circularly about the axis of the furnace. As shown, the burners in each horizontal row receive fuel mixture through corresponding individual valved branches M' of a circular manifold M serving the burners of that row. Each manifold M receives a combustible mixture through a corresponding valved branch N' from one or more vertical bus pipes N, to which the mixture is supplied through a supply pipe O including a regulating valve O', from a so-called mixing machine (not shown) or other means for supplying a combustible mixture of gas and combustion air of suitable composition, and at a suitable pressure.

In the construction shown, the products of combustion are discharged from the chamber EA through a vent system which, as shown, comprises a horizontal channel P extending radially inward to the center of the base member B from the exposed peripheral edge of the latter and communicating through a vertical channel portion P' with a space beneath the hearth plate D. That space, as shown, is divided into sections by spaced apart radial piers Q beneath the body of the hearth plate D and resting on an upper surface B² of the masonry portion of the base member B within and somewhat smaller than the inside diameter of the flange D². Communication is thus provided between the space above the surface B², and the spaces between the radially extending brick parts OA resting on the previously mentioned surface B' of the base B, and directly supporting the flange portion D² of the plate D. The last mentioned spaces open directly into the heating space EA. The channel P may open at its inner end directly into the atmosphere, or may open into a chimney connection, if the conditions of use are such as to make such disposition of the products of combustion desirable. The withdrawal of the products of combustion from the furnace through the base as illustrated in Figs. 1 and 2, while convenient, especially in the case of relatively small furnaces, is not essential. On the contrary, the products of combustion may be discharged through outlets formed in the vertical wall of the bell A, or through openings in the roof of the bell shown in the construction shown in Figs. 5 and 6.

In Figs. 5 and 6, I have illustrated the use of the present invention in a furnace of the bell type which is rectangular in horizontal cross section, and of a general design well adapted for use in relatively large capacity furnace units. The heating provisions of the furnace shown in Figs. 5 and 6, as shown, are identical in principle with those of the furnace first described, except that in the furnace of Figs. 5 and 6, the products of combustion are discharged from the space between the outer bell AA and inner bell or work cover EA, through outlet openings A¹⁰ in the roof of the bell AA. As shown, each outlet A¹⁰ is provided with a damper A¹¹ which may be adjusted to insure the proper distribution of discharge among the different outlets A¹⁰, and also, if desired, to maintain a pressure in the space EA somewhat in excess of atmospheric pressure in the space enclosed by the bell AA, and thus guard against leakage of air into said space.

In the rectangular form of furnace shown in Figs. 5 and 6, as well as in the cylindrical form shown in Fig. 1, burners may be incorporated in the top or roof wall of the bell, as well as in its vertical wall or walls, if and when the spe-

cial top heating effect thereby made possible, seems desirable. In each of the furnace forms illustrated, the branches M' from the horizontal manifold pipes M form suspension parts well adapted to support the weight of the manifold pipes M, and vertical bus pipes N, as well as when the bell is being moved into and out of place on a furnace base, as when stationary on the latter.

For operation, the bus pipes N may be connected through flexible hose pipes, or other connections customarily employed with gas fired bell type furnaces, to stationary supply piping (not shown) adjacent the furnace base member. When the supply pipe connection to the bus pipes N include flexible hose sections so that the connection may be established with the bell elevated above its base, the burner flames may be ignited by means of a torch extended into the bell through its then open bottom. To permit ignition to be initiated, electrical ignition devices such as are customarily employed with certain so-called radiant tube bell furnaces, or other expedients may be employed. In particular, the bell may be formed with passages A¹², normally closed by suitable refractory plug closure parts R, through each of which, when open, a torch may be inserted into the space EA to ignite one or more burners. The passages A² may be formed in either the vertical wall or the top wall or in both walls, as bell form dimensions and operating conditions make desirable.

The ignition operation is less important with my improved furnace than it would be, but for the unusually great turn down capacity of the Duradant type of burner, which is adapted to operate with a rate of combustion varying between a practical maximum, and a rate which is only five percent or so of the maximum rate. In consequence, in the furnace heating up operation, during which combustible mixture is ordinarily supplied continuously at or near the maximum practical rate, there is no risk of flame extinction, except as a result of an abnormal reduction in, or total failure of, the combustible mixture supply pressure. A reduction in that pressure resulting from some temporary interference with, but not entirely stopping the operation of the mixture forming and compressing apparatus, ordinarily will not result in the extinction of the burner flames. After the heating up operation is wholly or largely completed, the refractory material at the inner side of the bell wall, and particularly the portions thereof formed by the burner body elements L, are hot enough to automatically reignite the burner flames when the latter are extinguished as a result of an interruption, for a few seconds, or even a few minutes, in the supply of combustible mixture at an operative pressure.

In normal annealing operations in which the work is heated up to a temperature in the neighborhood of 1300° to 1450° F., or so, the entire inner surface of the outer bell will be heated to incandescence. The wall temperatures of the combustion spaces L' and their extensions h² will be substantially higher, however, than the temperatures of the flat portions of the inner surface of the bell between the different recesses h², while the work is being heated up. After the work has been fully heated up, and is being subjected to a "soaking" treatment at constant temperature so that the only substantial need for heat results from the external radiation and other furnace heat losses, the difference in the

temperatures of adjacent portions of the inner side of the bell may become quite small.

The burner spacing most suitable, from the practical standpoint, in any particular furnace will depend upon the furnace form and dimensions and operating conditions. In general, in such a furnace as is shown in Figs. 5 and 6, having all of its burners in its vertical walls and in which operating conditions make it desirable to supply heat at practically the same rate to all portions of the outer surface of the work cover E, the burner spacing should be such that every point in said surface will receive radiant heat in significant amounts directly from each of a plurality of burners. In general, the distance separating adjacent burners may be greater when the individual burners are relatively larger than when relatively small, and in a furnace adapted for a relatively rapid heating up operation, the burners should be more closely spaced than in a furnace intended for a less rapid heating operation.

Merely by way of illustration and example, and not by way of limitation, I note that in one rectangular furnace of the general form and character shown in Figs. 5 and 6, devised by me, for use in heating a metallic work charge of 35,000 pounds up to a temperature of 1450° F. in fourteen hours, and in which the space surrounded by the vertical walls of the outer bell is approximately twenty one feet long, six and one-half feet high and five and one-half feet wide, one hundred burners, all mounted in the vertical wall of the bell, are used. There is thus one burner for approximately every three and two-thirds square feet of inner vertical wall surface of the outer bell of said furnace, the diameter of the inner and larger end of the conical space h^2 of each burner being four inches, and in said furnace, the average distance between the inner vertical wall surface of the outer bell A, and the outer vertical wall surface of the work cover, E, is approximately 12 inches. Each of said hundred burners is adapted to liberate 20,000 B. t. u.'s per hour, but the maximum rate of heat liberation per burner required in the intended use of the furnace is substantially lower.

While in accordance with the provisions of the statutes, I have illustrated and described the best forms of embodiment of my invention now known to me, it will be apparent to those skilled in the art that changes may be made in the form of the apparatus disclosed without departing from the spirit of my invention as set forth in the appended claims and that in some cases certain features of my invention may be used to advantage without a corresponding use of other features.

Having now described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. In heating a furnace of the type specified having a removable cover member with an inner portion of its wall formed of refractory material, the method which consists in burning fuel wholly within a multiplicity of combustion space recesses formed in said wall at the inner side of and distributed over said wall and thereby so heating the walls of said recesses that a large portion of the heat of combustion is radiated directly from said recesses inwardly away from the inner side of said wall.

2. In heating a furnace of the type specified having a removable cover member with an inner

portion of its wall formed of refractory material, the method which consists in burning fuel in regulated amounts wholly within a multiplicity of combustion spaces recesses formed in said wall at the inner side of and distributed over said wall, and thereby so heating the walls of said recesses that a large portion of the heat of combustion is radiated directly from said recesses inwardly away from the inner side of said wall, and varying the relative amounts of fuel burned in the different recesses to thereby vary the relative amounts of heat liberated in said recesses.

3. In a furnace of the kind specified, the combination with a base member, of a removable cover member, having the inner portion of its wall formed of refractory material and recessed at its inner side to provide a multiplicity of distributed combustion spaces, each adapted to radiate heat inwardly away from the inner side of said wall and to discharge combustion gases into the space enclosed by said cover member, and means comprising a passage leading from the outer side of the cover member through the wall of the latter toward each combustion space for supplying fluid fuel and air for its combustion to said space and burner means within said wall through which each passage communicates with the corresponding combustion space and which is adapted to deliver said fuel and air thereto so as to effect its complete combustion within said space.

4. A combination, as specified in claim 3, including means for adjusting the amounts of fuel supplied to the different combustion spaces by the corresponding passages.

5. In a furnace of the kind specified, the combination with a base member, of a removable cover member having the inner portion of its wall formed of refractory material and recessed at its inner side to provide a multiplicity of distributed cup shaped combustion spaces, each adapted to radiate heat inwardly away from the inner side of said wall and to discharge combustion gases into the space enclosed by said cover member, and means comprising a passage leading from the outer side of the cover member through the wall of the latter toward each combustion space and burner means through which said passage communicates with the corresponding combustion space for supplying a combustible mixture of fuel and air to each combustion space at its outer side in a multiplicity of jets extending alongside and closely adjacent to corresponding sector portions of the wall of the space.

6. In a furnace of the kind specified, the combination with a base member, of a removable cover member having the inner portion of its wall formed of refractory material and having a multiplicity of passages transverse to and extending between the inner and outer sides of said cover member and a separate fluid fuel burner removably mounted in each passage and each comprising an inner end portion of refractory material forming a wall for a combustion space adapted to radiate heat inwardly away from the inner side of said wall and to discharge products of combustion at the inner side of said wall and means for supplying fluid fuel and air for its combustion to said combustion space in a multiplicity of jets in predetermined spaced relation with the wall of said space and so as to effect the complete combustion of the fuel within said space.

7. In a furnace of the kind specified, the combination with a base member, of a removable cover member having the inner portion of its wall formed of refractory material and having a multiplicity of passages transverse to and extending between the inner and outer sides of said cover member and a separate fluid fuel burner removably mounted in each passage and each comprising an inner end portion of refractory material forming a wall for a combustion space adapted to radiate heat inwardly away from the inner side of said wall and to discharge products of combustion at the inner side of said wall and a metallic outer portion adapted to engage the outer side of the wall at the margin of said opening and a tubular metallic portion mechanically connecting the said inner refractory and outer metallic burner portions and adapted to supply fluid fuel and air for its combustion to said combustion space so as to effect complete combustion of the fuel within said space.

8. In a furnace of the kind specified, the combination with a base member, of a removable cover member having the inner portion of its wall formed of refractory material and having a multiplicity of passages transverse to and extending between the inner and outer sides of said cover member, each passage including a conical portion diminishing in cross section as the distance from the outer side of cover member increases, and a separate fluid fuel burner removably mounted in each passage and each comprising a body portion of refractory material extending into and shaped to fill said conical portion passage and forming a wall of a combustion space adapted to radiate heat inwardly from, and to discharge products of combustion at, the inner side of said cover member wall, and comprising a metallic outer portion adapted to engage the outer side of the cover member wall at the margin of said opening and a tubular metallic part axially disposed in said body portion and mechanically connecting the latter to said outer metallic burner portion and adapted to pass fluid fuel and air for its combustion through said body portion in said space and so as to effect the complete combustion of the fuel in said space.

9. In a furnace of the kind specified, the com-

bination with a base member, of a removable cover member having an inner portion of its vertical walls formed of refractory material, and recessed at its inner side to provide a multiplicity of distributed combustion spaces arranged in superposed horizontal rows and each adapted to radiate heat inwardly away from the inner side of said wall and to discharge combustion gases into the space enclosed by said bell cover member, and means for delivering a regulable amount of a combustible mixture of fuel and air to each combustion space in jets of such character as to effect the complete combustion of the fuel within said spaces, said means comprising a passage leading from the outer side of the cover member through the wall of the latter to each combustion space, and horizontal manifold pipes each connected to the said passages leading to a plurality of combustion spaces in the same horizontal row.

10. In a furnace of the kind specified, the combination with a base member, of a removable cover member having an outer metallic shell and a lining formed of refractory material, and having a multiplicity of passages transverse to, and extending between the inner and outer sides of said cover member, and a separate burner element removably mounted in each passage and comprising a body portion of refractory material received in said passage, with its inner end forming a heat radiating outer wall of a combustion space open at its inner side and a metallic outer burner portion engaging the outer side of and detachably secured to said shell, at the margin of said passage, and a tubular metallic portion mechanically connecting said body and outer metallic burner portions and adapted to supply fluid fuel and air for its combustion to said combustion space in jets of such character as to effect the complete combustion of the fuel within said spaces, and fuel supply piping external to, connected to and supported from said outer metallic burner portions through vertical branch pipes, each mechanically connected at one end to a corresponding outer metallic burner portion and adapted to supply fuel to the outer end of the corresponding tubular metallic burner portion.