

Jan. 18, 1938.

F. HESS

2,105,533

GAS BURNING APPARATUS

Original Filed Jan. 19, 1934 2 Sheets-Sheet 2

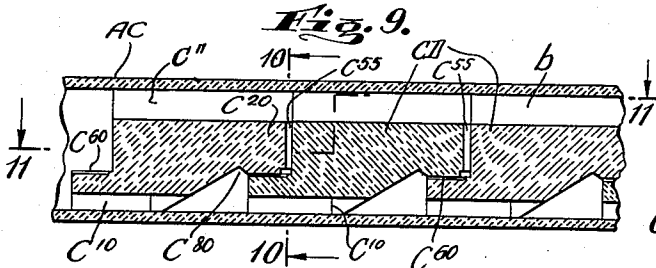


Fig. 9.

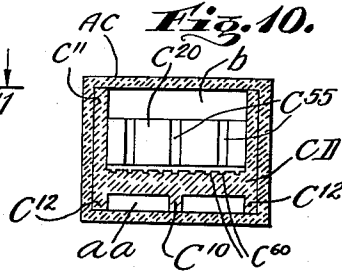


Fig. 10.

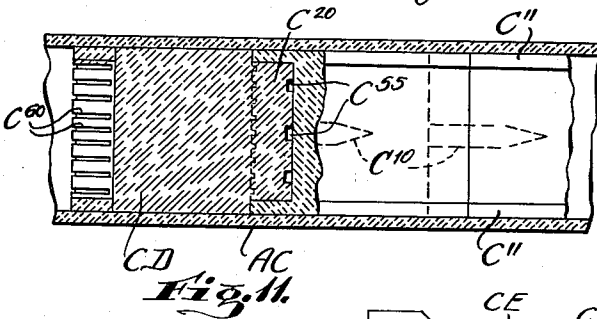


Fig. 11.

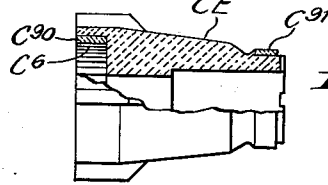


Fig. 12.

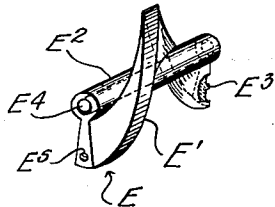


Fig. 13.

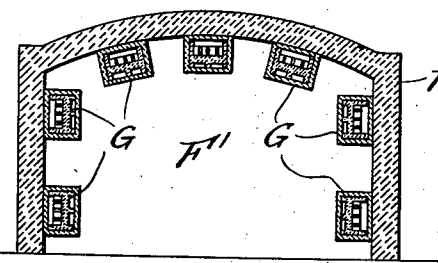


Fig. 14.

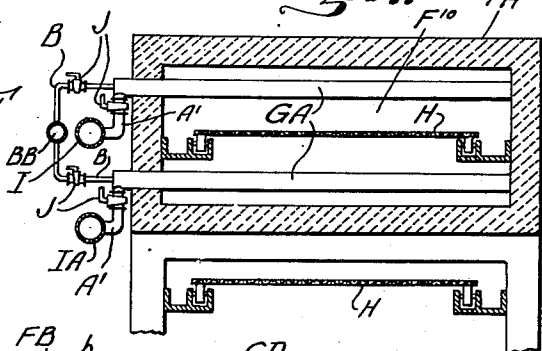


Fig. 15.

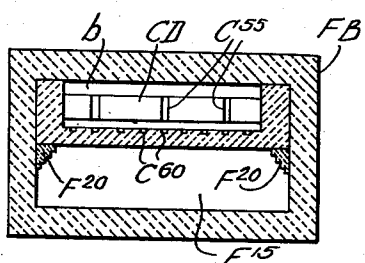
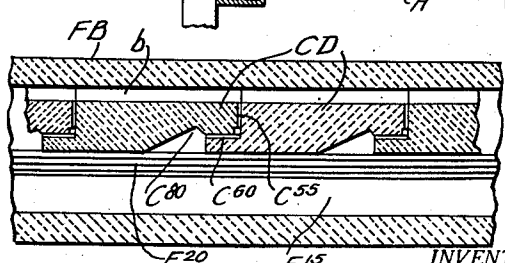


Fig. 16.



INVENTOR.
FRED HESS
BY John E. Hubbell
ATTORNEY

UNITED STATES PATENT OFFICE

2,105,533

GAS BURNING APPARATUS

Fred. Hess, Philadelphia, Pa., assignor to The
Selas Company, Philadelphia, Pa., a corpora-
tion of Pennsylvania

Application January 19, 1934, Serial No. 707,236
Renewed June 11, 1937

13 Claims. (Cl. 126—91)

The general object of the present invention is to provide improved apparatus for supplying heat by the combustion of a combustible mixture of air and gas.

5 A primary but more specific object of the invention is to provide a self-contained heating element having novel and desirable characteristics adapted for a wide range of uses and comprising an inlet for a combustible mixture of air and gas
10 and an outlet for the gaseous products formed by the combustion of such mixture, and which is adapted to emit the available heat generated within the element by radiation and/or conduction from the outer surface of the element without
15 contact of the burning mixture or products of combustion with the material or space heated. The diverse uses for which such an element is well adapted include the heating of a molten metal bath in which the element may be immersed,
20 the heating of a baking oven, a glass annealing furnace, and metal annealing kiln, and, in general the supplying of heat for practically any industrial process in which heat is desirably supplied by the combustion of fuel without exposing the material heated to contact with combustion gases.

Heating elements adapted and devised for the attainment of the specific object mentioned in the preceding paragraph, are characterized primarily by the special provisions which they comprise for distributing the fuel gas mixture to a
30 multiplicity of suitably distributed points at which combustion is initiated, and for preventing the mixture from being heated to its ignition temperature before it reaches said points, and by the provisions made for transferring the heat generated by the combustion of the mixture to the material or space to be heated.

While the temperatures attained by the heat
40 emitting external surface of the element may vary widely in elements intended for different uses, the temperatures attained at the points of combustion are necessarily high enough in all cases to make it desirable that those points should
45 be located at the outlet ends of burner passages or orifices in portions of the elements which are formed of material which is more refractory and of poorer heat conductivity than metal, and a specific object of the present invention is to provide heating element parts of refractory material specially shaped to facilitate their manufacture
50 and to permit their assemblage with similar parts to provide an extended refractory wall suitably pierced by a multiplicity of distributed burner orifices and interposed between a combustible

mixture inlet space and what may be regarded as the combustion chamber space of the element.

In a simple form of the present invention which is adapted for a wide range of uses, the element consists essentially of a tubular shell surrounding
5 an end to end series of similar tubular sections of refractory material which are relatively shaped at their abutting ends to provide a multiplicity of distributed passages or burner orifices for the discharge of a combustible mixture passed into
10 the bores of said bodies. In this form of the invention said bodies are advantageously formed with external projections or shoulders, whereby the bodies are suitably spaced or centered within the enclosing shell to provide a suitably shaped
15 combustion chamber and discharge passage for the burnt gases between the outer sides of the bodies and the inner wall of the shell. In such an element the combustible mixture is advantageously introduced and distributed by means of a
20 pipe axially disposed within the series of refractory bodies and formed with wall perforations distributed along its length for the passage of the gas to the inlet ends of the burner orifice passages provided at the ends of the refractory bodies. For many purposes, the outer shell of such
25 an element may be a tube of metal, but where high shell temperatures or other conditions make it desirable, the heat emitting wall of the element may be formed of a refractory material such as silicon carbide which has sufficient heat conductivity when heated to its normal working temperature and which is adapted to withstand higher temperatures than can be withstood by metals. The well known "Selas" gas apparatus mixing
30 machine may be used in preparing the combustible mixture supplied to such heating elements.

In a heating element of the specific form just described, all portions of the external shell surface of the element may emit heat at or about
35 the same rate. In heating various forms of kilns or furnaces in accordance with the present invention, however, the heating elements may line the walls of the heating chamber or may otherwise be so disposed as to make it desirable that
40 all or the major portion of the available heat emitted may be radiated or conducted away from one side of the shell or housing portion of the heat element, and the general principles of the present invention may be utilized in the construction of heating elements of various forms
45 which emit useful heat wholly or mainly at one side only.

While the present invention was primarily devised for use under conditions making it desirable

to prevent contact of the burning gases and products of combustion with goods in the space heated, some features of the present invention may be used in the construction of a heating device in which the combustible mixture burns in and the products of combustion pass through the chamber or space containing the goods or material to be heated.

Aside from the general features mentioned above, the present invention comprises various novel features of construction and arrangement, all of which are pointed out with particularity in the claims annexed to and forming a part of the present invention. For a better understanding of the invention, however, its advantages and specific objects obtained with its use, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described various forms of the present invention.

Of the drawings:

Fig. 1 is a longitudinal section of a heating element;

Fig. 2 is a section on the line 2—2 of Fig. 1;

Fig. 3 is a section taken similarly to Fig. 2, of a heating element differing in its external shape from that shown in Figs. 1 and 2;

Fig. 4 is a longitudinal section of a heating element differing in several respects from that shown in Figs. 1 and 2;

Fig. 5 is a longitudinal section of portions of a heating element, in which the major portion of the heat is dissipated at one side of the element;

Fig. 6 is a section on the line 6—6 of Fig. 5;

Figs. 7 and 8 are perspective views of opposite ends of a refractory material part of the heating element of Figs. 5 and 6;

Fig. 9 is a longitudinal section of a portion of another form of heating element;

Fig. 10 is a section on the line 10—10 of Fig. 9;

Fig. 11 is a section on the line 11—11 of Fig. 9;

Fig. 12 is a perspective view of a gas retarding part employed in the heating element of Fig. 4;

Fig. 13 is a somewhat diagrammatic transverse section of a heating device comprising a multiplicity of heating elements constructed in accordance with the present invention;

Fig. 14 is a view similar to Fig. 13 of a heating device comprising a different arrangement of heating elements;

Fig. 15 is a transverse section;

Fig. 16 is a partial longitudinal section of a heating device in which combustion occurs in, and products of combustion pass through the goods heating chamber of the device; and

Fig. 17 is an elevation, partly in section of a refractory tubular section of modified form.

The heating element shown in Figs. 1 and 2, comprises a tubular body A forming the outer wall or shell of the element. Ordinarily the shell member A is formed of metal, but for high temperature work, as already explained, the shell may be formed of ceramic material such as silicon carbide which has good heat conductivity when the element is at working temperatures. The body A is shown in Fig. 1 as having both ends closed except for a central aperture formed in one end for the passage of an air and gas mixture supply pipe B. Adjacent the last mentioned end of the shell A, the latter is formed with a lateral outlet A' for the discharge of gaseous products of combustion. The supply pipe

is ordinarily much smaller in diameter than the shell A and is axially disposed in the latter.

Surrounding the supply pipe B is a tubular refractory body portion formed by an end to end series of tubular sections of parts C, and end sections CA and CB at the opposite ends of the element. Each section C as shown is formed with external centering ribs or projections C' extending into engagement with the inner surface of the shell A, and is formed at one end with a spigot or reduced end portion C² and at the other end with a bell portion C³. In the assembled structure shown in Fig. 1, the spigot ends C² of the sections C all point in the same direction, and the bell end C³ receives the spigot end C² of the other of each two adjacent sections C. In Fig. 1, the left hand end section CA has a spigot end C² entering the bell end of the adjacent section C, and differs in form from each section C only in that it includes no bell end portion and in that it has its body portion adjacent the outlet A' somewhat smaller in diameter than the corresponding portion of each section C. The outer end section CB, is formed at one end with a bell end C³ to receive the spigot end C² of the adjacent section C, and at its opposite end with a cavity receiving a block C⁴ of ceramic material which closes the axial passage in the section CB, adjacent the closed end of the supply pipe B.

The axial passage or bore of each of sections C and CA is advantageously larger in diameter at all points along its length than the external diameter of the pipe B which passes centrally through the sections so that the tube B is not in direct heat conducting relation with any of said sections. The annular space between the sections C, CA and CB and the supply pipe B also provides a gas space advantageously divided up into an end to end series of annular gas chambers which may well be separated from one another as shown in Fig. 1, by a packing D of asbestos fiber or other suitable packing material. Each packing D fills the annular space surrounding the tube B for a portion of the length of each of the sections CA and C adjacent the spigot end of the section, said portion being advantageously enlarged in cross section to provide more space for the packing D. The annular gas space between each adjacent pair of packings D, and that between the block C⁴ and the packing D in the adjacent section C, receives gas from the pipe B through a corresponding set of radial outlet ports B' formed in the pipe wall. The gas passes from each such annular gas chamber to the inlet ends of burner channels or passages leading to the combustion chamber space a between the shell A and the series of sections C, CA and CB. The burner channels in the construction shown in Fig. 1 comprises radial slots or grooves C⁵ formed in the end surface of the spigot end of each of the sections C and CA, and comprise axially extending grooves or slots C⁶ formed in the inner concave wall of each bell portion C³. Preferably, as shown, each bell portion C³ has many more grooves C⁶ than there are grooves C⁵ in each spigot end C², to properly distribute the gas issuing from each set of grooves C⁵ to the inlet ends of the corresponding set of grooves C⁶. The adjacent bell and spigot end portions are relatively shaped, as by reducing the external diameter of the tip of each spigot end portion, to provide an annular distributing channel C⁷

through which each set of radial grooves C⁵ communicate at their outer ends with the adjacent axial grooves C⁶.

In the intended operation of the heating element shown in Figs. 1 and 2, ignition of the combustible mixture of air and gas occurs at the multiplicity of points, distributed circumferentially and longitudinally of the element, at which the grooves or channel sections C⁶ open into the combustion chamber space *a*. The combustion thus effected maintains the outer surface of the refractory body portion of the heating element at a temperature which will vary with the conditions of use, but in all cases is substantially above the ignition temperature of the combustible mixture.

In any steady condition of operation, the temperature of any portion of the heating element will be constant and the element will give out heat at the rate at which heat is generated by the element. The heat given out by the element will comprise a useful heat portion emitted by radiation or conduction from the outer surface of the shell A, and waste heat all of which is carried out of the element by the products of combustion issuing through the outlet A' except for an insignificant amount which may be conducted away from the element by the external portion of the pipe B. More or less of the heat carried out of the element by the gases leaving through the outlet A', which is waste heat so far as concerns the element shown in Figs. 1 and 2, may be utilized in external heating apparatus, or in some such adjunct of the heating element as is shown in Fig. 4. In any given condition of steady operation, the temperatures attained within the element will be those required to maintain the average temperature of the inner surface of the shell A sufficiently in excess of the average temperature of the outer surface of the shell for the conduction of heat through the shell wall at a rate equal to the rate of heat emission from the outer surface of the shell. For a given rate of heat emission, the shell outer surface temperature will depend, of course, on the manner in which the heat emitted is absorbed from the shell. For example, with the right hand end of the element shown in Fig. 1 extending downward into and heating a bath of molten metal, the temperature of the outer surface of the shell A will be practically equal to the temperature of the molten metal, and will be substantially less than it will be, for the same rate of heat emission from the shell of the element, when the latter extends into a heating chamber wherein the heat emission from the shell of the element is partly in the form of heat radiated to the walls and contents of the heating chamber and is partly in the form of heat imparted to the chamber atmosphere by contact with the shell. In any event, the heat absorbed by the shell of the element at its inner surface is partly heat absorbed by contact and radiation from the hot gases within the combustion chamber, but is largely heat radiated from the outer surface of the refractory body formed by the sections C, CA and CB which is normally heated at its outer surface to an incandescent temperature.

The maximum rate at which heat is generated within the heating element, or in other words the practical maximum heating capacity of the element, in any condition of operation must be low enough to avoid heating the combustible mixture to the ignition temperature within the supply pipe B, and should be low enough to prevent the

attainment of the ignition temperature within the gas channels or burner orifices portions C⁵, C⁶ and C⁷, as combustion therein tends to deterioration of the body of refractory ceramic material, and also increases the difficulty of avoiding unduly high temperature in the supply pipe B. The latter as previously described is arranged to absorb heat at a relatively low rate from the surrounding refractory body, and is subjected to a cooling action by the flow of combustible mixture there-through which increases as the rate of flow and effective heating capacity of the element is increased. The walls of the burner orifices or channel sections C⁵, C⁶ and C⁷ are also subjected to a cooling action by the gas flow through them which is especially effective due to the small cross section and consequent relatively high velocity of the gas flow through said sections. Preferably, the refractory body portion of the heating element shown in Fig. 1 is formed of ceramic material which is of relatively low heat conductivity when at its working temperature, as such low heat conductivity diminishes the heat transfer to the gas mixture entering the combustion chamber *a* through the pipe B and burner orifices.

In general, direct impingement of the flame jets extending away from the outer end of the groove C⁶ against the outer shell of the element should be avoided. In general, it is desirable also that the flame jets should extend in the general direction of the gas flow through the combustion chamber *a*. In the arrangement shown in Fig. 1, the flame jets are all directed toward the end of the element from which the gas outlet A' leads. As shown, a peripheral groove C⁸ is formed in each section C and CA adjacent the spigot end of the section and immediately in front of the adjacent bell end portion C³, and the portion of each section C and CA at the side of the groove C⁸ which is nearest the gas outlet A' of the element is bevelled off or given a conical form. This provides for the free expansion of the flame jets adjacent the discharge ends of the grooves C⁶ as combustion occurs and tends to enlarge the jets. It also tends to a relatively low temperature of the spigot end of each section and thereby desirably reduces the tendency of the flame to creep back into the grooves C⁶ wherein combustion is objectionable. At the same time, the flame jets by impinging on the bevelled off portion of the section adjacent the grooves C⁸—keeps that portion suitably incandescent to maintain rapid combustion and a desirably high rate of heat radiation.

As those skilled in the art will readily understand, an important advantage of the invention in the form shown in Figs. 1 and 2 arises from the fact that the shape of the refractory body sections C, CA, CB and C⁴ are such as to facilitate their proper construction by known processes and apparatus for producing specially shaped bodies of ceramic material at a relatively low cost, and with sufficient accuracy of dimensions. While for certain uses, the cylindrical form of housing shell shown in Figs. 1 and 2 is especially desirable, the shell may vary in form as conditions make desirable. For example, the shell instead of being circular may be square in cross section as shown in Fig. 3.

The shell AB of the heating element shown in Fig. 4 is formed with an outlet A¹⁰ at its end remote from that at which the tube B enters the element, and in Fig. 4 the body sections C are so arranged that the bell ends C³ of the sections C, and the flame jets at the ends of the channels

C⁶ all point toward the outlet end of the element. In Fig. 4 also the refractory body portion of the element consists entirely of similar sections C. The bell C³ of the section C at the outlet end of the shell AB receives a block of ceramic material C⁴⁰ which closes the adjacent end of the pipe B, and as shown the spigot end of the section C at the opposite end of the element is received in a centering ring C⁴¹ of ceramic material which has its periphery in engagement with the shell AB.

In the arrangement shown in Fig. 4, the outlet passage A¹⁰ from the shell AB is extended to form or communicates with a tubular body A¹¹ which forms a return passage for the products of combustion carrying them to the end of the element.

The omission from the heating element shown in Fig. 4 of specially shaped end sections of the refractory body of the element, such as the sections CA and CB of Fig. 1, obviously simplifies and tends to cause reduction in the cost of manufacture of such elements.

The heating element shown in Fig. 4 includes an adjunct for utilizing available heat in the gases leaving the combustion chamber *a* of the element through the outlet A¹⁰. This adjunct consists in a tubular extension A¹¹ of the outlet passage which as shown is parallel to the shell AB of the element proper. To retard the flow of the gases through and increase the rate of heat transfer from the gases to the wall of the tube A¹¹, I advantageously mount a flow retarding and heat radiating element in the tube or pipe A¹¹. Advantageously, the flow retarding element is formed of an end to end series of sections E which are formed of refractory material and are shaped to provide one or more ribs E¹ extending helically about the axis of the pipe A¹¹ and each of which has its peripheral edge in engagement with the inner wall of the pipe. In the preferred form shown, each section E comprises a central tubular body portion E² and a helical rib portion E¹. Each section E is advantageously formed at one end and at a distance from its axis with an axially extending projection E³, and at its opposite end with a recess E³ adapted to receive the projection E³ at the adjacent end of an adjacent section E. The use of the projections E³ and recesses E³ facilitates the assemblage of the sections with ends of the ribs of adjacent sections in register. The assemblage and handling of the sections E is facilitated also, by forming an axial passage E⁴ in each section through which a wire or string may extend to connect a plurality of such sections.

In general, the combustion chamber side or surface of the special refractory wall of a heating element constructed in accordance with the present invention is normally heated to incandescence, so that the gaseous products of combustion pass out of the combustion chamber of the element at a relatively high temperature. In consequence, the temperature of the gases entering the pipe A¹¹ of Fig. 4 is high enough to heat the retarding element, or at least the sections E thereof adjacent the heating element outlet A¹⁰, so highly that those sections are adapted to radiate heat to the inner wall of the pipe A¹¹. The relatively large area, and the disposition of the heat radiating surface of such a retarding element as is shown in Fig. 4, are such as to make the heat radiation from the retarder relatively large. The heat radiation from the sections E to the walls of the pipe A¹¹ may thus

materially increase the heat recovery from the gases passing through the pipe.

The element shown in Fig. 4 may advantageously be used, for example, in heating a bath of molten metal in which the element is vertically disposed, or for any other purpose making the use of such an adjunct as is formed by the pipe A¹¹, and the flow retarding element within the pipe, desirable, and in which it is desirable or convenient to discharge the heating gases at the end of the element at which the combustible mixture is supplied through the pipe B. Except for uses in which it is convenient or desirable to discharge the gases at the end of the element at which the combustible mixture is supplied, the adjunct of the element shown in Fig. 4 may be used equally well with such an element as is shown in Figs. 1 and 2. The element form shown in Fig. 4 may be used without change other than the omission of the pipe A¹¹.

In Figs. 5-8, I have illustrated a form of heating element differing essentially from those shown in Figs. 1-4, in that its combustion chamber *aa* is adjacent one flat side of the element shell AC which is rectangular in cross section. The refractory body sections CC of the element illustrated by Figs. 5-8 do not differ from the sections C previously described in respect to their association with the combustible mixture supply pipe B. The sections CC differ in external contour from the sections C, however, the body portion of each section CC being rectangular in cross section. At its side adjacent the combustion chamber *aa* of the element, each section CC is formed with one or more longitudinally extending ribs or projections C¹⁰ which extend from the body of the section into engagement with the adjacent flat wall of the shell AC. Each section CC is formed at one end with a tenon or projection C²⁰ rectangular in cross section but of less thickness than the body of the element and with its sides parallel to the sides of the rectangular housing, and is formed at its opposite end with a corresponding recess or groove, the sides of which are parallel to the combustion chamber wall of the element. The tenon C²⁰ of each section CC is received in the recess C³⁰ of an adjacent section, generally as the spigot end C² of a section C is received in the bell end C³, or in other words, each pair of end to end sections and portions cut away so that they may overlap or telescope. The end surface of each tenon portion C²⁰ is formed with gas channel slots C⁵⁰ corresponding generally to the slots C⁵ of the section C, but the slots C⁵⁰ of each section CC all lead to the flat combustion chamber side of the section. At that side of the section, the slots C⁵⁰ open into a transverse channel or groove C⁷⁰ serving the distributive function of the circular groove C⁷ of the section C. In the combustion chamber side of each recess C³⁰ of each section CC are formed a multiplicity of axially extending channels C⁶⁰, corresponding generally to the channels C⁶ of the section C. Each set of channels C⁶⁰ receives combustible mixture from the corresponding channel C⁷⁰ and discharge it axially of the element into the combustion chamber *aa*. Each section CC is advantageously formed as shown with a groove C⁸⁰ serving the purpose of the groove C⁸ of the section C, and adjacent the grooves C⁸⁰, and at the side of the latter remote from the adjacent tenon C²⁰, the combustion chamber side of each section is bevelled off or inclined to locally enlarge the combustion chamber and avoid impingement of flame

jets against the portion of the combustion chamber side of the section CC immediately adjacent the discharge ends of the channels C⁶⁰.

The separate combustible mixture supply pipe B extending into the element, employed in each of the constructions previously described, is not essential in all cases, as is illustrated in Figs. 9-11. The shell AC of the element shown in Figs. 9-11 may be and is shown as exactly like the shell AC of the element illustrated by Figs. 5-8. The refractory body sections CD of Figs. 9-11 are generally like the sections CC in respect to their portions at the combustion chamber sides of the combustible mixture supply space of the element and have their parts similarly designated. The end grooves C⁵⁵ of the section CD, however, advantageously extend transversely to the combustion chamber side of the element, and not radially from the element axis as do the grooves C⁵⁰ of the section CC.

The combustible mixture supply passage b of the element shown in Figs. 9-11, is a space formed between the body portions of the sections CD and the side of the shell AC remote from the combustion chamber aa. The sections CD are spaced away from the last mentioned side of the shell by longitudinally extending ribs C¹¹ located at the opposite side edges of the sections CD and forming the side walls of the supply passage b and extending into contact with the adjacent side of the shell AC. In effect, and except for the ribs C¹¹, each section CD terminates at the plane of the sides of the end projections C²⁰ remote from the combustion chamber side of the element. Where the width of the combustion chamber side of the element is relatively large, the refractory body sections may each be provided with more than a single positioning rib extending into engagement with the combustion chamber side of the element shell. Thus, each section CD has in addition to the central rib or projection C¹⁰, two ribs C¹² one at each side of the rib or projection C¹⁰.

In Figs. 13 and 14, I have illustrated by way of example two different heating devices, each including a heating chamber receiving heat from heating element constructed in accordance with the present invention. The heating device F shown in cross section in Fig. 13, is of the conventional type used in glass and metal annealing furnaces and kilns and has its heating chamber F' heated by heating elements G lining the walls of the chamber F and extending longitudinally of the latter. The heating elements G may be of any of the forms previously described or modifications thereof, but are advantageously of the type in which all or most of the heat emitted by each element is emitted at the side of the element directly facing the heating chamber, and as shown, the elements G are of the form shown in Figs. 9-11.

The heating device FA as shown in Fig. 14, is of the type commonly referred to as a continuous tunnel kiln in which the goods, for example, wares to be enameled are moved longitudinally through the kiln heating chamber F¹⁰ on a travelling screen or grid conveyor H of the endless belt type, the return portion of the belt running beneath the kiln structure proper. The heating elements GA of the kiln shown in Fig. 14 may be of any of the forms previously described. As conveniently illustrated, they are of the type shown in Figs. 1 and 2 and extend transversely to the heating chamber of the kiln one above and the other below the portion of

the conveyor within the kiln chamber. Ordinarily in such a kiln there will be a multiplicity of upper elements GA arranged in a row extending longitudinally of the chamber F¹⁰, and a similar row of lower elements. In the arrangement shown, the heat emitted from the sides of the heating elements GA remote from the articles on the conveyor H is in large part radiated to the top and bottom walls of the chamber F¹⁰ and re-radiated from the latter to said articles. As shown, the combustible mixture supply pipes B for the various elements GA are connected to and receive combustible mixture from a common supply main BB extending longitudinally of the kiln, and the outlet A¹ of each upper element is connected to main waste heat flue I and the outlet A¹ of each lower element is connected to a second main waste flue IA suitable valves J being provided to regulate the distribution of flow.

As previously explained, some of the features of the present invention may sometimes be used with advantage in heating devices in which it is unnecessary to prevent the heating gases from coming into contact with the work. One such heating device is illustrated by way of example in Figs. 15 and 16. The heating kiln or furnace FB is similar in form to the heating element shown in Figs. 9-11, but in Figs. 15 and 16 the refractory body or wall formed by the sections CD is mounted in the kiln chamber proper. In other words, the outer wall of the kiln or furnace FB replaces the special element shell AC of Figs. 9-11 and the goods space F¹⁵ of the kiln or furnace FB serves the combustion chamber function of the space aa of the element shown in Figs. 9-11. In Figs. 15 and 16, the ribs C¹⁰ and C¹² of the sections CD are omitted and the sections are supported on corbel portions F²⁰ of the side walls of the kiln or furnace.

In general, the refractory wall forming bodies, arranged and used as previously described, may be made of any usual or suitable ceramic material mix or composition employed in making refractory furnace parts subjected to similar or analogous temperatures. In some cases, however, it may be desirable to make the major portions of said bodies of a refractory material composition such as those commonly employed in making insulating refractories, which gives such a porosity or a shrinkage in manufacture of the portions so formed, that it is not well adapted for use in the formation of portions of the bodies including gas distributive channels which need to be accurately formed particularly when said channels are relatively fine or small in cross section. In such cases, each such body may well have its major portion formed of refractory material of one composition. For example, a tubular body of the general form of the bodies shown in Figs. 1 and 2, may be formed as is the body CE of Fig. 17, with a body portion wholly of material of one composition, and with other portions C⁹⁰ and C⁹¹ which are formed of a material of different composition and better adapted for use in forming the walls of the channels C⁶. As shown in Fig. 17, the portion C⁹⁰ is a ring forming the grooved cylindrical outer wall of the enlarged opening in the bell end of the body CE, while the part C⁹¹ is a ring shaped body surrounding the spigot end of the body portion of the member CE. As will be understood by those skilled in the art, the body portion of the member CE, and the ring portions C⁹⁰ and C⁹¹ are

separately formed and are cemented together to form the complete tubular body CE.

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. Apparatus for burning a combustible air and gas mixture comprising a casing and a wall therein dividing the interior of said casing into a supply passage for said mixture and a combustion space, said wall consisting of a plurality of bodies of refractory material arranged end to end and having overlapping end portions grooved to form distributed burner channels leading from said passage to said space.

2. Apparatus for burning a combustible air and gas mixture comprising a casing and a wall therein dividing the interior of said casing into a supply passage for said mixture and a combustion space, said wall consisting of a plurality of bodies of refractory material arranged end to end and having overlapping end portions grooved to form distributed burner channels leading from said passage to said space, said passages including inlet end portions extending transversely to said wall and outlet end portions extending in the general direction of said wall.

3. Apparatus for burning a combustible air and gas mixture comprising a casing and a wall therein dividing the interior of said casing into a supply passage for said mixture and a combustion space, said wall consisting of a plurality of bodies of refractory material arranged end to end and having overlapping end portions grooved to form distributed burner channels leading from said passage to said space and having outlet end portions extending in the general direction of the wall and all pointing in the same direction.

4. Apparatus for burning a combustible air and gas mixture comprising a casing and a wall therein dividing the interior of said casing into a supply passage for said mixture and a combustion space, said wall consisting of a plurality of bodies of refractory material arranged end to end and having overlapping end portions grooved to form distributed burner channels leading from said passage to said space and having their end portions extending in the general direction of said wall, said bodies being shaped to form recesses at the combustion chamber side of said wall into which the outlet ends of said channels open.

5. A heating element comprising a tubular heat emitting shell and a series of tubular bodies of refractory material axially disposed within said shell and spaced away from the latter to provide a combustion chamber space between said shell and bodies, adjacent bodies having overlapping end portions relatively shaped to provide burner channels between said overlapping portions for gas flow from the bores of said bodies into said space.

6. A heating element comprising a tubular heat emitting shell and a series of tubular bodies of refractory material axially disposed within said shell and spaced away from the latter to provide

a combustion chamber space between said shell and bodies, adjacent bodies having telescoping spigot and bell end portions grooved to provide radially extending channel portions at the end of each spigot end portion and axially extending grooves at the periphery of said spigot portion, said grooves collectively forming burner channels leading from the bores of said bodies to said combustion space.

7. A heating element comprising a tubular shell, a series of tubular refractory bodies arranged in end to end relation within said shell and spaced away from the latter to provide a combustion space between said shell and bodies, adjacent bodies having overlapping end portions shaped to provide burner channels leading to said combustion space, means for supplying a combustible gas mixture to said burner channels comprising a supply pipe within said bodies and perforated adjacent the different sets of overlapping ends to pass said mixture into the corresponding set of burner channels.

8. A heating element comprising a tubular shell, a series of tubular refractory bodies arranged in end to end relation within said shell and spaced away from the latter to provide a combustion space between said shell and bodies, adjacent bodies having overlapping end portions shaped to provide a set of burner channels leading to said combustion space, a combustible gas mixture supply pipe axially disposed within but not filling the bores of said bodies and packing material surrounding said pipe and dividing the space between the latter and said bodies into sections each of which communicates with a corresponding set of burner channels, said pipe being perforated to discharge said mixture into each of said sections.

9. A heating element comprising a heat emitting shell and an end to end series of bodies of refractory material within said shell and formed with projections at their opposite sides spacing said bodies away from one side of the shell to form a combustion space between that side of the shell and said bodies, and spacing said bodies away from the opposite side of the shell to provide an air and gas mixture space between the last mentioned side of the shell and said bodies, the adjacent end portions of adjacent bodies being relatively shaped to provide burner channels leading from the last mentioned space to said combustion space.

10. Apparatus for burning a combustible air and gas mixture, comprising a casing and a wall therein dividing the interior of said casing into a supply passage for said mixture and a combustion space, said wall consisting of a plurality of bodies of refractory material arranged end to end and having overlapping end portions grooved to form distributed burner channels leading from said passage to said space, said bodies comprising major portions formed of refractory material of one composition and other portions which are formed of refractory material of a different composition and provide walls for said channels.

11. A heating element comprising a heat emitting shell and refractory material therein forming a wall dividing the interior of the shell into a combustion chamber space and a passage adapted to receive a combustible air and gas mixture, said wall being formed with distributed burner channels leading to said space from said passage.

12. A heating element comprising an elongated heat emitting shell and refractory material there-

in forming a wall dividing the interior of the shell into a combustion chamber space and a passage adapted to receive a combustible air and gas mixture, said wall being formed with distributed burner channels leading to said space from said passage and having their combustion chamber ends all opening toward the same end of the shell.

13. A heating element comprising a heat emitting shell and refractory material therein form-

ing a wall dividing the interior of the shell into a combustion chamber space and a passage adapted to receive a combustible air and gas mixture, said wall being formed with distributed burner channels leading to said space from said passage, the combustion chamber side of said wall being recessed adjacent the discharge ends of said channels to provide local enlargement of the combustion chamber.

FRED. HESS. 10