

April 3, 1951

E. BLAHA
RADIANT GAS BURNER AND MEANS FOR
REMOVING PRODUCTS OF COMBUSTION

2,547,735

Filed April 18, 1946

2 Sheets-Sheet 1

Fig. 1.

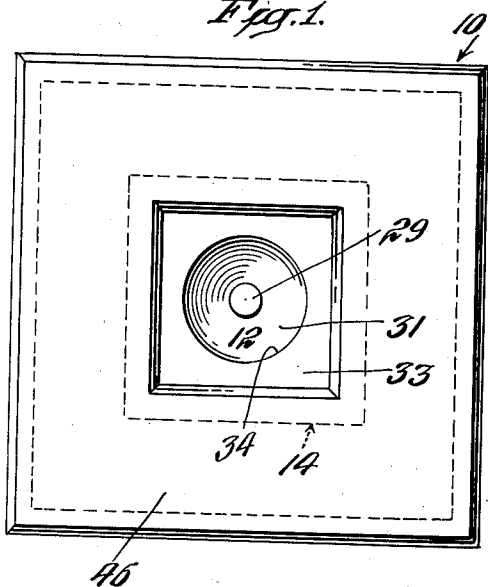


Fig. 2.

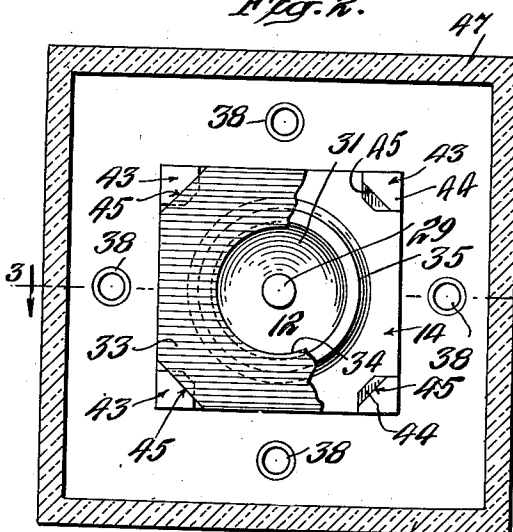


Fig. 3.

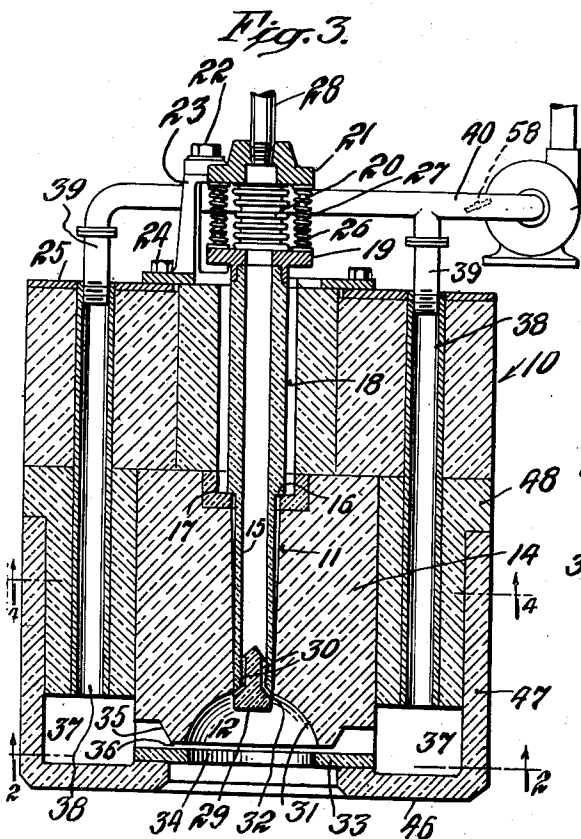


Fig. 4.

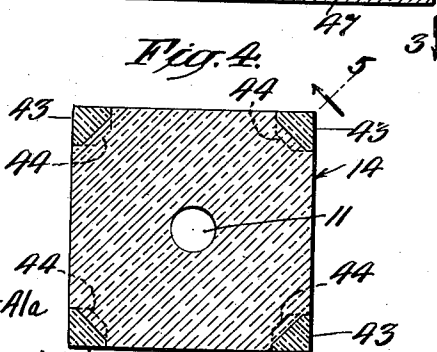
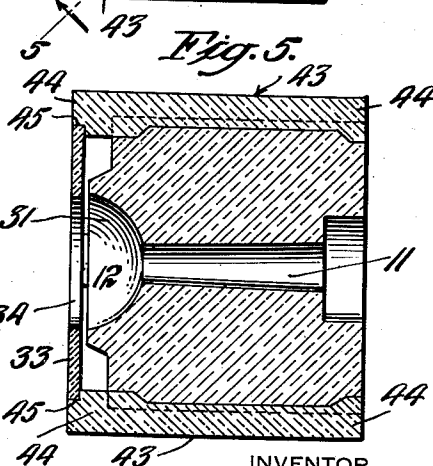


Fig. 5.



INVENTOR

Emil Blaha

BY E. F. Dwyer
his ATTORNEY

April 3, 1951

Filed April 18, 1946

E. BLAHA
RADIANT GAS BURNER AND MEANS FOR
REMOVING PRODUCTS OF COMBUSTION

2,547,735

2 Sheets-Sheet 2

Fig. 6.

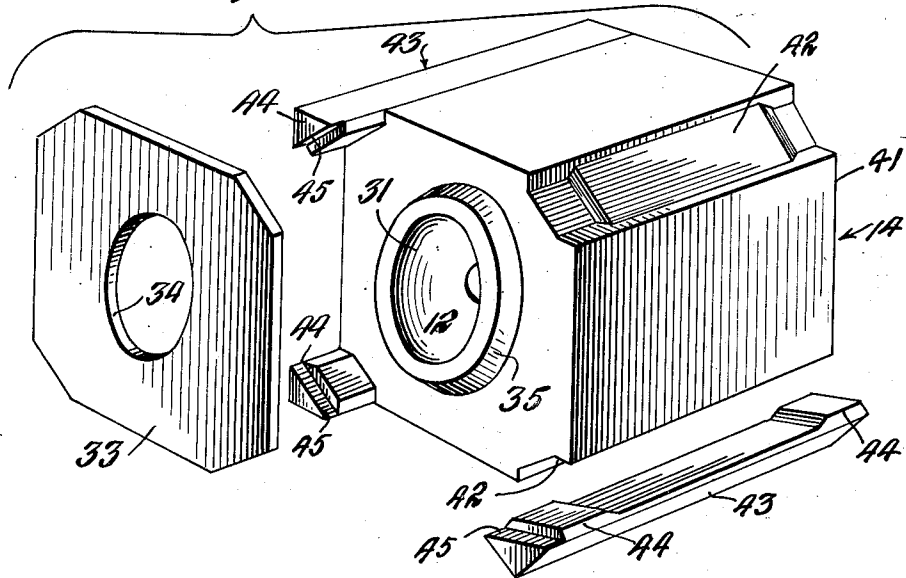


Fig. 7.

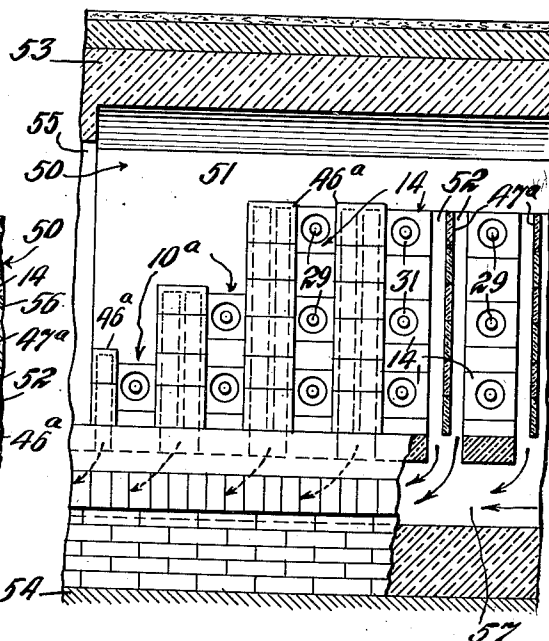


Fig. 8.

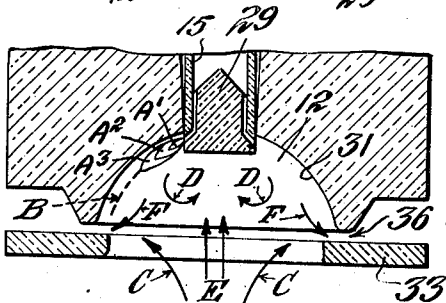
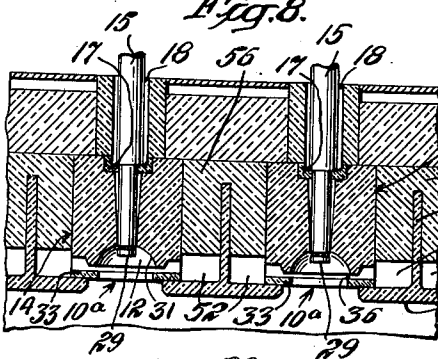


Fig. 9.

INVENTOR

Emil Blaha
BY Elt F. Mander
his ATTORNEY

UNITED STATES PATENT OFFICE

2,547,735

RADIANT GAS BURNER AND MEANS FOR
REMOVING PRODUCTS OF COMBUSTIONEmil Blaha, Cheltenham, Pa., assignor to Selas
Corporation of America, Philadelphia, Pa., a
corporation of Pennsylvania

Application April 18, 1946, Serial No. 663,157

13 Claims. (Cl. 158-7)

1

My invention relates to gas burners, and is especially concerned with burners of this type in which a large fraction of the heat generated and developed by combustion of a combustible gas mixture is converted to radiant heat.

It has already been proposed to produce radiant heat in a body having an open cavity which is provided with a high temperature inner refractory lining forming a combustion space. A combustible gas mixture is supplied to such space in which combustion of the mixture is accomplished to heat the inner lining to incandescence. By accomplishing a large part and preferably substantially all of the combustion of the mixture in the combustion space, extremely high combustion temperatures are developed for effectively heating the inner lining to a highly incandescent condition, thereby promoting the conversion of a large fraction of the heat developed and generated in the combustion space to radiant heat which is projected from the highly incandescent inner lining for doing useful work.

In such gas burners the highly heated gases produced in the combustion space, and consisting largely of heated products of combustion, pass from the open end of the cavity into the environment in which heating of work is to be effected. In many instances such highly heated gases may be efficiently utilized for convection heating purposes, and, together with the radiant heating component, effect the desired heating of work. However, there are certain heating applications in which the convection heating effected by the high temperature heating gases is objectionable and undesirable. This is especially true in the firing of articles to produce glazed surfaces, as in the glaze firing of ceramic ware and in vitreous enamelling, for example.

To produce enamelled articles having a vitreous or glass-like surface film, a coating of non-vitreous or inorganic material, usually in the form of a slurry, is applied to the articles which fuses when heated and is converted to a vitreous or glass-like film. This molten glass-like film solidifies and hardens when the articles to which the coating material is applied are subsequently cooled. Such vitreous or glass-like film, as well as the glazed surfaces produced in the glaze firing of ceramic ware, should be lustrous and smooth and free of surface defects.

When highly heated gases pass from the open cavity of a radiant type burner of the above type and circulate freely in a heating chamber in which articles are being fired to produce glazed surfaces thereon, such heating gases tend to im-

2

pair and adversely affect the smooth and lustrous surface desired. This is so because the high temperature products of combustion which come into contact with the articles contain harmful impurities, such as sulphur dioxide and sulphuric acid fumes, for example. In order to insure the production of glazed and glass-like surface on articles which are smooth and lustrous and free of any surface defects, it has been the general practice to employ internally fired heat radiating muffles to keep the articles out of physical contact with the high temperature gases consisting of heated products of combustion.

I have discovered that work can be fired at high temperatures by radiant heat projected from gas burners of the above radiant type without the necessity of shielding the work or goods from the combustion zones by a heat transfer wall or barrier, thereby effecting radiant heat transfer at the highest possible temperature from the combustion spaces or zones whose wall surfaces are heated to a highly incandescent condition. I accomplish this by supplying the combustible gas mixture to the combustion space or burner cavity in such a manner and at such a rate that the inner refractory lining thereof is maintained highly incandescent and a substantial part of the combustion of the mixture is completed in the space, and by withdrawing from the space the heated gases generated therein before such gases pass from the open end of the burner cavity into the environment to which heat is radiated from the inner lining.

In those heating applications where any pronounced forward movement of the heated gases from the open end of the burner cavity is objectionable, the gases at the region adjacent to the open end of the cavity may be maintained practically quiescent by withdrawing and diverting substantially all of the heated gases developed and generated in the combustion space of the burner. In such case the heated gases pass at a very slow rate and substantially by diffusion only from the combustion space through the open end of the burner cavity to the environment adjacent thereto.

When radiant burners of the invention are incorporated in a wall of a heating chamber, heated gases enter the heating chamber from the burners only by diffusion at the open ends of the burner cavities. This takes place at an extremely slow rate, and, in the glazing of articles, the degree to which sulphur impurities are carried into the chamber atmosphere is extremely small and insufficient to impair the smooth and

lustrous surface produced on such articles. Hence, in employing such radiant burners for heating work or goods in a closed chamber, the chamber is filled with gases which may be referred to as "poor products of combustion," that is, products of combustion which are impoverished in sulphur impurities.

An important operating characteristic of radiant burners embodying the invention is the practically quiescent condition of the gases at the region adjacent to the open end of the burner cavity. When the heated gases are withdrawn from the combustion space and diverted before such gases can pass from the burner cavity into the environment into which the radiant heating component is projected, there is no blast or current of heated gases which can be felt by the hand when it is momentarily placed in front of the burner cavity. Therefore, when radiant burners of the invention are employed in a wall of a heat chamber, the furnace atmosphere may be maintained practically quiescent and the only circulation of gas therein will be that due to any differences in temperature in different parts of the chamber.

The heated gases generated and developed in the combustion space of the burner are preferably withdrawn therefrom at a region removed from the inlet through which the combustible gas mixture is supplied to the burner cavity. In the embodiments illustrated and described hereinafter, the heated gases are withdrawn through an outlet provided at the large open end of the burner cavity. The outlet communicates with one or more passages to which are connected a suitable exhaust blower, whereby the suction effect produced by the blower is reflected back to the outlet to maintain the latter at a pressure below the pressure prevailing in the combustion space of the burner. Thus, the heated gases are effectively diverted through such outlet instead of passing from the combustion space into the environment to which heat is radiated from the inner wall surface of the burner cavity. In order to effectively utilize the heated gases thus diverted from the burner cavity when the burner is incorporated in a wall of a heating chamber, the passages through which such gases pass may be embodied in the wall of a heat chamber. In this manner the collecting flues for the withdrawn heated gases may serve as muffles for indirectly heating the chamber through the flue walls.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the claims. The invention, both as to organization and method, together with the objects and advantages thereof, will be better understood by reference to the following description taken in connection with the accompanying drawings of which Fig. 1 is a plan view of a front face of a gas burner embodying the invention; Fig. 2 is a sectional view, taken at line 2—2 of Fig. 3, to illustrate details of the gas burner immediately beneath the front face thereof; Fig. 3 is a central sectional view, taken at line 3—3 of Fig. 2, to illustrate the gas burner more clearly and the connection thereto of an exhaust blower for withdrawing heated gases developed and generated in the burner cavity; Fig. 4 is a fragmentary sectional view, taken at line 4—4 of Fig. 3, to illustrate details of the front inner body of the gas burners for holding an apertured plate at the enlarged open end of the

burner cavity; Fig. 5 is a sectional view taken at line 5—5 of Fig. 4; Fig. 6 is a perspective view of the parts forming the front inner body of the gas burner of Figs. 1 to 5 inclusive; Fig. 7 is a fragmentary longitudinal sectional view of a furnace in the side wall of which are incorporated gas burners illustrating another embodiment of the invention; Fig. 8 is a fragmentary horizontal sectional view of the burner wall of Fig. 7 to illustrate the burners and flue connections therefor more clearly; and Fig. 9 is a view diagrammatically illustrating the operating conditions that may prevail in the burner cavity.

In Figs. 1 to 6 inclusive is illustrated one form of gas burner in which a large fraction or proportion of the heated gases generated and developed by combustion of a combustible gas mixture is converted or translated to radiant heat. The gas burner of Figs. 1 to 6 comprises a molded burner block 10 of ceramic material. Although not to be limited thereto, the burner block 10 is especially suitable for mounting in a wall of a heating chamber, such as a kiln, lehr or furnace, for example. As will be readily understood, a number of burner blocks 10 may be distributed in a wall of a heating chamber in any suitable manner to produce the desired heating effect.

The burner block 10 is rectangular in cross-section and formed of a number of ceramic parts or bodies which are united together by a suitable high temperature cement. As shown, the burner block 10 is formed with a central passage 11 which extends therethrough and terminates at a cup-shaped space or cavity 12 provided in the ceramic body 14 at the front part of the burner block 10. Within the passage 11 is disposed a burner tube or sleeve 15 of refractory material having one end thereof terminating at a region closely adjacent to the end of the passage communicating with the cavity. An intermediate portion of the tube 15 is formed with an outwardly extending shoulder 16 which snugly fits against a collar 17.

The collar 17 is accurately positioned in an enlarged recess at the rear of body 14, as by cement, for example, so that the end of the tube 15 terminating at the cavity 12 is properly positioned with respect to the cavity. The portion of the tube 15 extending rearwardly from the shoulder 16 is positioned in an enlarged opening or well 18 which is in alignment with and serves as a continuation of the passage 11. To the rear end of the tube 15 is fixed, as by cement, for example, an apertured plate 19. One end of a contractible and expansible bellows 20 is secured to the apertured plate 19, the opposite end of which is secured to another apertured plate 21.

The plate 21 is removably secured, as indicated at 22, to the spaced apart legs of a supporting bracket 23. The bracket 23, the legs of which are distributed about the bellows 20, is bolt connected at 24 to a back plate 25 which is fixed in any suitable manner (not shown) to the burner block 10. In the opposing faces of plates 19 and 21 are provided pins 26 to receive the ends of helical coil springs 27 which are arranged to exert force against the tube 15. In this way the shoulder 16 of the tube 15 will always be urged snugly against the collar 17.

A combustible gas mixture is delivered from a suitable source of supply through a conduit 28 threadedly connected to the aperture in plate 21. Suitable controls (not shown) may be provided to adjust the pressure and rate at which the combustible gas mixture is supplied to the burner

block 10. The combustible gas mixture passes through the bellows 20 into the tube 15.

The end of the tube 15 adjacent to the cavity 12 is internally threaded to receive an exteriorly threaded part of an orifice member or burner tip 29 formed of refractory material. The gas mixture in the tube 15 is subdivided into a plurality of gas streams by a plurality of slots or channels 30 formed about the periphery of and extending lengthwise of the narrow part of the orifice member 29. The ends of the channels 30 at the rear of the enlarged end of the orifice member 29 flare outwardly toward the inner wall surface 31 of the cavity 12.

The gas mixture is discharged from the outlet ends 32 of the channels and it is at these regions that the burner flames are produced and maintained. The individual flames produced at the outlets 32 of the channels 30 flare outwardly and project into the cavity 12 alongside of the outwardly flaring wall surface 31. The gas flames maintained at the slot outlets 32 effect such heating of the inner wall surface 31 that the latter is heated to incandescence. The gas mixture then introduced into the cavity 12 is subjected to intense radiant heat of the inner wall surface 31 so that substantially complete burning of the gas mixture may be accomplished in the cavity before the heated gases pass from the open end of the cavity.

By accomplishing a large part and preferably substantially all of the combustion of the gas mixture in the combustion space formed by the cavity 12, extremely high combustion temperatures are developed to heat the inner wall surface or lining 31 to a highly incandescent condition. In this manner a large proportion of the heat developed and generated in the combustion space is converted or translated to radiant heat which is projected from the highly incandescent wall surface for doing useful work.

In accordance with the invention the highly heated gases generated in the cavity 12 and consisting primarily of heated products of combustion are withdrawn therefrom before such gases can freely pass from the open end of the cavity into the environment to which radiant heat is projected from the inner wall surface 31. I accomplish this by positioning at the open end of the cavity 12 a plate 33 having an opening 34 therein of approximately the same size as the cavity opening. The plate 33 is spaced a short distance from a lip 35 provided at the front face of the body 14 about the cavity opening to form a gap 36 therebetween.

The gap 36 serves as an outlet for the combustion space or cavity 12 and through which the heated gases are withdrawn and diverted before passing outwardly through the open end of the cavity. The diverted gases pass through the gap 36 into an annular-shaped manifold chamber 37 formed at the front face of the burner block 10 and thence flow through tubes 38 which extend rearwardly from the manifold through the burner block to the back plate 25. The rear ends of the tubes 38 are connected by conduits 39 to a main conduit 40 to which is connected the inlet of an exhaust blower 41a which may be driven in any suitable manner, as by an electric motor, for example.

The plate 33 is positioned relatively close to the forward edge of the lip 35 defining the open end of the cavity 12, so that a restricted outlet is provided by the gap 36 at which region the suction effect produced by the exhaust blower

41a is intensified in a manner similar to the suction effect produced at the nozzle of a vacuum cleaner. Since the burner block 10 is subjected to elevated temperatures as high as 2600° to 2800° F. at the inner face thereof, especially when incorporated in a refractory wall of a heating chamber, the plate 33 must not only withstand thermal shock but provision must be made for holding such plate accurately in position under all of the operating conditions encountered.

To this end the inner front body 14 of the burner block 10 is constructed in such a manner that the plate 33 forms a rigidly held part of the body. As shown most clearly in Fig. 6, the body 14 comprises a refractory shape 41 having slots or channels 42 extending lengthwise of the shape at the cut-away corners thereof. The slots or channels 42 are more or less U-shaped in cross-section and formed with outwardly flaring side walls to receive tie rods 43 having enlarged end portions 44. The slots 42 are deeper at the front and rear ends than at the intermediate portions, as shown in Figs. 5 and 6, to receive the enlarged ends 44 of the tie rods 43.

The tie rods 43, which are more or less triangular-shaped in section, are firmly secured in position in the slots 42, as by cement, for example. When the tie rods are secured in position, the refractory shape 41 and the tie rods embodied therein form the rectangular-shaped body 14 having smooth outer surfaces at the four side walls thereof to facilitate mounting such body in the burner block 10.

The enlarged forward ends 44 of the tie rods 43 are notched at the inner faces thereof, as indicated at 45, to receive the cut-away corners of the apertured plate 33. The notches 45 accurately position the plate 33 a fixed distance from the lip or raised portion 35 at the front face of the refractory shape 41, the plate 33 being secured in position in any suitable manner, as by cement.

After the body 14 is fixed in position in the burner block 10, a refractory part 46 forming the front face of the burner is secured in place. The refractory part 46 is provided with a central opening which is slightly larger than the opening 34 in the plate 33, and the edge portion of such part about the opening is adapted to bear against the plate 33.

The sides of the refractory part 46 are more or less L-shaped in section, as best shown in Fig. 3, and the flange or wall portion 47 thereof extending rearwardly from the front face of the burner block 10 is secured in position, as by cement, in a recessed portion formed about the periphery of an outer refractory wall part 48. The refractory parts 46 and 48 are formed to provide the enlarged manifold chamber 37 which extends about the entire front face of the burner block 10 and into which the heated gases pass through the gap 36 from the combustion space or cavity 12, as previously explained.

In Figs. 7 and 8 is illustrated another embodiment of the invention for incorporating a number of similar gas burners 10a in a side wall 50 of a heating chamber 51 having flue passages 52 therein communicating with the burners. The furnace providing the heating chamber 51 includes the spaced apart side walls 50, one of which is shown in Fig. 7, a connecting roof 53 and a floor 54. The goods or work to be heated may be carried on a car which is adapted to travel on the floor 54 through an end 55 of the furnace. The loading platform of the car

is preferably of such height that the goods or work to be fired or heated will be at a level directly opposite the burners 10a in the side walls 50.

The burners 10a are in spaced apart relation in the side walls 50 and arranged in vertical rows, as shown in Fig. 7. Each gas burner 10a comprises a body 14 of refractory material in which are embodied tie rods 44 and a front plate 33 similar to that shown in Figs. 2 to 6 inclusive and just described. The combustible gas mixture is supplied to the cavities 12 of the burners 10a in a manner generally like that shown in Fig. 3, similar parts being referred to by the same reference numerals.

In Figs. 7 and 8 the blocks or bodies 14 are mounted at the inner face of the side wall 50 between vertical rows of refractory blocks 56 which do not extend into the chamber 51 as far as the refractory bodies 14. Refractory plates 46a are arranged between adjacent vertical rows of burners 10a, the outer vertical edge portions of which bear against the plates 33 fixed to the refractory shapes 41. The refractory plates 46a correspond to the plates 46 in the gas burner first described and cooperate with the refractory blocks 56 to form vertically extending spaces between adjacent vertical rows of burners 10a.

The refractory plates 46a are T-shaped in section, as shown in Fig. 8, and the blocks 56 are formed with relatively deep slots to receive the rearwardly extending legs 47a of such plates. In this manner the vertical spaces in front of the blocks 56 are divided into two manifolds or flues 52 each of which communicates with the gaps 36 in one vertical row of burners 10a. Thus, for each vertical row of burners 10a, the heated gases generated and developed in the cavities 12 thereof can be withdrawn through the gaps 36 into the manifolds or flues 52 provided at both sides of the burners.

The T-shaped refractory plates 46a are provided directly one above the other to form the flues 52 which are coextensive in height with the vertical rows of burners 10a. The upper ends of the flues 52 are closed and the lower ends thereof communicate with a larger horizontal flue 57 provided at the bottom part of the side wall 50. The horizontal flue 57 extends longitudinally of the furnace and is connected by suitable conduit connections to an exhaust blower (not shown) in a manner generally similar to the connection of the exhaust blower 41a to the burner block 10 first described.

The principles of the present invention have been shown and described above in connection with gas burners of the radiant type like that disclosed in Hess Patent No. 2,215,079, granted on September 17, 1940, in which a large proportion of the heat generated by combustion of a combustible gas mixture in a combustion space or burner cavity is converted to radiant heat. In burners of this type the orifice member 29 is so positioned at the end of the tube 15 that the inner cones of the individual flames will always be out of contact with the cavity wall surface irrespective of the lengths of the flame. This is indicated more or less diagrammatically in Fig. 9 in which the inner cones of different size flames A', A² and A³ always extend more or less along an axis B alongside of the inner wall surface 31.

The relationship of the angle of divergence of the individual flames and the shape of the wall

surface 31 of the combustion space or cavity 12 is fully disclosed in the aforementioned Hess patent which may be considered as being incorporated in this application, and, if desired, reference may be had thereto for a more detailed description of the burner structure.

In accord with the present invention the suction effect produced by the exhaust blower is reflected back to the restricted outlet or gap 36 provided at the open end of the combustion chamber or cavity 12. The suction effect is intensified at the gap 36 and the pressure at this region is below and negative with respect to the pressure prevailing in the cavity 12. By providing any well known control provisions for controlling and regulating the suction pressure produced at the gap 36, such as a damper 58 in the conduit 40, substantially all or any desired fraction of the heated gases generated in the burner cavity 12 can be effectively withdrawn from the cavity and diverted through the gap 36, as indicated by the arrows F in Fig. 9, before such heated gases can pass from the combustion space through the open end of the cavity 12 into the environment into which heat is radiated from the wall surface 31.

The suction pressure produced at the gaps 36 of the burners 10 and 10a is related to the pressure at which the gas mixture is supplied to the burners and the lengths of the individual flames produced in the cavities 12. When the burners are being operated at low capacity and the flames are relatively small, the suction pressure produced at the gaps 36 is correspondingly adjusted so as to avoid pulling the flames from the wall surfaces 31 and reducing the effectiveness of the flames in heating the cavity lining to a high incandescent temperature. This is so because the flames produced in the burner cavities are what may be referred to as "lazy flames" when the burners are being operated considerably below maximum capacity. When the pressure at which the gas mixture is supplied to the burners is increased, the suction pressure produced at the gaps 36 may be also increased.

In gas burners of the type illustrated, there is a tendency for the individual flames to bend inwardly toward the axes of the burners in a manner akin to the bending of the ribs of an umbrella when it is fully opened. It has been found that the suction effect produced at the gap 36, which completely encircles the open end of the cavity 12, tends to overcome such lifting of the individual flames from the cup surface 31 and promote a more uniform incandescent heating of the wall surface. Hence the suction pressure produced at the gap 36 can be effectively controlled and nicely regulated to cause the flames, which vary in length depending upon the gas mixture delivery pressure, to remain closely adjacent to the wall surface 31 of the cavity and promote effective radiant heating of the cavity lining.

It has been observed that when a gas burner is being operated at less than maximum capacity, the area of the wall surface 31 of the cavity heated to incandescence is increased when radiant burners of the type described herein are provided with restricted outlets at the open end of the cavity at which a suction pressure may be produced. Thus, by maintaining the suction pressure at the gap 36, the radiant heat is at the same thermal head as heretofore but is distributed over a wider area of the cavity wall surface,

particularly when the burner is operated at less than maximum capacity.

The gas mixture supplied to the burners 10 and 10a may be a complete mixture in which all of the combustion supporting gas, such as air, for example, is supplied with the combustible gas to effect complete burning or combustion of the latter in the cup-shaped cavity 12. Under these conditions the suction pressure produced at the gap 36 may be regulated to withdraw and divert through the gap substantially all of the heated gases generated and developed in the burner cavity, so as to maintain the region at the open end of the cavity 12 practically quiescent. When such operation of the gas burner is effected, no blast of heated gases can be felt by the hand when it is momentarily placed over the open end of the burner cavity. The suction pressure produced at the gap 36 can therefore be regulated to maintain the gases immediately in front of the open cavity practically quiescent, so that the heated gases can pass substantially by diffusion only from the cavity into the environment immediately adjacent to the open end thereof.

The suction pressure produced at the gap 36 may be also regulated to minimize the flow of the heated gases by diffusion from the open end of the cavity. This may be accomplished by producing a suction pressure below the pressure prevailing in the cavity 12 and the region adjacent to the open end thereof which is of such magnitude as to produce a substantial inflow of the gases into the open end of the cavity, as indicated by the arrows C in Fig. 9. Such gases drawn into the open end of the cavity 12 pass toward the gap 36 and flow therethrough along with the heated gases diverted from the cavity. It is to be understood that there will always be a tendency for gases to be drawn into the open end of the cavity 12 due to the suction pressure produced at the gap 36. When a complete gas mixture is supplied to the burners, the suction pressure is preferably properly related to the gas mixture delivery pressure to effect substantially complete combustion of such mixture in the burner cavity.

When burners of the invention are employed to heat an enclosed space like the burners 10a in Figs. 7 and 8, the gas mixture supplied to the burners may be a partial mixture and some of the air to accomplish complete burning of the combustible gas may be drawn into the burner cavity by the negative pressure produced at the gap 36. The admission of air into heating chamber 51 may be positively controlled or may be due to leaks in the walls of the chamber. Such air passing into the heating chamber is heated therein and, due to such preheating, is capable of producing higher combustion temperatures in the burners when drawn into the cavities thereof.

Inward movement of heated air into a burner cavity 12 may be promoted due to the pressure conditions prevailing in the cavity. There is a low pressure region at the center of the cavity 12, adjacent to the enlarged end of the tip or orifice member 29, into which gases tend to be drawn, as indicated by the arrows D in Fig. 9. Since the suction effect produced at the gap 36 is strongest at the rim of the cavity and weakest at the central region thereof, an adequate flow of heated air may be induced at the center of the cavity, as indicated by the arrows E in Fig. 9, to supply part of the combustion supporting gas for effecting combustion of the combustible gas supplied in a partial mixture to the cavity 12.

Gas burners embodying the invention are especially useful in the firing of glazed surfaces, as in the glost firing of ceramic ware and in vitreous enamelling, for example. In such heating applications the work can be fired at high temperatures by radiant heat projected directly from the wall surfaces 31 of the cavities 12, without the necessity of shielding the work by a heat transfer wall, so that radiant heat transfer can be effected at the highest possible temperature from the burner cavities whose wall surfaces are heated to a highly radiant condition.

When the heating chamber 51 is employed for firing articles to produce glazed surfaces thereon the furnace is first brought up to the desired temperature by the burners 10a. If no provision were made for diverting the heated gases generated through the gaps 36 and the heated gases could freely pass into the heating chamber 51, the impurities in such gases, such as sulphur dioxide and sulphuric acid fumes, for example, would adversely affect the glazed or glass-like surfaces produced on articles being fired. However, in operating the burners 10a, heated gases can pass by diffusion only from each burner cavity 12, into the chamber 51.

Since the rate at which the heated gases pass into the chamber atmosphere by diffusion is relatively low, the extent to which objectionable impurities are carried into the gas present in the chamber is extremely small and insufficient to adversely affect the smooth and lustrous glazed surfaces produced on work. The heating chamber 51 is desirably closed after the work or goods to be fired is positioned therein for producing glazed surfaces on the work. Under these conditions the chamber 51 is filled with gases which are impoverished in impurities and usually referred to as "poor products of combustion."

When burners of the invention are incorporated in a wall of a heating chamber which is substantially closed, as the heating chamber 51 of Fig. 7, for example, the pressure in the chamber is below atmospheric pressure and "negative" due to the suction pressure produced at the gaps 36 of the burners 10a. Hence, the pressure in a closed heating space fired with burners 10a will be less than the pressure in the usual furnace or heater in which the gaseous atmosphere is "positive" and above atmospheric pressure. The fact that a heating space or chamber is at a negative pressure when fired by burners of the invention is not objectionable, unless there is excessive leakage of air in the chamber, as through cracks in the walls thereof, for example. An excessive amount of air in the heating chamber exercises a cooling effect and tends to reduce the temperature of the wall surfaces 31 of the burner cavities 12.

When an excessive amount of air enters the heating chamber the adverse effect of such air at the burner cavities can be overcome by increasing the suction pressure produced at the gaps 36. However, it is desirable to eliminate the leakage of air into the heating chamber when the presence of an excessive amount of air in the chamber interferes with the operation of the burners, especially when it is desired to operate the burners to provide radiant heat at the highest possible temperature to produce a high thermal head for heating work in a minimum length of time.

When work is being fired in a closed heating space, such as the heating chamber 51, to produce glazed or glass-like surfaces on work, the

atmosphere in the chamber is desirably oxidizing. In such case air admitted into the heating chamber may be referred to as "essential air" in that it purges the gases in the heating chamber and contributes to the production of high quality glazed surfaces on the work. However, any air passing into the heating chamber over and above that necessary to effect the desired end result may be referred to as "unessential air," because such air causes an undesirable drop in temperature in the heating chamber and does not serve any useful purpose.

In the operation of the heating chamber 51 of Fig. 7, when the latter is completely closed at both ends thereof, whatever circulation of gas takes place therein is due solely to leakage of air through the walls thereof. In a properly constructed heating chamber, a more or less stagnant atmosphere is maintained in the heating space during operation of the burners 10a, and any possible slight movement of the gases will occur only by reason of difference in temperatures in different parts of the heating space.

The manifold 37 for the gas burner 10 and the vertical flues 52 for the burners 10a are preferably of such size that the paths of flow provided for the diverted heated gases will be adequate to withdraw practically all of such heated gases generated and developed in the burner cavities when the burners are being operated at maximum capacity. Further, the flues 52 are considerably larger in cross-section than the gaps 36 so that the heated gases will pass at a lower velocity through the flues and give up heat to the side walls 50 in which they are incorporated and also to the chamber 52 through the flue walls formed by the plates 46a.

In the event any unburned gases are withdrawn and diverted from the cavities 12 through the gaps 36 into the flues 52, combustion of such gases may be completed in the flues because the cover plates 46a become heated to an incandescent temperature which is above the ignition temperature of the combustible gas. Under such conditions the flues 52 serve as heat radiating muffles and contribute to the heating of work in heating chamber 51.

When a combustible gas mixture of ordinary city gas and air is supplied to the burners 10a, such gas having a rating of about 550 B. t. u. per cubic foot, the wall surfaces of the cavities 12 may be heated to temperatures as high as 2800° F. and higher and are at a high thermal head for heating work in the chamber 51. The cover plates 33 for the burners are also heated to a high incandescent temperature which may be in the neighborhood of about 2500° F. and at a thermal head slightly below the wall surfaces 31 of the burner cavities. The plates 46a for the flues 52 are also heated to incandescence and are at a lower thermal head which may be in the neighborhood from about 50° to 100° F. and higher than the temperature of the gases in the heating chamber 51.

In view of the high temperature produced at the cover plates 33, such cover plates and the tie rods 43 are preferably formed of a refractory material, such as silicon carbide, for example, which is capable of holding up under extremely high temperatures without developing cracks and also possesses high tensile strength and resistance to thermal shock. The refractory plates 46 for the burner 10 and the refractory plates 46a for the flues 52 may be also formed of refractory material consisting entirely or pre-

ponderantly of silicon carbide. Since heat transfer is effected from the flues 52 through the cover plates 46a to the gases in the chamber 51, it is desirable to provide cover plates 46a formed of refractory material possessing good thermal conductive properties, such as silicon carbide, for example.

The refractory body 14 for the burners 10 and 10a may be formed of mullite or any other suitable refractory material having poor thermal conductive properties, so that the wall surface 31 of the cavity 12 formed at the front face of each body 14 can be effectively heated to the highest possible temperature. The tie rods 43 effectively hold each refractory body 14 together when the inner face thereof is heated to a highly radiant condition and stresses are induced in the body due to the rear parts remaining relatively cool while the regions adjacent to and at the inner surfaces 31 are heated to high temperatures.

In view of the foregoing, it will now be understood that an improved gas burner has been provided for heating work to high temperatures by radiant heat projected from refractory wall surfaces heated to a highly incandescent condition by combustion of a combustible gas mixture. The gas burner provided embodies the refractory shape or body 14 having tie rods 43 which not only serve to increase the life of such shape but also maintain the apertured plate 33 accurately positioned a short distance from the raised lip 35. The tie rods 43 of high tensile strength tend to retard cracks developing in the refractory shape 14 and also tend to retard the growth of cracks after they once occur. Further, when the refractory shapes 14 are subjected to repeated thermal shock over a long interval of time and such shapes may split, the tie rods 43 effectively hold each body together and prevent any part thereof being dislodged.

While the exhaust blower 41a has been provided to produce a suction pressure at the gap 36 of the burner 10 in Fig. 3, it will be understood that such suction pressure may be produced at the burner 10 and also the burners 10a in Figs. 7 and 8 in any other well known manner, such as, for example, by a steam or air ejector. Moreover, if it is desired to avoid the necessity of employing a high temperature exhaust blower, air may be drawn into the inlet of the exhaust blower along with the withdrawn heated gases to reduce the temperature of the latter. In addition, a heat exchanger may be connected in the conduit 40 to bring the withdrawn heated gases in heat exchange relation with another fluid to which heat is given up by the heated gases.

In the embodiments of the invention shown and described, the size of the aperture 34 in the plate 33 of each burner is suitably related to the opening of the cavity 12 at the rim 35, so that the heated gases will be effectively withdrawn from the cavity when a suction pressure is produced at the gap 36. This is accomplished in the embodiments of Figs. 1 to 6 and Figs 7 and 8 by providing apertures 34 in the plates 33 which are slightly less in diameter than the extreme open ends of the burner cavities.

Attention is called to applicant's copending application Serial No. 663,158 filed concurrently herewith, now Patent No. 2,509,856, which is directed to the structure of a kiln or furnace wall. Attention is also called to applicant's copending application Serial No. 663,159 filed con-

13

currently herewith, now Patent No. 2,474,301, which is directed to a method of firing a kiln.

Although I have shown and described several embodiments of the invention, it will be obvious to those skilled in the art that modifications and changes may be made without departing from the spirit and scope of the invention. Thus, the principles of the invention may be applied equally well to other forms of gas burners than that disclosed herein in which a large fraction or proportion of the heated gases generated and developed by the combustion of a combustible gas mixture is converted or translated to radiant heat. I therefore aim in the following claims to cover all modifications and changes which fall within the true spirit and scope of the invention.

What is claimed is:

1. A gas burner comprising flame distributing means for spreading a burning gaseous mixture including a combustible gas and a combustion supporting gas, structure including a member having a high temperature cup-shaped refractory surface, the distributed flame produced by said distributing means extending alongside said surface, said distributed flame being effective to heat said surface to incandescence, said member cooperating with said distributing means so that substantially the only combustion supporting gas passing through said member to the region at which the distributed flame is produced is that supplied by said distributing means, and said structure providing an outlet surrounding the edge of said cup-shaped surface and communicating therewith and extending outwardly in a radial direction therefrom, and means through which a pressure which is negative with respect to the pressure at the region the distributed flame is maintained and through which is discharged and diverted a large fraction of the heated gases generated at said region instead of flowing therefrom into the environment to which heat is radiated from said surface.

2. A gas burner comprising structure including a body having an open cavity at a face thereof, said cavity being provided with a high temperature inner refractory wall surface forming a combustion space having an apertured inlet member for subdividing into a plurality of gas streams a fuel mixture supplied thereto which may burn within said space to heat said inner wall surface to incandescence and produce a region of intense heat in which a large fraction of the combustion is completed, and said structure providing a radially extending outlet axially aligned in front of said cavity and communicating therewith and surrounding the same, and means through which said outlet is maintained at a pressure which is negative with respect to the pressure in said space and through which is discharged and diverted a large fraction of the heated gases generated in said space instead of flowing outwardly therefrom into the environment to which heat is radiated from said inner wall surface.

3. A gas burner comprising structure including a body of high temperature refractory having an open cavity at a face thereof provided with an inlet member formed with a series of flame projecting orifices, said cavity having a wall surface alongside of which the flames projected from said orifices extend, the flames being effective to heat said inner wall surface to incandescence, and said structure providing an outlet for said cavity encircling the edge thereof at a region

14

removed from said orifices and communicating therewith and extending radially outward therefrom, passage means communicating with the outlet, and means embodied in the passage means for producing a suction effect at the outlet to maintain the latter at a pressure below the pressure prevailing in said cavity to divert through the outlet into said passage means a large fraction of the heated gases generated in said cavity instead of flowing outwardly therefrom into the environment to which heat is radiated from said inner wall surface.

4. A gas burner comprising flame distributing means, structure including a cup-shaped member having a high temperature refractory surface alongside of which the distributed flame produced by said distributing means extends, said distributed flame being effective to heat said surface to incandescence, said structure providing an outlet associated with said member entirely around the edge of said surface at a region removed from said distributing means and communicating therewith and extending radially outward therefrom, passage means communicating with the outlet, and means embodied in said passage means for producing a suction effect at the outlet to maintain the latter at a pressure below the pressure prevailing at the region the distributed flame is produced to divert through the outlet into said passage means a large fraction of the heated gases generated at said region instead of flowing therefrom into the environment to which heat is radiated from said surface.

5. A gas burner comprising flame distributing means, structure including a member having a high temperature refractory surface alongside of which the distributed flame produced by said distributing means extends, said distributed flame being effective to heat said surface to incandescence, said structure providing at a region removed from said distributing means an outlet entirely surrounding the edge of said member and communicating therewith and extending radially outward therefrom, passage means communicating with the outlet, and means including an exhaust blower connected in said passage means for producing a suction effect at the outlet to maintain the latter at a pressure below the pressure prevailing at the region the distributed flame is produced to divert through the outlet into said passage means a large fraction of the heated gases generated at said region instead of flowing therefrom into the environment to which heat is radiated from said surface.

6. A gas burner comprising structure including a body of refractory material having an open cavity at a face thereof, said cavity having an inner wall surface forming a combustion space provided with an inlet through which a fuel mixture supplied under pressure may be burned within said space to heat the inner surface to incandescence, said structure including a member of refractory material having an opening therein said member being positioned at said face with said opening in front of said cavity, aligned therewith and spaced therefrom to provide a radially extending gap between said face and member, and means to maintain said gap at a pressure which is negative with respect to the pressure in said space and through which heated gases generated in said space may be discharged and diverted instead of flowing outwardly therefrom into the environment to which heat is radiated from the inner surface through the opening in said chamber.

7. A gas burner comprising structure including a body of refractory material having an open cavity at a face thereof, said cavity having an inner wall surface forming a combustion space provided with an inlet through which a fuel mixture supplied under pressure may be burned within said space to heat said surface to incandescence, said structure including a plate of refractory material having an opening therein, said plate being positioned over the open end of said cavity with said opening aligned with said cavity and said plate spaced from said face to provide a gap therebetween which is removed from the inlet, passage means communicating with the gap, and means operatively associated with said passage means for producing a suction effect at the gap to maintain the latter at a pressure below the pressure prevailing in said space to divert through the gap into said passage means heated gases generated in said space instead of flowing outwardly therefrom into the environment to which heat is radiated from the inner surface through the opening in said plate.

8. A gas burner comprising structure including a refractory shape having an open cavity at a face thereof, said cavity having an inner wall surface forming a combustion space provided with an inlet through which a mixture of a combustible gas and a combustion supporting gas supplied under pressure may produce combustion in said space which heats the surface to incandescence, means embodied in the shape to hold the latter together when the inner surface of said cavity is heated to a highly radiant condition and stresses are induced in said shape due to uneven heating thereof at regions adjacent to and removed from the inner surface, said structure including a plate of refractory material having an opening therein, and means including said shape holding means for locating said plate over the open end of said cavity with the opening therein aligned with said cavity and said plate spaced from said face to provide a gap therebetween which may be maintained at a pressure below the pressure prevailing in said space and through which may be discharged and diverted the heated gases generated in said space instead of flowing outwardly therefrom into the environment to which heat is radiated from the inner surface through the opening in said plate.

9. A gas burner comprising structure including a refractory shape having an open cavity at a face thereof, said cavity having an inner wall surface forming a combustion space provided with an inlet through which a mixture of a combustible gas and a combustion supporting gas supplied under pressure may produce combustion within said space which heats the surface to incandescence, means embodied in said shape for holding the latter together when the inner surface of said cavity is heated to a highly radiant condition and stresses are induced in the shape due to uneven heating thereof at regions adjacent to and removed from the inner surface, said holding means comprising tie rods of refractory material of greater tensile strength than the material forming said shape for anchoring regions of the latter adjacent to and removed from the inner surface, said structure including a member of refractory material having an opening therein which is positioned over the open end of the cavity with said opening aligned with said cavity, and means including said shape holding means for positioning said member in spaced relation to said face to provide a gap therebetween which

may be maintained at a pressure below the pressure prevailing in said space and through which may be discharged and diverted heated gases generated in said space instead of flowing outwardly therefrom into the environment to which heat is radiated from the inner surface through the opening in said member.

10. A gas burner comprising structure including a refractory shape having an open cavity at a face thereof, said cavity having an inner wall surface forming a combustion space provided with an inlet through which a mixture of a combustible gas and a combustion supporting gas supplied under pressure may produce combustion within said space which heats the inner surface to incandescence, means embodied in said shape for holding the latter together when the inner surface of said cavity is heated to a highly radiant condition and stresses are induced in the shape due to uneven heating thereof at regions adjacent to and removed from the inner surface, said structure including a plate of refractory material having an opening therein disposed over the open end of the cavity with said opening aligned with said cavity, means including said shape holding means for positioning said plate in spaced relation with said face to provide a gap therebetween, pressure means communicating with the gap, and means associated with said passage means for producing a suction effect at the gap to maintain the latter at a pressure below the pressure prevailing in said space to divert through the gap heated gases generated in said space instead of flowing outwardly therefrom into the environment to which heat is radiated from the inner surface through the opening in said plate.

11. A gas burner comprising structure including a refractory shape including an open cavity at a face thereof, said shape having a projecting rim at said face defining the extreme open end of the cavity whose inner wall surface forms a combustion space provided with an inlet through which a mixture of a combustible gas and a combustion supporting gas supplied under pressure may produce combustion within said space which heats the inner surface to incandescence, and said structure including a substantially flat plate of refractory material having an opening therein positioned over the open end of the cavity with said opening aligned with said cavity, the edge portion of said plate about the opening therein overlying said rim and being spaced therefrom to provide a narrow gap therebetween which may be maintained at a pressure below the pressure prevailing in said space and through which may be diverted heated gases generated in said space instead of flowing outwardly therefrom into the environment to which heat is radiated from the inner surface through the opening in said plate.

12. A gas burner comprising structure including a refractory shape having an open cavity at a face thereof, said cavity having an inner wall surface forming a combustion space provided with an inlet through which a mixture of a combustible gas and a combustion supporting gas supplied under pressure may produce combustion within said space which heats the inner surface to incandescence, a first member of refractory material having an opening therein which is positioned at said face with said opening aligned with said cavity and spaced therefrom to provide a gap therebetween, and a second refractory member overlying said first refractory member and cooperating with said shape to form a chamber communicating with said space in which a

17

suction effect may be produced to maintain the pressure at said gap below the pressure prevailing in said space for diverting into said chamber through said gap heated gases generated in said space instead of flowing outwardly therefrom into the environment to which heat is radiated from the inner surface through the opening in said first refractory member.

13. A gas burner comprising structure including a refractory shape having an open cavity at a face thereof, said cavity having an inner wall surface forming a combustion space provided with an inlet through which a mixture of a combustible gas and a combustion supporting gas supplied under pressure may produce combustion within said space which heats the inner surface to incandescence, a plate of refractory material having an opening therein which is positioned at said face with said opening aligned with said cavity and spaced therefrom to provide a gap therebetween, and a member of refractory material overlying said plate and cooperating with said shape to form a chamber communicating with said space, passage means communicating with said chamber, and means operatively associated with said passage means for producing a

18

suction effect at said gap to maintain the latter at a pressure below the pressure prevailing in said space and divert through said gap into said chamber heated gases generated in said space instead of flowing outwardly therefrom into the environment to which heat is radiated from the inner surface through the opening in said plate.

EMIL BLAHA.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,144,785	Rector	June 29, 1919
1,345,361	Good	July 6, 1920
2,117,356	Perry	May 17, 1938
2,215,079	Hess	Sept. 17, 1940
2,220,928	Kienle	Nov. 12, 1940
2,268,987	Hess	Jan. 6, 1942
2,268,988	Hess	Jan. 6, 1942
2,287,246	Hess	June 23, 1942
2,361,097	Hess	Oct. 22, 1944
2,379,017	McCollum	June 26, 1945