Sept. 16, 1947. C. R. BERGER, JR 2,427,545

INTERNAL-COMBUSTION GAS BURNER

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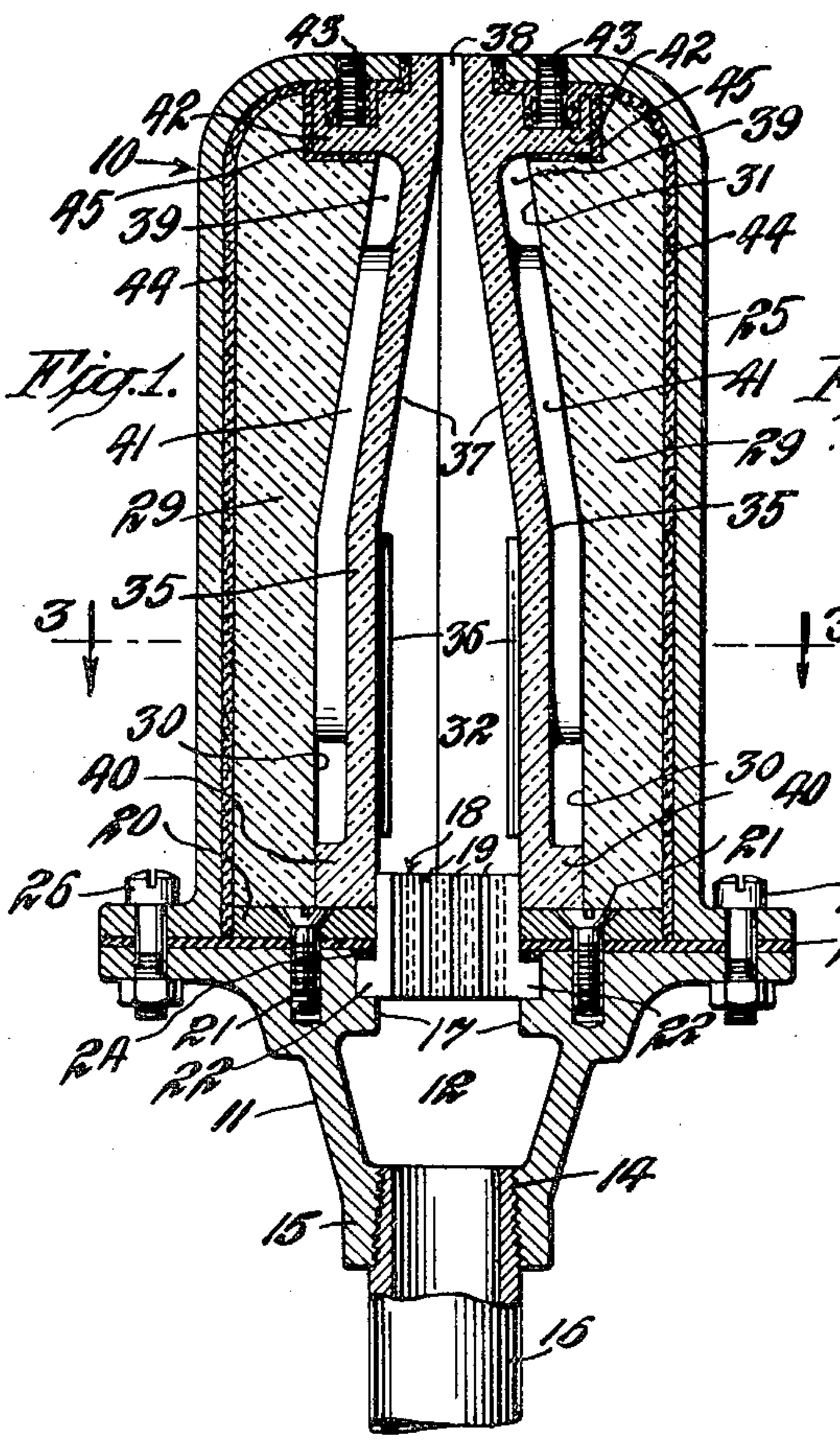

Fig. 1.

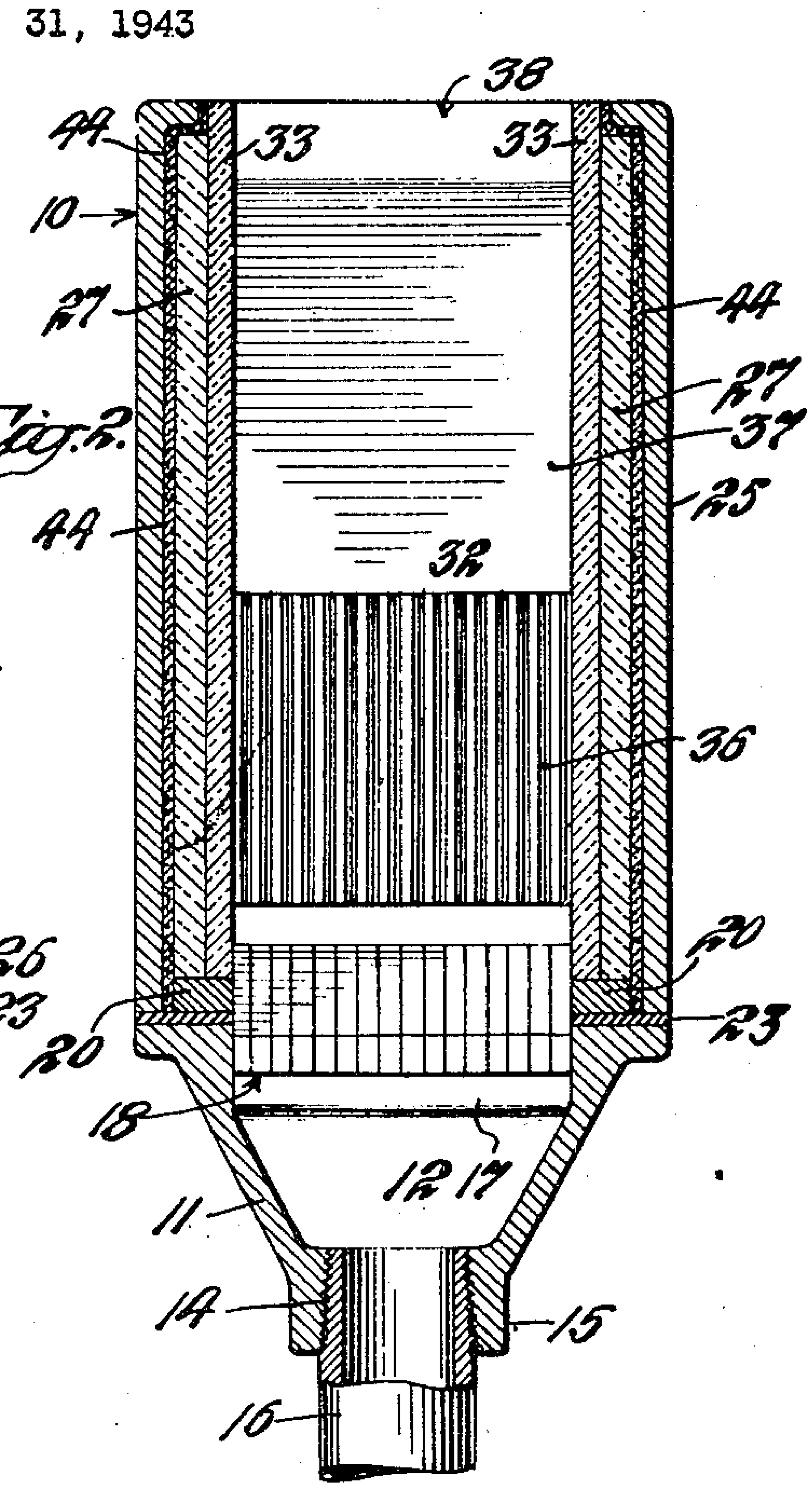

Fig. 2.

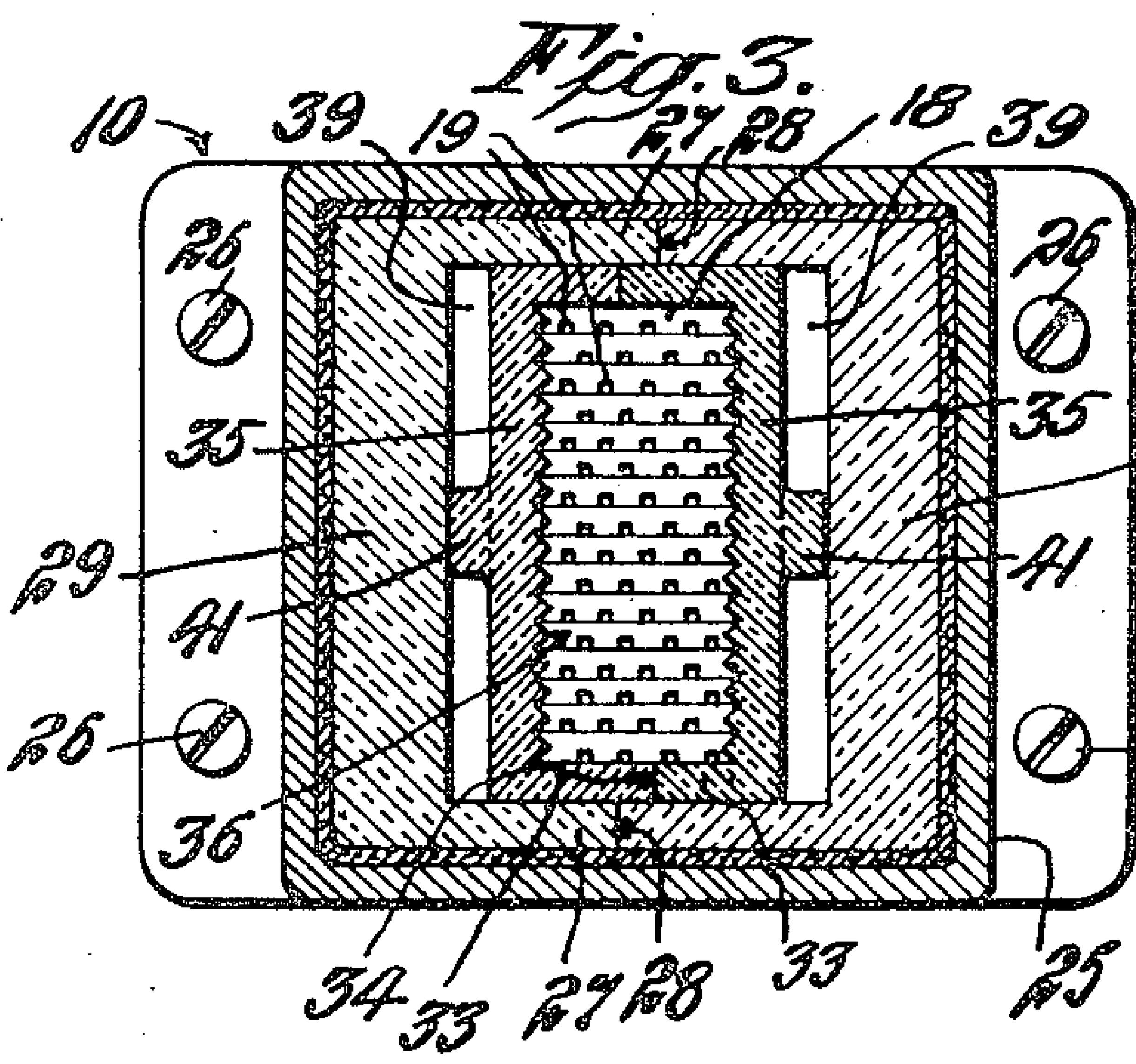

Fig. 3.

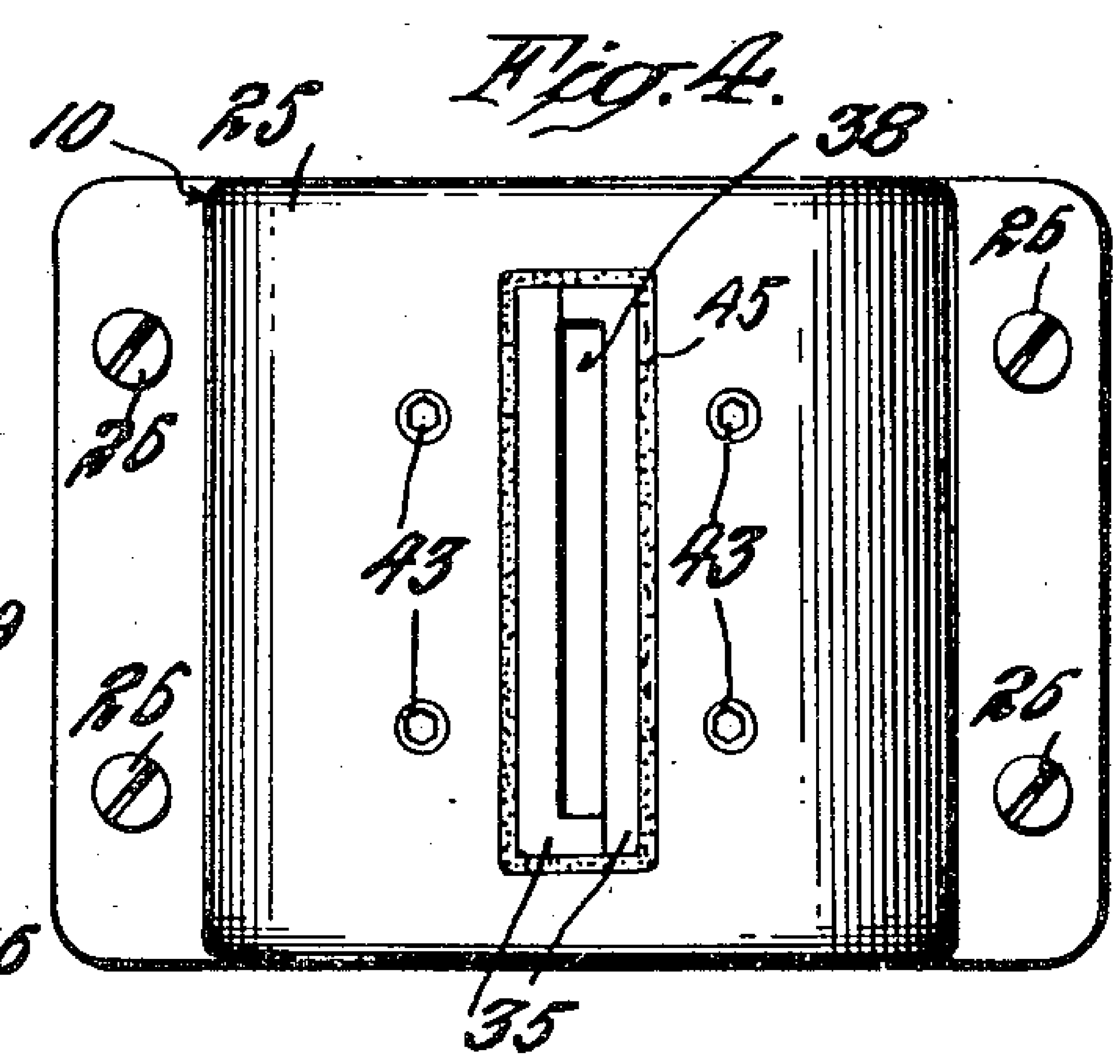

Fig. 4.

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INTERNAL-COMBUSTION GAS BURNER

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8 Claims. (Cl. 158—116)

1

My invention relates to gas burners, and more particularly to gas burners for producing a high velocity gas stream consisting of highly heated products of combustion developed substantially entirely within a combustion chamber embodied in the burner.

It is an object of the invention to provide an improvement for gas burners of this type, so that heat will be more effectively liberated in the combustion chamber and thereby increase the temperature of the heated products of combustion and velocity at which these heated gases are discharged from the combustion chamber.

The above and other objects and advantages of the invention will be more fully understood upon reference to the following description and the accompanying drawing forming a part of this specification, and of which Figs. 1 and 2 are end and side vertical sectional views, respectively, of a gas burner embodying the invention; Fig. 3 is a sectional view, taken on line 3—3 of Fig. 1, to illustrate the burner more clearly; and Fig. 4 is a top plan view of the burner.

Referring to the drawing, the gas burner 10 embodying the invention includes a base member 11 shaped to form an inlet chamber 12 communicating with an inlet opening 14 formed in a nipple connection 15. The nipple connection 15 is internally threaded to receive a conduit 16 through which a combustible fuel is delivered from a suitable source of supply.

The base member 11 is formed with internal shoulders 17 above the inlet chamber 12 to receive an apertured member or burner screen 18 formed with a plurality of openings or passages 19. As shown, the burner screen 18 comprises a plurality of relatively thin plates stacked and closely held together. One face of each plate is formed with a plurality of slots of relatively narrow depth, and the plates are stacked together with a slotted face of each plate, except one end plate, contiguous to and contacting a smooth face of an adjacent plate. Although not to be limited thereto, the thin plates forming the burner screen 18 may be formed of suitable refractory material.

To the top surface of the base member 11 is secured a slotted clamping plate 20, as by screws 21, for example, which overlies flanges or lugs 22 formed at opposing sides of the burner screen 18. In order to obtain a gas-tight seal about the burner screen 18, a gasket 23 formed of a suitable material, such as asbestos, for example, is interposed between the plate 20 and base member 11. The spaces 24 above the lugs 22 may be filled with a suitable high temperature fire-brick cement.

The open end of a cup-shaped metal shell or casing 25 is removably secured at 26 to the base member 11. Within the metal shell 25 is provided an outer wall or lining of refractory material. The outer refractory lining is formed by

2

a hollow rectangular shell comprising two similar or complementary wall parts, U-shaped in horizontal section, and having parallel ends or end walls 27, as shown in Fig. 3. The extreme edges of opposing end walls 27 at each end of the burner 10 are in abutting relation, as indicated at 28 in Fig. 3.

The closed ends or side walls 29 of the U-shaped parts are thicker in section than the end walls 27 and have the outer surfaces thereof conforming to the shape of the metal shell 25. The inner surfaces of the end walls 27 are straight throughout the heights of these walls, as best shown in Fig. 2. The inner surfaces of the side walls 29 include straight wall portions 30 extending upward from the plate 20 to an intermediate part of the outer refractory lining, and inwardly sloping wall portions 31 terminating at the upper part of the metal shell 25, as shown most clearly in Fig. 1.

A second inner refractory wall or lining is disposed within the outer refractory lining just described and forms a combustion chamber 32. The inner refractory lining is also formed by a hollow rectangular shell comprising two similar or complementary wall parts, U-shaped in horizontal section, and having parallel ends or end walls 33 over which snugly fit the ends 27 of the outer refractory wall parts, as shown in Fig. 3. The extreme edges of opposing end walls 33 at each end of the burner 10 are in abutting relation at 34, as shown in Fig. 3.

The inner surfaces of the end walls 33 are straight throughout the heights of these walls, as seen in Fig. 2. The closed ends or side walls 35 of the U-shaped parts forming the inner refractory lining include straight wall portions 36 extending upward from the plate 20 substantially the same distance as the straight wall surface portions 30 of the outer refractory lining, and inwardly sloping wall portions 37 terminating in a narrow rectangular-shaped slot or discharge orifice 38 projecting or extending through an opening at the top part of the metal shell 25. It will be seen that the inner surfaces of the straight walled portions 36 are vertically ribbed, as shown most clearly in Figs. 2 and 3, to increase the surface area presented by these portions of the inner refractory lining. The bottom edges of the inner refractory lining overlie and fit snugly against the peripheral edges of the narrow portion of the apertured member or burner screen 18 extending through the slot in clamping plate 20 toward the outlet 38.

The closed ends or side walls 35 of the inner refractory lining are spaced from the side walls 29 of the outer refractory lining to provide air gaps or spaces 39 therebetween. In order to provide the spaces 39 and at the same time rigidly hold the inner refractory lining within the outer refractory lining, the bottom edges of the side walls 35 of the inner refractory lining are provided with raised bosses 40 which butt against the bottom edges of the side walls 29 of the outer refractory lining, as shown in Fig. 1. In addition, the side walls 35 of the inner refractory lining are formed with vertical extending raised portions 41 of the shape shown in Fig. 3, which butt against both the straight wall portions 30 and sloping wall portions 31 of the side walls 29 of the outer refractory lining.

The U-shaped parts forming the inner refractory lining are provided at their upper ends with flanges 42 extending into and fitting in notched or recessed portions formed at the top edges of the side walls 29 of the outer refractory lining. Each of the flanges 42 is formed with a plurality of recesses at its top surface in alignment with threaded openings formed in the outer metal shell 25 to receive locking or retaining screws 43.

In order to retain the inner and outer refractory linings rigidly in position within the outer metal shell 25, so that each inner wall part is snugly nested within an outer wall part, the outer refractory lining is fixed to the inner surface of the shell 25 by a coating 44 of a suitable high temperature fire-brick cement. The flanges 42 of the inner refractory lining are also fixed at 45 to the recessed portions of the outer refractory lining by such high temperature cement, as shown in Fig. 1. Likewise, the abutting edges of the end walls 27 and 33 of the outer and inner refractory linings, respectively, may be united by high temperature cement. The recesses formed at the top surface of the flanges 42 are also filled with high temperature firebrick cement which, after hardening, firmly anchors the screws 43 in position and at the same time protects the screws from the high temperatures developed in the inner refractory lining during operation of the burner.

When it is desired to employ the burner 10 for heat treating purposes, a combustible fuel mixture, such as, for example, air and ordinary city gas, natural gas or the like, is supplied thereto through the conduit 16 from a suitable source of supply. When the burner 10 is relatively cool and at the temperature of the surroundings, the fuel mixture supplied thereto passes through the inlet chamber 12, burner screen 18 and chamber 32 from which it is discharged through the outlet or discharge orifice 38.

The combustible fuel mixture is initially supplied to the burner 10 at a relatively low pressure, such as five or six inches of water pressure, for example, so that the fuel mixture discharged from the chamber 32 can be ignited to produce and maintain a flame at the discharge orifice 38. When a flame is being maintained at the discharge orifice 38, the pressure of the fuel mixture supplied to the burner 10 is then reduced sufficiently to cause the flame to backfire from the discharge orifice 38 onto the burner screen 18 in chamber 32. When this occurs a plurality of flames are produced and maintained at the upper ends of the openings 19.

When the flames are being maintained within chamber 32 at the upper end of the burner screen 18, the pressure of the fuel mixture supplied to the burner 10 may be increased. After a short interval of time, the flames maintained at the top surface of the burner screen 18 effect such heating of the surfaces of the inner refractory lining that these surfaces are heated to a high temperature which may reach incandescence. Due to heating the inner refractory lining to a high temperature, complete combustion of the fuel mixture is effected in chamber 32 before the fuel mixture reaches the discharge orifice 38. From the orifice 38 is discharged a high velocity jet or stream of heated gases consisting substantially entirely of the heated products of combustion.

It is desirable in gas burners like that illustrated and just described to discharge the heated products of combustion at a maximum velocity and at the highest temperature possible. This is so because the rate of heat input effected by the gas stream discharged from the burner outlet 38 is dependent upon the temperature of the heated gases forming the gas stream, and the rate at which the gases are delivered from the refractory lined combustion chamber 32 embodied in the burner. In order to achieve this end it is necessary to give up to the heated products of combustion substantially all of the heat liberated in the refractory lined combustion chamber 32, and to reduce to a minimum the loss of heat through the walls of the combustion chamber.

In reducing heat loss through the walls of the combustion chamber to a minimum and thereby maintaining exceedingly high combustion chamber temperatures, it is necessary to provide an inner refractory lining which will, for prolonged periods of use, be capable of withstanding intense heat shock and temperature differential within the combustion chamber without fusing, blistering or cracking.

By embodying a double-walled refractory combustion chamber in the burner 10, an arrangement is provided in which heat loss through the burner walls is reduced considerably. Further, the inner and outer refractory linings may be formed of different refractory materials each possessing such properties that optimum burner performance will be obtained. Thus, the inner refractory lining, because of its being subjected to high combustion temperatures developed in combustion chamber 32, is preferably formed of a refractory material having relatively high resistance to thermal shock over a wide temperature range. Further, the inner refractory lining is preferably formed of a refractory which will provide a wall structure of exceptional strength and have rigidity under all burner operating conditions. In addition, the inner refractory lining must possess such physical properties that the inner highly heated surface will withstand the relatively high pressure of the gases at the high temperatures developed in combustion chamber 32.

Since the outer refractory lining is not directly subjected to the intense high temperatures developed in combustion chamber 32, the refractory material selected for the outer refractory lining is not chosen so much for its ability to withstand thermal shock, but primarily for its insulating or poor thermal conducting properties. In this way an effective thermal insulating wall structure is provided about the combustion chamber 32 which will effectively stand up for prolonged periods of use to produce a high temperature gas stream of high velocity and to which is given up substantially all of the heat liberated in combustion chamber 32.

In order to improve further the insulating characteristics of the combustion chamber wall structure, the air spaces 39 are provided between the inner and outer refractory linings. The spaces 39 provide regions in which the air is more or less stagnant, thereby improving the insulating characteristics of the two side walls of the burner 10. In addition, the provision of the air spaces further reduces the temperatures to which the outer refractory lining is subjected at the sides of the burner 10.

By way of example only, I have found that an outer refractory lining or wall formed of a material of the mullite type is very satisfactory. A refractory of this type possesses good insulating properties and preferably is of such porosity that it will have adequate strength to serve as the outer refractory lining and stand up under the uses normally encountered by a gas burner like that of burner 10.

Although not to be limited thereto, the inner refractory wall or lining may be formed of silicon carbide because of its high resistance to heat shock and rigidity and strength at high temperatures.

In the usual type of gas burner producing a bright and luminous flame burning in the open, the burner is usually positioned with respect to the object to be heated so that the tip of the flame, which is the region at the highest temperature, impinges the surface of the object. In gas burners operating with such a bright and luminous flame in the open, combustion or burning of the gas mixture takes place in the open. Under these conditions, combustion of the gas mixture is not taking place at the highest possible temperature because the heat liberated by the combustion reaction is given up to the cooler surroundings.

The burner 10 of the invention is characterized by the absence of a bright and luminous flame during normal operation of the burner. It is only when the burner 10 is first started that a flame is momentarily maintained at the elongated slot or discharge orifice 38, as previously explained. After the gas mixture has once been ignited, the gas delivery pressure is reduced sufficiently to cause backfiring into the chamber 32, so that burning of the gas mixture will take place at the top surface of the burner screen 18.

Each of the burner flames initially produced at the upper surface of burner screen 18 consists of an inner cone of unburned gas and air and an outer cone constituting the portion of the flame in which the combustion reaction is taking place. When operation of the burner 10 is first started and the inner refractory lining is relatively cool, the inner cones of the individual flames extending into the combustion chamber 32 are relatively long in length. As the inner refractory lining becomes heated, the inner cones of the individual flames become increasingly shorter and shorter. When the surfaces of the inner refractory lining become heated to a high temperature approaching incandescence, the inner cones of the individual flames become appreciably shorter from their original lengths when initially produced. It may be stated that under normal operating conditions, when the inner refractory lining reaches a high temperature approaching incandescence, the inner cones practically disappear and are not distinctly visible when the lower end of the combustion chamber 32 is viewed through the slot 38.

It should now be understood that combustion conditions are such in chamber 32 that rapid flame propagation is effected, thereby permitting an increase in the pressure at which the gas mixture is delivered to the combustion chamber. The combustion of the gas mixture is effected substantially entirely within the combustion chamber and heated products of combustion are discharged from the outlet 38 at an elevated temperature of 3200° F. and higher. Since the theoretical flame temperature of a gas mixture of air and ordinary gas is about 3700° F., it will be seen that a gaseous source of heat is made available by the burner 10 of the invention which is at a temperature approaching theoretical flame temperature.

Since the gas mixture is introduced into the combustion chamber 32 at a temperature of about 70° F. and heated to a temperature of 3200° F. and higher, the gases expand at least seven fold and at a rate directly proportional to increase in absolute temperature. In view of the fact that combustion of the gas mixture is effected substantially entirely within the combustion chamber 32 and the gases undergo considerable expansion, as just pointed out, any increase in the gas mixture delivery pressure consistent with the intended mode of operation effects an enormous increase in the rate at which the heated gases are discharged from the combustion chamber.

Burners like the burner 10 have been successfully used commercially with gas mixture delivery pressures up to 5 lbs. per square inch. In burners generally similar to the burner 10 and having an outlet slot or discharge orifice 2" x 1/8", and operating at a gas mixture delivery pressure of about 5 lbs. per square inch, it may be stated that the heated gases issue from the outlet at temperatures of 3200° F. and higher. In addition, it may be stated that these heated gases, consisting substantially entirely of heated products of combustion, are discharged from the burner at an average velocity of 900 feet or more per second and at a maximum velocity of about 1300 feet or higher per second. Burners of this type have been operated experimentally at gas mixture delivery pressures in excess of 5 lbs. per square inch and have produced high temperature gas streams at correspondingly higher temperatures and increased velocities.

An important operating character of the burner 10 is that the combustion chamber 32 is maintained above atmospheric pressure during normal operation of the burner. The ratio of the size of the restricted outlet 38 to that of the inlet formed by the openings or orifices 19 in burner screen 18, is such that the gas pressure will be maintained above atmospheric pressure in the combustion chamber 32 when the gas mixture is delivered at a pressure coming within the normal operating range usually encountered in practice. When the gas mixture is delivered at pressures up to 5 lbs. per square inch, and even at pressures above this delivery pressure, the ratio of the size of the outlet to that of the inlet of the combustion chamber is such that the gas pressure in the combustion chamber will be above atmospheric pressure. The maintenance of the combustion chamber above atmospheric pressure, together with the heating of the inner refractory surface of the combustion chamber to a high temperature, is of considerable importance in effecting rapid flame propagation and the attainment of a high rate of combustion.

When operating with a combustible gas mixture of air and city gas having a rating of about 500 B. t. u. per cubic foot, and at a gas mixture delivery pressure of about 5 lbs. per square inch, burners like that just described and illustrated are capable of liberating 40,000,000 or more B. t. u. per hour per cubic foot of combustion chamber space. In view of this high rate of heat liberation, the scope and field of application of burners like the burner 10 have been widened considerably. Although I do not wish to be limited thereto, it is my belief that the gas mixture introduced into the combustion chamber 32 is subjected to intense heat radiated from the highly heated surfaces of the inner refractory lining, thereby effecting complete burning of the gas mixture within the combustion chamber before the gas mixture reaches the outlet 38.

The double-walled inner refractory linings contributes materially to the excellent operating performance of the burner 10. Moreover, the insulating characteristics of the burner wall structure are improved by providing the air spaces 39 at two of the side walls of the burner. With this arrangement the loss of heat through the walls of the combustion chamber 32 is reduced to a minimum, as explained above, and substantially all of the heat liberated in the refractory lined combustion chamber 32 is given up to the heated products of combustion. The enormous expansion of the gases effected in the combustion chamber 32, in addition to the high temperatures attained, provides a source of gaseous heat capable of doing useful work in which large volumes of heated gases are developed at exceedingly high temperatures substantially equal to the high temperatures prevailing in the combustion chamber.

While I have shown two air spaces 39 at opposite side walls of the burner 10, it will be apparent that such air spaces may be provided at all of the side walls of the burner. Also, it may be desirable to fill the air spaces 39 with crumbled grog or the like to break down the dead air spaces 39 into smaller air spaces with a suitable heat insulating medium. Instances will also arise where it may be desirable to provide a burner like burner 10 in which no air spaces 39 are provided and the inner and outer refractory linings are more or less in abutting relation at all of the side walls of the burner. In such case, sufficient allowance may be made in dimensioning the inner and outer refractory linings so that the inner refractory lining can expand freely during burner operation and snugly fit and butt against the outer refractory lining. I therefore aim in the following claims to cover all changes and modifications which fall within the true spirit and scope of the invention.

What is claimed is:

1. A gas burner comprising a base and wall structure forming a combustion chamber having an inlet and a restricted outlet, said wall structure including an inner wall of high temperature refractory material defining the restricted outlet and having raised portions at the exterior thereof adjacent the inlet and outlet, a second wall of refractory material disposed about the inner wall having a recess forming a shoulder adapted to receive the raised portion of the inner wall adjacent the outlet, the inner and second walls at the inlet end of the chamber being adjacent to said base and extending therefrom, and an outer metallic shell removably secured to the base and enveloping the second wall, said shell having an opening at the region of the restricted outlet and acting against the raised portion of the inner wall adjacent the outlet, so that the raised portion of the inner wall adjacent the inlet will be firmly seated on the base.

2. A gas burner comprising a base having an opening and wall structure projecting therefrom forming a combustion chamber having an inlet communicating with the opening and a restricted outlet, said wall structure including an inner pair of complementary wall parts of refractory material extending axially of the burner and forming an inner wall for the chamber and an outer pair of complementary wall parts of refractory material disposed about and substantially coextensive in length with the inner wall parts and forming another wall surrounding the inner wall, each of said wall parts being U-shaped in section in a plane transverse to the axis of the burner and including a closed side and spaced apart ends transverse thereto and abutting the spaced apart ends of the complementary wall part, the wall parts being formed so that the ends of the outer wall parts snugly fit over the ends of the inner wall parts when each inner wall part is nested within an outer wall part, at least one of the closed sides of each pair of nested wall parts having projections extending from a surface thereof adapted to bear against the closed side of the other wall part in nested relation therewith to maintain the closed sides of the inner and outer wall parts in spaced apart relation and form gaps therebetween, and means to maintain the regions of the wall parts adjacent to the inlet firmly anchored to the base.

3. A gas burner comprising a base having an opening and wall structure projecting therefrom forming a combustion chamber having an inlet communicating with the opening and a restricted outlet, said wall structure including an inner pair of complementary wall parts of refractory material extending axially of the burner and forming an inner wall for the chamber and an outer pair of complementary wall parts of refractory material disposed about and substantially coextensive in length with the inner wall parts and forming another wall surrounding the inner wall, each of said wall parts being U-shaped in section in a plane transverse to the axis of the burner and including a closed side and spaced apart ends transverse thereto and abutting the spaced apart ends of the complementary wall part, the wall parts being formed so that the ends of the outer wall parts snugly fit over the ends of the inner wall parts when each inner wall part is nested within an outer wall part, at least one of the closed sides of each pair of nested wall parts having a rib integral therewith which extends lengthwise of the combustion chamber and is adapted to bear against the closed side of the other wall part in nested relation therewith to maintain the closed sides of the inner and outer wall parts in spaced apart relation and form gaps therebetween, and means to maintain the regions of the wall parts adjacent to the inlet firmly anchored to the base.

4. A gas burner comprising a base having an opening and wall structure projecting therefrom forming a chamber provided with an outlet and an inlet communicating with the opening having a multiplicity of apertures, said wall structure including an inner pair of complementary wall parts of refractory material extending axially of the burner and forming an inner wall for the chamber and an outer pair of complementary wall parts of refractory material disposed about and substantially coextensive in length with the inner wall parts and forming another wall surrounding the inner wall, each of said wall parts being U-shaped in section in a plane transverse to the axis of the burner and including a closed side and

spaced apart ends transverse thereto, and abutting the spaced apart ends of the complementary wall part, the wall parts being formed so that the ends of the outer wall parts snugly fit over the ends of the inner wall parts when each inner wall part is nested within an outer wall part, means including refractory material formed integrally with at least one of the closed sides of each pair of nested wall parts which is adapted to bear against the closed side of the other wall part in nested relation therewith to maintain the closed sides of the inner and outer wall parts in spaced apart relation and form gaps therebetween, and means to maintain the regions of the wall parts adjacent to the inlet firmly anchored to the base.

5. A gas burner comprising a base having an opening and wall structure projecting therefrom providing a combustion chamber having a restricted outlet in the form of a slot and an inlet communicating with the opening having a multiplicity of apertures, said wall structure including an inner pair of complementary wall parts of refractory material extending axially of the burner and forming an inner lining and the restricted outlet for the chamber and an outer pair of complementary wall parts of refractory material disposed about and substantially coextensive in length with the inner wall parts and forming another wall surrounding the inner wall, each of said wall parts being U-shaped in section in a plane transverse to the axis of the burner and including a closed side and spaced apart ends transverse thereto and abutting the spaced apart ends of the complementary wall part, the wall parts being formed so that the ends of the outer wall parts snugly fit over the ends of the inner wall parts when each inner wall part is nested within an outer wall part, means including refractory material formed integrally with at least one of the closed sides of each pair of nested wall parts which is adapted to bear against the closed side of the other wall part in nested relation therewith to maintain the closed sides of the inner and outer wall parts in spaced apart relation and form gaps therebetween, and means to maintain the regions of the wall parts adjacent to the inlet firmly anchored to the base.

6. A gas burner comprising a base having an opening recessed to form a seat, and wall structure forming a combustion chamber having an inlet and a restricted outlet, said wall structure including a flanged apertured member positioned at the opening in the seat therein, the apertured member serving as the inlet and having the narrow portion thereof projecting from the base toward the outlet, means including a slotted clamping plate removably secured to the base for retaining the apertured member in position at the opening, the narrow portion of the apertured member passing through the slotted plate, an inner wall of high temperature refractory material having an end thereof adjacent to the inlet adapted to bear against the clamping plate and overlie the narrow projecting portion of the apertured member, a second wall of refractory material disposed about the inner wall and having an end thereof adjacent to the inlet adapted to bear against the clamping plate, at least one of the walls having projections extending from a surface thereof adapted to bear against the other wall to hold at least parts of the walls in spaced apart relation and form a gap therebetween, and means including an open-ended metallic shell which envelops the walls and is removably secured at one open end thereof to the base to hold the ends of the walls adjacent to the inlet firmly seated on the clamping plate, the opening at the other end of the shell being disposed at the region of the restricted outlet.

7. A gas burner comprising a base having an opening, and wall structure forming a combustion chamber having an inlet and a restricted outlet, said wall structure including an apertured member, means for removably holding the apertured member in position at the opening in the base, the apertured member serving as the inlet and having a portion thereof projecting from the base toward the outlet, an inner wall of high temperature refractory material having the end thereof adjacent to the inlet adapted to bear against the base and overlie the projecting portion of the apertured member, a second wall of refractory material disposed about the inner wall and having the end thereof adjacent to the inlet adapted to bear against the base, at least one of the walls having ribs integral therewith which extend lengthwise of the combustion chamber, the ribs on the one wall being adapted to bear against the other wall to hold at least parts of the walls in spaced apart relation and form a gap therebetween, and means to hold the outer wall positioned against the inner wall and both of the walls against the base including an open-ended metallic shell removably secured at one open end thereof to the base, the opening at the other end of the shell being disposed at the region of the restricted outlet.

8. A gas burner comprising a base having an opening, and wall structure forming a combustion chamber provided with a restricted outlet in the form of a slot and an inlet, said wall structure including a multi-apertured member at the opening in the base, the apertured member serving as the inlet and having a portion projecting from the base toward the outlet, an inner wall of high temperature refractory material having the end thereof adjacent to the inlet adapted to bear against the base and overlie the projecting portion of the apertured member, a second wall of refractory material disposed about the inner wall and having the end thereof adjacent to the inlet adapted to bear against the base, at least one of the walls having projections extending from a surface thereof adapted to bear against the other wall to hold at least parts of the walls in spaced apart relation and form a gap therebetween, and means acting to hold the outer wall snugly pressed against the inner wall and hold both of the walls against the base including an outer shell removably secured to the base, the shell having an opening at the region of the outlet and enveloping a major portion of the outer wall.

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