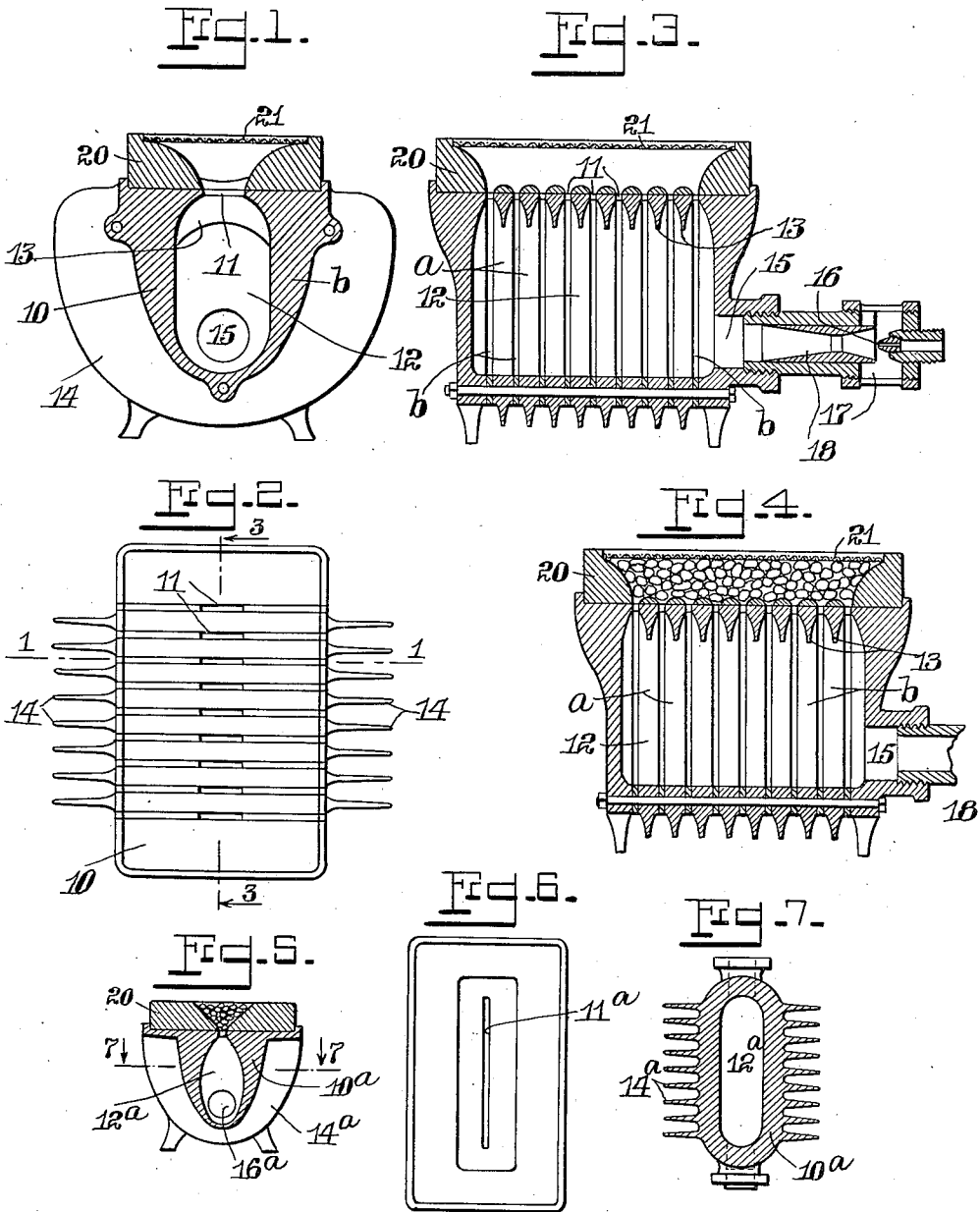


C. E. LUCKE.
 APPARATUS FOR BURNING EXPLOSIVE GASEOUS MIXTURES.
 APPLICATION FILED SEPT. 8, 1915. RENEWED OCT. 31, 1918.

1,313,196.

Patented Aug. 12, 1919.

3 SHEETS—SHEET 1.



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3 SHEETS—SHEET 2.

Fig. 2.

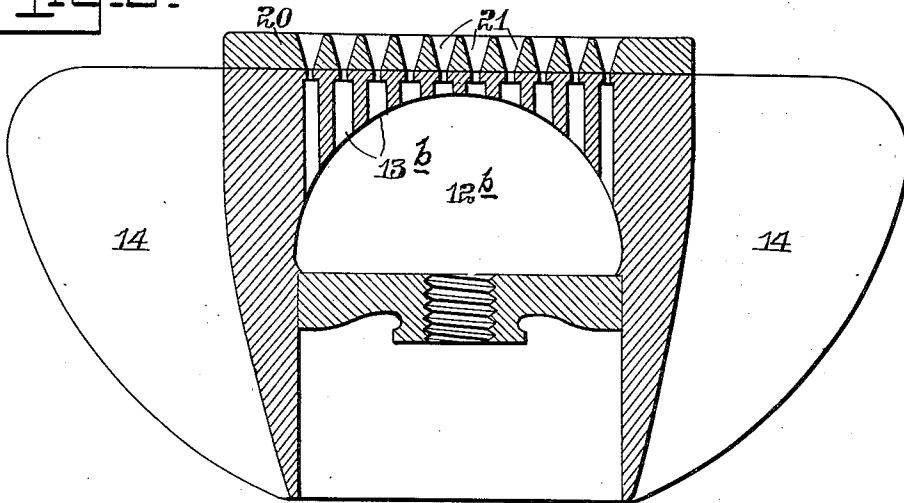
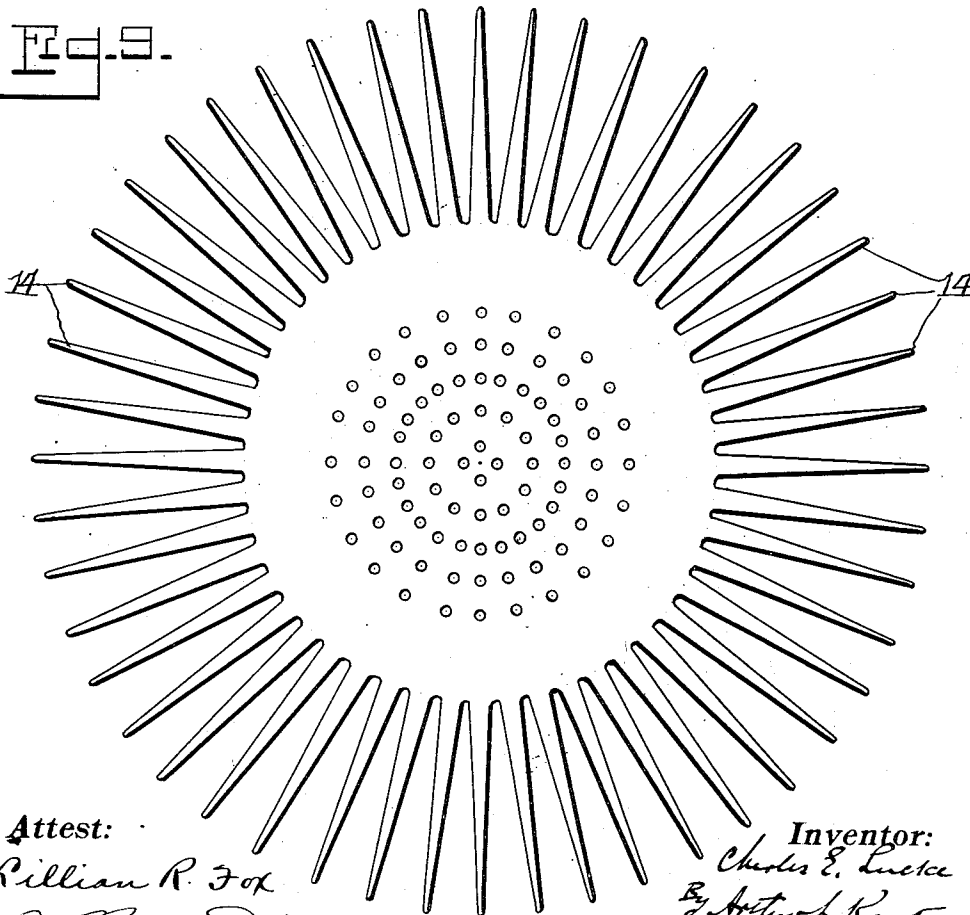


Fig. 3.



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3 SHEETS—SHEET 3.

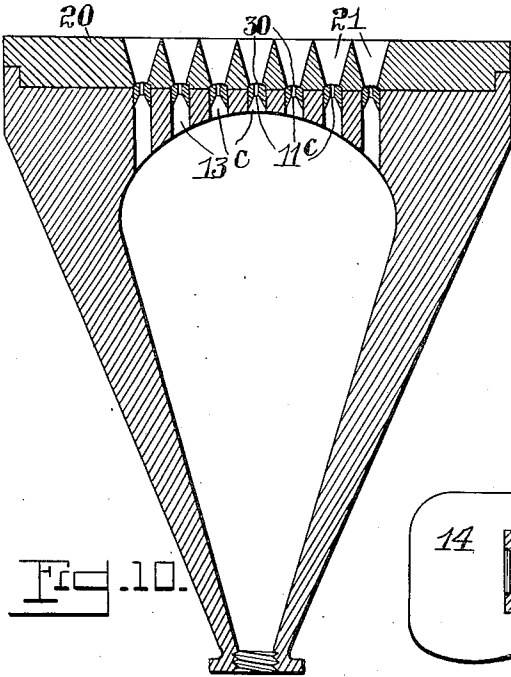


Fig. 10.

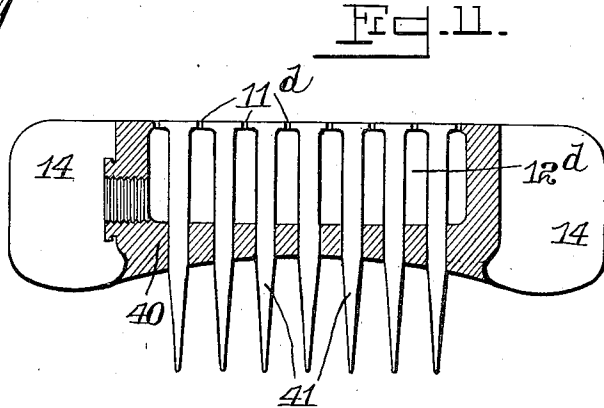


Fig. 11.

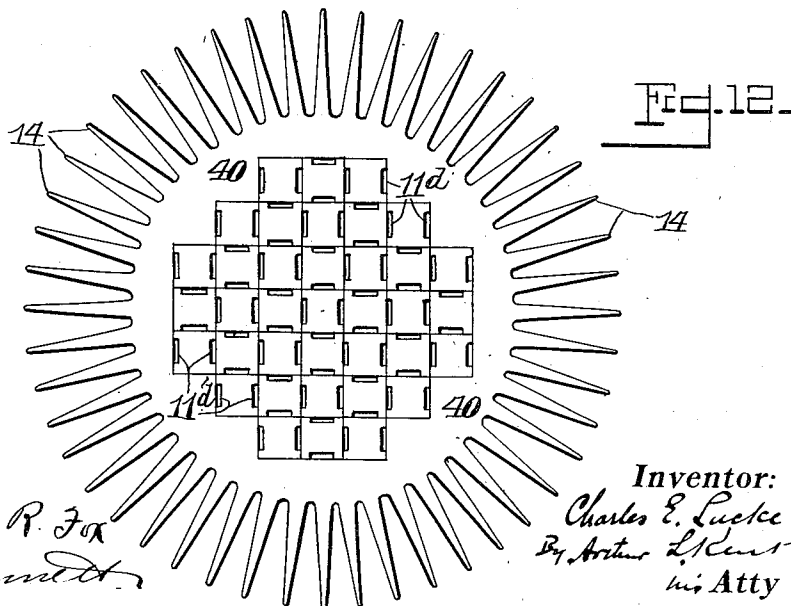


Fig. 12.

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APPARATUS FOR BURNING EXPLOSIVE GASEOUS MIXTURES.

1,313,196.

Specification of Letters Patent.

Patented Aug. 12, 1919.

Application filed September 8, 1915, Serial No. 49,561. Renewed October 31, 1918. Serial No. 260,544.

To all whom it may concern:

Be it known that I, CHARLES E. LUCKE, a citizen of the United States, residing at New York city, in the county of New York and State of New York, have invented certain new and useful Improvements in Apparatus for Burning Explosive Gaseous Mixtures, fully described and represented in the following specification and the accompanying drawings, forming a part of the same.

This invention relates to apparatus for burning explosive gaseous mixtures. The object of the invention is to provide apparatus suitable for use generally and by which localized and non-explosive or continuous combustion of such mixtures may be maintained with the mixture supplied under comparatively low pressure.

Continuous and localized combustion of explosive gaseous mixtures may be maintained by feeding the mixture through a passage with a velocity greater than the rate of propagation of inflammation of the mixture in order to prevent back-flashing and then rapidly reducing the flow velocity and burning the mixture where the flow velocity equals the rate of propagation of inflammation of the mixture, and also by feeding the mixture with a velocity less than the rate of propagation of inflammation of the mixture through a flame interrupting passage or orifice which is of such width that back-flashing will be prevented by the cooling action on the mixture of the walls of the passage or orifice, the mixture then burning as it escapes from the passage or orifice. In an apparatus for burning explosive gaseous mixtures in either of these ways, where the combustion takes place closely adjacent to the discharge opening, it is necessary that the apparatus be constructed so as to prevent heat from being conducted backward through the walls of the supply passage to such extent as to heat the walls of the mixture supply chamber to the temperature of ignition of the mixture, and in an apparatus operating on the principle of the flame-interrupting passage, to prevent back-flashing it is necessary that the walls of the flame-interrupting passage or passages shall be kept at such comparatively low temperature that they may continue to perform their function of cooling, or abstracting heat from, the mixture itself flowing through the passage or passages sufficiently to prevent

ignition thereof by heat communicated back through the mixture and consequent back-flashing. The difficulty of preventing backward conduction of heat through the walls of the supply passages is especially troublesome in apparatus in which the mixture is supplied to the place of combustion through a large number of closely adjacent passages.

U. S. Patents Nos. 1,113,171, granted on an application of Frank Creelman, and 1,113,174, granted on an application of Charles E. Lucke and Frank Creelman, both dated October 6, 1914, show apparatus constructed to prevent backward conduction of heat from the combustion zone to the supply chamber to such an extent as might cause ignition of the mixture in the supply chamber; and in my application Serial No. 768,774, filed May 20, 1913, there is disclosed a low pressure burner or apparatus for burning explosive gaseous mixtures intended especially for preventing back-flashing by the cooling action on the mixture stream of the walls of passages of a flame-interrupting screen which is formed to dissipate the heat conducted from the place of combustion to such an extent as to maintain the flame interrupting property of the screen and to prevent portions of the screen adjacent the supply chamber from becoming heated to the temperature of ignition of the mixture. The construction of the apparatus of each of said patents and of said application is such that the heat is conducted away from the walls of the mixture passages to such an extent as to secure the desired results, and in each of them the passages through which the mixture is supplied to the place of combustion lead from a mixture supply chamber located close to the place of combustion so as to reduce the length of the small supply passages and thereby avoid excessive resistance to flow of the mixture.

A principal object of the present invention is to still further reduce the resistance to flow of the mixture in passing from the mixture chamber to the place of combustion so as to further reduce the pressure required to be maintained in the mixture chamber. To reduce the flow resistance as much as possible, it is necessary to reduce as much as possible the length of the small passage or passages through which the mixture flows to the combustion space. I therefore provide in apparatus embodying the present invention very short discharge pas-

sages or orifices. As a body or plate of a thickness equal to the length of such very short passages or discharge orifices, even if made of a metal of high thermal conductivity, would not have the necessary conducting capacity for carrying heat away from the walls of the orifices rapidly enough to maintain such walls at the desired comparatively low temperature, I form the metal body in which the discharge orifices are located so that it shall have the necessary large heat conducting capacity by making it of such form that it shall have a rapidly increasing cross-section in the direction of the flow of heat from the walls of each orifice and shall be of such cross-section or mass at any part that such part shall have the required heat conducting capacity for carrying away at the necessary rate all heat reaching such part from the walls of any one or more of the discharge orifices. This result is most desirably attained by providing a body of metal of high heat conductivity of the required mass or cross-section and forming through it discharge passages leading from a supply chamber to the place of combustion constricted at their discharge ends to form the desired discharge orifices.

Suitable means must also of course be provided for dispersing the heat conducted outward through the metal body, and for this purpose suitable dissipating surfaces of large extent are most desirably provided for discharging the heat directly to the surrounding atmosphere. It is desirable that the burner or apparatus shall not be dependent upon the provision of any circulating fluid for carrying away heat from the metal body, but the invention in its broader aspect is not to be limited in this respect. The body in which the discharge orifices are formed should, as before stated, be of a material of high thermal conductivity, and most desirably is formed of a metal of a conductivity of the class of that of copper, aluminum, etc., and including suitable alloys; and of these metals I consider aluminum the best, for the reason that while it is not the best conductor, it is the best for cost and availability.

The invention has been made especially with the idea of providing a burner for explosive gaseous mixtures intended for burning mixture supplied under a pressure not sufficient to cause the mixture to flow through the discharge orifice or orifices with a velocity in excess of the rate of propagation of inflammation of the mixture, and in which back-flashing is prevented by the cooling action of the walls of the discharge orifice or orifices on the mixture flowing there-through, such discharge orifices having a cross-section or width sufficiently small to so act; and of securing in such a burner the

necessary abstraction of heat from the walls of the discharge orifices with a minimum mixture flow resistance so that a suitable quantity of mixture may be discharged through the orifice or orifices with a very low supply pressure. The invention is also applicable to, and of great value for, burners intended for burning explosive gaseous mixtures supplied under pressure sufficient to cause the mixture to flow through the discharge orifice or orifices with a velocity greater than the rate of propagation of inflammation of the mixture, and in which such excess flow velocity is depended on to prevent back-flashing, and localization of combustion is secured by rapidly reducing the flow velocity of the escaping mixture. In such burners also, the reduction of resistance to flow of the mixture and consequent reduction of the pressure necessary to give the required velocity of discharge is sometimes of great advantage. Such burners need not, of course have their discharge orifices of such small width as to serve as flame-interrupting passages or orifices which prevent back-flashing by cooling the mixture stream. But by providing burners having flame-interrupting orifices with means for causing the mixture flowing from the orifices to spread out rapidly with reduction of flow velocity, they are made adaptable for burning explosive mixtures supplied under a range of pressures including pressures sufficient to cause the mixture to flow through the discharge orifices with a velocity in excess of the rate of propagation of inflammation of the mixture and pressures not sufficient to cause such excess flow velocity through the discharge orifices.

When it is desirable to develop radiant heat with a burner not provided with velocity reducing means, some suitable solid matter is disposed with reference to the discharge orifices, so that it will be heated to incandescence when the burner is in operation. Such matter should most desirably be arranged so as not to reflect heat back to the metal body of the burner to any considerable extent. A hearth of fire brick or other suitable refractory material of low heat conductivity, formed with flaring holes registering with the discharge orifices and covering practically all of the outer or hearth wall of the metal body without offering any gas flow resistance, is desirably provided. The side walls of the flaring holes of such hearth will become radiant themselves, but may be supplemented by suitably disposed screens of a suitable metal, such as nickel or a nickel alloy, or other suitable material.

It will be understood that by the term "explosive gaseous mixture" as used herein is meant a mixture of a suitable combustion supporting gas, either oxygen alone or air

or other oxygen-containing gas, with combustible matter in a gaseous or other finely divided state in proper proportions, that is, in proportions such that the mixture will have the property of self-propagation of inflammation. For producing the highest temperature, the oxygen should be undiluted and the mixture should contain oxygen and combustible matter in chemical combining proportions at the time of combustion; but there may be an excess of either the combustible matter or the combustion supporting gas within the limits which determine the property of self-propagation. The mixture may be varied in this respect according to the desired character of the products of combustion, that is, whether it is desired that the products shall be neutral, oxidizing or reducing. Also, the mixture may of course contain neutral gas such is nitrogen, carbon dioxide or water vapor, so long as the amount of such neutral gas is not sufficient to make the mixture non-explosive.

The accompanying drawings illustrate various forms of apparatus made in accordance with the present invention. In said drawings:

Figure 1 is a sectional view taken on line 1—1 of Fig. 2 of a burner made in accordance with the invention;

Fig. 2 is a plan view of the burner shown in Fig. 1 with the layer of refractory material or hearth removed;

Fig. 3 is a sectional view taken on line 3—3 of Fig. 2;

Fig. 4 is a view similar to Fig. 3 but showing the burner supplied with a combustion localizing bed;

Fig. 5 is a sectional view of a single slot burner shown as provided with a combustion localizing bed;

Fig. 6 is a plan view of the burner shown in Fig. 5 with the combustion localizing bed removed;

Fig. 7 is a section taken on line 7—7 of Fig. 5;

Fig. 8 is a sectional view of another form of burner embodying features of the invention;

Fig. 9 is a plan view of the burner shown in Fig. 8;

Fig. 10 is a sectional view of a burner which is a modification of the form of burner shown in Figs. 8 and 9;

Fig. 11 is a sectional view of another illustrative form of burner, and

Fig. 12 is a plan view of the burner shown by Fig. 11.

Referring to the drawings, and first to Figs. 1, 2 and 3, the burner shown in these figures comprises a metal body 10 formed to provide a plurality of discharge orifices 11 through which explosive gaseous mixture from a mixture chamber 12 is discharged to be burned. The discharge orifices in the

particular form of burner shown in these figures are in the form of a plurality of parallel slots extending through the upper wall of the metal body 10. The discharge orifices are made very short in the direction of flow of the mixture through them, and below the orifices and between the orifices and the mixture chamber proper the metal of the body is extended downward or inward between the discharge slots or orifices so as to provide a comparatively substantial body 13 of metal between the slots and connected with the portions of the body beyond the ends of the slots. The openings or passages between such inwardly extending portions 13 of metal between the slots are of greater cross-sectional dimension than the slots, the walls of such openings most desirably spreading outward or away from each other in the directions both widthwise and lengthwise of the slots, so as to avoid resistance to flow of the mixture and thereby reduce the resistance to flow of mixture escaping from the supply chamber to that minimum resistance offered by the discharge orifice itself. The body may be considered as being formed with discharge passages leading from the mixture chamber which are constricted at their upper or discharge ends to provide short portions or discharge orifices of the desired cross-sectional dimension or width.

The walls of the passages or flow spaces leading to the discharge orifices being as shown and as above described, the metal body will have the desired rapidly increasing cross-section in the direction in which heat received by the walls of the orifices will flow from such walls through the body. The body should also be of such cross-section or mass at any part thereof which receives heat flowing through the body from the walls of the orifices that such part shall have the required heat conducting capacity for conducting at the necessary rate all heat reaching such part from the walls of any of the discharge orifices. Any suitable means may of course be resorted to for taking from the body the heat conducted through it. It is most desirable, however, and especially for small burners, not to resort to means involving forced circulation in contact with the body of water or other cooling liquid or gas, but to secure the discharge of heat from the body to the surrounding atmosphere by providing the body with an extended heat-dissipating surface of suitable area, and for this purpose the body, itself suitably extended, may be provided with relatively thin ribs or fins 14 extending therefrom. The body is best extended downward about the mixture chamber, and I consider it most desirable to have the body extend completely about the mixture chamber, that is, that the mixture chamber shall be formed within the

metal body as shown, as I thereby secure a large extent of discharging surface of the body with simple construction. The portions of the body extending downward and about the sides and bottom of the chamber are desirably made of gradually decreasing thickness since the required heat conducting capacity decreases in the portions more remote from the discharge orifices by reason of the heat already disposed of.

When the cooling action of the walls of the discharge orifices on the mixture passing through them is to be depended upon to prevent back-flashing through the orifices and ignition of the mixture in the supply chamber, the width of the orifices must of course be sufficiently small to secure this result. While the maximum width of the orifices will vary according to the character of the mixture to be burned, orifices of between .02 and .03 of an inch in width will usually be found most suitable.

An inlet opening 15 is provided to the mixture chamber through which the explosive mixture may be supplied from any suitable source or in any suitable manner. As shown, a mixing injector is provided for supplying an explosive mixture of fuel gas and air, the gas being supplied to the injector nozzle 16 under suitable pressure and air being drawn into the combining tube 17 of the injector by the gas jet, and the gas and air then passing through the neck of the injector and through the discharge or pressure cone 18 to the supply chamber. The injector should be designed and the nozzle and combining tube set in proper relative position, as by adjusting either one, to supply a mixture containing the gas and air in suitable combining proportions, and the gas should reach the injector under sufficient pressure to cause the mixture in the supply chamber to be maintained under such pressure as will cause the mixture to flow through the discharge orifices in quantities sufficient for the desired rate of combustion, though not with a velocity in excess of the rate of propagation of flame through the mixture when no means for causing lateral spreading of the mixture leaving the orifice is provided. The supply chamber should be large enough to permit the mixture to move therein with such comparatively low velocity as to secure a substantially uniform supply of mixture to all the discharge orifices.

A layer or hearth 20 of fire brick or other suitable refractory material of low heat conductivity is best provided covering the outer or hearth wall of the metal body and formed with outwardly flaring openings or holes registering with the discharge orifices. Such hearth or covering layer protects the metal body from a great deal of heat which would otherwise enter it, and also provides walls adjacent the place where combustion takes

place which become highly heated and serve as sources of radiant heat. Such walls of the flaring openings will reflect little if any heat back to the metal body. As sources of radiant heat, they may also be supplemented by a suitably disposed screen 21 of a suitable non-oxidizable metal, such as nickel or a nickel alloy, or other suitable material best formed with openings for the escape of the products of combustion, such for example, as a perforated silica or metal plate or woven wire netting.

The metal body, in order that it shall have the necessary heat conducting capacity, is best made, as before pointed out, of metal of high thermal conductivity such as copper or aluminum. The body may be formed of a single integral piece of metal or of separate parts formed and secured together in any suitable manner so as not to interfere with the flow of heat through the body from the walls of the discharge orifices. In the burner shown in Figs. 1, 2 and 3, the body is formed of a series of body sections *a* alternating with thin spacing sections *b*, the end body sections being formed to provide end walls for the mixture supply chamber. The intermediate body sections are each formed so that the metal extends completely about a central opening and is cut away at the top of the opening as shown to provide the portions 13 which extend downwardly between adjacent discharge passages. The spacing sections are of the same general form as the body sections except that each spacing section has an opening through the top portion thereof of a length equal to and which determines the length of the discharge orifice. The body sections and spacing sections are shown as secured together by bolts which extend through lugs projecting outward from the sections.

In use, assuming the discharge orifices of the burner to be of such small width as to serve as flame-interrupting orifices, and assuming the burner to be used as shown without being provided with any means for reducing the flow velocity of escaping mixture, then the explosive gaseous mixture supplied to the mixture chamber 12 will be maintained under such low pressure therein that the velocity of flow of the mixture through the discharge orifices will be less than or equal to or not much in excess of the rate of propagation of inflammation of the mixture, and the mixture will burn at the discharge side of the orifices or slightly within the orifices. Heat entering the body adjacent the orifices will pass through the body and be discharged from the fins 14, and the temperature of the walls of the orifices and other walls in contact with the mixture will be kept suitably low so that ignition of mixture in the mixture chamber or in the passages 13 will be prevented and the flame-

interrupting property of the discharge orifices will be maintained. In a properly designed burner having a body of aluminum or other metal of a like order of heat conductivity, the hottest parts of the body near the mixture exits will not be materially hotter than the most distant parts, that is, by providing for sufficient amount of heat conducting capacity of the body the temperature difference between the hottest and coolest parts of the body may be controlled in a similar manner and by similar means as the difference in potential between parts of an electrical conductor is controlled. The layer or hearth 20 will serve as a heat insulating body protecting the hearth face of the body from heat which would otherwise enter it and limiting the loss of heat, and at the same time the walls of the hearth layer adjacent the discharge orifices become highly heated and serve as a source of radiant heat. The screen 21, if provided, will also become highly heated and radiate heat.

If the burner is to be operated with such pressure maintained in the mixture chamber as to cause the mixture to flow through the discharge orifices with a velocity appreciably in excess of the rate of propagation of inflammation of the mixture, then means should be provided for causing the mixture flowing from the discharge orifices to spread out with rapid reduction of its flow velocity. Fig. 4 shows a burner of the construction shown in Figs. 1 to 3 provided with a porous and permeable combustion bed of refractory material formed to cause the mixture entering it from the discharge orifices with an excess velocity to spread out and advance with rapidly increasing cross-section and decreasing velocity, such bed being shown as formed by broken, molded or other suitable pieces of highly refractory material such as alundum, chrome ore or magnesite, or fire-clay, filled into the space between the flaring walls of the openings in the hearth or layer 20. The pieces or granules forming the bed may be either loose or bonded together and may vary in size according to the size, design and intended use of the burner, and especially according to the thickness of the bed. A burner such as shown in Fig. 4 having discharge orifices of a width sufficiently small to prevent back-flashing by cooling, or abstracting heat from, the mixture streams passing through the orifices may be operated with mixture maintained in the supply chamber under a range of pressures including those which will cause the mixture to be discharged through the orifices with a velocity greater than the rate of propagation of inflammation of the mixture and lower pressures which will not cause such excess velocity of discharge. When the mixture flows through the discharge orifices with a velocity less than the rate of propagation of in-

flammation of the mixture, combustion will take place at or just within the mouths of the orifices, but when the mixture is discharged with a flow velocity appreciably in excess of the rate of propagation of inflammation, the mixture leaving the discharge orifices with such excess velocity will have its velocity reduced as it advances through the combustion bed and the surface or zone of combustion will then locate within or at the outer surface of the bed where the reduced flow velocity equals the rate of propagation of inflammation. When sufficient mixture is being burned, the combustion bed will become uniformly heated to a high state of incandescence and serve as a source of radiant heat. If because of the small amount of mixture being burned and the size of the granules the bed does not become uniformly heated, the radiating screen 21 may still be uniformly heated to incandescence by the products of combustion escaping through the bed and passing the screen. Heat received by portions of the body adjacent the place of combustion will be conducted away and dissipated as before pointed out, so that ignition of mixture in the supply chamber and in the flow passages 13 will be prevented, and the property of the narrow orifices of preventing back-flashing when the mixture is flowing with a velocity less than the rate of propagation of inflammation will be maintained.

This burner provided with velocity reducing means such as that shown in Fig. 4 need not have its discharge orifices of such small width as to act as flame-interrupting orifices provided it is to be operated only with the mixture maintained under such pressure in the supply chamber that backflashing will be prevented by reason of the fact that the mixture flows through the discharge orifices with a velocity greater than the rate of propagation of inflammation of the mixture.

Figs. 5, 6 and 7 illustrate a simple form of burner having a single elongated or slot shaped discharge orifice 11^a and a body 10^a formed of a single piece of metal shaped to provide an elongated mixture supply chamber 12^a located wholly within the body. The discharge orifice communicates with the upper part of the mixture chamber and the orifice and the upper part of the chamber may be considered as forming a mixture flow or discharge passage of decreasing cross-area terminating in a discharge orifice. The mixture to be burned is supplied to the chamber through an inlet 16^a, and the chamber may be formed with such an inlet opening at each end either one to be used and the other to be plugged as shown, this both for convenience in manufacture and to enable the supply connection to be made to either end of the burner.

The upper portion of the body is made

sufficiently thick so that the portions adjacent the discharge orifice shall be of rapidly increasing cross-section in the direction of flow of heat through the body from the walls of the orifice or from the heat receiving parts of the body, and is formed so that all parts of the body shall have the required heat conducting capacity to conduct away all heat reaching such parts at the necessary rate. The extension of the body about the mixture chamber gives an extended heat dissipating surface and such surface is desirably extended by providing fins or ribs as shown. The lower portions of the body to which only a part of the heat received by the body is conducted, may be, and for lightness desirably are, of less thickness than the portions nearer the discharge orifice. The burner is provided with a hearth layer 20 formed with a flaring opening registering with the discharge orifice, the hearth face of the body being shown as extended to provide a sufficient support for such hearth layer. The hearth 20 performs the same functions in this burner as in the burner previously described. As in the case of the burner of Figs. 1 to 4, also, the discharge orifice may be of such small width as to serve as a flame-interrupting orifice, in which case means for reducing the velocity of gas escaping from the orifice may or may not be provided as desired, or the orifice may be of greater width so that backflashing will be prevented only by causing the mixture to flow through the orifice with a velocity greater than the rate of propagation of inflammation of the mixture, in which case a bed of pieces of refractory material or other suitable velocity reducing means must be provided for causing the velocity of the escaping mixture to be reduced and combustion to be localized. Such a bed of broken refractory material is shown in Fig. 5.

Figs. 8 and 9 illustrate a form of burner having a comparatively large number of small round discharge orifices opening through the hearth face of the burner body. The body is formed to provide a mixture chamber 12^b from which a plurality of discharge passages 13^b extend through the body, said passages being constricted at their outer ends to form the discharge orifices of the desired size. The passages may thus be considered as passages of decreasing cross area terminating in a discharge orifice. The passages are shown as decreasing sharply or suddenly in cross area, but the decrease might obviously be more or less gradual as in the case of forms of apparatus illustrated by other figures of the drawings. The portions of the metal adjacent each orifice will be of increasing cross-section in the direction of the flow of heat from the walls of the orifice, and, as in the case of the burners before described, the body is made of such

cross-section or mass at any part that such part shall have the required heat conducting capacity to conduct away all heat reaching such part from the walls of any of the discharge orifices. For this purpose the upper part of the body or part adjacent the hearth face thereof must be made sufficiently massive and the discharge orifices must be suitably spaced. The portion of the body lying between the mixture chamber and the hearth face of the body must be of sufficient thickness or depth in the direction of the discharge passages, dependent on the number and arrangement of the passages, to have at all points the required heat conducting capacity. As the inner or central portions of this part of the body receive less heat than the outer portions which have to conduct away not only the heat from their immediately adjacent discharge orifices but also heat reaching them from the inner orifices, it is not necessary that the inner or central portion of this part of the body be made so thick as the outer portions, and in order to reduce the amount of metal in the burner, therefore, it is desirable to so shape the upper wall of the mixture chamber with relation to the shape of the hearth face that the portion of the body between the mixture chamber and the hearth face shall be of decreasing thickness toward the center of the burner. When the burner is formed with a flat hearth face as shown, the upper wall of the chamber will be of generally concave form. The body is shown as provided with heat dissipating fins or ribs 14, and the side walls of the body are shown as extended downward to further increase the capacity of the body of disposing of heat received from the walls of the discharge orifices, such extended portions of the walls being desirably of decreasing thickness as shown since the required heat conducting capacity of portions more remote from the orifices is less than that of nearer portions because of the fact that only a part of the heat reaches such remote portions. The burner is provided with a hearth layer 20 of refractory material of low heat conductivity formed with outwardly flaring openings 21 registering with the discharge orifices, such layer being similar to and serving the same purpose as the hearth layer of the burners previously described.

Fig. 10 shows a form of burner similar to that of Figs. 8 and 9, except that the metal body is further extended so as to secure the necessary dissipation of heat to the surrounding atmosphere without its being provided with heat dissipating fins or ribs, and that the discharge orifices or constricted portions of the discharge passages are provided by driving plugs 30 formed with the small discharge orifices 11^c into the outer ends of the passages 13^c extending through

the body from the mixture chamber and opening through the hearth face of the body.

Figs. 11 and 12 illustrate a form of burner in which heat conductors pass from the hearth face or side of the body through the mixture chamber to the opposite side of the body. In the particular construction shown in these figures the burner body comprises a heavy casing 40 providing the side walls and bottom wall, or wall opposite the hearth wall, of the mixture chamber 12^a, and a hearth wall formed by enlarged or head portions of a plurality of conducting members or rods 41 which are driven into openings in the bottom wall of the casing 40, and which most desirably extend through and beyond the bottom wall of the casing as shown. The heads of these conducting members or rods 41 are formed so as to provide between adjacent heads discharge orifices of the desired shape and capacity. The heads may be square as shown, and each formed with a recess in two opposite sides so that when the heads are arranged as shown and in contact with each other they will form a wall having short slot shaped orifices 11^a through which mixture will be discharged from the mixture chamber 12^a. The heavy casing 40 and the conducting bodies or rods 41 are made of a metal of suitable high heat conductivity, as in the case of the bodies of the other burners illustrated. When the burner is in operation heat will be conducted by the conducting members or rods directly to the bottom wall of the casing 40, some of the heat being conducted through the bottom wall of the casing to be discharged from its side walls which are provided with suitable dissipating fins or ribs 14, or from which heat may be withdrawn by other suitable means. Some of the heat will pass on through the extended end portions of the conducting members or rods 41 to be discharged therefrom. The parts being suitably proportioned, heat will be conducted away from the heat receiving portions of the body and disposed of at the required rate to maintain the walls of the discharge orifices sufficiently cool and to prevent any part in contact with the mixture before it reaches the orifices from becoming heated to the ignition temperature. The conducting bodies or rods will of course be made of suitable size to have the required heat conducting capacity, and the casing 40, and especially the bottom wall thereof through which the conducting rods pass, will be of sufficient mass to carry away all heat received by it from the rods. The required heat conducting capacity of the outer portions of this bottom wall will be greater than that of the inner portion thereof, and the inner portion may therefore be made thinner than the outer portion, as

shown in the drawing. It will be seen that by providing the rods with slightly enlarged heads the desired discharge orifices or short passages are provided and a sufficiently large flow space is also provided between the rods to avoid any appreciable resistance to flow of the mixture to the orifices. The mixture chamber may be considered as divided by the rods into connecting flow passages or discharge passages which are constricted at their discharge ends to form the discharge orifices, or which are of decreasing cross area terminating in the discharge orifices. It will also be seen that the metal adjacent each orifice increases in cross-section in the direction of flow of heat therethrough from the walls of the orifice.

What is claimed is:

1. A burner for explosive gaseous mixtures, comprising a structure providing a body of metal of high heat conductivity inclosing and forming a mixture supply chamber and a mixture discharge passage of decreasing cross area terminating in a discharge orifice having a width sufficiently small to prevent backward propagation of inflammation therethrough, said body being so formed and of such mass in portions thereof to which heat is conducted from parts adjacent to which combustion takes place that such portions shall have sufficient heat conducting capacity to conduct the heat reaching them to a point from which heat is discharged with sufficient rapidity to keep the temperature of the walls of the discharge orifice sufficiently low to maintain the flame-interrupting property of the orifice and to prevent the walls of the discharge passage and the supply chamber from becoming heated to the ignition temperature.

2. A burner for explosive gaseous mixtures, comprising a structure providing a body of metal of high heat conductivity inclosing and forming a mixture supply chamber and a mixture discharge passage of decreasing cross area terminating in a discharge orifice, said body being so formed and of such mass in portions thereof to which heat is conducted from parts adjacent to which combustion takes place that such portions shall have sufficient heat conducting capacity to conduct the heat reaching them to a point from which heat is discharged with sufficient rapidity to prevent the walls of the supply chamber from becoming heated to the ignition temperature.

3. A burner for explosive gaseous mixtures, comprising a structure providing a body of metal of high heat conductivity inclosing and forming a comparatively large mixture flow space extending close to the place where combustion occurs and a mixture discharge orifice for the discharge of mixture from such flow space to the place

where combustion occurs, said orifice having a width sufficiently small to prevent backward propagation of inflammation therethrough, and said body being so formed and of such mass in portions thereof to which heat is conducted from parts adjacent to which combustion takes place that such portions shall have sufficient heat conducting capacity to conduct the heat reaching them to a point from which heat is discharged with sufficient rapidity to keep the temperature of the walls of the discharge orifice sufficiently low to maintain the flame-interrupting property of the orifice and to prevent the walls of the discharge passage and the supply chamber from becoming heated to the ignition temperature.

4. A burner for explosive gaseous mixtures, comprising a structure providing a body of metal of high heat conductivity inclosing and forming a comparatively large mixture flow space extending close to the place where combustion occurs and a mixture discharge orifice for the discharge of mixture from such flow space to the place where combustion occurs, said body being so formed and of such mass in portions thereof to which heat is conducted from parts adjacent to which combustion takes place that such portions shall have sufficient heat conducting capacity to conduct the heat reaching them to a point from which heat is discharged with sufficient rapidity to prevent the walls of the supply chamber from becoming heated to the ignition temperature.

5. A burner for explosive gaseous mixtures, comprising a structure providing a body of metal of high heat conductivity inclosing and forming a mixture supply chamber and a plurality of mixture discharge passages of decreasing cross area terminating in discharge orifices having a width sufficiently small to prevent backward propagation of inflammation therethrough, said body being so formed and of such mass in portions thereof to which heat is conducted from parts adjacent to which combustion takes place that such portions shall have sufficient heat conducting capacity to conduct the heat reaching them to a point from which heat is discharged with sufficient rapidity to keep the temperature of the walls of the discharge orifices sufficiently low to maintain the flame-interrupting property of the orifices and to prevent the walls of the discharge passages and of the supply chamber from becoming heated to the ignition temperature.

6. A burner for explosive gaseous mixtures, comprising a structure providing a body of metal of high heat conductivity inclosing and forming a mixture supply chamber and a plurality of mixture discharge passages of decreasing cross area terminat-

ing in discharge orifices, said body being so formed and of such mass in portions thereof to which heat is conducted from parts adjacent to which combustion takes place that such portions shall have sufficient heat conducting capacity to conduct the heat reaching them to a point from which heat is discharged with sufficient rapidity to prevent the walls of the discharge passages and of the supply chamber from becoming heated to the ignition temperature.

7. A burner for explosive gaseous mixtures, comprising a structure providing a body of metal of high heat conductivity, a mixture supply chamber, and a discharge orifice opening through the body for the passage of mixture from the supply chamber to the place where the mixture burns, the portions of the body adjacent the orifice being of rapidly increasing cross-section in the direction of the flow of heat through the body from the walls of the orifice, and the body being of such cross-section or mass at any part that such part shall have the required heat conducting capacity to conduct away heat reaching such part from the portions adjacent the discharge orifice at a rate sufficient to prevent the walls of the supply chamber from becoming heated to the ignition temperature.

8. A burner for explosive gaseous mixtures, comprising a structure providing a body of metal of high heat conductivity, a mixture supply chamber, and a discharge orifice opening through the body for the passage of mixture from the supply chamber to the place where the mixture burns, said discharge orifice having a width sufficiently small to prevent backward propagation of inflammation therethrough, and the portions of the body adjacent the orifice being of rapidly increasing cross-section in the direction of the flow of heat through the body from the walls of the orifice, and the body being of such cross-section or mass at any part that such part shall have the required heat conducting capacity to conduct away heat reaching such part from the portions adjacent the discharge orifice at a rate sufficient to keep the temperature of the walls of the orifice sufficiently low to maintain the flame-interrupting property of the orifice and to prevent the walls of the supply chamber from becoming heated to the ignition temperature.

9. A burner for explosive gaseous mixtures comprising a structure providing a body of metal of high heat conductivity, a mixture supply chamber, and a discharge orifice opening through the body for the passage of mixture from the supply chamber to the place where the mixture burns, the portions of the body adjacent the orifice being of rapidly increasing cross-section in the direction of the flow of heat through

the body from the walls of the orifice, and the body being of such cross-section or mass at any part that such part shall have the required heat conducting capacity to conduct away heat reaching such part from the portions adjacent the discharge orifice at a rate sufficient to prevent the walls of the supply chamber from becoming heated to the ignition temperature, and means for causing unburned mixture escaping from the discharge orifice with a velocity greater than the rate of propagation of inflammation to spread out with rapid reduction of flow velocity.

10. A burner for explosive gaseous mixtures, comprising a structure providing a body of metal of high heat conductivity, a mixture supply chamber, and a discharge orifice opening through the body for the passage of mixture from the supply chamber to the place where the mixture burns, said discharge orifice having a width sufficiently small to prevent backward propagation of inflammation therethrough, and the portions of the body adjacent the orifice being of rapidly increasing cross-section in the direction of the flow of heat through the body from the walls of the orifice, and the body being of such cross-section of mass at any part that such part shall have the required heat conducting capacity to conduct away heat reaching such part from the portions adjacent the discharge orifice at a rate sufficient to keep the temperature of the walls of the orifice sufficiently low to maintain the flame interrupting property of the orifice and to prevent the walls of the supply chamber from becoming heated to the ignition temperature, and means for causing unburned mixture escaping from the discharge orifice with a velocity greater than the rate of propagation of inflammation to spread out with rapid reduction of flow velocity.

11. A burner for explosive gaseous mixtures, comprising a structure providing a body of metal of high heat conductivity, a mixture supply chamber, and a discharge orifice opening through the body for the passage of mixture from the supply chamber to the place where the mixture burns, the portions of the body adjacent the orifice being of rapidly increasing cross-section in the direction of the flow of heat through the body from the walls of the orifice, and the body being of such cross-section or mass at any part that such part shall have the required heat conducting capacity to conduct away heat reaching such part from the portions adjacent the discharge orifice at a rate sufficient to prevent the walls of the supply chamber from becoming heated to the ignition temperature, and means for withdrawing heat from said body.

12. A burner for explosive gaseous mixtures, comprising a structure providing a body of metal of high heat conductivity, a

mixture supply chamber, and a discharge orifice opening through the body for the passage of mixture from the supply chamber to the place where the mixture burns, the portions of the body adjacent the orifice being of rapidly increasing cross-section in the direction of the flow of heat through the body from the walls of the orifice, and the body being of such cross-section or mass at any part that such part shall have the required heat conducting capacity to conduct away heat reaching such part from the portions adjacent the discharge orifice at a rate sufficient to prevent the walls of the supply chamber from becoming heated to the ignition temperature, and heat dissipating fins for withdrawing heat from the body and discharging it to the surrounding atmosphere.

13. A burner for explosive gaseous mixtures, comprising a structure providing a body of metal of high heat conductivity, a mixture supply chamber, and a discharge orifice opening through the body for the passage of mixture from the supply chamber to the place where the mixture burns, the portions of the body adjacent the orifice being of rapidly increasing cross-section in the direction of the flow of heat through the body from the walls of the orifice, and the body being of such cross-section or mass at any part that such part shall have the required heat conducting capacity to prevent the walls of the supply chamber from becoming heated to the ignition temperature, and a hearth formed by a layer of refractory material of low heat conductivity having a flaring opening registering with the discharge orifice.

14. A burner for explosive gaseous mixtures, comprising a structure providing a body of metal of high heat conductivity, a mixture supply chamber, and a discharge orifice opening through the body for the passage of mixture from the supply chamber to the place where the mixture burns, the portions of the body adjacent the orifice being of rapidly increasing cross-section in the direction of the flow of heat through the body from the walls of the orifice, and the body being of such cross-section or mass at any part that such part shall have the required heat conducting capacity to prevent the walls of the supply chamber from becoming heated to the ignition temperature, a hearth formed by a layer of refractory material of low heat conductivity having a flaring opening registering with the discharge orifice, and a combustion localizing bed formed by pieces of refractory material placed within the flaring opening of the hearth.

15. A burner for explosive gaseous mixtures, comprising a structure providing a body of metal of high heat conductivity, a

mixture supply chamber, and a plurality of discharge orifices opening through the body for the passage of mixture from the supply chamber to the place where the mixture
 5 burns, the portions of the body adjacent each orifice being of rapidly increasing cross-section in the direction of flow of the heat through the body from the walls of the orifice, and the body being of such cross-
 10 section or mass at any part that such part shall have the required heat conducting capacity to conduct away heat reaching such part from the portions adjacent the discharge orifices at a rate sufficient to pre-
 15 vent the walls of the supply chamber from becoming heated to the ignition temperature.

16. A burner for explosive gaseous mixtures, comprising a structure providing a
 20 body of metal of high heat conductivity, a mixture supply chamber, and a discharge passage leading from the supply chamber through the body, said passage being constricted at its discharge end to form a dis-
 25 charge orifice, the portions of the body adjacent the discharge orifice being of rapidly increasing cross-section in the direction of flow of heat through the body from the walls
 30 of the orifice, and said body being of such cross-section or mass at any part that such part shall have the required heat conducting capacity to conduct away heat reaching such
 35 part from the portions adjacent the discharge orifice at a rate sufficient to prevent the walls of the passage and of the supply chamber from becoming heated to the igni-
 tion temperature.

17. A burner for explosive gaseous mixtures, comprising a structure providing a
 40 body of metal of high heat conductivity, a mixture supply chamber, and a plurality of discharge passages leading from the supply chamber through the body to the place where
 45 the mixture burns, said passages being constricted at their discharge ends to form discharge orifices, the portions of the body adjacent each orifice being of rapidly increas-
 50 ing cross-section in the direction of flow of heat through the body from the walls of the orifice, and said body being of such cross-section or mass at any part that such part shall
 55 have the required heat conducting capacity to conduct away heat reaching such part from the portions adjacent the discharge orifices at a rate sufficient to prevent the walls
 of the passages and of the supply chamber from becoming heated to the ignition temperature.

18. A burner for explosive gaseous mix-
 60 tures, comprising a structure providing a body of metal of high heat conductivity, a mixture supply chamber, and a plurality of discharge passages leading from the supply chamber through the body, said passages
 65 being constricted at their discharge ends to

form discharge orifices having a width sufficiently small to prevent backward propa-
 70 gation of inflammation therethrough, the portions of the body adjacent each orifice being of rapidly increasing cross-section in the direction of flow of heat through the body from the walls of the orifice, and said
 75 body being of such cross-section or mass at any part that such part shall have the required heat conducting capacity to conduct away heat reaching such part from the portions
 80 adjacent the discharge orifices at a rate sufficient to keep the temperature of the walls of the discharge orifices sufficiently low to maintain the flame-interrupting prop-
 erty of the orifices and to prevent the walls of the discharge passages and of the supply chamber from becoming heated to the igni-
 tion temperature.

19. A burner for explosive gaseous mix- 85
 tures, comprising a structure providing a body of metal of high heat conductivity, a mixture supply chamber, and a plurality of discharge passages leading from the supply
 90 chamber through the body, said passages being constricted at their discharge ends to form discharge orifices having a width sufficiently small to prevent backward propa-
 95 gation of inflammation therethrough, and said body being of such cross-section or mass at any part that such part shall have the required heat conducting capacity to keep the temperature of the walls of the
 100 discharge orifices sufficiently low to maintain the flame-interrupting property of the orifices and to prevent the walls of the discharge passages and of the supply chamber from becoming heated to the ignition tem-
 105 perature, and a hearth formed by a layer of refractory material of low heat conductivity having flaring openings registering with the discharge orifices.

20. A burner for explosive gaseous mix-
 110 tures, comprising a structure providing a body of metal of high heat conductivity, a mixture supply chamber, and a plurality of discharge passages leading from the supply chamber through the body, said passages
 115 being constricted at their discharge ends to form discharge orifices, the portions of the body adjacent each orifice being of rapidly increasing cross-section in the direction
 120 of flow of heat through the body from the walls of the orifice, and said body being of such cross-section or mass at any part that such part shall have the required heat con-
 125 ducting capacity to conduct away heat reaching such part from the portions adjacent the discharge orifices at a rate sufficient to prevent the walls of the passages and of the supply chamber from becoming heated
 130 to the ignition temperature, and means for causing unburned mixture escaping from the discharge orifices with a velocity greater than the rate of propagation of inflamma-

tion to spread out with reduction of flow velocity.

21. A burner for explosive gaseous mixtures, comprising a structure providing a body of metal of high heat conductivity, a mixture supply chamber, and a discharge passage leading from the supply chamber through the body of decreasing cross area and terminating in an elongated or slot shaped discharge orifice, the portions of the body adjacent the orifice being of rapidly increasing cross-section in the direction of flow of heat through the body from the walls of the orifice, said body being of such cross-section or mass at any part that such part shall have the required heat conducting capacity to conduct away heat reaching such part from the portions adjacent the discharge orifice at a rate sufficient to prevent the walls of the passage and of the supply chamber from becoming heated to the ignition temperature.

22. A burner for producing by the combustion of an explosive gaseous mixture a substantially continuous incandescent surface of considerable extent, comprising a structure providing a mixture supply chamber having a wall formed by a body of metal of high heat conductivity, a plurality of discharge passages extending from the supply chamber through said body, said passages being constricted at their discharge ends to form discharge orifices which are close together and at which the mixture burns, and a hearth formed by a layer of solid refractory material on the outer face of said body having openings registering with the discharge orifices, said body being of such cross-section or mass at any part that such part shall have the required heat conducting capacity to conduct away heat

reaching such part from the walls of the discharge orifices at a rate sufficient to prevent the walls of the passages from becoming heated to the ignition temperature.

23. A burner for producing by the combustion of an explosive gaseous mixture a substantially continuous incandescent surface of considerable extent, comprising a structure providing a mixture supply chamber having a wall formed by a body of metal of high heat conductivity, a plurality of discharge passages extending from the supply chamber through said body, said passages being constricted at their discharge ends to form discharge orifices having a width sufficiently small to prevent backward propagation of inflammation therethrough and which are close together and at which the mixture burns, and a hearth formed by a layer of solid refractory material on the outer face of said body having openings registering with the discharge orifices, said body being of such cross-section or mass at any part that such part shall have the required heat conducting capacity to conduct away heat reaching such part from the walls of the discharge orifices at a rate sufficient to keep the temperature of the walls of the discharge orifices sufficiently low to maintain the flame-interrupting property of the orifices and to prevent the walls of the passages from becoming heated to the ignition temperature.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

CHARLES E. LUCKE.

Witnesses:

DAVID C. LEWIS,
A. L. KENT.