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APPARATUS FOR BURNING EXPLOSIVE GASEOUS MIXTURES.

APPLICATION FILED JAN. 8, 1913.

**1,113,174.** Patented Oct. 6, 1914.

*Fig. 1.*

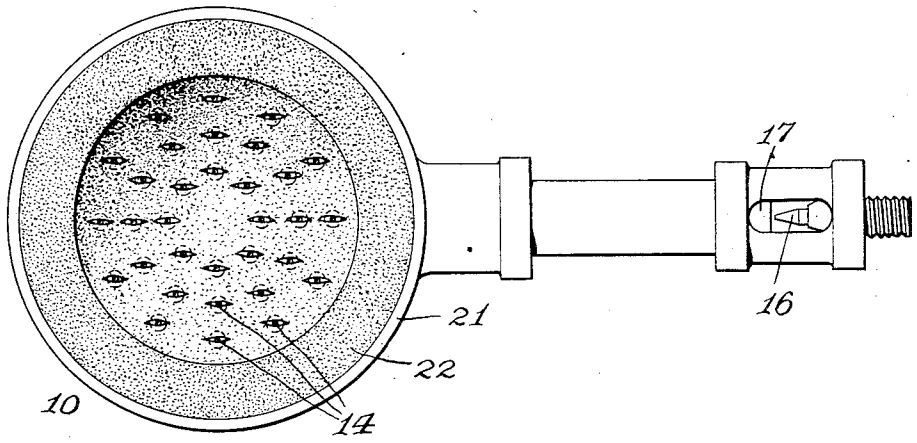



*Fig. 2.*

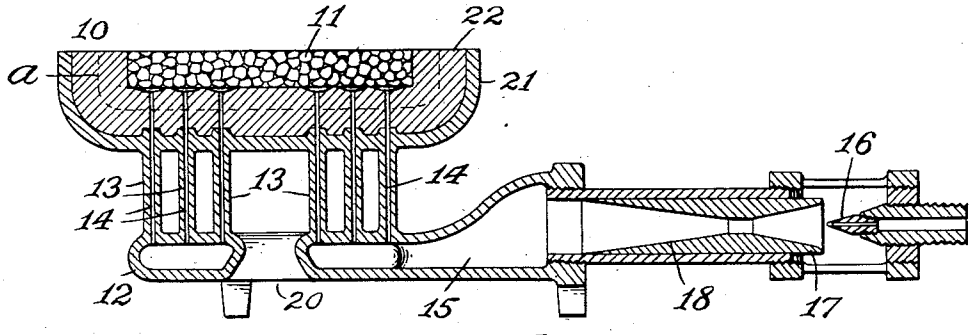
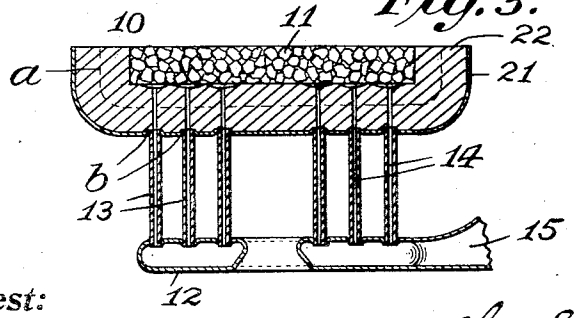



*Fig. 3.*




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# UNITED STATES PATENT OFFICE.

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## APPARATUS FOR BURNING EXPLOSIVE GASEOUS MIXTURES.

1,113,174. Specification of Letters Patent. Patented Oct. 6, 1914.

Application filed January 8, 1913. Serial No. 740,896.

*To all whom it may concern:*

Be it known that we, CHARLES E. LUCKE and FRANK CREELMAN, citizens 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 invention has been made more particularly with the idea of improving apparatus of that class by which such mixtures are burned continuously or non-explosively as distinguished from non-continuous or intermittent combustion of such mixtures, and more especially such apparatus in which back-flash or backward propagation of inflammation from the combustion chamber or space is prevented by causing the mixture to flow to the combustion chamber or space with a velocity greater than the rate of propagation of inflammation through the mixture, and in which the surface or zone of combustion is then localized and blow-off prevented by rapidly reducing the flow velocity of the mixture. Various styles of apparatus have been made which operate successfully in this way. More or less difficulty has, however, been encountered in maintaining the continuous and localized combustion of explosive gaseous mixture for long periods of time with apparatus that is otherwise wholly effective, resulting from the conduction of heat backward from the zone where it is generated through solid matter constituting the walls of the supply passages and consequent ignition of the mixture at a place where it may be moving with a velocity less than the rate of propagation of inflammation. This difficulty is not met with so much, being more easily obviated by the natural design of the apparatus, in burners or apparatus where the mixture is supplied through a single supply orifice or passage or a comparatively small number of supply orifices or passages, but becomes more serious when it is desired to supply the mixture through a larger number of supply passages arranged to distribute the mixture in the combustion chamber or space. With such an apparatus it is desirable that the comparatively small supply passages through which the mixture is caused to flow to the combustion chamber or space shall be as short as possible consistent with the attainment of the necessary cooling action in order to avoid excessive friction losses which necessitate increased power to compress and feed the mixture, and in order, also, to permit of a more compact and simple structure than would otherwise be possible. It is desirable, therefore, in a burner or apparatus of this kind that the mixture may be fed at a comparatively low velocity to a fairly large supply chamber adjacent to the combustion space or chamber and from which the mixture is supplied to the combustion chamber through a plurality of comparatively small supply passages of such size and so spaced with respect to each other at their delivery ends as to supply and properly distribute the proper amount of mixture to generate the desired total heat per square foot of final heating surface. The closer the supply chamber is to the combustion space, however, and the shorter the supply passages, the greater the liability of ignition of the mixture in the supply chamber by heat conducted back through the structure.

The present invention aims to provide an apparatus fulfilling these requirements and whereby the conduction of heat from the combustion zone backward to the supply chamber to such an extent as might cause ignition of the mixture in the supply chamber, is prevented, and which shall yet be of comparatively simple and inexpensive construction and of high efficiency.

An understanding of the invention can best be given by a description of a preferred form of apparatus embodying the various features of the invention, and such a description will now be given in connection with the accompanying drawings showing such a preferred apparatus, and in which:—

Figure 1 is a plan view of the apparatus with the combustion bed removed. Fig. 2 is a central sectional view of the apparatus shown in Fig. 1, but showing a combustion bed in place. Fig. 3 is a view similar to Fig. 2 of a modified construction, partly broken away.

Referring to the drawings, the burner proper comprises a burner body or head 10,

a combustion bed 11 supported by or against a face of the burner body, a casing or header 12 providing a supply chamber, and a plurality of connecting members 13 extending between the burner body and the header 12, a plurality of comparatively small supply passages 14 extending from the supply chamber to the combustion bed through the connecting bodies 13 and the burner body 10. The casing 12 is provided with an inlet opening 15 through which the explosive mixture is supplied to the chamber by any suitable means and from any suitable source. As shown, a mixing injector is provided for supplying an explosive mixture of a suitable fuel gas and air, the fuel gas being supplied to the injector nozzle 16 under a suitably high pressure and the 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 within the casing 12. The injector should be designed, and the nozzle and combining tube set in proper relative positions, as by adjusting either one, to supply a mixture containing the gas and air in suitable proportions; and the gas should reach the injector under sufficient pressure to cause the mixture in the supply chamber to be maintained under a pressure such as will cause the mixture to flow through the supply passages 14 with a velocity greater than the rate of propagation of inflammation through the mixture when the mixture is to be burned according to the method hereinbefore referred to.

The combustion bed 11 may be of any suitable character to cause the mixture entering the bed from the passages 14 to spread out and be distributed through the bed and have its velocity rapidly reduced. A bed of broken or other suitable pieces of highly refractory material as indicated in Fig. 2 of the drawings is what we prefer to use at the present time. Any suitable refractory material may be used, such as alundum, chrome ore or magnesite, or even fire brick where a gas of low heating power is to be burned. The pieces or granules forming the bed may be bonded together in any suitable manner, but a bed of loose unbonded pieces is for most purposes wholly satisfactory and preferable. For retaining such a bed of loose pieces of refractory material in position, suitable retaining means are provided according to the position in which the burner is to be used. The burner head or body is conveniently formed with a recess in its face to receive and hold in place the pieces of refractory material forming the bed, and when the burner is to be used in an upright position as shown with the bed supported in horizontal position in the upper face of the burner body or head, no additional means will ordinarily be required for holding the material of the bed in place. The bed may be of any superficial size and of various thicknesses, and the size of the pieces of refractory material composing the bed will vary according to the size of the bed and especially its depth or thickness. When quick heating of the bed to the desired maximum intensity is to be considered, as in the particular form of burner illustrated which is intended especially for use as a cook stove burner, it is desirable that the bed shall be comparatively thin or shallow, and in order to secure the best distribution of the mixture supplied to such a bed it is desirable that the supply passages shall be in greater number than would be required to secure the proper distribution for a bed of greater thickness, each passage being of comparatively smaller size and the mixture sometimes being caused to move through the passages with a velocity not so greatly in excess of the rate of propagation of inflammation as would usually be employed with a thicker bed. With such a burner, therefore, the prevention of heat conduction back from the combustion bed through the structure to the supply chamber, or point where the mixture is not moving with a velocity in excess of the rate of propagation of inflammation, becomes more difficult.

The space occupied by the combustion bed is the space or chamber in which the combustion takes place, and the function of the bed is mainly two-fold, namely: to distribute and rapidly reduce the flow velocity of the gaseous mixture within the combustion space or chamber by causing the mixture to spread out as it advances through the bed, and, secondly, to serve as a source of radiant heat after it becomes heated by the combustion taking place within it or at its outer surface. Other forms of porous and permeable combustion beds might of course be employed and various other means provided for quickly reducing the flow velocity of the mixture as it leaves the high velocity supply passages.

In order to avoid the conduction of heat back to the supply chamber, the connecting members 13 are separated to permit free circulation of air or other cooling fluid against and past the heat discharging surfaces of the individual connecting members, and preferably these connecting members are tubular in form, each having a single supply passage. When the burner is to be set with the burner head and combustion bed extending horizontally and with the supply chamber casing 12 beneath the burner head, an effective induced current of air for cooling the members 13 may be secured by forming the casing 12 with an opening through which air may flow upward toward the bottom of the burner head and outward

past the connecting members or tubes 13, and with a round topped burner or one of substantially equal horizontal cross dimensions, the casing 12 is preferably made of annular form with a central air opening 20 as indicated in Fig. 2.

The burner head or body 10 should be of highly refractory material to withstand the great heat to which it is subjected and preferably of material of low heat conductivity, and is preferably made of a suitable refractory cement filled into a cup shaped shell or casing 21 formed by a metal plate with a peripheral flange as shown. We preferably form the head casing 21, the casing 12 and the connecting members or tubes 13 from a single casting as shown in Figs. 1 and 2. The cement filling 22 of the head casing is preferably molded directly in the casing so as to insure a gas tight fit with the casing walls about the orifices of the tubes or connecting members 13, and in so forming the filling 22 we preferably place in the passages 14 of the connecting members 13 rods which extend upward through the space to be occupied by the cement so that when the rods are withdrawn after the cement has set the burner will have uniform passages extending from the supply chamber to the combustion space through the connecting members and through the burner head. The supply passages should be of such size or capacity and in such number and so spaced at their delivery ends as to supply and properly distribute the proper amount of mixture to generate the desired total heat in the combustion space when the mixture is maintained under the pressure in the supply chamber for which the burner is intended. 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 of the supply passages.

The filling 22 of the burner head may be of the same material throughout, a suitable highly refractory material being used, preferably a suitable cement such as alundum cement, or the outer portion of the filling or body may be of a material which, while not so highly refractory as the material forming the inner portion, is a better non-conductor of heat. For example, in the burner shown in Fig. 1 the portion of the filling adjoining the combustion space or chamber may be of alundum cement or other suitable highly refractory material, while the portion outside of the dotted line *a* might be of a material such as magnesium carbonate, kaolin or asbestos stove lining cement which, though not so highly refractory as the alundum cement, is of lower heat conductivity and lighter in weight. The use of such a lighter material of lower heat conductivity for the outer portion of the head filling of the burner is of advantage in giving better insulation and thereby reducing the loss of heat by conduction through the burner structure from the combustion zone and also in affording some additional protection against the conduction of heat toward the supply chamber. It is also of advantage in reducing the weight of the burner.

Instead of forming the head casing 21, supply casing 12 and connecting members or tubes 13 from a single casting as shown in Figs. 1 and 2, we may, of course, use separately formed connecting members or tubes 13 suitably secured in the head casing and supply casing, as shown in Fig. 3. The burner might be so formed by casting the head casing and the supply casing about the ends of the connecting tubes. It is sometimes desirable, however, to reduce the weight of the burner so far as possible, and for this purpose the head casing and supply casing may be formed of sheet metal perforated to receive the ends of the tubes 13. For better securing the ends of the tubes to the casings, the perforations in the latter will preferably be made by means of a punch which will leave an inwardly extending bur as shown at *b* in Fig. 3. The tubes may then be positioned and secured in these burred perforations by being simply forced therein or may be further secured as by hard soldering or brazing or by having the meeting parts welded together.

In the use of the burner shown, when the gaseous mixture is supplied to the chamber within the supply chamber casing 12 and maintained under such pressure therein that the mixture flows through the supply passages to the combustion space with a velocity in excess of the rate of propagation of inflammation of the mixture, as the mixture passes from the supply passages into the porous and permeable combustion bed, it is caused to spread out and advance in increasing volume and with rapidly decreasing velocity, so that its velocity is reduced to the rate of propagation of inflammation within the limits of the bed or combustion space and without mixing or diffusion with additional air or other gas. The mixture having been ignited, the surface or zone of combustion will then locate within or at the surface of the bed at the zone or surface where equality between the flow velocity and the rate of propagation of inflammation is attained, and with a burner of the form shown the combustion will take place close to the face of the burner head. A very intense heat will be generated by the burning of the explosive mixture and the pieces of refractory material forming the combustion bed will thereby be quickly raised to, and thereafter during continuance of the combustion maintained at, a very high temperature so that the bed becomes highly in-

candescent and the heat generated at the combustion zone becomes available not only through the escaping highly heated products of combustion but also to a very large degree as radiant heat from the glowing refractory bed.

The burner head heats up quickly and heat is conducted to a greater or less degree back through the tubes or bodies 13 to the header casing 12. The passage of heat from the bodies 13 to the air or other fluid in contact with them, however, limits the amount of heat reaching the casing 12 and prevents any part of the walls of the supply chamber from being raised to the ignition temperature of the mixture. Heat from the burner structure causes a current of air to flow past the separated bodies or tubes 13, this current in the form of burner shown in the drawings passing upward through the opening 20 in the supply chamber casing 12 and outwardly past the bodies or tubes 13, and as the burner structure becomes more highly heated this induced flow of air increases. It has been found that the extraction of heat from the bodies or tubes 13 by this induced current is entirely effective in preventing the heating of any part of the casing 13 to the ignition point of the mixture through long periods of continuous operation even when the supply casing is set quite close to the combustion space and the tubes 13 are correspondingly short. The burner may, therefore, be made very compact, occupying but comparatively little space in the direction from the combustion space to the supply chamber, and the friction loss in forcing the mixture through the small supply passages is thus largely reduced.

Other means might, obviously, be provided for forcing air or other cooling fluid past the heat discharging surfaces of the connecting bodies or tubes, or for supplying other cooling media for receiving heat from the connecting tubes, but we have found apparatus depending on the air current induced by the heat from the burner entirely satisfactory where the apparatus is suitably designed to maintain such current to a sufficient degree, and such an arrangement is for many purposes preferable, especially in small burners.

The amount of heat generated and the temperature attained will depend, of course, upon the character and amount of the mixture supplied to the burner. When the mixture contains the fuel elements and oxygen in chemical combining proportions the products of combustion leaving the burner will be neutral or inert. For some purposes for which the invention may be used it may be desirable to have the escaping products of combustion of an oxidizing or reducing character. An excess of oxygen in the mixture will give oxidizing products of combustion, and by supplying the mixture with an excess of fuel reducing products may be obtained which will burn beyond the surface of the bed if oxygen or air is given access thereto.

As before stated, the particular form of burner illustrated in the drawings is intended primarily to be used as a cook stove burner or for other similar purpose for which it may be found suitable, and as being most convenient for this purpose the burner is made with its burner body or head and combustion bed round and flat on top. Obviously, however, the burner might be made to provide a burner head or heating part of other suitable desired shape, the rest of the structure being then correspondingly changed as may be desirable.

It will be understood that the invention is not to be limited to the exact construction, arrangement and form of the apparatus shown and to which the foregoing description has been largely confined, but that it includes changes and modifications thereof within the claims.

What is claimed is:

1. An apparatus for burning explosive gaseous mixtures comprising a burner body or head of refractory material and of low heat conductivity, a combustion bed of porous and permeable refractory material supported against the burner head, a mixture supply chamber adjacent to but spaced off from the burner head, a plurality of separated connecting members extending between the burner head and the supply chamber leaving a space between the burner body and the supply chamber through which a current of air induced by the heat from the structure may pass in contact with said connecting members, and a plurality of supply passages extending from the supply chamber to the combustion bed through said connecting members and through the burner head for the flow of the explosive mixture to the combustion bed.

2. An apparatus for burning explosive gaseous mixtures comprising a burner body or head of refractory material and of low heat conductivity formed with a recessed face, a combustion bed of loose pieces of refractory material in the recess in the burner head, a mixture supply chamber adjacent to but spaced off from the burner head, a plurality of separated connecting members extending between the burner head and the supply chamber and having heat discharging surfaces to limit the backward conduction of heat, and a plurality of supply passages extending from the supply chamber to the combustion bed through said connecting members and through the burner head for the flow of the explosive mixture to the combustion bed, said passages being of sub-

stantially uniform size throughout their lengths.

3. An apparatus for burning explosive gaseous mixtures comprising a burner body or head of refractory material and of low heat conductivity having a recess in one face forming a combustion chamber, a mixture supply chamber adjacent to but spaced off from the burner head, a plurality of separated connecting members extending between the burner head and the supply chamber and having heat discharging surfaces to limit the backward conduction of heat, a plurality of supply passages extending from the supply chamber to the combustion chamber through said connecting members and through the burner head for the flow of the explosive mixture to the combustion bed, means for maintaining a supply of the gaseous mixture in the supply chamber under a pressure sufficient to cause the mixture to flow through the supply passages with a velocity greater than the rate of propagation of inflammation through the mixture, and means within the combustion chamber for reducing the flow velocity of the mixture entering the chamber from the supply passages.

4. An apparatus for burning explosive gaseous mixtures comprising a burner body or head of refractory material and of low heat conductivity, a mixture supply chamber adjacent to but spaced off from the burner head, a plurality of separated tubular members extending between the burner head and the supply chamber, passages through the burner head connecting with the bores of said tubular members whereby through supply passages are provided for the flow of the explosive mixture from the supply chamber to and through the burner head, and means for reducing the flow velocity of the mixture escaping from the supply passages and preventing diffusion with other gas.

5. An apparatus for burning explosive gaseous mixtures comprising in combination a burner body or head of refractory material and of low heat conductivity, a combustion bed of porous and permeable refractory material supported against the burner head, a casing beneath the burner head providing a mixture supply chamber and formed with an opening for the passage of a cooling current of air upward therethrough toward the burner head, a plurality of separated tubular connecting members extending between said casing and the burner head, the burner head being formed with passages connecting with the bores of said tubes to provide through supply passages for the flow of the explosive mixture from the supply chamber to the combustion bed.

6. A flat top burner for burning explosive gaseous mixtures comprising in combination a burner head having a recess in its upper face, a combustion bed formed of loose pieces of refractory material in said recess in the burner face, a casing beneath the burner head providing a mixture supply chamber and formed with a central opening for the passage of a cooling current of air upward therethrough, and a plurality of separated connecting members extending between said casing and the burner head and having heat discharge surfaces against which said cooling current of air will flow, the burner head and said connecting members being formed with through supply passages for the flow of the explosive mixture from the supply chamber to said recess in the face of the burner head.

7. A burner for burning explosive gaseous mixtures comprising a burner head or body of refractory material, a mixture supply chamber adjacent to but spaced off from the burner head, a plurality of separated connecting members extending between the burner head and the supply chamber and having heat discharging surfaces, the burner head and said connecting members having passages therein forming through supply passages for the flow of the explosive mixture from the supply chamber to the combustion space, and means within the combustion space adjoining the face of the burner head for reducing the flow velocity of the mixture escaping from the supply passages, the portion of the refractory material of the burner head nearest the combustion space being the more highly refractory and a part nearer the connecting members being of lower heat conductivity.

8. A burner for burning explosive gaseous mixtures comprising an integral casting providing a mixture supply chamber and a head casing and a plurality of separated connecting members having heat discharging surfaces, a filling of refractory material in the head casing, and a porous and permeable combustion bed supported against said filling of refractory material, said filling of refractory material and said connecting members having passages therein forming through supply passages for the flow of the explosive mixture from the supply chamber to the combustion bed.

9. A burner for burning explosive gaseous mixtures comprising an integral casting providing a mixture supply chamber and a head plate and a plurality of separated connecting members having heat discharging surfaces, a body of refractory material supported against the head plate, said body of refractory material and said connecting members having passages therein forming supply passages for the flow of the explosive mixture from the supply chamber to and through the body of refractory material.

means adjacent said body of refractory material for reducing the flow velocity of the mixture escaping from said supply passages, said body of refractory material being of two kinds of material, the portion nearest said velocity reducing means being the more highly refractory and a part nearer the head plate being of lower heat conductivity.

10. A burner for burning explosive gaseous mixtures comprising a burner head formed of a metal casing and a filling of refractory material within the metal casing and shaped to provide a recess to form a combustion chamber, the portion of said filling adjoining the combustion chamber being the more highly refractory and a part surrounding such portion being of lower heat conductivity, a plurality of mixture supply passages extending through said filling to the combustion chamber, a supply chamber connected with said supply passages to supply the explosive mixture thereto, and means within the combustion chamber for reducing the flow velocity of the mixture entering the combustion chamber.

11. A burner for burning explosive gaseous mixtures comprising a burner head or body, a mixture supply chamber adjacent to but spaced off from the burner head, a plurality of separated connecting members extending between the burner head and the supply chamber, said connecting members and the burner head having passages therein forming through supply passages for the flow of the explosive mixture from the supply chamber to and through the burner head, and said parts being arranged to cause a cooling current of air induced by the heat from the burner structure to flow between the burner head and the supply chamber past said connecting members, and means for reducing the flow velocity of the mixture escaping from the supply passages and causing the combustion to locate close to the burner head.

12. A burner for burning explosive gaseous mixtures comprising a burner head or body, a mixture supply chamber adjacent to but spaced off from the burner head, a plurality of separated connecting members extending between the burner head and the supply chamber, said connecting members and the burner head having passages therein forming through supply passages for the flow of the explosive mixture from the supply chamber to and through the burner head, means for reducing the flow velocity of the mixture escaping from the supply passages and causing the combustion to take place close to the burner head, and means for causing a current of a cooling fluid to flow between the burner head and the supply chamber past said connecting members.

13. A burner for burning explosive gaseous mixtures comprising a burner head or body, a mixture supply chamber adjacent to but spaced off from the burner head, a plurality of separated connecting members extending between the burner head and the supply chamber, said connecting members having mixture supply passages extending therethrough for the flow of the explosive mixture from the supply chamber and being formed to limit backward conduction of heat to prevent ignition of mixture in the supply chamber, and means for reducing the flow velocity of the mixture escaping from the supply passages and causing the combustion to locate close to the burner head.

14. A burner for burning explosive gaseous mixtures comprising a burner head or body, a mixture supply chamber adjacent to but spaced off from the burner head, a plurality of separated connecting members extending between the burner head and the supply chamber, each of said connecting members having a single mixture supply passage extending therethrough for the flow of the explosive mixture from the supply chamber, and said connecting members being formed to limit backward conduction of heat to prevent ignition of mixture in the supply chamber, and means for reducing the flow velocity of the mixture escaping from the supply passages and causing the combustion to locate close to the burner head.

15. An apparatus for burning explosive gaseous mixtures comprising a burner head or body, a mixture supply chamber adjacent to but spaced off from the burner head, a plurality of separated connecting members extending between the burner head and the supply chamber, said connecting members having mixture supply passages extending therethrough for the flow of the explosive mixture from the supply chamber and being formed to limit backward conduction of heat to prevent ignition of mixture in the supply chamber, means for maintaining a supply of the gaseous mixture in the supply chamber under a pressure sufficient to cause the mixture to flow through the supply passages with a velocity greater than the rate of propagation of inflammation through the mixture, and means for reducing the flow velocity of the mixture escaping from the supply passages and causing the combustion to take place close to the burner head.

In testimony whereof we have hereunto set our hands in the presence of two subscribing witnesses.

CHARLES E. LUCKE.
FRANK CREELMAN.

Witnesses:
W. S. CALDWELL,
A. L. KENT.