R. F. METCALFE.

METHOD OF AND APPARATUS FOR BURNING COMBUSTIBLE MIXTURES.

APPLICATION FILED AUG. 14, 1918.

1,380,997. Patented June 7, 1921.

2 SHEETS—SHEET 1.

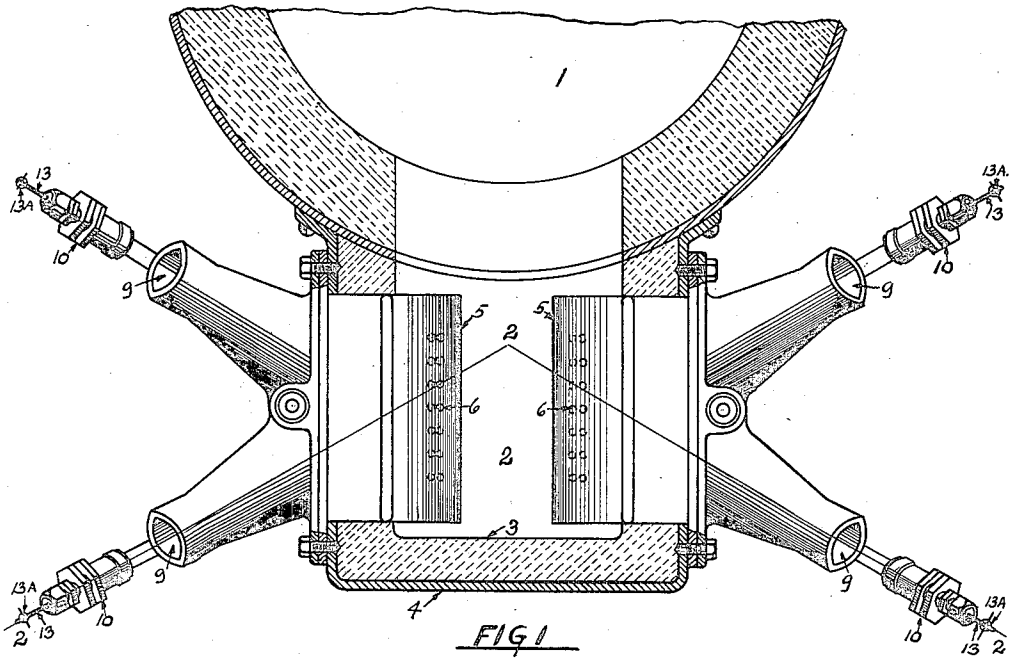

FIG 1

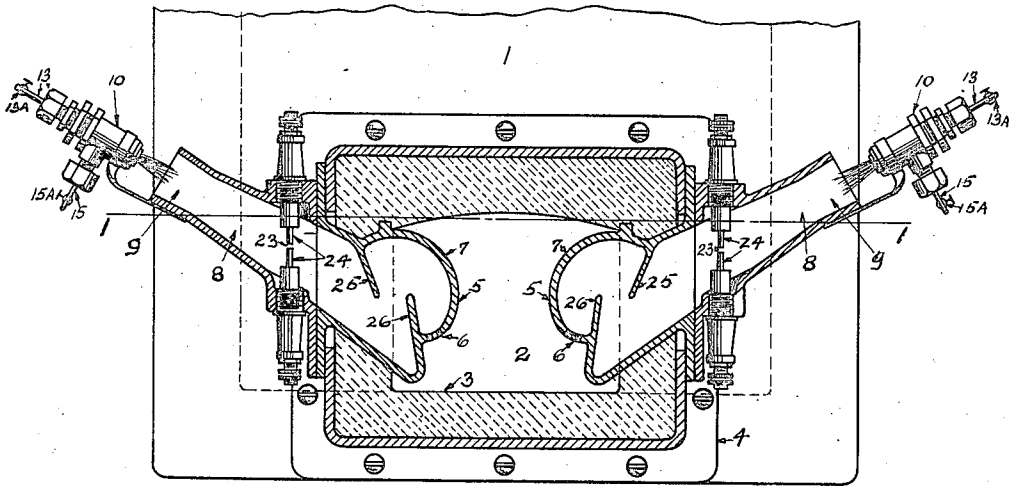

FIG 2

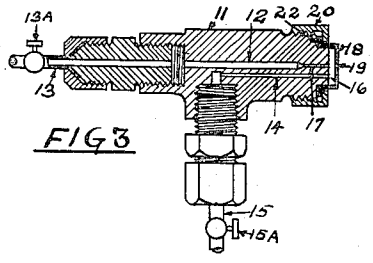

FIG 3

Inventor

Robert F Metcalfe

By

Attorney

R. F. METCALFE.

METHOD OF AND APPARATUS FOR BURNING COMBUSTIBLE MIXTURES.

APPLICATION FILED AUG. 14, 1918.

1,380,997. Patented June 7, 1921.

2 SHEETS—SHEET 2.

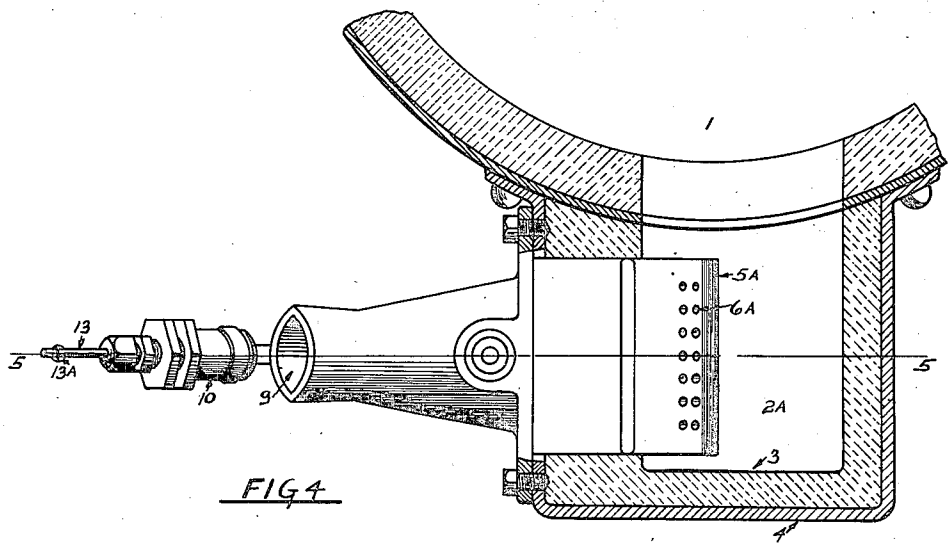

FIG 4

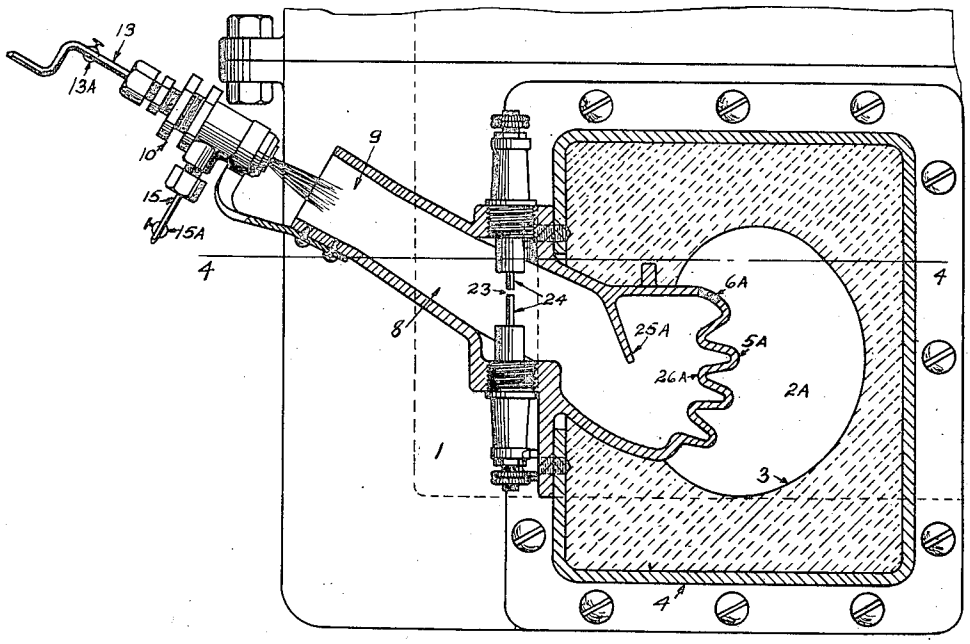

FIG 5

Inventor

Robert F Metcalfe

By H. L. Lewis

Attorney

UNITED STATES PATENT OFFICE.

ROBERT F. METCALFE, OF ERIE, PENNSYLVANIA.

METHOD OF AND APPARATUS FOR BURNING COMBUSTIBLE MIXTURES.

1,380,997. Specification of Letters Patent. Patented June 7, 1921.

Application filed August 14, 1918. Serial No. 249,777.

To all whom it may concern:

Be it known that I, ROBERT F. METCALFE, a citizen of the United States, residing at Erie, in the county of Erie and State of Pennsylvania, have invented new and useful Improvements in the Methods of and Apparatus for Burning Combustible Mixtures, of which the following is a specification.

This invention relates to the method of and apparatus for burning combustible mixtures and consists in certain improvements therein as will be hereinafter fully described and pointed out in the claims.

The apparatus for utilizing the method and forming the subject matter of the invention is illustrated in the accompanying drawings as follows:—

Figure 1 shows a horizontal section of a boiler furnace and burner on the line 1—1 in Fig. 2.

Fig. 2 is a section on the lines 2—2 2—2 in Fig. 1.

Fig. 3 is an enlarged sectional view of the spraying nozzle or atomizer.

Fig. 4 is a horizontal section of a furnace and modified form of burner on the line 4—4 in Fig. 5.

Fig. 5 is a section on the line 5—5 in Fig. 4.

1 marks the furnace. This may be of any desired type, as shown a cylindrical boiler furnace, only a fragment being shown. Communicating with the furnace and preferably at one side of it is a burner heating and combustion chamber 2. This chamber 2 is lined preferably with fire brick 3 capable of receiving and radiating heat so as to heat the burners. The chamber has a casing 4 and burners 5 are secured to the casing and extend into the chamber from each side.

In the construction shown in Figs. 1 and 2 there are four atomizers and four mixer throats through which fuel is delivered to the burners.

The burner jets 6 are arranged in the burner heads 7 and lead from the mixing chambers 8. The mixing chambers are provided with the throats 9 preferably in the shape of a Venturi tube and the atomizers 10 deliver spray through the throats entraining air, carrying it to the mixing chamber and the burner.

The atomizer may be of any desired construction but preferably is as shown. It has a body 11 with an air duct 12 leading through it from a source of supply connected with the passage 12 by the pipe 13 controlled by a valve 13^a. Fuel is delivered to the passage 14 arranged in the body 11 by means of a pipe 15 leading from a source of supply and controlled by a valve 15^a. The fuel passage 14 leads to a chamber 16 and the passage 12 terminates in a nozzle 17 leading to the chamber 16. The chamber 16 is formed by a flanged cap 18 in which there is a jet opening 19 in alinement with the nozzle 17. The cap is secured to the body by a flanged nut 20.

The spray operates in a well-known manner. Air under pressure passing from the nozzle 17 through the opening 19 entrains and atomizes fuel delivered to the chamber through the passage 14. The action of the air through the opening 19 reduces the pressure in the chamber 16 below atmosphere and induces a flow of fuel to the chamber proportionate to the velocity of air. Consequently while the velocity of the air and consequently the volume of the air may be varied the volume of fuel is also automatically varied. Further by using this construction the fuel may be lifted a slight distance and in consequence when the air is turned off there is no danger of leakage of fuel. The quantity of fuel entrained may be varied by varying the distance between the nozzle 17 and the jet opening 19. This is accomplished by placing thin washers 22 under the flanged cap 18.

A spark gap 23 is arranged between the spark plugs 24, the spark plugs being supplied with current from any convenient source (not shown).

The operation of the apparatus and the carrying out of the method is as follows:

Air under pressure is turned into the line 13 and delivered through the nozzle 17 spraying a very rich mixture of atomized fuel and air through the throat 9, thus entraining additional air. Sufficient air is thus entrained to make a combustible mixture. Consequently no added air is necessary for the purposes of combustion. The jet openings 6 are so proportioned with relation to the chamber and the spray device and the air pressure which is used that the

initial velocity through the jets is such acting in connection with the cooling action of the metal surrounding the jets as to confine the flame within the chamber. The mixture is ignited by the spark at the spark plug and burns in the form of explosions following each other with quite high frequency, the frequency increasing as the walls of the burner become heated. As the burner becomes hot the mixture is heated, the air expanded and the fuel content vaporized and expanded and this increases the velocity through the jets by reason of the greater volume and greater fluidity or lower viscosity of the mixture. The burner itself is also heated so that the metal directly surrounding the jets does not tend to cool the mixture flowing through the jets and consequently there is a communication of flame from within the burner to without the burner. Finally the heat of the burner is sufficient in connection with the velocity of the jet to carry the flame to a point entirely without the chamber. It will be understood that after the first few explosions the current is turned off the spark plugs and the explosions are continued from remaining gases in the burner. After the flame is established at a point without the burner, the burner cools down, especially that part of the burner directly around the jets and a cooling effect is, therefore, given to the jets preventing the back-flow of flame to the burner. In order to vaporize and expand the gases in the burner and get a more efficient velocity of jets and combustible mixture it is desirable to continue the heating of the burner sufficiently for this purpose and this is accomplished by heat from the combustion chamber and particularly radiation from the walls of the combustion chamber. These should be proportioned to keep the burner hot enough to vaporize the fuel but not so hot that the part immediately adjacent to the jets ceases to act to prevent a back movement of flame. This is important because after the flame is established without the burner and the burner is cooled especially at the jets it is possible to turn down the air supply to a point very much below the initial pressure at which the action is started and thus give a very light flame and a very wide range of flexibility to the burner. At this point the velocity of gases with relation to the flame propagation is very slow and consequently the cooling effect at the jets is desirable.

In starting the burner it is usual to use about 15 pounds of air pressure and the jet openings are so formed as to confine the mixture in the chamber making an air pressure in the chamber of about $1\frac{1}{2}''$ water column above atmospheric. After the flame has established itself without the burner the air pressure in the chamber will have increased by reason of the evaporation of the fuel content of the mixture and the expansion of the air in the chamber so as to give an air pressure in the chamber of about $1\frac{3}{4}''$ water pressure above atmospheric. The air pressure in the chamber, of course, is not so important except that it controls the varying velocity through the jet openings. After the flame is established without the burner and the burner is sufficiently cooled especially at the jet the air pressure may be reduced to 4 pounds per sq. in. Under these conditions the pressure in the burner will be reduced to $\frac{1}{4}''$ water pressure. There are certain variations possible in this but this will give a relation which will give good results. It will be understood that the mixture delivered by the atomizer is very rich and should be such as to give just the right mixture with the air entrained through the throat. This can be readily accomplished by the adjustment of the valve controlling the fuel in the ordinary manner of adjusting such spray devices, or it may be adjusted by varying the elevation to which the fuel is lifted.

In order that there may be as great a variation in expansion of the mixture in the chamber as possible I prefer to deliver the mixture to the chamber cold and along the same line in the normal operation of the burner I prefer to heat it sufficiently to vaporize the fuel content of the mixture as this gives a greater expansion of the gases and makes a gaseous as distinguished from an atomized burning mixture at the jet and this secures more perfect combustion.

In order to more readily heat the mixture I provide the plates 25 and 26 extending from the outer shell of the burner to within the chamber so as to give a greater heating surface to the mixture in the chamber.

In Figs. 1 and 2 there are double burners while in the structure shown in Figs. 4 and 5 a single burner is used and in the structure shown in Figs. 1 and 2 the jet openings extend downwardly while in Figs. 4 and 5 the jet openings are at the top of the burner.

In the construction shown in Figs. 4 and 5 the combustion chamber 2^a is similar in a general way to the combustion chamber shown in Figs. 1 and 2 except that the walls are formed slightly different to deflect the gases along the walls of the lining so as to more readily heat said walls and convey the heat to the burner. The burner has the corrugations 26^a and an inwardly extending plate 25^a for increasing the heating surface. Otherwise the structures are similar.

What I claim as new is:—

1. The method of burning combustible mixtures which consists in delivering a combustible mixture under pressure, confining the mixture delivered, discharging the mixture from said confinement with a re-

stricted flow area, and heating the mixture confined to give to the flow an added velocity due to the heating greater than the rapidity of flame propagation in the mixture discharged.

2. The method of burning combustible mixtures which consists in delivering a cold combustible mixture under pressure, confining the mixture delivered, discharging the mixture from said confinement with a restricted flow area, and heating the mixture confined to add velocity at the point of discharge and to give to the flow an added velocity due to the heating greater than the rapidity of flame propagation in the mixture discharged.

3. The method of burning combustible mixtures which consists in delivering a combustible mixture under pressure, confining the mixture delivered, discharging the mixture from said confinement with a restricted flow area having a cooling medium adjacent thereto, igniting the confined mixture, the flow having a velocity with relation to the cooling medium retarding the passage of flame from the confined mixture to the mixture discharged, and continuing the burning of the mixture to increase the velocity of the flow at the temperature of the cooling medium to permit the transfer of flame from the confined mixture to the discharged mixture.

4. The method of burning combustible mixtures which consists in delivering a combustible mixture under pressure, confining the mixture delivered, discharging the mixture from said confinement with a restricted flow area having a cooling medium adjacent thereto, igniting the confined mixture, the flow having a velocity with relation to the cooling medium retarding the passage of flame from the confined mixture to the discharged mixture, continuing the burning of the mixture to increase the velocity of the flow at the temperature of the cooling medium to permit the transfer of flame from the confined mixture to the discharged mixture, and reducing the temperature of the cooling medium to retard the return of flame along the mixture as it is discharged to the confined mixture.

5. The method of burning combustible mixtures which consists in delivering a combustible mixture under pressure, confining the mixture delivered, discharging the mixture from said confinement with a restricted flow area having a cooling medium adjacent thereto, igniting the confined mixture, the flow having a velocity with relation to the cooling medium retarding the passage of flame from the confined mixture to the discharged mixture, continuing the burning of the mixture to increase the velocity of the flow at the temperature of the cooling medium to permit the transfer of flame from the confined mixture to the mixture discharged, and continuing a supply of heat to the confined mixture after the transfer of flame.

6. The method of burning combustible mixtures which consists in delivering a combustible mixture under pressure, confining the mixture delivered, discharging the mixture from said confinement with a restricted flow area having a cooling medium adjacent thereto, igniting the confined mixture, the flow having a velocity with relation to the cooling medium retarding the passage of flame from the confined mixture to the discharged mixture, continuing the burning of the mixture to increase the velocity of the flow at the temperature of the cooling medium to permit the transfer of flame from the confined mixture to the discharged mixture, and continuing a supply of heat to the mixture after the transfer of flame sufficient to vaporize the fuel content of the mixture.

7. The method of burning combustible mixtures which consists in delivering a combustible mixture under pressure, confining the mixture delivered, discharging the mixture from said confinement with a restricted flow area having a cooling medium adjacent thereto, igniting the confined mixture, the flow having a velocity with relation to the cooling medium retarding the passage of flame from the confined mixture to the discharged mixture, continuing the burning of the mixture to increase the velocity of the flow at the temperature of the cooling medium to permit the transfer of flame from the confined mixture to the discharged mixture, and continuing the supply of heat to the confined mixture, taking the heat therefor from the flame at the discharge.

8. The method of burning combustible mixtures which consists in delivering a combustible mixture under pressure, confining the mixture delivered, discharging the mixture from said confinement with a restricted flow area having a cooling medium adjacent thereto, igniting the confined mixture, the flow having a velocity with relation to the cooling medium retarding the passage of flame from the confined mixture to the discharged mixture, continuing the burning of the mixture to increase the velocity of the flow at the temperature of the cooling medium to permit the transfer of flame from the confined mixture to the discharged mixture, and continuing to heat the confined mixture, the heat delivered to the confined mixture giving to the cooling medium a temperature below that reached by the cooling medium during the combustion of the confined mixture.

9. The method of burning combustible mixtures which consists in delivering a cold combustible mixture under pressure, confin-

ing the mixture delivered, discharging the mixture from said confinement with a restricted flow area having a cooling medium adjacent thereto, igniting the confined mixture, the flow having a velocity with relation to the cooling medium retarding the passage of flame from the confined mixture to the discharged mixture, and continuing the burning of the mixture to increase the velocity of the flow at the temperature of the cooling medium to permit the transfer of flame from the confined mixture to the discharged mixture.

10. The method of burning combustible mixtures which consists in delivering a cold combustible mixture under pressure, confining the mixture delivered, discharging the mixture from said confinement with a restricted flow area having a cooling medium adjacent thereto, igniting the confined mixture, the flow having a velocity with relation to the cooling medium retarding the passage of flame from the confined mixture to the discharged mixture, continuing the burning of the mixture to increase the velocity of the flow at the temperature of the cooling medium to permit the transfer of flame from the confined mixture to the discharged mixture and reducing the temperature of the cooling medium to retard the return of flame to the confined mixture.

11. The method of burning combustible mixtures which consists in delivering a cold combustible mixture under pressure, confining the mixture delivered, discharging the mixture from said confinement with a restricted flow area having a cooling medium adjacent thereto, igniting the confined mixture, the flow having a velocity with relation to the cooling medium retarding the passage of flame from the confined mixture to the discharged mixture, continuing the burning of the mixture to increase the velocity of the flow at the temperature of the cooling medium to permit the transfer of flame from the confined mixture to the discharged mixture, and continuing a supply of heat to the confined mixture after the transfer of flame.

12. The method of burning combustible mixtures which consists in delivering a cold combustible mixture under pressure, confining the mixture delivered, discharging the mixture from said confinement with a restricted flow area having a cooling medium adjacent thereto, igniting the confined mixture, the flow having a velocity with relation to the cooling medium retarding the passage of flame from the confined mixture to the discharged mixture, continuing the burning of the mixture to increase the velocity of the flow at the temperature of the cooling medium to permit the transfer of flame from the confined mixture to the discharged mixture, and continuing a supply of heat to the confined mixture after the transfer of flame sufficient to vaporize the fuel content of the mixture.

13. The method of burning combustible mixtures which consists in delivering a cold combustible mixture under pressure, confining the mixture delivered, discharging the mixture from said confinement with a restricted flow area having a cooling medium adjacent thereto, igniting the confined mixture, the flow having a velocity with relation to the cooling medium retarding the passage of flame from the confined mixture to the discharged mixture, continuing the burning of the mixture to increase the velocity of the flow at the temperature of the cooling medium to permit the transfer of flame from the confined mixture to the discharged mixture, and continuing the supply of heat to the confined mixture, taking the heat therefor from the flame at the discharge.

14. The method of burning combustible mixtures which consists in delivering a cold combustible mixture under pressure, confining the mixture delivered, discharging the mixture from said confinement with a restricted flow area having a cooling medium adjacent thereto, igniting the confined mixture, the flow having a velocity with relation to the cooling medium retarding the passage of flame from the confined mixture to the discharged mixture, continuing the burning of the mixture to increase the velocity of the flow at the temperature of the cooling medium to permit the transfer of flame from the confined mixture to the discharged mixture, and continuing to heat the confined mixture, the heat delivered to the confined mixture giving to the cooling medium a temperature below that reached by the cooling medium during the combustion of the confined mixture.

15. In an apparatus for burning combustible mixtures the combination of a burner having a mixing chamber with flame discharge and a mixer throat; a spraying device delivering a cold combustible mixture to the mixing chamber through the throat; mechanism for controlling the spraying device pressure; and means igniting the mixture in the burner, the spraying device and discharge having a relation confining combustion to the mixture in the burner initially and transferring the flame to without the burner as the temperature of the burner is increased.

16. In an apparatus for burning combustible mixtures the combination of a burner having a mixing chamber with flame discharge and a mixer throat; a spraying device delivering a cold combustible mixture to the mixing chamber through the throat; mechanism for controlling the spraying device pressure; means igniting the mixture in the burner, the spraying device and discharge

having a relation confining combustion to the mixture in the burner initially and transferring the flame to without the burner as the temperature of the burner is increased; and means outside the chamber for continuing the heat of the chamber.

17. In an apparatus for burning combustible mixtures the combination of a burner having a mixing chamber with flame discharge and a mixer throat; a spraying device delivering a cold combustible mixture to the mixing chamber through the throat; mechanism for controlling the spraying device pressure; means igniting the mixture in the burner, the spraying device and discharge having a relation confining combustion to the mixture in the burner initially and transferring the flame to without the burner as the temperature of the burner is increased; and means for continuing to heat the burner, said means permitting the reduction of temperature of the walls of the burner adjacent to the jet openings to retard the return of flame to the mixture within the burner.

18. In an apparatus for burning combustible mixtures the combination of a burner having a mixing chamber with flame discharge and a mixer throat; a spraying device delivering a cold combustible mixture to the mixing chamber through the throat; mechanism for controlling the spraying device pressure; means igniting the mixture in the burner, the spraying device and discharge having a relation confining combustion to the mixture in the burner initially and transferring the flame to without the burner as the temperature of the burner is increased; and means outside the chamber for continuing the heat of the chamber, said means being supplied with heat from the flame of the burner.

19. In an apparatus for burning combustible mixtures the combination of a furnace; a confined combustion chamber having walls adapted to absorb and radiate heat; a burner in the combustion chamber having a mixing chamber with flame discharge and a mixer throat; and a spray device for spraying combustible mixture into the chamber through the throat.

20. In an apparatus for burning combustible mixtures the combination of a furnace; a confined combustion chamber having walls adapted to absorb and radiate heat; a burner in the combustion chamber having a mixing chamber with flame discharge and a mixer throat; and a spray device for spraying combustible mixture into the chamber through the throat, the heating surface of the burner chamber receiving radiant heat from the combustion chamber sufficient to vaporize the fuel content of the mixture.

21. In an apparatus for burning combustible mixtures the combination of a furnace; a confined combustion chamber having walls adapted to absorb and radiate heat; a plurality of burners in the combustion chamber, each burner having a mixing chamber with flame discharge and a mixer throat; and a spray device for spraying combustible mixture into each chamber and through the throats.

In testimony whereof I have hereunto set my hand.

ROBERT F. METCALFE.