Aug. 2, 1932. E. X. SCHMIDT 1,869,585

METHOD OF AND MEANS IN CALORIMETRY FOR BURNING GASES OF RELATIVELY LOW HEATING VALUE

Filed Aug. 18, 1930 2 Sheets-Sheet 1

Fig. 2

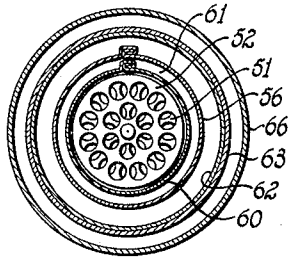


Fig. 1

Fig. 3

Fig. 4

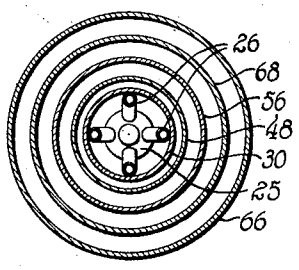
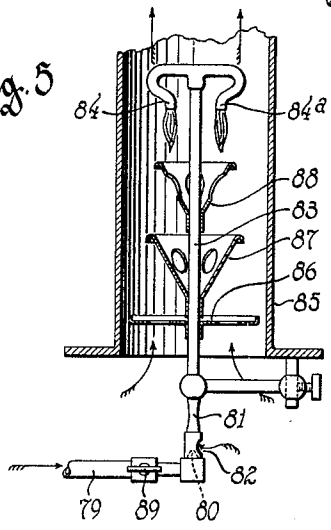


Fig. 5



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Fig. 6

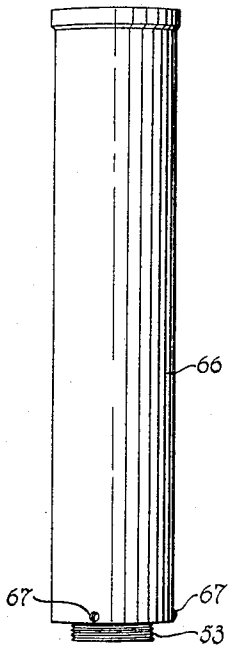


Fig. 7

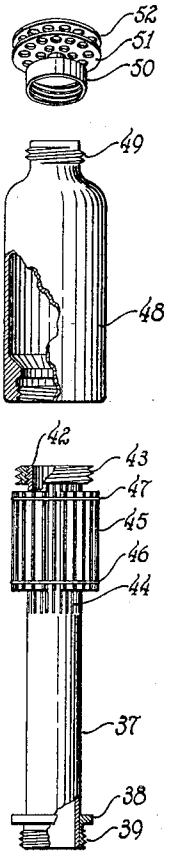


Fig. 8

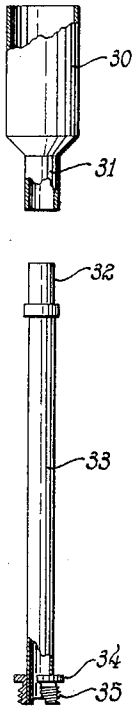
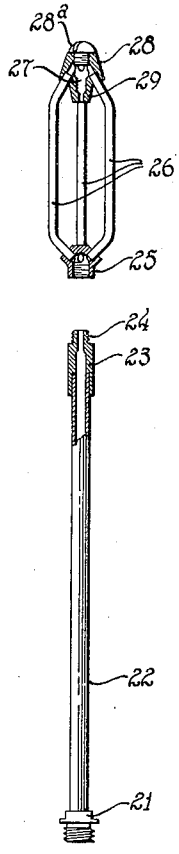


Fig. 9



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UNITED STATES PATENT OFFICE

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METHOD OF AND MEANS IN CALORIMETRY FOR BURNING GASES OF RELATIVELY LOW HEATING VALUE

Application filed August 18, 1930. Serial No. 475,922.

This invention relates to methods of and means in calorimetry for burning gases of relatively low heating value.

It is extremely difficult to burn gases containing a small percentage of hydrogen and a large percentage of inert or noncombustible constituents, due, primarily, to the characteristic low velocity of flame propagation of such gases. Gases such as blast furnace gas and low heating value producer gas have a high percentage of inert constituents, and it is practically impossible to efficiently burn these or similar low heating value gases in calorimeters having burners of the character heretofore employed.

To overcome the aforementioned difficulties, I have devised a burner utilizing a counter-flow principle,—that is, the gas flows in a direction opposite to the direction of flow of the combustion air. I prefer to provide for a downward flow of the gas at the point of combustion thereof, so that the natural or convection currents caused by thermal effects will not upset the stabilized condition the counter-flow arrangement tends to produce. I also arrange the gas conveying tube or tubes in such manner that the products of combustion come in contact therewith, thereby insuring a substantial degree of preheating of the gas. In burning of the gas, I prefer to use no primary air of combustion; although with certain gases the velocity of flame propagation may, to advantage, be increased by the introduction of a small quantity of primary air into the gas stream.

Accordingly, one object of the invention is to provide an improved method in calorimetry for burning gases of relatively low heating value per unit volume.

Another object is to provide an improved calorimeter burner for performing the method aforementioned.

Another object is to provide such a burner having novel details of construction and operation to thereby increase the accuracy of the determinations of the calorimeter of which it forms a part.

Another and more specific object is to provide a burner wherein the gas at the point of combustion is caused to flow in a direction opposite to the direction of flow of the combustion air, whereby a stabilized and efficient flame is insured.

Another object is to provide a burner utilizing the counter-flow principle just mentioned, in which the gas at the point of combustion is caused to flow downwardly, and whereby the location of the gas flame may be utilized to effect a substantial degree of preheating of the gas.

Other objects and advantages of the invention will hereinafter appear.

The accompanying drawings illustrate certain embodiments of the invention which will now be described, it being understood that the embodiments illustrated are susceptible of modification in the details thereof without departing from the scope of the appended claims.

In the drawings, Figure 1 is a vertical sectional view of a gas calorimeter burner constructed in accordance with my invention.

Fig. 2 is a sectional view, on the line 2—2 of Fig. 1, showing the staggered relation of the openings in the baffle plates.

Fig. 3 is a top plan view of the burner tip portion and the small gas-conveying pipes leading thereto.

Fig. 4 is a sectional view, on the line 4—4 of Fig. 1.

Fig. 5 is a view, partly in elevation and partly in vertical section, of a simplified form of calorimeter burner embodying certain of the novel features of my invention.

Fig. 6 is a side elevation of the outer cylinder or jacket of the burner illustrated in Figs. 1 to 4, and

Figs. 7, 8 and 9 are slightly enlarged detail views, in elevation, of certain of the parts illustrated in Figs. 1 to 4,—the parts in each figure being shown in separated relation.

The burner illustrated in Figs. 1 to 4 and 6 to 9 is particularly well adapted for use in conjunction with a calorimeter of the type disclosed in the patent of Horace N. Packard No. 1,662,802, dated March 13, 1928; but it is to be understood that certain basic features of my invention are likewise adapted for use in conjunction with other types of

calorimeter, as, for instance, the simplified type illustrated in Fig. 5 herein.

Following in general the teachings of the aforementioned Packard patent, it may be assumed that test gas, combustion air and cooling air are caused to flow through the pipes or conduits 15, 16 and 17, respectively, at constantly proportional volumetric rates relative to each other,—said fluids being subjected to influences adapted to bring the same to like conditions of temperature, pressure and saturation. Thus the three streams of fluid are initially supplied, at atmospheric pressure, to three fluid pumps of the wet displacement type (not shown),—such fluids being subjected in the pumps to contact with the body of liquid in the tank of the calorimeter, thus bringing the fluids to like conditions of temperature and saturation. The liquid level is indicated by the dotted line 18 in Fig. 1.

The burner structure includes a cup-shaped support 19, which is preferably a metal casting, said support having a relatively small lower chamber 20 to which one end of pipe 15 is connected. The upper wall of chamber 20 is provided with a tapped opening to accommodate the externally threaded portion of a nut 21 into which the lower end of a relatively small tube 22 is brazed or soldered for support of the latter. Silver soldered or otherwise suitably attached to the upper end of tube 22 is an enlarged tip 23 (Fig. 9), the upper end 24 of said tip being adapted for threaded engagement with a hollow supporting member 25.

The head of member 25 is provided with a plurality of openings within which the lower ends of a corresponding number of relatively small gas conveying pipes 26 are secured, as by soldering. In the particular form of burner illustrated four equally spaced outwardly bowed pipes 26 are provided,—but it is to be understood that the number and size of such pipes may be varied of desired. The upper ends of pipes 26 are likewise soldered within openings leading to a chamber 27 in the upper member 28 of the burner. Member 28 is provided with a downwardly projecting nozzle or burner tip 29 whereby the jet or stream of gas is directed downwardly at the point of combustion thereof. Member 28 is provided at its upper end with a clean-out opening, said opening being tapped to receive a closing screw 28*a* or the like.

Adapted to surround and fit snugly against the pipes 26 for the major portion of the length thereof is a metal cylinder 30 (Fig. 8) having a reduced cylindrical lower end portion 31 which is adapted to telescope onto the shouldered upper end 32 of a tube 33. Attached to and surrounding the lower end of tube 33 is a nut 34, the threaded portion 35 of which takes into a tapped opening in the upper wall of a second chamber 36.

Arranged concentrically about the tubes 22 and 33 is a tube 37 (Fig. 7) to the lower end of which is soldered or otherwise rigidly secured a nut 38 the threaded portion 39 of which takes into a tapped opening in the lower wall 40 of a chamber or passage 41. The upper end of tube 37 is externally threaded as indicated at 42 for cooperative engagement by the internally threaded face of a member 43,—said member 43 being permanently held in such threaded engagement with tube 37 as by keying and/or soldering the former to the latter. Member 43 is likewise threaded externally for a purpose to be later described.

As shown the upper portion of tube 37 is provided with a multiplicity of equally spaced shallow radial grooves 44 into which are fitted and secured, as by soldering or brazing, a corresponding number of radial heat-dissipating fins or vanes 45; the outer edges of said vanes having circumferentially alined notches to receive the reinforcing rings or wires 46 and 47.

Adapted for threaded engagement with the member 43 is a metal cylinder 48,—the upper reduced end 49 of said member being externally threaded to receive the closing cap 50. Rigidly attached to the upper end of cap 50, in spaced relation to the latter and to each other, are a pair of perforated baffle plates 51 and 52,—said plates being preferably arranged as shown in Fig. 2 with the multiplicity of perforations therein in offset or staggered relation to each other.

Threaded into a tapped opening in the upper wall of chamber or passage 41 is a member 53 having inner and outer annular flanges 54 and 55. Slidably fitted against the outer surface of the inner flange 54 and adapted to rest upon the body portion of member 53 is a tube 56 which extends throughout substantially the entire length of the burner structure. Slidably fitted against the inner surface of said flange 54 and extending upwardly for a portion of the length of tube 56 is a tube 57 (Fig. 1), the upper end of tube 57 being secured to a ring or annulus 58 of bronze, which is in turn secured to tube 56,—thus providing an annular dead air space 59 between said tubes.

Also secured in a similar manner to the interior of the upper portion of tube 56 is a tube 60, whereby a second annular dead air space 61 is provided. Projecting upwardly beyond and rigidly secured to the upper end of tube 56 is a tube 62 of relatively larger diameter, and telescopically fitting over tube 62 is a tube 63 having a plurality of perforations 64 at the lower end thereof,—said lower end having rigidly secured thereto an annular plate or baffle 65 which fits rather closely between the outer surface of tube 56 and the

inner surface of the outer tube or jacket 66. As shown the lower end of tube 66 is secured to the outer flange 55 of member 53 as by means of a plurality of screws 67. Also secured to and depending from the annular plate 65 and between tubes 56 and 66 is a tube 68 which preferably envelops the combustion chamber of the burner.

Closely fitting over the upper end of tube 62 is a closure cap 69, said cap being provided with a central opening whereby the supporting elements 70 of an electrical resistance thermometer 71 may be clamped in position.

The aforementioned telescopic connection between tubes 62 and 63 is intended to provide for adjustment of the length of the multiple reflexed portion of the flow of cooling fluid during testing of the burner at the factory, and when the adjustment desired or required has been effected, I preferably spot solder the telescoped portions of such tubes to maintain the same in adjusted position.

The cup-shaped member 19 has attached to its upper end an inverted trough-shaped member 72, the lower edge of which is located below the level 18 of liquid in the calorimeter tank, thus forming in conjunction with passage 41 and a U-shaped pipe 73 a conduit for the cooling fluid. Member 72 is provided in its upper side with an opening 74 over which is placed the cover plate 75, said cover plate having an opening about which the elements 76 are clamped to support a second electrical resistance thermometer 77 in position within the passage.

Thus, assuming constantly proportional volumetric rates of flow of test gas, combustion air, and cooling air through the pipes or conduits 15, 16 and 41, respectively, such fluids are thereupon directed in the respective paths indicated by the arrows,—it being noted that the test gas is ejected downwardly from nozzle 29 into the combustion chamber and against the upwardly flowing stream of combustion air. The jet of gas having been initially ignited in the usual manner by temporarily removing certain of the parts of the burner casing, such parts are then replaced, so that the products of combustion flow naturally in an upward direction in contact with the upper portions of the gas conveying pipes 26, whereupon said combustion products are directed downwardly in an annular stream between the exterior of cylindrical member 30 and the interior of cylinder 48, and thence further in a downward direction between the exterior of tube 33 and the interior of tube 37, whence the same are discharged into a chamber 78 formed in member 19, and to atmosphere.

It will be noted that no means are provided for mixing or diluting the gas stream with air or other fluid prior to ejection thereof from nozzle 29,—and I prefer this arrangement where the gas being tested is of relatively low heating value (such for instance, as blast furnace gas or producer gas having a heating value of, say, less than 100 B. t. u's. per cubic foot). By the arrangement illustrated the products of combustion are utilized to effect substantial preheating of the gas and air, whereas by directing the flow of cooling fluid in the path indicated by the arrows an efficient heat exchange is effected between the same and the products of combustion.

Thus the cooling fluid is directed upwardly in an annular stream between the exterior of tube 37 and the interior of tube 57, thence upwardly between the exterior of cylinder 48 and the interior of tube 56, through the relatively offset multiple perforations in baffle plates 51 and 52 into contact with the electrical resistance thermometer 71. Thereupon the cooling fluid is caused to flow downwardly in an annular stream between the exterior of tube 56 and the interior of tube 62 (for a distance determined by the adjustment of tubes 62 and 63), thence through openings 64 and upwardly between the exterior of tubes 62 and 63 and the interior of the outer tube or casing 66 to atmosphere. The relative temperature of the cooling fluid having been ascertained by the effect thereof upon the electrical resistance thermometer 77, it is obvious that the heating value per unit volume of the test gas may be ascertained and/or recorded by the other elements of a calorimeter of the type disclosed in the Packard patent aforementioned.

If the gas being tested is sufficiently rich to permit dilution thereof with primary combustion air, obviously a measured stream of such primary air of combustion may be admitted to the gas stream at a suitable point in the flow of the latter. The effect of such addition of primary combustion air under favorable conditions will be to increase the velocity of flame propagation of the gas, which feature is extremely desirable in certain cases.

Where extreme accuracy of the determinations of the calorimeter is not required, a simple burner of the type illustrated in Fig. 5 may be employed,—said burner embodying the feature of directing the jet or jets of gas downwardly into the path of the flow of air to support and assist in combustion thereof when ignited. In this arrangement the continuous test sample of gas is caused to flow at a predetermined volumetric rate through conduit 79, whence it discharges upwardly through jet 80 into a restricted passage or Venturi tube 81, an opening 82 being provided for entrance of an amount of primary combustion air which will be determined by the rate of flow or pressure of the gas.

The mixed air and gas then flows upwardly through a central pipe 83 and thence discharges in a downward direction from the twin- or multiple-jets 84 and 84*a*. Surrounding the burner jets and extending downwardly a considerable distance therebelow is a tube or cylinder 85 which is preferably open at both ends. The secondary combustion air flows upwardly as a result of the natural draft caused by combustion of the gas, suitable perforated baffle plates or cones 86, 87 and 88 being preferably provided to slightly restrict the flow of such air. Any suitable or well known thermally responsive element or elements (not shown) may be employed to ascertain and/or indicate the quality or heating value per unit volume of the gas. A valve 89 may be provided to vary the rate of flow of the test gas.

What I claim as new and desire to secure by Letters Patent is:

1. The method, in calorimetry, of efficiently burning a continuous sample of combustible gas having a low rate of flame propagation, which method comprises causing a downward flow of the gas from a burner tip, igniting said flow of gas, and simultaneously causing a flow or air upwardly against said flow of gas to support combustion of the latter.

2. The method, in calorimetry, of efficiently burning a continuous sample of combustible gas having a low rate of flame propagation, which method comprises causing a downward flow of the gas from a burner tip, igniting said flow of gas, simultaneously causing a flow of air upwardly against said flow of gas to support combustion of the latter, and subjecting said gas prior to combustion to the preheating effect of the products of combustion of said gas and air.

3. The method, in calorimetry, of efficiently burning a continuous sample of combustible gas having a low rate of flame propagation, which method comprises causing a downward flow of the gas from a burner tip, igniting said flow of gas, simultaneously causing a flow of air upwardly against said flow of gas to support combustion of the latter, and effecting a downward flow of the products of combustion in heat exchanging relation to said flows of gas and air.

4. In calorimetry, the method of burning a test sample of gas of relatively low heating value in a manner to substantially stabilize the flame at the point of combustion of the gas, which method comprises effecting a downward flow of the gas at the point of combustion thereof, igniting said flow of gas, and simultaneously effecting a flow of fluid upwardly directly against said flow of gas to support combustion of the latter.

5. The method, in calorimetry, which method comprises causing ejection of a combustible gas at a predetermined rate from an inverted burner tip, igniting said flow of gas, and simultaneously effecting a flow of air upwardly against said flow of gas to support combustion of the latter, whereby the gas flame is substantially stabilized notwithstanding extremely wide variations in heating value per unit volume of said gas.

6. The method, in calorimetry, which method comprises supplying to a burner a continuous stream of combustible gas and a continuous stream of air to support combustion thereof, definitely proportioning said streams of gas and air relatively to each other, and directing said streams of gas and air against each other from opposite directions respectively at the point of combustion thereof whereby snuffing of the flame under conditions of low heating value of the gas is avoided.

7. The method, in calorimetry, which method comprises supplying to a burner a continuous stream of combustible gas and a continuous stream of air to support combustion thereof, definitely proportioning said streams of gas and air relatively to each other, directing said streams of gas and air against each other from opposite directions respectively at the point of combustion thereof whereby snuffing of the flame under conditions of low heating value of the gas is avoided, effecting a separate continuous flow of fluid in heat exchanging relation to the products of combustion of said gas and air, and measuring the relative values of the temperatures of said fluid before and after said heat exchange.

8. The method, in calorimetry, of burning a combustible gas having a heating value of less than 100 B. t. u's. per cubic foot, which method comprises ejecting a continuous stream of such gas downwardly into an upwardly flowing continuous stream of air, and igniting said stream of gas, said stream of air being adapted to support combustion of said stream of gas.

9. In a calorimeter burner for combustible gases of relatively low heating value per unit volume, in combination, a burner tip, means for directing a continuous flow of combustible gas to the burner tip, said burner tip being arranged to direct the flow of gas downwardly therefrom, and means for directing a flow of air upwardly toward said burner tip to support and assist in combustion of said gas, whereby the gas flame is substantially stabilized under conditions of variation in the combustion characteristic of said gas.

10. In a calorimeter burner for combustible gases of relatively low heating value per unit volume, in combination, a burner tip, means for directing a continuous flow of combustible gas to the burner tip, said burner tip being arranged to direct the flow of gas downwardly therefrom, and means for directing a flow of air upwardly toward said burner tip to support and assist in combustion of said gas, whereby the gas flame is

substantially stabilized under conditions of variation in the combustion characteristics of said gas, said burner having portions thereof located directly in the path of the products of combustion of said gas and air whereby substantial preheating of the gas is insured.

11. In a burner for gas calorimeters, in combination, a combustion chamber, means for supplying continuously proportioned streams of gas and air to said combustion chamber, said stream of gas being caused to flow downwardly at the point of combustion thereof, and said stream of air being caused to flow upwardly directly against said stream of gas, for the purpose set forth.

12. In a burner for gas calorimeters, in combination, a burner tip, means for directing a continuous flow of combustible gas to the burner tip, said burner tip being arranged to direct the flow of gas downwardly therefrom, means for directing a flow of air upwardly toward said burner tip, and means for providing a separate flow of fluid in heat exchanging relation to the products of combustion of said gas and air when ignited.

13. In a burner for gas calorimeters, in combination, a burner tip, means for directing a continuous flow of combustible gas to the burner tip, said burner tip being arranged to direct the flow of gas downwardly therefrom, means for directing a flow of air upwardly toward said burner tip, means for providing a separate flow of fluid in heat exchanging relation to the products of combustion of said gas and air when ignited, and electrothermally responsive elements located in the path of said last mentioned flow of fluid on opposite sides of the heat exchanging portion of the latter.

14. In a burner for gas calorimeters, in combination, a combustion chamber closed at its upper end, concentrically arranged supply tubes for gas and combustion air leading upwardly to said combustion chamber, a tube surrounding the aforementioned tubes and forming a continuation of the walls of said combustion chamber to convey the products of combustion downwardly in heat exchanging relation to the flows of gas and air, an inverted burner tip for directing the flow of gas downwardly against the flow of combustion air within the combustion chamber, a tubular element surrounding said combustion chamber and the continuation thereof to provide an annular path for a separate flow of cooling fluid in heat exchanging relation to the products of combustion of said gas and air when ignited, and tubular elements surrounding said last mentioned tubular element and communicating therewith to provide a multiple reflexed annular flow of said cooling fluid above said combustion chamber.

15. In a burner for gas calorimeters, in combination, a combustion chamber closed at its upper end, concentrically arranged supply tubes for gas and combustion air leading upwardly to said combustion chamber, a tube surrounding the aforementioned tubes and forming a continuation of the walls of said combustion chamber to convey the products of combustion downwardly in heat exchanging relation to the flows of gas and air, an inverted burner tip for directing the flow of gas downwardly against the flow of combustion air within the combustion chamber, a tubular element surrounding said combustion chamber and the continuation thereof to provide an annular path for a separate flow of cooling fluid in heat exchanging relation to the products of combustion of said gas and air when ignited, tubular elements surrounding said last mentioned tubular element and communicating therewith to provide a multiple reflexed annular flow of said cooling fluid above said combustion chamber, and a pair of electrical resistance thermometers located in the path of said cooling fluid to be subjected respectively to the temperatures of the latter before and after the heat exchange.

In witness whereof, I have hereunto subscribed my name.

EDWIN X. SCHMIDT.