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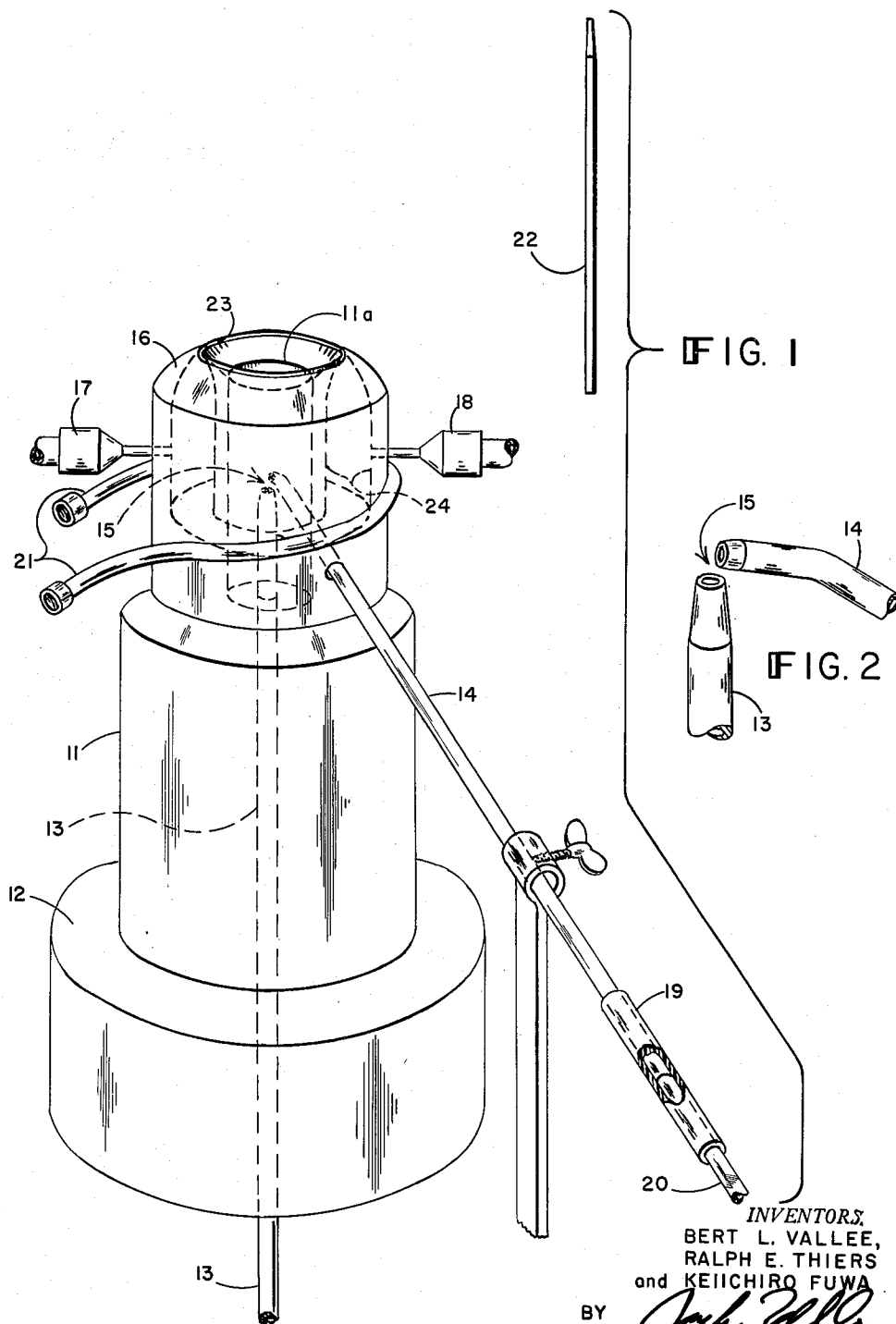
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2,990,748

BURNER FOR FLAME SPECTROPHOTOMETER

Filed April 8, 1957

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 3

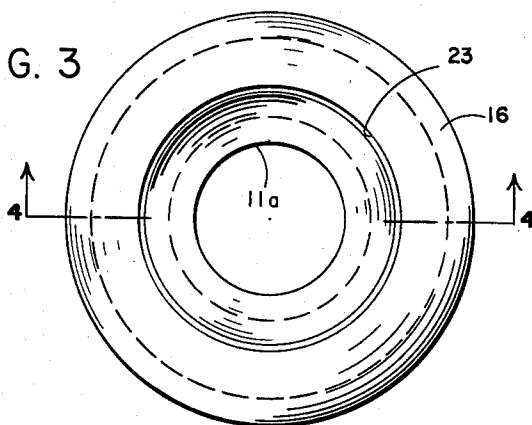
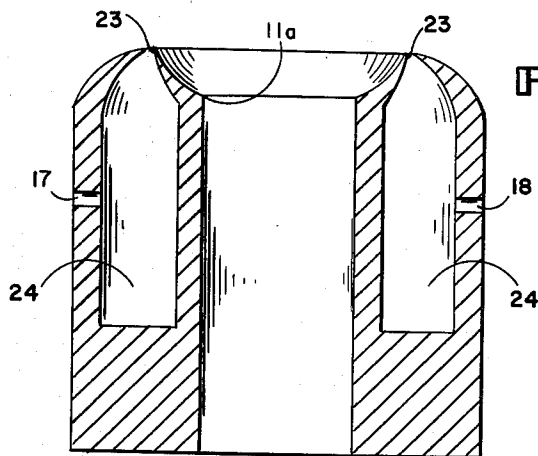


FIG. 4

FIG. 6

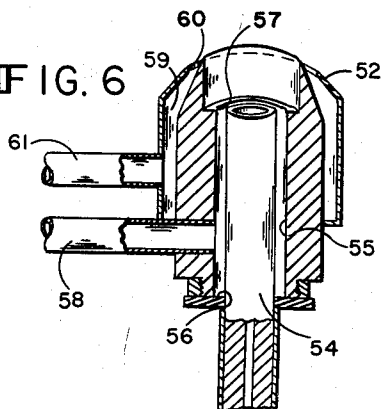
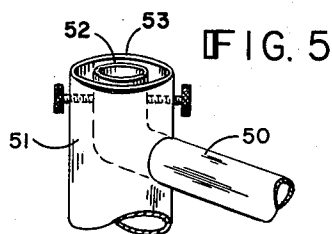


FIG. 5

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BURNER FOR FLAME SPECTROPHOTOMETER
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assignments, to Technicon Instruments Corporation,
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12 Claims. (Cl. 88—14)

This invention relates to burners for flame spectrophotometers. In particular, it relates to a novel burner useful with a cyanogen-oxygen flame for spectrochemical analysis of elements with high excitation potentials.

In the publications of Vallee and Baker, Anal. Chem. 27:320 (1955), Vallee and Baker, J. Optical Soc. America 45:773 (1955), Vallee and Bartholomay, Anal. Chem. 28:1753-55 (1956), the cyanogen-oxygen flame is described as being far more sensitive a spectrochemical flame source for analysis of trace metals than any previously described flame. Thus, concentrations varying from 0.36 to 36.0 parts per million of metals such as aluminum, barium, calcium, cobalt, copper, iron, lead, magnesium, manganese, nickel, and strontium can be determined as well as the alkali metals, which latter are quantitatively measurable by other previously described flames. The greatly improved sensitivity of the cyanogen-oxygen flame compared with other flames is attributed to its high temperature whereby adequate energies are provided to excite elements requiring high excitation energies. The temperatures of most conventional flames used in analysis, such as hydrogen-air, hydrogen-oxygen, acetylene-oxygen, propane-oxygen, and methane-oxygen give reliable, quantitative spectra primarily with elements of low excitation potential such as the alkali metals and alkaline earth metals.

The burner described by Vallee and Baker for utilizing the cyanogen-oxygen flame comprises passing a stream of oxygen through a nebulizer into the sample solution to provide a fine fog of sample suspended in the oxygen stream. Part of this stream is then mixed in a burner chamber with equimolar amounts of cyanogen and passed through an orifice in the tip of the burner where the flame is formed. However, subsequent experiments have shown this arrangement to be impractical because of a large and uncertain fraction of sample which is lost. Also, the flame temperature is often not high enough with the result that insufficient excitation energy is obtained.

In accordance with the present invention, a novel burner is provided which permits a stable, uniform flame of substantially maximum temperature, uniform sample injection, and great sensitivity when used with cyanogen-oxygen. This novel burner also enables substantially greater uniformity, stability and sensitivity to be derived from previously described spectrochemical flames.

In essence, the novel burner of this invention comprises a principal feed through which a stream of premixed flammable gas and air or oxygen are fed under pressure to an orifice, a separate tube connecting the liquid sample to a position in the stream so that sample is aspirated by flow of the stream, and a separate auxiliary burner surrounding the orifice. A central flame is thus provided into which the sample is sucked and which is surrounded by an auxiliary flame. Optical sampling is preferably confined to the portion just above the inner cone where a cyanogen-oxygen central flame is used and may be accomplished photographically, electronically, or by other conventional means of spectrochemical analysis.

A preferred embodiment of this invention is described below with reference to the drawings wherein:

FIGURE 1 is a schematic perspective of the burner assembly.

FIGURE 2 is a schematic perspective of the adjacent central feed and sample feed tips,

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FIGURE 3 is a top view of the auxiliary burner.

FIGURE 4 is a cross section along line 4—4 of FIGURE 3.

FIGURE 5 is a variation of the central feed and sample feed-tip arrangement.

FIGURE 6 is another variation of the complete burner as shown in cross section.

The burner chamber 11, supported on mount 12 is provided with a relatively long central conduit 13 to prevent back-flame and a separate sample conduit 14 whose tips meet adjacent to one another in location 15. Surrounding the central conduit is a concentric annular auxiliary burner 16 fed by conduits 17 and 18. Conduit 14, which is a thin tube, is connected by a flexible sleeve 19 to an interchangeable capillary tube 20 which controls the flow in conduit 14. In a separate chamber (not shown) cyanogen and oxygen are mixed together, preferably in equimolar quantities and the resulting stream fed to the central conduit 13. The capillary 20 is arranged to be inserted into a container of the liquid sample to be analysed. Conduit 17 is connected to a source of a combustible gas, as for example, cyanogen (although other gases such as carbon monoxide, acetylene, hydrogen, or methane can be used). Supply line 18 is connected to a source of oxygen. The entire top portion of the burner is cooled by a water condenser 21. A panel 22 is provided to screen the inner cone of the central flame from the viewing apparatus.

The auxiliary burner 16 has an annular orifice 23 near the top of burner chamber 24, which is separate and distinct from chamber 11.

In operation, the cyanogen and oxygen are separately fed through conduits 17 and 18 into the chamber 24 and then ignited so as to form the auxiliary flame at orifice 23. Then the stream of premixed cyanogen and oxygen is fed through conduit 13 and in turn is ignited at orifice 11a. The sample conduit 14 is dipped into the sample solution so that the stream of gas flowing out of the tip of conduit 13 draws off a steady quantity of sample into the main flame. By the use of this burner the temperature of the central flame is close to its maximum and is maintained. Further, the flow of sample is uniform with the result that the flame is completely stable and uniform and produces spectra which are very sensitive even at the high excitation potentials of the elements being measured.

The arrangement of tips of the sample and central feed may be also made in various other ways such as shown in FIGURES 5 and 6.

In FIGURE 5 the main-stream tube 51 is vertical. The sample tube 50 enters tube 51 and has its terminus 52 concentric and in same flow direction as the terminus 53 of tube 51.

In FIGURE 6 the sample tube 54 is vertical and surrounded by another short tube 55 which is closed on one end 56, open at its other end 57, and has a side connection to main stream feed tube 58. In this case auxiliary burner chamber 59 with orifice 60 is fed by an already mixed stream of combustible gas through tube 61. A single source of premixed gases for both burners can be obtained by connecting tube 61 to the main stream tube below the burner.

Although the materials and dimensions are not critical, it is preferred that the materials be rugged and resistant to heat, oxidation, and corrosion and that the dimensions be such as are convenient for use with a selected analyzing device. Thus, the sample tube can be made of an acid resistant metal such as platinum or palladium while the gas tubes and chambers can be made of stainless steel.

In one particular burner built in accordance with FIGURE 1, the gas tube 13 has an inside diameter of 0.4

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millimeter, the sample tube 14 an inside diameter of 0.3 millimeter, the main burner opening 11a a width of 3 millimeters, and the annular opening for the pilot flame a width of about 0.1 millimeter. The width of the entire burner is about 8 millimeters, the length of the tube 13, 51.5 millimeters, and the length of the sample tube 14, approximately 40 millimeters. Plastic tubing is used to connect the capillary tube 20 immersed in the sample solution to the sample tube 14. In general, the distance from the point at which the sample stream enters the main gas stream should be as short as possible. The overall width of the annular auxiliary flame is about 5.0 millimeters.

Sample flow control is preferably obtained by the use of different size replaceable capillaries, the rate of flow depending upon the length and inner diameter of the capillary.

Although the pilot flames as shown in the embodiments described above are in the form of concentric annuli, this is not required. The pilot flame is operative in any form that would surround the main flame. It is preferable, however, that it surround it in a symmetrical manner. Thus, for example, four individual jets or slot orifices symmetrically placed around the main flame would be equally satisfactory to the annulus. The temperature and flow rate of the auxiliary flame are not critical. The principal requirement of the auxiliary flame is that it provide sufficient continuous heat to keep the high velocity main flame from being extinguished. The speed of the main stream is preferably between 100 and 200 meters per second for the particular embodiments illustrated above using cyanogen-oxygen with a pressure at the burner of 10 pounds per square inch for each of the gases. The resultant temperatures are approximately 4500° K. where an equimolar mixture of cyanogen and oxygen is used in the main stream in the embodiment of FIGURE 1.

The novel burner of this invention is useable not only with cyanogen-oxygen, but with previously described flames, such as acetylene-oxygen, hydrogen-oxygen, manufactured gas-oxygen, methane-oxygen, acetylene-air, hydrogen-air, etc.

The term "self-combustible" as used in the appended claims is intended to mean a self-supporting mixture containing its required oxygen or oxygen source and not requiring the atmosphere or other oxygen source to sustain combustion.

We claim:

1. A method of obtaining a sensitive and uniform flame source with a selected combustible gas, comprising pre-mixing said gas with an oxygen source in suitable proportions, supplying a stream of the resulting mixture to a burner orifice so as to form a central flame when ignited, providing in another burner a mixture of a combustible gas and oxygen so as to form an auxiliary flame when ignited which symmetrically surrounds said central flame, and introducing a separate flow of test liquid into said stream.

2. A method of obtaining a sensitive and uniform flame source with a selected combustible gas, comprising pre-mixing said gas with an oxygen source in suitable proportions, supplying a stream of the resulting mixture to a burner orifice so as to form a central flame when ignited, providing in another burner a mixture of a combustible gas and oxygen so as to form an auxiliary flame when ignited which symmetrically surrounds said central flame, and aspirating a separate flow of test liquid into said central flame by said stream being supplied to said burner orifice.

3. In the art of flame photometry for the analysis of a sample liquid, the method of providing an oxygen-cyanogen spectral flame, comprising forming a mixture of oxygen and cyanogen in equi-molar proportions, forming a flame from a stream of said mixture, and introducing a stream of the sample liquid into said oxygen-cyanogen flame.

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4. In the art of flame photometry for the analysis of a sample liquid, the method of providing an oxygen-cyanogen spectral flame, comprising forming a mixture of oxygen and cyanogen in equi-molar proportions, forming a flame from a stream of said mixture, and aspirating a stream of the sample liquid into said oxygen-cyanogen flame by said stream of said mixture.

5. In the art of flame photometry for the analysis of a sample liquid, the method of providing an oxygen-cyanogen spectral flame, comprising forming a mixture of oxygen and cyanogen in equi-molar proportions, forming a flame from a stream of said mixture, concurrently forming an auxiliary flame from a stream of a mixture of a combustible gas and oxygen separate from said first mentioned flame but adjacent thereto, and aspirating a sample liquid into said first mentioned flame by the stream of the gas mixture from which said first mentioned flame is formed.

6. In the art of flame photometry for the analysis of a sample liquid, the method of providing an oxygen-cyanogen spectral flame, comprising forming a mixture of oxygen and cyanogen in equi-molar proportions, forming a flame from a stream of said mixture, concurrently forming an auxiliary flame from a stream of a molar mixture of oxygen and cyanogen separate from said first mentioned flame but adjacent thereto, and aspirating a sample liquid into said first mentioned flame by the stream of the gas mixture from which said first mentioned flame is formed.

7. In the art of flame photometry for the analysis of a sample liquid, the method of providing an oxygen-cyanogen spectral flame, comprising forming a mixture of oxygen and cyanogen in equi-molar proportions, forming a flame from a stream of said mixture, concurrently forming an auxiliary flame from a stream of a molar mixture of oxygen and cyanogen separate from said first mentioned flame but adjacent thereto, and introducing a stream of the sample liquid only into said first mentioned flame.

8. As a source of excitation for a spectrochemical device; a flame source comprising a chamber having a principal flame orifice, an auxiliary burner spaced adjacent said orifice and being equipped with conduit means for supplying a combustible mixture of gases, separate primary conduit means connected to a source containing a self-combustible mixture of cyanogen and oxygen and terminating in said chamber to supply a stream of said mixture, and separate conduit means connecting liquid sample to a position in said chamber within said stream between the termination of said primary conduit means and said principal orifice.

9. In a spectral flame burner, a main body having means providing a spectral flame zone, means adjacent to said spectral flame zone providing an auxiliary flame zone, means for supplying to each of said zones a combustible mixture consisting essentially of a gaseous fuel and combustion-supporting gas, and a liquid-sample feed means having an outlet in direct communication with said spectral flame zone and segregated from said auxiliary flame zone whereby the sample liquid is introduced only into the spectral flame and the auxiliary flame devoid of sample liquid aids in sustaining the spectral flame in said spectral flame zone.

10. In a spectral flame burner, a main body having an inner open-end chamber, a combustible-gas supply tube for a combustible mixture consisting essentially of a gaseous fuel and a combustion-supporting gas, said combustible-gas supply tube having an outlet in said chamber adjacent said open end and providing a spectral flame zone directly at said end of the chamber, said main body having an outer chamber surrounding said inner chamber and provided with inlet means for a combustible gas and with outlet means for the formation of an auxiliary flame laterally adjacent to said spectral flame, and a sample-liquid supply tube extending into said inner chamber and having an outlet disposed adjacent to said combustible-

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gas supply tube with the outlet of the latter in aspirating relation to the outlet of said liquid supply tube whereby the flow of the combustible mixture into said spectral flame zone induces a flow of sample liquid directly from the outlet of said liquid supply tube into the spectral flame and segregated from the auxiliary flame.

11. In a spectral flame burner, a main body having an inner open-end chamber, a combustible-gas supply tube for a combustible mixture consisting essentially of a gaseous fuel and a combustion-supporting gas, said combustible-gas supply tube having an outlet in said chamber adjacent said open end and providing a spectral flame zone directly at said end of the chamber, said main body having an outer chamber surrounding said inner chamber and provided with inlet means for a combustible gas and with outlet means for the formation of an auxiliary flame laterally adjacent to said spectral flame, and a sample-liquid supply tube extending transversely into said inner chamber and having an outlet disposed adjacent to said combustible-gas supply tube with the outlet of the latter in aspirating relation to the outlet of said liquid supply tube whereby the flow of the combustible mixture into said spectral flame zone induces a flow of sample liquid directly from the outlet of said liquid supply tube into the spectral flame and segregated from the auxiliary flame.

12. In a spectral flame burner, a main body having means providing a spectral flame zone, means adjacent to said spectral flame zone providing an auxiliary flame

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zone, means for supplying to each of said zones a combustible mixture consisting essentially of a gaseous fuel and combustion-supporting gas, and a liquid-sample feed having an outlet in direct communication with said spectral flame zone and segregated from said auxiliary flame zone whereby the sample liquid is introduced only into the spectral flame and the auxiliary flame devoid of sample liquid aids in sustaining the spectral flame in said spectral flame zone, means for forming said combustible mixture before it is supplied to said zones, and means for supplying from said forming means a pre-formed combustible mixture to said zones in separate streams, respectively.

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