

[54] FLAME DETECTOR

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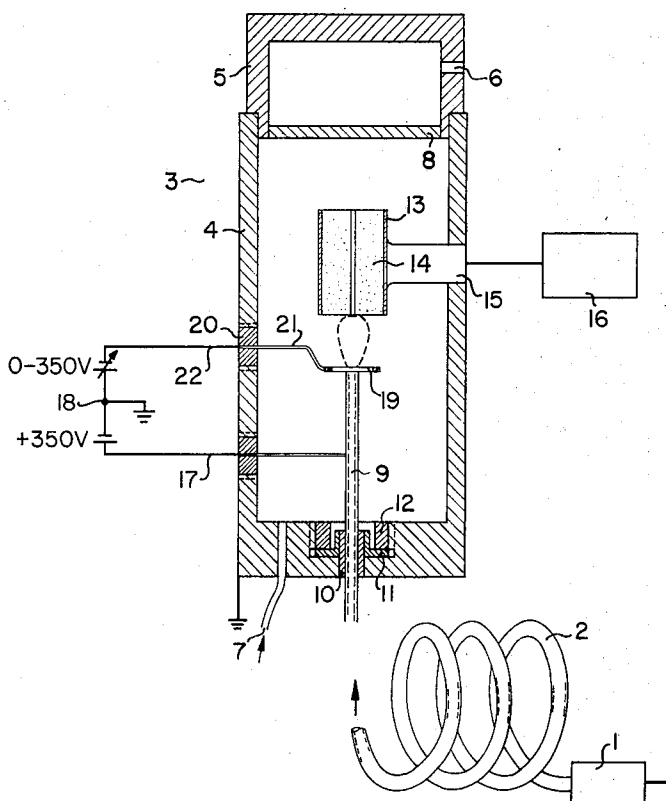
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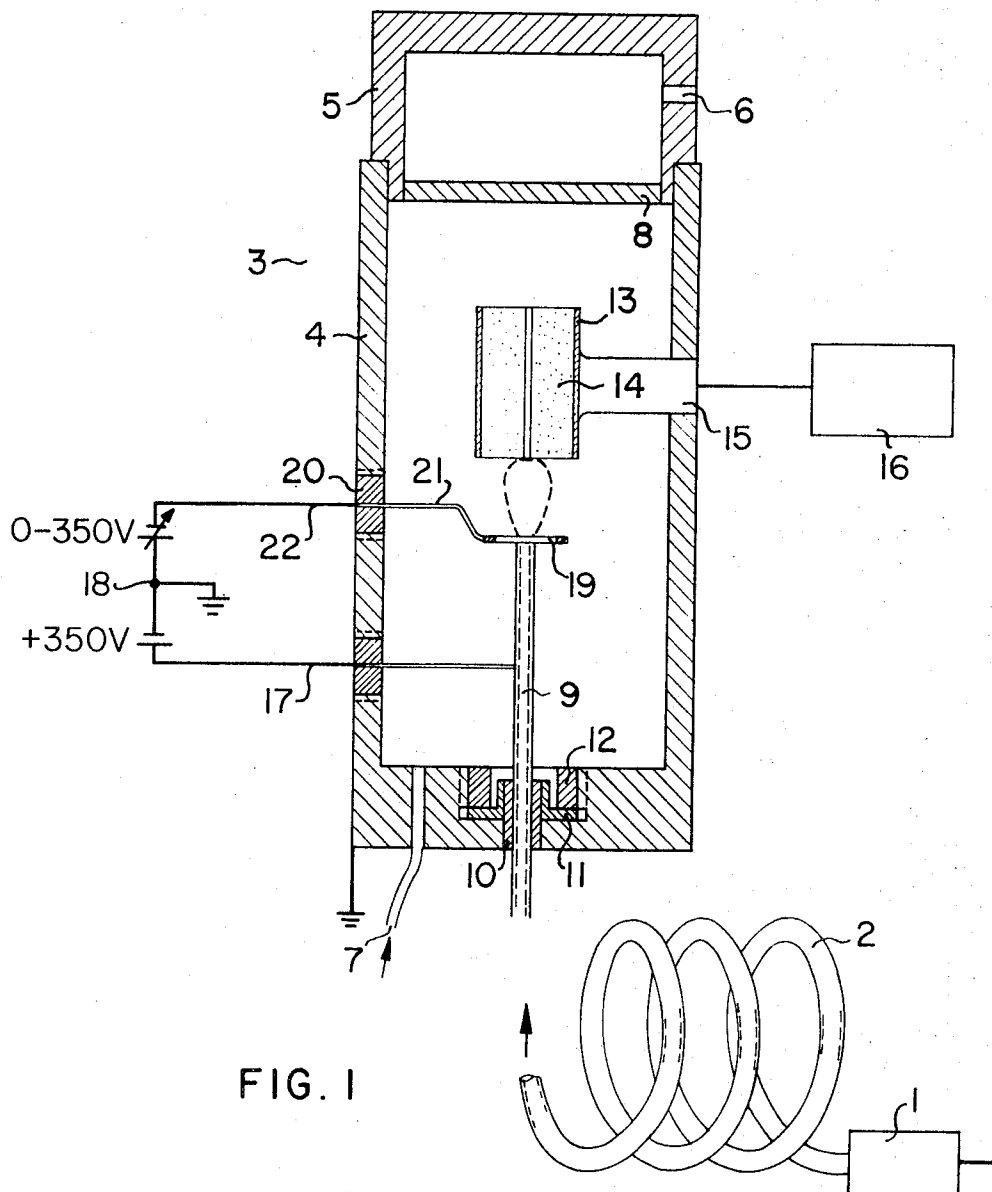
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ABSTRACT

In a flame detector a gas mixture to be analyzed is supplied to a flame jet and ionized. The signal derived from the ions or photons emanating from the flame are used to identify specific gas components. The signal to noise ratio with this kind of detector may be improved by surrounding the top of the flame nozzle with an annular electrode to which a negative potential relative to the potential of the nozzle is applied. It is supposed that the improved performance results from the absorption of positive carbon containing ions of organic components which otherwise would cause background noise.

4 Claims, 2 Drawing Figures





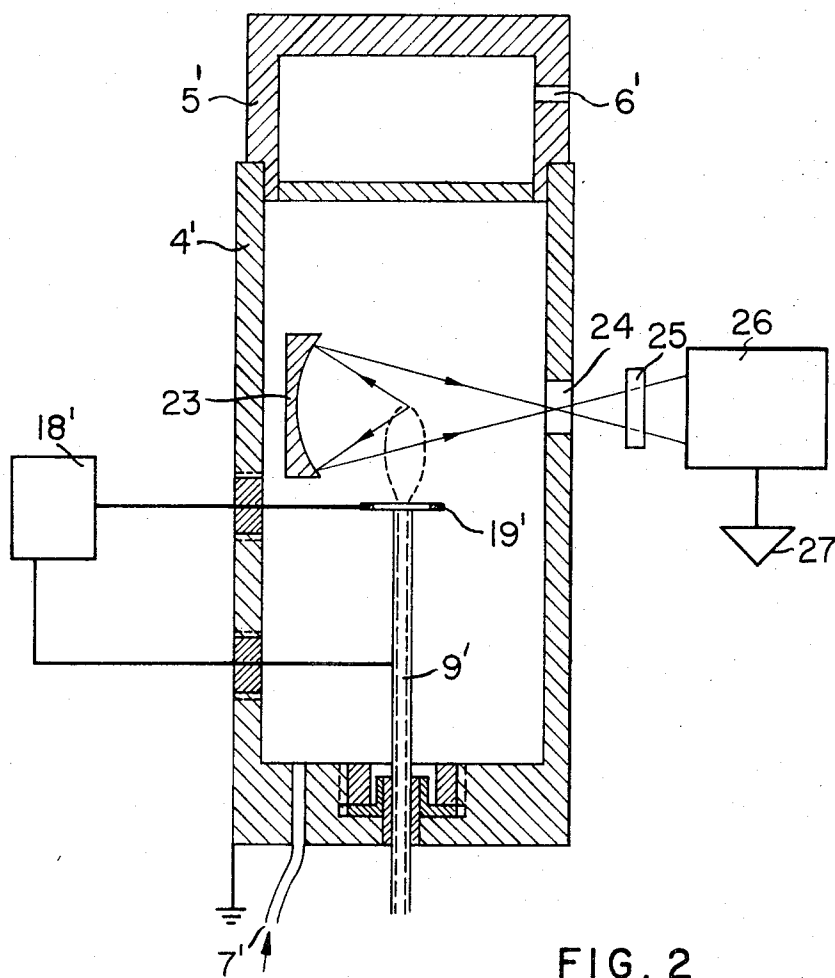


FIG. 2

FLAME DETECTOR

BACKGROUND OF THE INVENTION

This invention is related to a flame detector which includes a housing, a flame nozzle, a carrier gas pipe, a combustion gas pipe, a compressed air pipe, and a measuring device for detecting a characteristic value generated in the flame caused by the gas being tested. In general, flame detectors can be divided into three groups: non-selective flame ionization detectors responsive to substantially all carbon containing compounds, selective thermionic flame detectors having a salt insert responsive to certain compounds, and photometric flame detectors utilizing the photon current emanating from the flame. The sensitivity of each of the aforementioned kinds of flame detectors is limited by inherent noise.

SUMMARY OF THE INVENTION

The main objectives of the invention are to improve the signal to noise ratio and the selectivity of flame detectors. This objective is accomplished by placing an annular electrode at the level of, and concentric to, the open end of the flame nozzle. A source of voltage is connected between the annular electrode and the nozzle, and this voltage source maintains the annular electrode at a negative potential relative to the nozzle. Although the reaction mechanism is not set forth in detail herein, measurements have shown that such an arrangement increases the signal to noise ratio by a factor of about two.

The flame detector and the annular electrode can be modified to be a flame ionization detector. This embodiment includes a collector electrode located above the flame nozzle, a first electrical terminal connected to the collector electrode for supplying an electrical potential, and a second electrical terminal for supplying another electrical potential to the flame nozzle. The potential of the annular electrode is negative relative to the potential of the collector electrode and the potential of the collector electrode is negative compared to the potential of the flame nozzle. This apparatus increases the signal to noise ratio by a factor of ten over conventional flame ionization detectors. Presumably this results because the ring electrode absorbs the positive carbon containing ions of organic compounds in the lower region of the flame and therefore decreases the background noise.

Further the flame ionization detector with the annular electrode can be modified to be a thermionic detector if a salt insert is provided above the flame nozzle. Thereby the optimum balance between signal to noise ratio on one hand, and selectivity on the other, need no longer be adjusted by mechanically changing the distance between the collector electrode and the flame nozzle. Instead it may be accomplished by varying the voltage of the annular electrode. Finally, as previously discussed, the absorption of ions in the lower flame region also decreases noise in a flame photometric detector.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of a flame detector including the annular electrode according to the invention.

FIG. 2 is a sectional view of a flame photometric detector, also including the electrode according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

According to FIG. 1 a vaporizer 1, a gas chromatographic column 2, and a flame ionization detector 3 are serially connected. The housing of the detector is formed by a cylindrical body 4 and a cover 5 for said body, the cover 5 including an opening 6. At the bottom of the cylindrical body 4 there is a pipe 7 for compressed air. The top of the cylindrical body 4 includes a relatively narrow grid 8 consisting of a metal foam frit. A centrally located flame nozzle 9 extends from an isolating bushing 10 in the bottom of the cylindrical body 4. This bushing is fitted in a holder 11 which is fixed by a screw 12 which in turn is screwed into a central recess in the bottom of the cylindrical body 4. A cylindrical collector 13 is located a distance above the flame jet 9. The collector 13 is electrically isolated and mounted in the cylindrical body 4 and supports in its interior a salt crystal 14. The collector 13 is connected with an ion measuring device 16 via a terminal 15. The flame jet 9 is connected with a source of voltage 18 via a line 17 and is kept at a potential of 350 volts during operation.

According to the invention, an annular electrode 19 is located at the upper end of the flame nozzle 9 and has a diameter of about 0.2 inches. The annular electrode 19 is mounted in an isolating bushing 20 of the cylindrical body 4 by a holder 21, and is electrically connected with the voltage source 18 via a lead 22. The potential of the annular electrode 19 is adjustable from 0 volts to -350 volts.

The apparatus according to the invention can be operated as follows: Assume the salt insert is rubidium bromide, the combustion gas is hydrogen and the carrier gas is nitrogen. The sample is contained within the carrier gas. Furthermore, it is supposed that the potential of the flame nozzle is +350 volts, and the potential of the annular electrode is variable from 0 volts to -350 volts. The gases are supplied to the interior of the cylindrical body 4, and because of the grid 8 there will be a slight overpressure relative to the exterior of the housing, thus preventing penetration of surrounding air into the cylindrical space through the opening 6 in the cap 5. The nitrogen containing the organic sample is supplied to the flame; the organic carbon ions are ionized in the lower region of the flame, while the organic nitrogen portion (N-C-H-residuals) is essentially ionized in the upper portion of the flame. The voltage source allows adjusting the potential of the annular electrode so the positive carbon ions are essentially absorbed by the electrode, while the organic nitrogen ions are gathered by the collector electrode. Typically only the organic carbon (e.g. C-H-residuals) is absorbed at the annular electrode.

It should be obvious that the preferred embodiment can be modified in several ways without departing from the scope of the invention. For example, the chemical composition of the salt crystal may vary depending upon the sample being tested. The potential difference between the collector electrode and the flame nozzle may be adjusted so the collector absorbs a sufficient quantity of ions generated in the flame. Furthermore, the geometry of the collector electrode and the annular

electrode can be modified although a configuration of rotational symmetry is set forth here. The respective differences in potential between the collector electrode, the flame nozzle, the annular electrode may also be adjusted.

Since the potential of the annular electrode is negative compared with the potential of the flame nozzle, presumably not only the noise increasing ions containing carbon but also other positive ions are absorbed. Naturally this will cause a decrease in the degree of ionization of the organic compound under test. Thereby the absolute sensitivity will decrease, while the signal to noise ratio increases.

In each case the shape of the annular electrode should match the shape of the flame, which in turn depends primarily on the flow rate of the combustion and carrier gases. The additional electrode should not be used as an ignition electrode, but a separate ignition circuit may be provided.

The embodiment of the invention with a non-selective flame ionization detector is illustrated in FIG. 2. This figure shows a photometric flame detector in which the measuring electrode gathers photons. A flame nozzle 9' is mounted in a housing 4' and is provided with carrier gas and combustion gas pipes (not shown). Furthermore, the housing includes in its lower section a pipe 7' for compressed air as well as an outlet opening 6' in the upper cap section 5'.

An image forming device 23 in the form of a concave mirror is located in the housing to reflect the photons emanating from the upper region of the flame through window 24 and filter 25 onto a photoelectric transducer 26 which is responsive to the current of photons. The output signal of the transducer is supplied to an amplifier 27 and can be used for the purposes of indication or recording.

According to the invention an annular electrode 19' is provided in the housing at the top of, and circumferentially to, the flame nozzle. The potential of the electrode is maintained negative in relation to the potential of the flame jet by an adjustable voltage source 18'. The source is connected with the ring electrode and the flame nozzle by leads which are isolated from the hous-

ing.

The annular electrode absorbs ions in the lower flame region which would otherwise cause noise. Especially, the electrode prevents the carbon ions from reaching the upper flame region where they would suppress the light spectrum of the gases being analyzed.

We claim:

1. A flame detector for a gas chromatograph comprising:

a housing;

a flame nozzle mounted in the housing, the nozzle having an open end at which a flame may be maintained;

first inlet means for directing a mixture of a carrier gas and a sample gas to the flame nozzle;

second inlet means for supplying a combustible gas to the vicinity of the flame nozzle;

a collector electrode mounted in the housing apart from the flame nozzle;

ion measuring and biasing means conductively connected between the collector electrode and the flame nozzle for biasing the collector at a negative potential relative to the flame nozzle;

a ring shaped electrode disposed about and directly adjacent to the open end of the flame nozzle; and second bias means conductively connected to the ring electrode for biasing the ring electrode at a negative potential relative to the collector electrode.

2. A flame detector as in claim 1 wherein a piece of salt is disposed between the flame nozzle and the collector electrode.

3. A flame detector as in claim 1 further including overpressure means for maintaining the interior of the housing at a pressure greater than the exterior of the housing.

4. A flame detector as in claim 3 wherein the overpressure means includes an opening in the housing separated from a portion of the volume of the housing by a grid for maintaining said portion of the housing at a pressure greater than the remainder of the housing and the exterior of the housing.

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