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RADIOLOGICAL GAS ANALYZER

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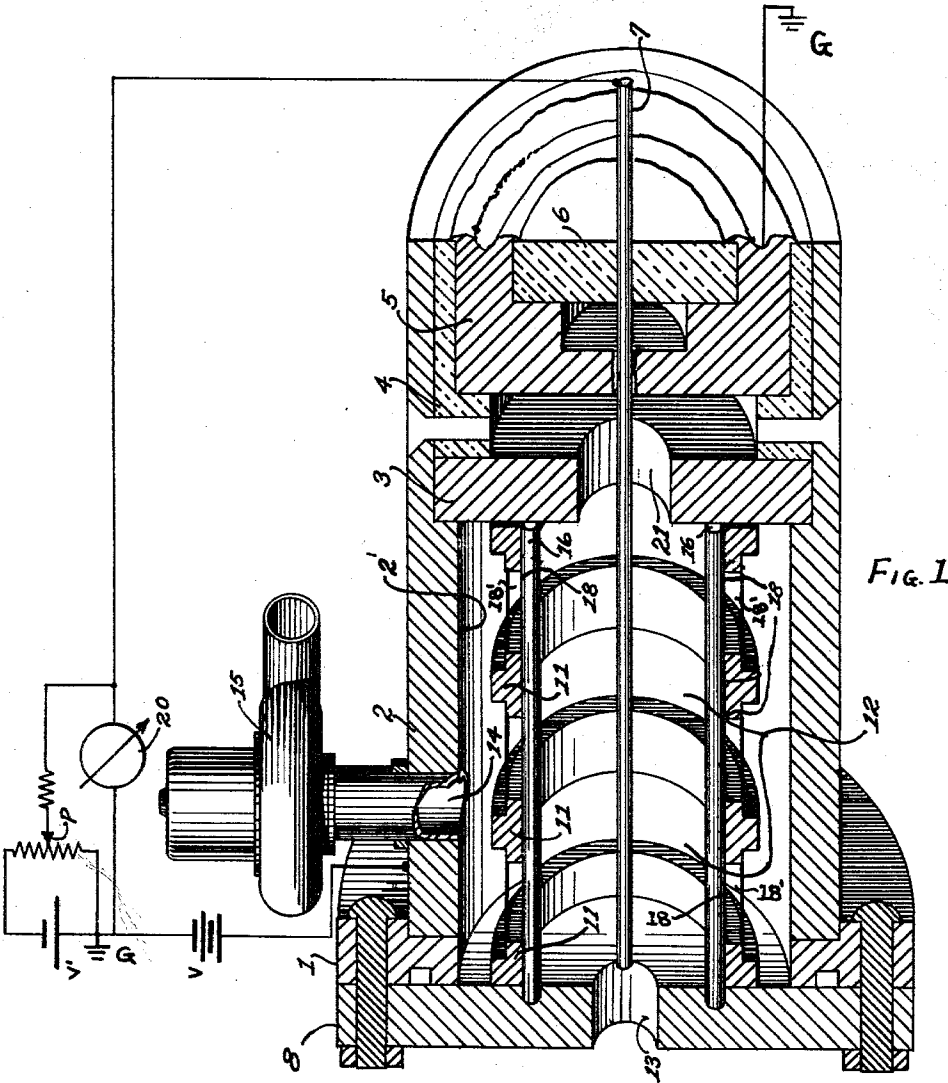


Fig. 1

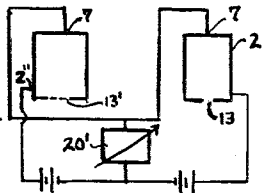


Fig. 2

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RADIOLOGICAL GAS ANALYZER

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12 Claims. (Cl. 250—43.5)

The present invention relates to methods of and apparatus for the analysis of radiological gases and the like, and, more particularly, to an improved radiological gas analyzer.

The problem of providing a ready and simple analysis of gas mixtures and the like has long plagued the art. Numerous proposals have been involved for enabling the detection of particular gases or vapors. Included among these are radiological gas analyzers in accordance with which the radio-active emanations or radiations of particles, such as alpha, beta and gamma rays and the like, are directed in the space between a pair of electrodes, an anode and a cathode, within which space the gas or other mixture to be analyzed may be passed. Variations in the ionization current, as these particle radiations produce more or less ionization effects upon the gas, are detected by providing a collector voltage source, usually of the order of 1000 volts, more or less, that enables the ionization current to flow to an indicator.

The accepted principles for the operation of such devices have been predicated upon the theory that larger cross-section foreign gas particles present in a predetermined gas may be detected by a slight increase in ionization current caused by the further ionization current resulting from the ionization of the greater cross-section foreign gas particles. The usual criterion accepted in the art for such counters requires that the strength of the radio-active source and the position between the anode and cathode be such that while the radiation particles give up some of their energy to cause ionization in passing through the gas, the particles still can reach one of the electrodes and be collected thereon. Under such circumstances, the before-mentioned theory of increased ionization effect, as the result of greater cross-section gas-molecule ionization applies. Unfortunately, however, the sensitivity of such gas analyzers is extremely limited and the increase in current is a very small order effect which must be very carefully detected.

In accordance with the present invention, it has been found that very much more sensitive operation can be obtained through a somewhat different method of operation. While the invention is not to be construed as limited to any particularly theory of operation, it is believed that the theory underlying this invention is correct and that it is based upon the principle of large-size gas molecules and the like serving to recombine, or to collect upon their surfaces, ions otherwise generated in the gaseous medium, thus to produce a decrease in the ion current that is collected. Certain important constructional changes are required to effect this kind of operation, as contrasted with the prior-art greater cross-section ionization operation, above described. Whether this theory is or is not exactly correct, however, it is sufficient to describe the invention as it has been found to work in practice; and so the present invention is also directed to the preferred structures that have been found to produce the markedly greater indications of the presence of foreign gas particles and the like in gas mixtures and the like.

An object of the invention, accordingly, is to provide a new and improved and more sensitive radiological gas analyzer and method of gas analysis operating upon the last-mentioned principle.

A further object is to provide a new and improved gas detector of more general utility, as well.

Other and further objects will be explained hereinafter

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and will be more particularly pointed out in connection with the appended claims.

The invention will now be described in connection with the accompanying drawing, the FIG. 1 of which is a longitudinal cross-sectional view of a preferred embodiment of the invention; and FIG. 2 is a block diagram of a modification.

A preferably cylindrical conductive housing 2 is shown provided with an inner surface 2' that serves as an anode electrode defining a gas-receiving space 12 between the surface 2' and a coaxially disposed preferably cylindrical inner cathode electrode 7. An inlet 13 for receiving the gas mixture and allowing the same to pass generally axially within the space 12 between the anode electrode surface 2' and the cathode 7 is provided at the center of an annular base flange 8 at the bottom of the housing electrically connected thereto. An outlet for the gas transmitted through the space 12 is shown provided at 14. A blower 15 may be provided at the outlet 14 for drawing the mixture of gases into and through at least a portion of the space 12, as for the purpose of detecting the presence of foreign gas particles in a predetermined gas that is permitted to enter the inlet 13.

In accordance with the present invention, a plurality of metal or conductive bands 18' are provided, each coated on their inner surfaces with radio-active layers 18, such as radium-impregnated foil bands. The members 18'-18, are shown mounted or supported between rings 11 upon a pair of conductive rods 16 that extend substantially vertically upward from the base 8 and that are accordingly electrically connected with the base 8 and the anode 2. The plurality of bands 18', with their radio-active inner surface members 18 are thus concentrically disposed within the active anode surface 2' but external to the inner coaxial cathode electrode 7, and are spaced longitudinally along the space 12.

A source of ionization collector-current potential is shown at V, of value preferably insufficient to effect gas ionization of itself, connected with a positive terminal applied to the anode 2 and a negative terminal connected through an electrometer or other sensitive indicator 20 to the cathode 7.

In order to shield insulating mounting members 6 and 4 that separate the cathode 7 from the cylinder 2 at the upper end thereof, from the deleterious action thereupon of radiations emanating from the radiation strips 18, which would otherwise build up charges upon these insulators that, in turn, would serve to deflect subsequent radiation and introduce noise into the system, a shield 3 is provided, such as a conductive disc, provided with a central opening 21 through which the cathode 7 may pass into the space 12. Insulator 6, sealed to the upper end of the cathode 7, is also shown providing mechanical support for the cathode electrode 7. A conductive guard ring 5, preferably connected to ground G, is disposed intermediate the insulators 6 and 4, respectively adjacent the inner cathode electrode 7 and the outer cylinder anode 2, and serves to by-pass any leakage current that may occur.

It has been found that through the utilization of radiations that emanate from the plurality of longitudinally spaced radio-active sources 18 radially inward, a sufficiently uniform radiation-particle generation is produced in the space 12 to enable adequate ionization for the purposes of the invention, with the desirable end of employing a very minimum amount of radio-active material.

In operating this system with, for example, air, large foreign gas molecules, such as oil-like molecules or other heavy gases of molecular weight of the order of 250, more or less, have been successfully detected with great sensitivity, apparently as a result of the re-combination

and surface attraction effect produced by the introduced foreign large molecule gases. It has been observed that the current in the electrometer 20 has been markedly decreased as the result of this effect. The decreasing current effect, moreover, has been found to be far more appreciable than the increase of current based upon the measurement of ionization of increased cross-section gas molecules, before described in connection with the prior-art systems. One of the reasons for this appears to reside in the fact that, in operating in accordance with prior-art principles and structures, only a small percentage of the large gas molecules will actually increase the current since these molecules are rapidly passing in and out of the space 12, and operation is predicated upon the ionization of certain of these larger cross-section molecules. In accordance with the present invention, on the other hand, it appears that the large number of the molecules passing in this space 12 are adapted to produce the re-combination or collection of ions along their surfaces which then allows far greater decreases in ionization current. As an illustration, in connection with the system of FIG. 1, a few parts per billion of heavy gas molecules in, for example, an air mixture have been detected in accordance with the present invention, as contrasted with a few parts in a million that can be detected in accordance with the increase cross-section ionization principle of the prior art. In these tests, the inner diameter of the cylinder 2 was about $1\frac{1}{4}$ inches; the diameter of the cathode collecting electrode 7 was about $\frac{1}{16}$ of an inch; the inner diameter of the radiation source rings 18 was approximately $\frac{3}{8}$ of an inch; and the space 12 was about 2 inches in axial length. The value of the voltage source V was of the order of 1500 volts and the electrometer 20 was a vacuum-tube electrometer.

While the above structure has been found admirably to produce the desired results and to do so with equipment that is highly portable and relatively inexpensive, which is very important for many utilizations of this type of device, it is considered that preferred operation is obtained, in accordance with the theory above expressed, when the value of the intensity of the radiation emanating from the sources 18, with respect to the spacing between the cathode collecting electrode 7 and the inner surface 18, is adjusted, such that, contrary to the prior-art, the range of the radiation particle in penetrating the space 12 is insufficient to permit those particles to terminate upon the opposite electrode wall or surface. Thus, in the preferred arrangement, a radiation particle emanating from, say, a left-hand point of the radiation band 18'-18, is preferably completely absorbed before reaching the right-hand side thereof.

The system may be duplicated to provide a balancing or comparison device 2'', FIG. 2, which has a filter at 13', as of activated charcoal or the like, for eliminating the large-size gas molecules, and thereby canceling out the current in, for example, a differential amplifier indicator 20', due to the ordinary air or other predetermined gas, further enabling that minute changes be detected. Alternately, as shown in FIG. 1, a bucking current may also be passed through the electrometer 20 from a source V' that is controlled in accordance with the position of the slider of a potentiometer P to produce such a bucking current of magnitude that corresponds to that produced by ionization of the air or other predetermined gas, alone.

While the invention has been described in connection with a preferred embodiment that has been found to produce the remarkable results before-described, it is to be understood that some of the features of the present invention may also be employed in similar devices with other electrode configurations and geometries. Further modifications also will occur to those skilled in the art and all such are considered to fall within the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. Radiological gas-analyzing apparatus having, in com-

5 bination, a housing provided with an inlet and an outlet for transmitting gases along a predetermined path there-
through, spaced anode and cathode electrodes disposed
within the housing along the said predetermined path, a
source of particle radiation disposed to direct radiation
into the space between the electrodes, a source of voltage
connected between the anode and the cathode, the in-
tensity of a particle radiation source being adjusted with
respect to the space between the anode and cathode elec-
trodes within the housing such that the energy of the
radiation particles emitted into the said space becomes
substantially completely absorbed in the gas within the
said space and substantial particles do not impinge upon
an electrode, and an ionization-current indicator con-
nected in circuit between the source of voltage and the
electrodes for indicating the ionization current passing
between the electrodes.

2. Apparatus as claimed in claim 1 and in which the
anode electrode and the particle-radiation source are sub-
stantially cylindrical and substantially coaxially disposed
with the anode electrode external to the source and the
source external to the cathode electrode.

3. Radiological gas-analyzing apparatus having, in com-
bination, a housing provided with an inlet and an outlet
for transmitting gases along a predetermined path there-
through, spaced anode and cathode electrodes disposed
within the housing along the said predetermined path,
a plurality of sources of particle radiation disposed to
direct radiation into the space between the electrodes
and spaced from one another in the direction of the said
path, a source of voltage connected between the anode
and the cathode, the intensity of the particle radiation
sources being adjusted with respect to the space between
the anode and cathode electrodes within the housing such
that the energy of the radiation particles emitted into
the said space becomes substantially completely absorbed
in the gas within the said space and substantial particles
do not impinge upon an electrode, and an ionization-
current indicator connected in circuit between the source
of voltage and the electrodes for indicating the ionization
current passing between the electrodes.

4. Apparatus as claimed in claim 3 and in which the
anode electrode and the particle-radiation sources are
substantially cylindrical and substantially coaxially dis-
posed with the anode electrode external to the sources
and the sources external to the cathode electrode.

5. Radiological gas-analyzing apparatus having, in com-
bination, a housing provided with an inlet and an outlet
for transmitting gases along a predetermined path there-
through, spaced anode and cathode electrodes disposed
within the housing along the said predetermined path, a
source of particle radiation disposed to direct radiation
into the space between the electrodes, a source of voltage
connected between the anode and the cathode electrodes
of value insufficient by itself to ionize the gas, the in-
tensity of the particle radiation source being adjusted with
respect to the space between the anode and cathode
electrodes within the housing such that the energy of the
radiation particles emitted into the said space becomes
substantially completely absorbed in the gas within the
said space and substantial particles do not impinge upon an
electrode, and an ionization-current indicator connected
in circuit between the source of voltage and the electrodes
for indicating the ionization current passing between the
electrodes and any decrease therein caused by the ion-
recombination and collecting action of any large-molecule
gases that may enter the housing.

6. Radiological gas-analyzing apparatus having, in com-
bination, a housing provided with an inlet and an out-
let for transmitting gases along a predetermined path
therethrough, spaced anode and cathode electrodes dis-
posed within the housing along the said predetermined
path, a plurality of sources of particle radiation dis-
posed to direct radiation into the space between the
electrodes and spaced from one another in the direction
of the said path, a source of voltage connected between

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the anode and the cathode electrodes of value insufficient by itself to ionize the gas, the intensity of the particle radiation source being adjusted with respect to the space between the anode and cathode electrodes within the housing such that the energy of the radiation particles emitted into the said space becomes substantially completely absorbed in the gas within the said space and substantial particles do not impinge upon an electrode, and an ionization-current indicator connected in circuit between the source of voltage and the electrodes for indicating the ionization current passing between the electrodes and any decrease therein caused by the ion-recombination and collecting action of any large-molecule gases that may enter the housing.

7. Radiological gas-analyzing apparatus having, in combination, a cylindrical conductive housing provided with an inlet and an outlet for transmitting gases in an axial direction therethrough, the inner surface of the housing serving as an anode, a coaxially disposed inner cathode electrode, and a plurality of bands of radio-active material coaxially disposed between the anode and cathode and spaced along the length of the cylindrical housing.

8. Apparatus as claimed in claim 7 and in which the cathode electrode is supported by an insulating terminal

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member separated from the bands by a radio-active-particle shield.

9. Apparatus as claimed in claim 7 and in which the cathode electrode is insulatingly separated at one end from the anode, and intermediate the insulation a conductive member is provided for by-passing charges that might otherwise accumulate upon the said insulation.

10. Apparatus as claimed in claim 7 and in which a current indicator circuit is connected between the anode and cathode electrode and a source of compensatory bucking current is connected across the indicator.

11. Apparatus as claimed in claim 5 and in which a further similar radiological gas-analyzing apparatus is provided, having means for filtering out any large-molecule gases, and connected to the said indicator to provide a differential indication.

12. Apparatus as claimed in claim 1 and in which the said source of particle radiation is disposed within the said path of gas transmission.

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