Dec. 8, 1959 R. D. THOMAS ET AL 2,916,626

ELECTROSTATIC PRECIPITATOR SAMPLE COUNTER

Filed Oct. 26, 1956 3 Sheets-Sheet 1

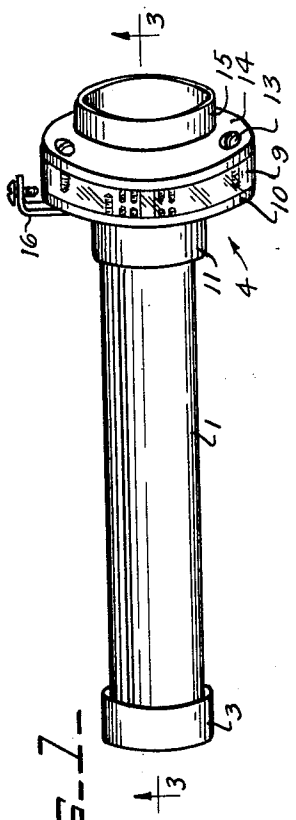


Fig. 1

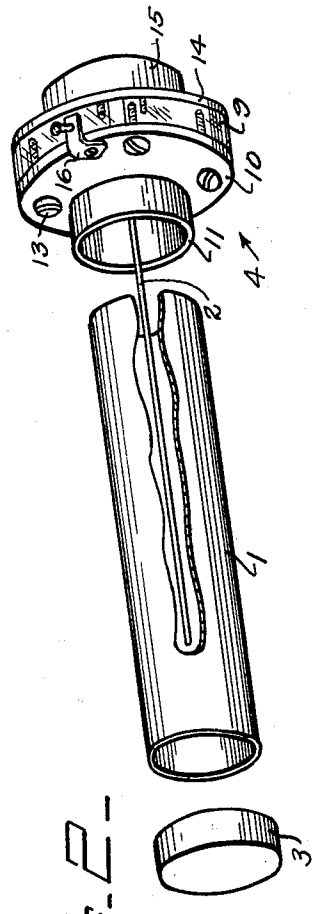


Fig. 2

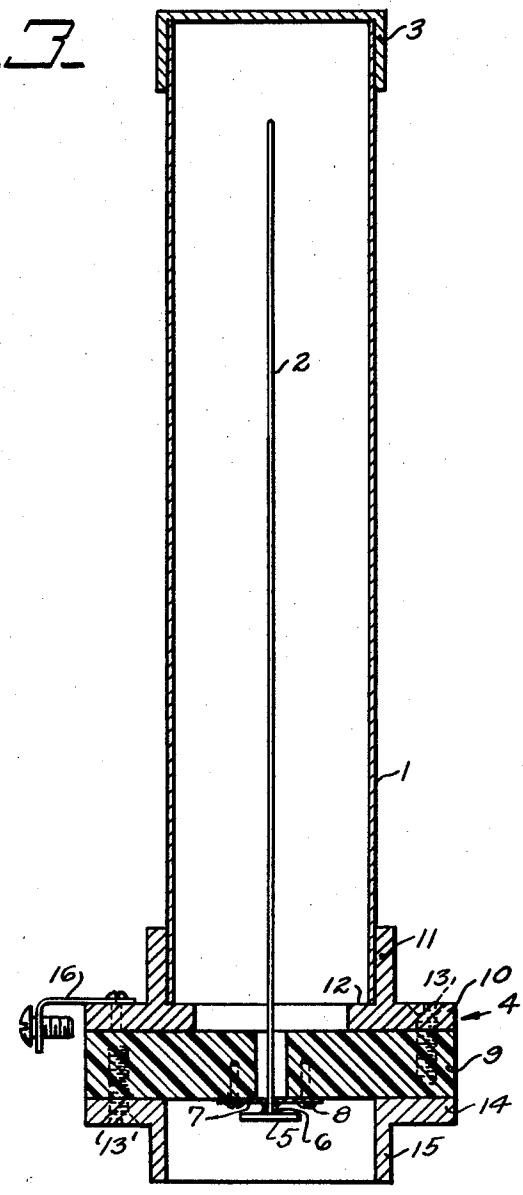
INVENTORS.
ROBERT D. THOMAS
EDWARD A. BURKE
BY Wade Kooney AND
Orlando M. McCoy
ATTORNEYS

Dec. 8, 1959 R. D. THOMAS ET AL 2,916,626

ELECTROSTATIC PRECIPITATOR SAMPLE COUNTER

Filed Oct. 26, 1956 3 Sheets-Sheet 2

Fig. 3



INVENTORS.
ROBERT D. THOMAS
EDWARD A. BURKE
BY
Wade Doority AND
Orlando K. McCoy
ATTORNEYS

Dec. 8, 1959 R. D. THOMAS ET AL 2,916,626

ELECTROSTATIC PRECIPITATOR SAMPLE COUNTER

Filed Oct. 26, 1956 3 Sheets-Sheet 3

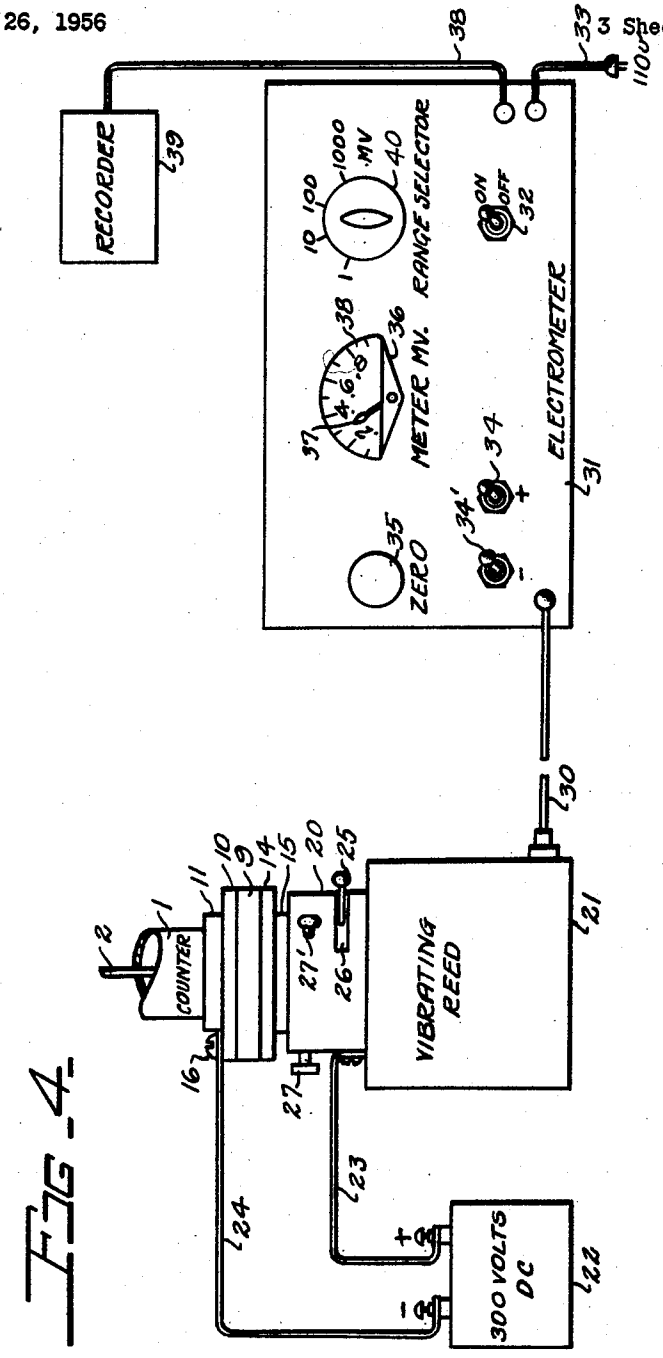


FIG. 4

INVENTORS.
ROBERT D. THOMAS
EDWARD A. BURKE
BY
Wade Kroutz
Orlando Z. McCoy
AND
ATTORNEYS

United States Patent Office 2,916,626 Patented Dec. 8, 1959

2,916,626

ELECTROSTATIC PRECIPITATOR SAMPLE COUNTER

Robert D. Thomas, Fairborn, Ohio, and Edward A. Burke, South Boston, Mass., assignors to the United States of America as represented by the Secretary of the Air Force

Application October 26, 1956, Serial No. 618,658

8 Claims. (Cl. 250—83.6)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the United States Government for governmental purposes without the payment to us of any royalty thereon.

This invention pertains to a new and an improved method for making radioactivity in air determinations, together with an ionization chamber or counter for rapidly and accurately making quantitative determinations of radioactive particulate concentrations in air, with negligible decay in the half-life of the radioactive particles, and more particularly to a method and a device which permits rapid, accurate and reproducible quantitative analysis of radioactive particulate materials in air, such as the air breathed in work areas where radioactive materials are being processed and for comparable determinations.

As background to make the present invention, as claimed, clearly understandable, in work areas where radioactive materials are processed, the health of workers may be impaired by physiologically excessive concentrations of dust particles which are laden with radioactive material, of which alpha, beta and gamma radiations may be taken as being illustrative.

In the making of past determinations quantitatively by an electrostatic precipitation method, a commercially available MSA Electrostatic Sampler, which is manufactured and distributed by the Mine Safety Appliance Company of Pittsburgh, Pennsylvania, has been used. Cylindrical aluminum tubes form part of the equipment of this type of electrostatic sampler device and are prepared for the collection of radioactive particulate material on the surface of a thin clean aluminum foil which is carefully and smoothly spread against the inner surface of the tube over all of the tube internal area. One end of the tube is then inserted into a blower housing part of the electrostatic sampler and a switch on the blower housing grip is actuated, causing air which is to be tested to be drawn through the tube at the rate of 3 cubic feet per minute for one hour, for a total test sample air volume of 180 cubic feet. Solid particles floating as dust in the air being tested are caused to adhere to the aluminum foil within the sampling tube during the above illustrative one hour sample collecting time by a potential difference between an inner electrode and the aluminum foil within the tube of from 12 to 15 thousand volts direct current depending upon the relative humidity of the air under test.

At the end of the prescribed time for collecting a sample, the air sampling tube is removed from the blower housing of the electrostatic sampler and the aluminum foil is very carefully removed from the sampling tube and is cut with shears into squares of a size to fit into a sampling chamber in another commercially available piece of equipment, such as a Proportional Counter Converter model PCC 10 marketed by the Nuclear Measurements Corporation of Indianapolis, Indiana. In the use of this commercially available proportional counter converter, each piece of aluminum foil is separately inserted and a reading taken of the magnitude of the radioactive material adhering to that piece of aluminum foil. This procedure is repeated for each piece of aluminum foil into which the particle bearing test foil has been subdivided. The count readings for each piece of foil then are added together in arriving at the total quantitative radioactivity content of the total air test sample.

The described total air sample radioactivity content determination consumes about another hour of time, during which time the radioactivity of the radioactive particles on the pieces of aluminum foil suffer their particular characteristic decay rates which introduce errors. A further source of error is the particle mechanical loss resulting from the handling and the cutting of the aluminum foil.

The design and the operation of dynamic condenser electrometers are adequately explained in the Review of Scientific Instruments, published in May 1927, volume 18, pages 298 to 314, inclusive. A second information source is "Radiological Monitoring Methods and Instruments," issued April 7, 1952, by the National Bureau of Standards, available from the Superintendent of Documents, Washington 25, D.C.

The present invention uses the same mine safety electrostatic precipitator which is described above for collecting samples. This invention has as its advantageous novelty the complete avoidance of the use of aluminum foil, together with the difficulty encountered in the required smooth, careful and complete application of the aluminum foil to the inside surface of the air sampling tube. Also avoided are the removal, the handling and the cutting of the aluminum foil taken from the tube. Also are avoided the running of separate determinations on the resultant pieces of aluminum foil. The invention effectively minimizes the mechanical loss of particles of radioactive material from the sample collected and the loss of radioactivity carried by the particles on the foil from aging. The present invention further permits accurate data reproducibility in quantitative determinations made in a matter of minutes, as compared with an hour or more in the making of each determination by the previously established method. The procedure introduced by this invention eliminates mechanical losses, reduces the radioactive half-life losses of the particulate material, and materially conserves time in the actual making of the determinations. The improved accuracy of the quantitative determinations contemplated in the practice of the present invention is further attested by the dependable reproductions of determinations made thereby.

The general statement of the matter and the substance of the present invention commensurate, consistent and in harmony with the claims appearing in the patent issuing hereon, comprises in nature a method and apparatus for making quantitative analyses of the radioactivity content of the particulate matter in an air sample.

In substance the present invention comprises a method for analyzing air for its radioactivity content and comprises an ionization chamber consisting of a hollow cylindrical air sampling tube, a cap closing one end of the tube, and a socket base closing the end of the tube remote from the cap. The socket base supports an anode electrode wire which extends axially along the center of the tube and is supported at one end in the socket base. A positive electrical contact in the base is connected to the anode electrode wire. A negative electrical contact supplies a negative potential to the tube. The resulting ionization chamber comprises a closed tube entrapping air in its interior and insulated from an anode collector electrode extending axially inside the tube.

The general statement object of the present invention commensurate with the invention as claimed, is the provision of a substantially direct reading instrument which provides quantitative determinations of the radioactivity of particulate materials in air, such as the air found in

work areas where radioactive materials are handled and processed.

Other objects of the present invention are the provision of a rugged, dependable, conveniently manufactured practical air analysis device which is usable with commercially readily available equipment in accomplishing the quantitative analysis of air for the detection of concentrations of radioactive material which are detrimental to health.

In the accompanying drawings is shown an illustrative embodiment of the present invention.

Fig. 1 is a perspective view of an ionization chamber part of the present invention comprising a tube, a cap and a base in assembled relation.

Fig. 2 is a perspective exploded view of the separable parts of the device shown in Fig. 1.

Fig. 3 is a section taken along the line 3—3 of Fig. 1; and

Fig. 4 is a fragmented view of the ionization chamber shown in Fig. 1, mounted with commercially available instruments for reading radioactivity in microcuries per milliliter of air sample.

In the accompanying drawings the ionization chamber shown consists of two conductors which are insulated from each other and which have an air gap therebetween. The outer conductor is a hollow cylindrical tube which is dimensioned to be used interchangeably with similar tubes supplied as parts of the Mine Safety Appliance Electrostatic Precipitator, Model 1175, produced and marketed by the Mine Safety Appliance Company of Pittsburgh, Pennsylvania. The ionization chamber outer conductor tube **1** has extending axially along the center thereof an anode collector electrode **2**. The tube **1** is closed at one end by removable cap **3** and is closed at its opposite end by an adaptor base **4** which supports the inner electrode **2**. The tube **1**, preferably makes a slip fit with the cap **3** at one end and with a socket of the adaptor base **4** at its opposite end. The distance from the free end of the inner collector electrode **2** to the cap **3** is the same or less than the distance from the tube **1** to the electrode **2** for the maintaining of a uniform electrostatic field between the electrodes **1** and **2** which are of opposite polarity.

The tube **1** illustratively may be made of aluminum and the inner collector electrode **2** may be a wire made of copper, brass or the like. The ionization chamber inner conductor or collector electrode **2** is attached at one end to a central contact plate **5**, also of copper, brass or a similar electrical conductive material. The wire **2** and the plate **5** are shown in the drawings to be attached by solder **6** to an anchor plate **7**. It will be apparent that the anchor plate **7**, which is secured by screws **8** to an insulator **9** of polymerized methyl methacrylate or the like, may be assembled into a single unit if desired. The insulator **9** must have an adequate electrical resistance for its intended use, such illustratively as 10^{15} ohms, which is a characteristic of polymerized methyl methacrylate merchandized as Lucite. Plexiglas is an alternate.

The insulator **9**, illustratively may be a circular disk as shown. One side of the plastic insulator **9** has permanently attached thereto a circular metal plate **10** with a flange **11** dimensioned to receive one end of the tube **1** preferably inwardly thereof. The end of the tube **1** may rest against a plate shoulder **12** or against the insulator **9** without the shoulder, as preferred. The opposite side of the insulator **9** has permanently secured thereto a second metal plate **14** which also has an axially extending flange **15** projecting therefrom. The plates **10** and **14** and their flanges are made of the same metal as the tube, to avoid objectionable electrical effects therebetween. Screws **13**, **13'**, etc. attach the metal disks **10** and **14** to opposite sides of the disk **9**. The upper circular plate **10** is provided with an electrical contact **16** for the attachment thereto of a lead conducting direct current electricity of a polarity opposite to that applied to the central contact **5**. The flange **15**, which is concentric with the central connector **5**, is dimensioned and shaped to engage a turret contact of a commercially available vibrating reed electrometer. A suitable representative electrometer is available from the Applied Physics Corporation of Pasadena, California.

The vibrating reed type of electrometer preferably used in the practice of the present invention measures currents and comprises a vibrating reed which produces a varying capacitance. The varying capacitance is amplified and is applied to a reversible motor which acts as a synchronous detector. The motor output drives the contactor of a potentiometer where a signal is simultaneously recorded and balanced. The final determinations are commonly expressed in microcuries per milliliter of air sample. For purposes of conversion one microcurie equals 10^{-6} curie and one millicurie equals 10^{-3} curie.

Preparatory for the collection of radioactive particles on the inside wall of the tube **1**, the separable parts of the ionization chamber are cleaned thoroughly, as with dilute nitric acid, distilled water and an uncontaminated air stream, or the like. One end of the tube then is inserted into the blower housing of the electrostatic precipitator, which incorporates a central electrode. The blower of the electrostatic precipitator is then energized and air is drawn through the tube **1** at a predetermined velocity and for a predetermined period of time to provide the passage of a predetermined volume of air through the tube. As particulate material enters the air sampling tube **1** the high electrostatic field potential between the central electrode and the inner surface of the tube **1** causes the deposit on the inner surface of the tube **1** of airborne particulate materials. The cap **3** is then placed on the unattached end of the tube **1** and the opposite end of the tube **1** is removed from the blower housing and is inserted into flange **11** of the base **4** in such a way that the electrode **2** extends axially centrally inside of the tube **1**.

The tube **1** contains radioactive particulate material which is adhered upon the inner surface of the tube. The particulate radioactive material exerts an ionizing effect on the air within the tube. The assembled ionization chamber comprising the tube **1**, the cap **3** and the base **4** is then mounted on the turret **20** of a vibrating reed device **21**, as is shown in Fig. 4 of the accompanying drawings. The components in Fig. 4, to which the ionization chamber is to be connected, remain connected together for an hour or more for the soaking-in effect, prior to the making of a determination. The soaking-in effect is prolonged for a sufficient period of time for the substantially complete orientation of the insulator **9** in regards to the negative and positive charges applied to the respective anode and cathode of the ionization chamber. When so assembled the downwardly extending flange **15** and the central contact **5** of the base **4** bear a positive charge which is supplied over a lead **23** from a direct current source **22** of illustratively 300 volts. The negative terminal of the direct current source **22** is connected through a lead **24** to a contact **16** and impresses a 300 volt direct current of negative polarity through the upper disk **10** to the tube **1**.

The turret **20** of the vibrating reed device **21** is equipped with a lever **25** which can be moved along a slot **26**. The operation of the lever **25** selectively places in circuit any one of three resistors of magnitudes 10^{10}, 10^{11} and 10^{12} ohms housed within the turret. The turret lever **25** is in its ground position when preliminary adjustments are made. Set screws **27**, **27'**, etc. thread through the collar of the turret **20** and bear firmly against the outer surface of the flange **15** which depends from the disk **14** part of the counter base **4**. In assembling the ionizing chamber base **4** with the turret **20**, the anode contact plate **5** at the

lower end of the wire electrode 2 engages to depress an upwardly spring loaded contact at the center of the turret.

The potential of the center electrode 2 is changed in magnitude by the collection of ions produced in the surrounding air medium by the nuclear particles emitted by the radioactive particulate material adhering to the inside wall of the tube 1. The radioactive material within the tube produces ionization of the entrapped air at a constant rate. Changes of potential on the collecting electrode 2 are proportional to the degree of air ionization. Potential loss from the ionization chamber is restored at a constant rate from the battery 22 during the collection of electrons on the collecting electrode 2. The loss of potential supplied by the battery 22 to the collection electrode 2 of the ionization chamber produces current at the contact plate 5 driven to 10^{14} or 10^{15} amperes. The current so produced passes through the vibrating reed device 21 over the connecting cable 30 to the electrometer 31 where it is measured and then over the cable 38 to the recorder 39 where current changes on a time basis are recorded.

The electrometer 31 is provided with an on-off switch 32 from a power supply line lead 33 of 110 volts potential which energizes the electrometer. The electrometer 31 is provided with two polarity switches 34 and 34' which are switched on after the equipment is warmed up. The switch 34 impresses a selective polarity on the meter 36. The switch 34' impresses a selective polarity on a galvanometer within the recorder 39. These switches 34 and 34' are moved just before a determination is made. The meter 36 is zeroed prior to each run by a zero adjusting dial 35. The meter 36 is provided with a hand 37 which travels along a scale 38 which is calibrated in millivolts. A range selector 40 establishes the multiplication factor for the meter readings on the meter 36. The lead 38 conducts output from the electrometer 31 to the recorder 39. The range selector 40 is energized from the electrometer on-off switch 32.

The electrical effects so recorded are accurate indications quantitatively of the relative concentrations of radioactive particles in the total air sample drawn through the tube 1 and under analysis and consequently the relative degree of physical hazard to the workers who are employed within the test area from which the air sample was taken. The calibration of sensitivity for the equipment described herein in the detection of radioactive particulates, illustratively has been determined to be 6.325 alpha counts per minute per millivolt. The counter has a very high counting efficiency for all radioactive particulates.

The counter has potential use in radiation facilities in general, such as with hot cells, with atomic reactors, as an instrument for making safety checks in atomic powered vehicles such as submarines or the like. The counter is particularly well adapted for the making of daily monitoring checks of the air in work areas where radioactive materials may be processed, stored or the like.

It is to be understood that the tube, the collector electrode wire, the cap and the base which comprise the physical parts of the present invention, together with procedural steps by which these parts are used with commercially available equipment, and also the method or the process steps by which determinations are made by the use of the described equipment, are submitted hereby as successfully operating embodiments of the present invention and that comparable modifications may be made in both the parts of the device and in the steps of the processes described herein without departing from the scope of the present invention.

What we claim is:

1. The method for quantitatively determining radioactive particulate material inclusive of alpha particles and deposited by the electrostatic precipitation method on the inside of a tubular cathode with removable cap adapters making slip fits with both ends of the cathode and through which cathode a predetermined volume sample at ambient temperature and pressure of contaminated air is drawn at a constant velocity, with both cap adapters removed from the ends of the cathode making a static state air ionization chamber by enclosing a static air medium within the tubular cathode with the adapters closing the opposite ends of the tubular cathode, and measuring the ionization produced in the air medium within the ionization chamber acted on by the radioactive particulate material collected from the air sample.

2. The method for making quantitative determinations of radioactive particulate material inclusive of alpha particles in air using a static air filled ionization chamber contoured as a hollow cylinder with end caps making slip-fit engagement with both ends of the cylinder and the chamber containing radioactivity bearing particulate material accumulated within the ionization chamber by the electrostatic precipitation method from a known volume of air, forming an ionization chamber by enclosing a static predetermined volume of air medium within the tubular cathode provided with an anode extending axially centrally thereof and with both end caps slipped on the ends of the hollow cylinder, impressing a substantially constant direct current potential between the anode-cathode electrodes of the ionization chamber in maintaining the anode at a substantially fixed potential and at a substantially constant current output, and measuring the current output from the ionization chamber as being indicative of the quantitative determination of the amount of radioactivity contained in the deposited material collected from the test air sample by the electrostatic precipitation method.

3. An ionization chamber comprising a hollow cylindrical tube, a cap making a slip-fit on one end of the hollow cylindrical tube, and a base making a slip-fit on the end of the hollow cylindrical tube remote from the cap and the base supporting a collecting electrode extending axially and substantially centrally of the tube, with the cap and the base slipping axially on the opposite ends of the tube and thereby cooperating in closing in freely removable slip-fit the opposite ends of the tube for entrapping air in its static state therein.

4. The ionization chamber defined in the above claim 3 wherein the tube is a hollow cylinder releasably closed at one end by the cap when advanced by axial movement along the hollow cylinder and at the other end by the collecting electrode supporting base when advanced by axial movement along the hollow cylinder in a capping action therewith and the base, and the base comprising a dielectric insulator of a magnitude of 10^{15} ohms electrically between the tube and the collecting electrode.

5. The method of running a quantitative determination on the radioactive particulate material content in contaminated air by passing a predetermined quantity of contaminated air between an anode and a clean cathode of an electrostatic precipitator for depositing the particulate material content of a test air sample on the cathode, modifying the precipitator cathode by enclosing the ends thereof by sliding axially thereover clean closure members resulting in an ionization chamber with a predetermined volume of static air entrapped therein and with an indeterminate quantity of particulate material adhering to the inner surface of the cathode, impressing upon and maintaining at a predetermined electrical potential the anode and the cathode within the ionization chamber, and measuring quantitatively the air ionization by the radioactive particulate material within the ionization chamber.

6. The method of running a quantitative determination on the radioactive particulate material content in contaminated air by passing a predetermined volume of air between an anode and a hollow and cylindrical clean cathode serving as an electrostatic precipitator with a predetermined potential maintained between the anode and the cathode for accomplishing the deposition and the retention on the inner surface of the cylindrical cathode of an unknown quantity of radioactive particulate material from the contaminated air which has passed therebetween

during a predetermined period of time, the entrapping of an unknown quantity of radioactive particulate material retained on inner surface of the cathode with a known volume of air maintained in the static state between the anode and the cathode by closing both ends of the cathode with clean caps making axially sliding engagement therewith to serve with the cathode as a closed ionization chamber, applying a predetermined electrical potential to the chamber electrodes for a predetermined period of time for accomplishing the ionization of the entrapped air by the deposited particulate materials within the ionization chamber until a current reading is obtained to indicate the degree of ionization which is relative to the amount of radioactive materials deposited in the chamber.

7. The method described in the above claim 6 wherein the predetermined period of time for purposes of standardization is one hour and the predetermined electrical potential is 300 volts direct current.

8. The method for quantitatively determining radioactive particulate material deposited by the electrostatic precipitation method on the inside surface of a tubular

cathode through which a predetermined volume sample of contaminated air is drawn at a constant velocity, making a static state air ionization chamber by enclosing a constant volume of static air within the tubular cathode with clean cup shaped slip on adapters closing both of the ends of the tube, applying a saturation potential between the anode and the cathode of the ionization chamber under standard conditions of temperature and pressure, and reading on a vibrating reed electrometer as current drift occasioned by ions collected in the chamber and produced by the deposited radioactive materials as the quantitative determination of radioactive particulate material in the contaminated air per unit volume sample.

References Cited in the file of this patent

UNITED STATES PATENTS

2,519,007	Wilson	Aug. 15, 1950
2,596,080	Raper et al.	May 6, 1952
2,625,657	Kanne	Jan. 13, 1953
2,666,865	Borkowski	Jan. 19, 1954
2,755,391	Keyes	July 17, 1956