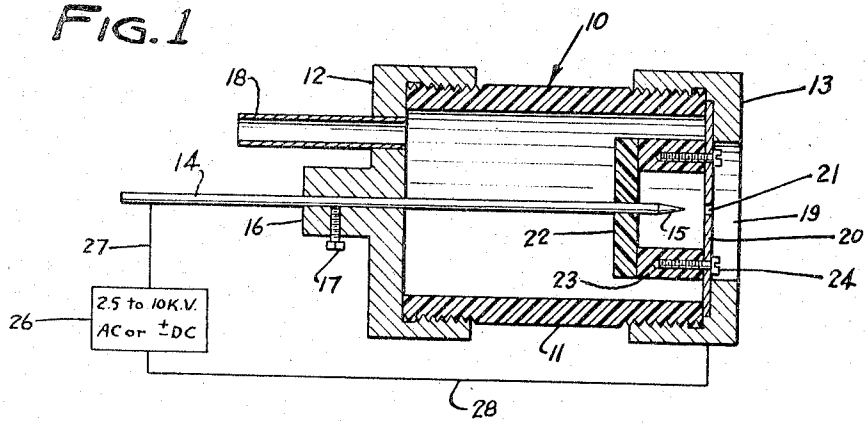
May 2, 1967 K. T. WHITBY 3,317,790

SONIC JET IONIZER

Filed Aug. 29, 1960

FIG. 1



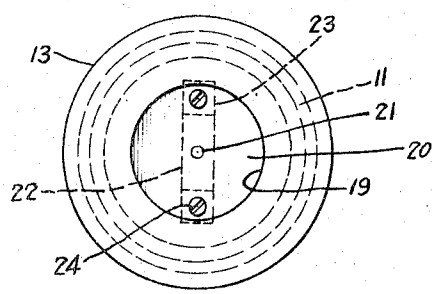


FIG. 2

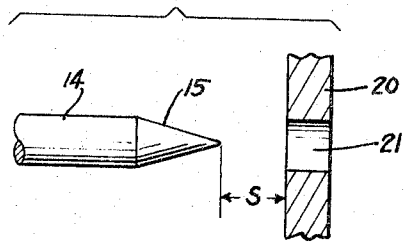


FIG. 3

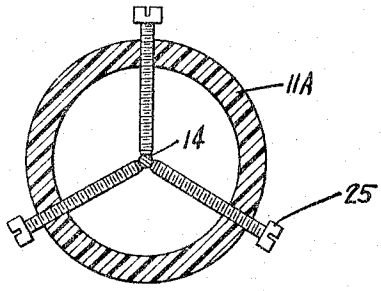


FIG. 4

INVENTOR.
KENNETH T. WHITBY
BY
Moore, Wiles & Burd
ATTORNEYS

United States Patent Office

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SONIC JET IONIZER

Kenneth T. Whitby, Minneapolis, Minn., assignor to The Regents of The University of Minnesota, Minneapolis, Minn., a corporation of Minnesota

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This invention relates to apparatus and method for the production of gas ions at normal atmospheric pressure and temperature. More particularly the present invention relates to the ionization of a sonic air jet in a corona and to a sonic jet ionizer device.

In general, gas ions may be produced in air at normal atmospheric pressure and temperature by a number of methods, such as heated surfaces, ionizing radiation (radioactive materials), X-rays, ultraviolet light, high frequency electric fields and corona discharge. Of these, the use of ionizing radiation and a corona discharge are the most practical. However, the use of ionizing radiation is practical only for the production of small quantities of ions and is expensive and involves health hazards when large quantities of ions are required. The corona discharge method involves the creation of ions by impressing high A.C. or D.C. voltages on a needle and plate or wire and plate arrangement. These corona ionizers are relatively simple and involve less hazards than ionizers employing radioactive isotopes but they are relatively inefficient ion producers. The reason for this is that the same high voltage which produces the ionizing corona is also extremely effective in collecting the ions. Gas ions have a mobility of about 2 centimeters per second per volt per meter. Thus, in the usual wire and plate ionizer the gas ions are moving at a substantial fraction of the speed of sound and practically all are collected.

It has now been discovered that a sonic jet may be utilized to flush ions, created in the corona between a needle and an orifice in a plate, through the orifice before the ions can be collected on the orifice edge. This system produces ions at a high rate nearing or equalling 100% efficiency and low power consumption. Ion concentrations in the gas jet may be produced which are 100,000 times normal atmospheric levels and 100 times higher than the concentrations which can be produced by any other corona ionizer. This offers a two order of magnitude improvement over other known corona ionizers. Positive ions, negative ions or an equal mixture of positive and negative ions can be produced at will.

As is known, sonic flow will be obtained in an orifice or nozzle when a critical pressure ratio, that is, the ratio of the pressure of a gas at the throat of the nozzle to the upstream pressure, is equal to a critical ratio. See, for example, Mark's Handbook, 1951 Edition, pages 332 to 334; Engineering Thermodynamics by N. A. Hall and Warren E. Ibele, pages 390 to 394 and Perry's Chemical Engineer's Handbook, 1950 Edition, pages 402 and 403. The critical pressure ratio for air is 0.53.

The principal object of this invention then is to provide a highly efficient method of producing gas ions in a sonic jet at a low rate of power consumption.

It is a further object of this invention to provide a method of producing gas ions by passing a gas stream under pressure through a corona between a needle tip and an orifice in a plate.

Another object of this invention is to provide apparatus for ionizing a sonic gas jet through the corona existing between a needle maintained at high voltage and an orifice plate.

Other objects of the invention will become apparent as the description proceeds.

To the accomplishment of the foregoing and related ends, this invention then comprises the features hereinafter fully described and particularly pointed out in the claims, the following description setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principles of the invention may be employed.

The invention is illustrated by the drawings in which the same numerals refer to corresponding parts and in which:

FIGURE 1 is a side elevation, in section, of the sonic jet ionizer according to the present invention shown connected schematically to a power source;

FIGURE 2 is an end elevation of the ionizing device of FIGURE 1;

FIGURE 3 is an enlarged fragmentary partial sectional view showing the relationship between needle and orifice; and

FIGURE 4 is a transverse section through the ionizer housing showing an alternative means of centering the needle.

Referring now to the drawings, the sonic jet ionizer apparatus is indicated generally at **10**. The illustrated form of ionizer includes a cylindrical housing body **11** enclosed at either end by caps **12** and **13**. The cylindrical housing body **11** is formed from an electrically non-conductive material such as, for example, methyl methacrylate tubing sold under the trade names "Lucite" or "Plexiglas" and is externally threaded adjacent its ends. Caps **12** and **13** are internally threaded to permit the caps to be screwed on to the ends of the housing body.

Cap **12** is provided with a central opening through which a thin wire or rod electrode **14** having a needle tip **15** may be passed with a slide fit. The outer surface of cap **12** is provided with a boss **16** through which the central opening extends. A set screw **17** permits the needle electrode to be held tight against longitudinal axial movement. Cap **12** is provided with a further opening into which is fit a gas inlet tube **18** adapted to be connected to a source of gas under pressure, such as compressed air. Cap **13** is provided with a large central opening **19**. The cap **13**, which thus is in the form of an annular ring, is ctilized to secure a plate **20** in place against the end of tubular housing body **11**. Caps **12** and **13** and plate **20** are formed from an electrically conductive material. Plate **20** is desirably of copper or brass.

Plate **20** is provided with a small central orifice **21** aligned with the needle electrode tip **15**. In order to hold the needle tip in precise alignment with the orifice there is provided a bridge structure including a transverse bar **22** disposed spaced from and substantially parallel to the inner surface of plate **20** and supported from the plate by a pair of spacer members **23** and secured to the plate by means of screws **24** or similar attaching means. The bar **22** is provided with an opening into which the needle fits with a slide fit. This opening is in precise alignment with the orifice **21** in order to maintain the alignment of the orifice and the needle tip. The bridge bar and

spacers are relatively narrow as shown in FIGURE 2 in order not to substantially interfere with flow of gas through the housing from the gas inlet tube to the orifice. The aligning bridge is composed of electrically non-conductive material, such as methyl methacrylate, in order that the needle may be held out of electrical contact with the plate **20**.

As shown in FIGURE 4, an alternative means for aligning the needle tip with the plate orifice may be provided by three screws **25** spaced 120° apart around the periphery of a tubular housing **11A**.

The tip of the needle is spaced from the orifice by a disatnce S, as shown in FIGURE 3 and as defined hereinafter. As best shown in FIGURE 3, the orifice **21** is provided with sharp edges. The needle electrode is connected to any suitable high voltage source by means of a connecting conductor **27** and plate **20** is similarly connected through cap **13** and conductor **28**, as shown schematically in FIGURE 1.

In operation of the ionizer device the needel electrode is maintained at between about 2500 and 10,000 volts, and preferably between about 3000 and 5000 volts different from the orifice plate. The applied voltage may be alternating current or positive or negative direct current. A variety of high voltage power packs and transformers are commercially available as the power source.

Gas is introduced to the ionizer housing through the gas inlet tube at pressures between about 15 and 200 lbs. per square inch gauge and desirably between about 15 and 50 lbs. p.s.i.g. At lower gas pressures low efficiency results with little advantage over existing ionizing devices. Although higher gas pressures may be used than the indicated upper limits, no corresponding advantage results.

The flow of gas functions to flush the ions through the orifice **21** before they can be collected on the orifice edge. The ions are liberated in the corona at the needle point and are accelerated toward the orifice edge. The sonic gas flow in the orifice passes the ions through the orifice and out with the gas jet with nearly 100% efficiency. The resulting stream of gas ions may be directed for use as desired.

Exemplary commercial applications of the ionizer include utilization of the ion jet for the dissipation of processing charges which occur on dielectric materials. These include the dissipation of static charges occurring in the processing of plastics and the operation of printing presses and the like, and the prevention of clinging of lint in laundry driers and the like. The high ion concentrations issuing from the ionizer in a high velocity gas jet are in an almost ideal form for dissipating static charges. The jet ionizer can be placed several feet away from the work and perform just as efficiently, or more so, than radioactive ionizers which, because of the extremely rapid neutralization of the ions, require that the ionizers be placed within an inch or less of the surface to be neutralized.

It has been determined experimentally that for maximum efficiency the orifice **21** should desirably have a diameter between about 0.0156 and 0.125 inch, that is, between about 1/64 and 1/8 inch. The diameter of the needle is not critical but the needle must have a sharp point. It has been determined that the radius of the needle point should be less than about 0.001 inch. The distance S, shown in FIGURE 3, that is, the spacing between the needle point and orifice, should be between about ½ to 10 millimeters.

The following is a typical example of the operation of the sonic jet ionizer according to the present invention. An ionizer device substantially as illustrated and described was employed. The diameter of the orifice plate was 1.59 mm., that is, about 1/16 inch in diameter. The needle tip was spaced from the orifice by a distance of 1.71 mm., that is, just slightly more than 1/16 inch. Air was supplied to the air inlet tube at about 30 lbs. per square inch gauge. A negative direct current voltage of 5000 volts was applied to the needle electrode. The ion concentration measured along the axis of the jet ionizer at a distance of about 15 centimeters from the orifice was about 4×10^8 ions per cubic centimeter. Under the same conditions, but with an applied voltage of positive direct current of 5000 volts, substantially the same ion concentration of positive ions was measured. Under the same conditions, but utilizing 3500 volt alternating current, an ion concentration of more than 1.0×10^8 per cubic centimeter was measured. The concentrations of ions measured along the axis of the jet ionizer at a distance of about 100 centimeters from the orifice were 6×10^6 positive ions per cubic centimeter resulting from the use of 5000 volt positive direct current, 4×10^6 negative ions per cubic centimeter resulting from the use of 5000 volt negative direct current and 2×10^6 mixed ions per cubic centimeter resulting from the use of 3500 volt alternating current.

It is apparent that many modifications and variations of this invention as hereinbefore set forth may be made without departing from the spirit and scope thereof. The specific embodiments described are given by way of example only and the invention is limited only by the terms of the appended claims.

What is claimed is:

1. A gas ionizing device for operation under sonic jet flow conditions comprising a housing, a gas inlet to said housing, said housing including an electrically conductive plate, an orifice centrally disposed in said plate, the diameter of said orifice being between about 1/64 and 1/8 inch, said orifice having sharp edges, said orifice providing an ionized gas discharge port from said housing, a pointed needle electrode centrally disposed in said housing, said needle adapted for connection to a high voltage electric power source for applying a high electrical voltage to said needle, said housing being closed save for said gas inlet and orifice, said inlet adapted for connection to a source of gas under pressure sufficient that the ratio of the pressure at the orifice to the inlet gas pressure at least equals the critical pressure ratio for the gas, said needle electrode and orifice plate being electrically insulated from each other and from the housing body, aligning means within said housing spaced from said orifice and electrically insulated from the orifice plate and adapted to hold the pointed tip of said needle electrode in axial alignment with the orifice, the tip of said needle electrode having a diameter of less than 0.001 inch, said electrode tip being associated with said orifice and spaced therefrom by about ½ to 10 millimeters to produce a gas-ionizing discharge therebetween upon application of voltage to said needle electrode.

2. A gas ionizing device for operation under sonic jet flow conditions comprising a housing, a gas inlet to said housing, said housing including an electrically conductive plate, an orifice centrally disposed in said plate, said orifice having sharp edges, said orifice providing an ionized gas discharge port from said housing, a pointed needle electrode centrally disposed in said housing, said needle adapted for connection to a high voltage power source for applying a high electrical voltage to said needle, said housing being closed save for said gas inlet and orifice, said inlet adapted for connection to a source of gas under pressure sufficient that the ratio of the pressure at the orifice to the inlet gas pressure at least equals the critical pressure ratio for the gas, said needle electrode and orifice plate being electrically insulated from each other and from the housing body, aligning means within said housing spaced from said orifice and electrically insulated from the orifice plate and adapted to hold the pointed tip of said needle electrode in axial alignment with the orifice, the tip of said needle electrode being associated with and slightly spaced from said orifice to produce a gas-ionizing discharge therebetween upon application of voltage to said needle electrode.

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MILTON O. HIRSHFIELD, *Primary Examiner.*

E. JAMES SAX, SAMUEL BERNSTEIN, *Examiners.*

D. YUSKO, J. D. KALLAM, J. A. SILVERMAN, *Assistant Examiners.*