Aug. 23, 1955 J. R. BATINA 2,715,993

IONIZATION PUMP

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Fig. 1

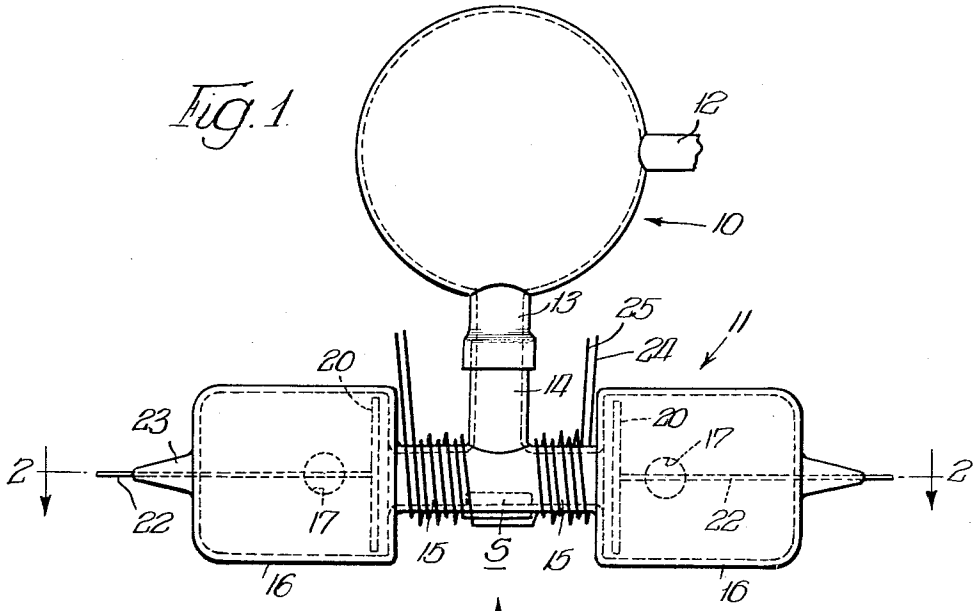


Fig. 2

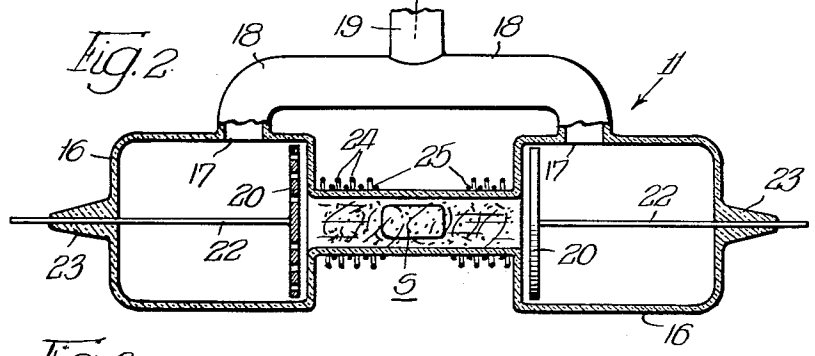
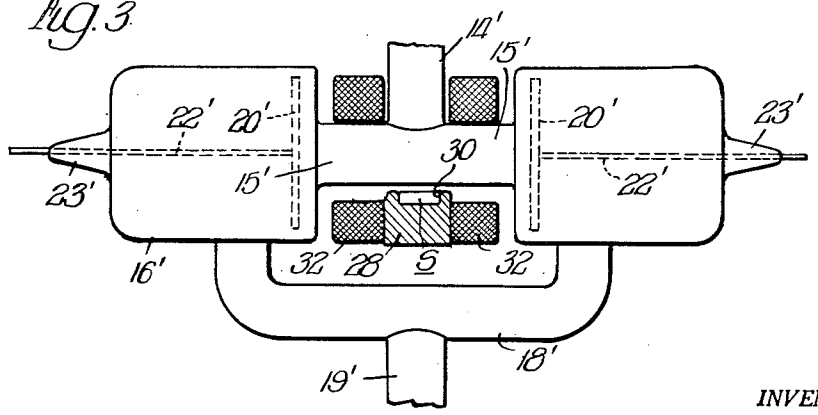


Fig. 3



INVENTOR.
Jerome R. Batina,
BY
Cromwell, Greist & Warden
attys.

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Fig. 4

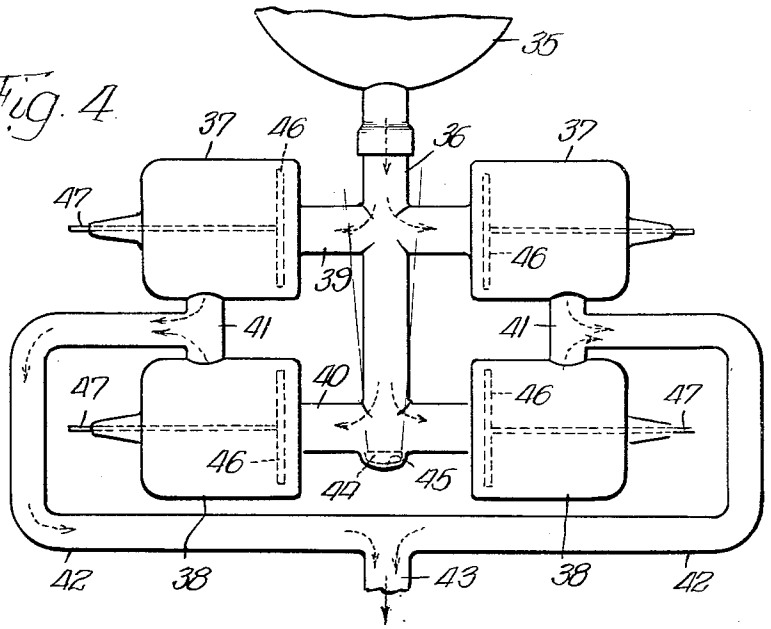
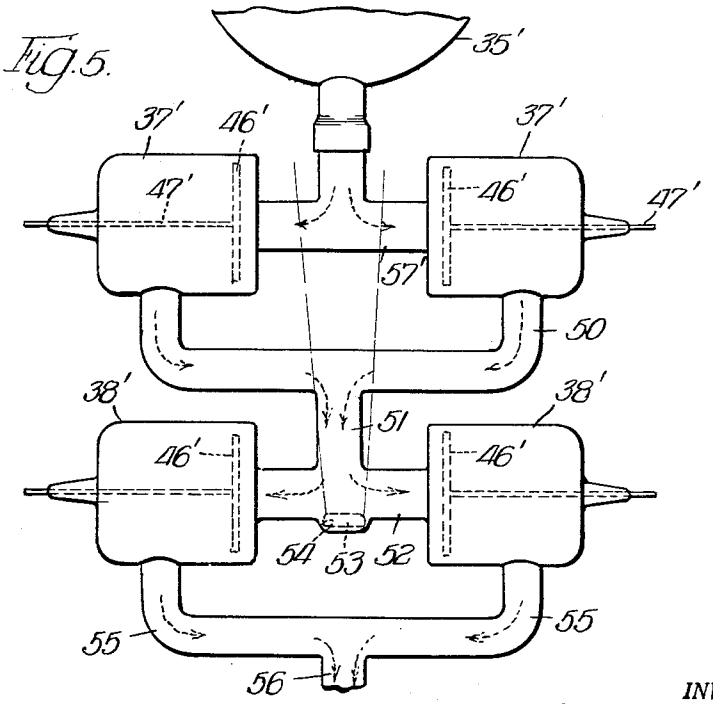


Fig. 5.



INVENTOR.
Jerome R. Batina,
BY
Cromwell, Grant + Warden
attys

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IONIZATION PUMP

Jerome R. Batina, Chicago, Ill., assignor to W. M. Welch Manufacturing Company, Chicago, Ill., a corporation of Illinois

Application June 6, 1952, Serial No. 292,213

5 Claims. (Cl. 230—69)

The present invention relates to improvements in a high vacuum pump, affording a unit capable of obtaining a pressure substantially lower than the pressures attainable by present day diffusion pumps. More particularly, the invention relates to a vacuum pump by means of which the interior of a vessel to be evacuated is subjected to the direct ionizing action of a space discharge voltage, and/or some other externally energized source of ionizing action, and to the action of alpha particles or other radioactive particles independent of any externally impressed voltage source. Such combined electrical and radioactive sources complete the ionization and evacuation of gas in the vessel to a degree substantially greater than is possible by any other pumping operation of which I am aware, mechanical, diffusion or combined.

The production of an electrical discharge in an enclosed system is known to result in lowering of the pressure therein. Thus, one known technique of reducing pressure involves the production of an electrical discharge between two electrodes in a vessel communicating directly with a space containing a rarified gas, such as a vacuum type radio tube. As a result, gaseous molecules in the tube are ionized, the ions are displaced in the electric field existing between the electrodes, arrive rapidly at one thereof, lose their charge and are carried away, with consequent drop in the pressure in the space.

However, it has been found necessary to use a high electrical potential for this operation. It is also found that the pressure rises again upon interruption of the discharge. Likewise, the electrical discharge relied on to ionize the gas is itself dependent upon the existence of a gas pressure in the vessel in question to maintain the discharge; hence when a predetermined, minimum vacuum is obtained the discharge can no longer be maintained. Operation of the unit ceases. Aside from this inherent and inescapable limitation in such an externally energized vacuum pumping system, the requisite voltage is so high as to constitute a factor of danger.

The present invention provides an ionization type pump which is of the above general classification, but one in which there are multiple sources of ionization of the gaseous molecules remaining in a system or vessel to be evacuated, including a source independent of external electrical space discharge voltage, hence independent of the degree of pressure of the gas remaining in the system or vessel. In the illustrated embodiment alpha particles, or equivalent particles of any self-sustaining source of emission, are utilized to ionize such remaining gas, assisting in the separation of the gas molecules from the walls of the vessel and expediting removal of the ionized particles. These are recombined at an electrode or electrodes of a further, externally energized source of ionization by direct current space discharge voltage. They are eventually discharged, as by the use of a mechanical or diffusion pump. A still further high frequency excitation by an external voltage source is preferably resorted to, as shown in one of the embodiments of the invention illustrated herein, for the purpose of exciting the molecules independently, and in order to improve the ionizing effect of the inter-electrode ionizing flow and the radio-emissive ionizing charge upon the gaseous molecules in the vessel.

The independent source of particle emanation which is exposed to gas in the system, or a vessel communicating with that system, in accordance with the invention, may be a capsule containing radium, radioactive derivative, nuclear fission by-product, and the like. The life cycle of such an emitter is infinite, for all practical purposes. The voltages required for the other purposes referred to above are simply obtained and non-excessive in value. Likewise no particular maintenance is required as regards servicing, replacement of parts, etc.

It will therefore be seen that it is a general object of the invention to provide an improved high vacuum pump, which may, incidentally, be used by itself or as one stage of a multi-stage unit incorporating an associated pump stage or stages of mechanical or diffusion type, which improved pump utilizes the principle of ionization of gaseous molecules to substantially lower pressure, by subjecting such molecules to the combined action of an externally energized and controlled electrical field or space discharge and an independent source of radioactive electrical particle emission; which pump is very inexpensive to produce and operate and, moreover, to operate with entire safety; which is rendered self-sustaining to the extreme limit of its almost indefinite age and ionizing capacity; and which calls for little or no maintenance work in operation over a long period of time.

The foregoing statements are indicative in a general way of the nature of the invention. Other and more specific objects will be apparent to those skilled in the art upon a full understanding of the construction and operation of the improved pump.

Several embodiments of the invention are presented herein for purpose of illustration. It will be appreciated that the invention may be incorporated in still other modified forms coming equally within the scope of the appended claims.

In the drawings:

Fig. 1 is a fragmentary front elevational view, quite diagrammatic in character, illustrating structural components and associated wiring provisions of a high vacuum, ionization type pump in accordance with one embodiment of my invention;

Fig. 2 is a fragmentary plan view of the pump provisions shown in Fig. 1, being partially broken away and in horizontal section along a line corresponding to line 2—2 of Fig. 1; and

Figs. 3, 4 and 5 are fragmentary schematic elevational views of pumps in accordance with modified adaptations of the invention, Figs. 4 and 5, in particular, illustrating staged arrangements of pump units similar to those of Figs. 1, 2 and 3.

Referring to Figs. 1 and 2 of the drawings, the reference numeral 10 generally designates a vacuum chamber and the reference numeral 11 generally designates an arrangement of electrode chambers and associated electrical operating means for the pump, to be hereinafter described in detail. In the form of the invention shown, vacuum chamber 10 is provided with a laterally opening coupling tube or intake nipple 12 by means of which it is adapted to be connected, as by suitable high vacuum connection (not shown), with any vessel to be evacuated. As stated above, the pump of the present invention may also be employed as a staged unit with other pumps of known type and, moreover, either as a roughing or finishing stage. Hence the intake nipple 12 may be connected to the discharge side of a preceding, finish stage pump; alternatively, the present ionization pump may be used as a finishing stage, its discharge end (to be described) being coupled to a succeeding stage of any desired type.

Vacuum chamber 10 has a radially extending discharge neck 13 which is coupled in sealed relation to the intake passage 14 of the unit 11. Passage 14 opens in opposite lateral directions to a pair of aligned branch passages 15, each of which in turn opens to an enlarged glass or insulated electrode chamber 16.

As illustrated in Fig. 2, each of the electrode chambers 16 has a lateral discharge port 17, the ports 17 being communicated by discharge passages 18 with a common central discharge tube or pipe 19. This pipe may open to atmosphere or may communicate with the intake of a rotary, reciprocating or diffusion type pump if staging is contemplated, as described above.

Perforated circular plate electrodes 20 are disposed in the respective chambers 16, with their flat surfaces closely adjacent the branch passages 15. These electrodes present substantial space discharge surface areas for the direction and emission of electrons through the aligned communicating passages 15, when the electrodes are properly energized. Conductors 22 are provided for the last named purpose, extending rearwardly in opposite directions from the electrodes to which they are connected and through enlargements 23 on the rear walls of the electrode chambers 16. The conductors are of course in air-tight, electrically insulated relationship to the chambers 16, and they are connected to the positive and negative poles of a suitable steady D. C. potential of, say, 800 volts. Of course, this value as well as the amperage value may vary in accordance with the pumping pressure and other factors.

Primary and secondary coils 24, 25 are coiled about the branch passages 15 of unit 11. Conductor coil 24 is the output coil of a suitable high frequency oscillator circuit (not shown) and coil 25 is a step-up secondary excited by the high frequency current in coil 24.

The functions of the electrodes 20 and A. C. coils will be enlarged on at a later point. For the present it suffices to point out that the former are relied on to give mobility and direction to the dissociated molecules, and in certain pressure ranges, to furnish an electron stream to ionize gaseous molecules in branches 15, and space communicating therewith, while the high frequency field of coils 24, 25 (or any equivalent field to which the interior of unit 11 is subjected) also has a similar ionizing action. More important than this, however, the high frequency field has the effect of causing a swirl or turbulence of electrons in branches 15 and adjoining space, which augments the efficacy of molecule ionization by increasing the path of travel of electrons and radioactive particles (to be described) in unit 11. Localization or concentration of ionization in the zone adjoining and between electrodes 20 is also promoted.

In order to further intensify and sustain ionization of gas molecules, particularly after a predetermined low pressure has been reached, there is provided an active, separate source of emanation of alpha particles, beta particles, or like independent source of radioactive emission. This source is generally designated S. As stated, it may be in the form of a capsule of a suitable radioactive derivative, a suitable by-product of nuclear fission, radium, radium-bearing compound, or the like. The capsule or other container may be held in place in unit 11 by any appropriate means, with which the invention does not specifically deal.

In use, with the vacuum chamber 10 connected directly or indirectly by coupling 12 with a vessel to be evacuated, the sets of conductors 22 and 24 are electrically energized by their respective D. C. and A. C. sources. The electron stream between electrodes 20 substantially ionizes gaseous molecules in the electrode vessel. The same result is produced by the high frequency field of coils 24, 25. Both of these effects continue, with resultant dropping of pressure in the vessel, but at a diminishing rate, so far as these externally energized sources are concerned. The field created by coils 24, 25 disturbs and imparts swirl to the

electron stream, as roughly depicted by broken line and stippling in Fig. 2.

The radioactive emission source S continues to ionize molecules practically indefinitely, and is reduced in its ionizing rate only to the extent that rarification of the vessel leaves fewer gas molecules to be struck and ionized.

However, the field of coils 24, 25 continues to impart energy to the lower energy radioactive particles and rays, and to the respective particles of the molecules which they ionize in branches 15 and passage 14, producing a swirl and turbulence, increasing the likelihood of collision with other gas molecules and thus maintaining a desired rate of ionization, notwithstanding the otherwise deteriorated conditions for ionization. The high frequency field substantially expedites attraction of ionized particles to electrodes 20.

While I have illustrated a pair of coils 24, 25 for the purpose of producing a high frequency field in the unit 11, it should be understood that other structural provisions may be employed to this same end, such as rings or clips applied to branches 15 and energized from a suitable alternating source.

A modified embodiment of the invention is illustrated in Figure 3 of the drawings. Its structural components are, in most respects, similar to those illustrated in Figs. 1 and 2, hence corresponding reference numerals, primed, are employed in Fig. 3 to designate corresponding parts. Further description of such parts is dispensed with.

A suitable external support 28 is provided for the radioactive source, here designated S', adjacent the junction of the passage 14' with the branch passages 15'. As illustrated, support 28 is provided with a cavity 30 in which the capsule or source S' is disposed. Alternatively, the source S' may be mounted within the unit 11', as in Figs. 1 and 2.

A permanent magnet, or suitably energized electromagnet 32 is associated with the unit 11' surrounding branches 15' of the same with its poles in opposed relation to one another at the junction of branches 15' with passage 14'. In other respects the embodiment of Fig. 3 is like that of Figs. 1 and 2. The field of magnet 32 imparts swirl or turbulence to the electron stream between electrodes 20' and to the radio-active particles emitted from the source S'. Efficiency of ionization of the gas molecules remaining in the space to be evacuated is thus promoted. In other respects the operation of the unit of Fig. 3 is as described in connection with Figs. 1, and 2, with the exception that no high frequency field phenomenon is involved. However, the high frequency field may be added to increase the efficiency of the pump. Figs. 4 and 5 illustrate series—and parallel—staged arrangements of ionization pump units of the character described above. Inasmuch as these two forms differ primarily only as to the physical arrangement of certain chambers, conducting passages, etc., with relation to one another, rather than in details of those individual components themselves, only general reference will be made to such details.

Referring to Fig. 4, the vacuum chamber 35 is connected by a quadruple branched supply conduit 36 with two sets of electrode chambers, marked 37, 37 and 38, 38, respectively. Lateral intake passages 39 open from conduit 36 to the laterally aligned chambers 37 and corresponding intake passages 40 open from the conduit to the chambers 38. The respective pairs of chambers 37, 38 are each provided with a common discharge conduit 41 which is communicated by piping 42 with a common discharge line 43. The independent source of radiant energy emission, designated 44, is disposed in a recessed portion of the supply conduit 36, designated 45. Space discharge electrodes 46 and conductors 47 therefor are as in the first described embodiment.

The form of the invention illustrated in Fig. 5 differs solely from that of Fig. 4 in that the respective sets of electrode chambers are arranged in a series, rather than

a parallel, arrangement. Hence corresponding parts are designated by the same reference numerals, primed, as are employed in Fig. 4.

A branched discharge line **50** leads from the respective electrode chambers **37'** and joins a common discharge passage **51**, which in turn communicates through branch passages **52** with the electrode chambers **38'**. The source of radioactive particle emanation **53** is disposed in a recess **54** between the branch passages **52**. Discharge passages **55** from the chambers **38'** meet at a common exhaust line **56**.

It will be understood that secondary externally energized excitation means, corresponding to coils **24**, **25** of Figs. 1 and 2 or to magnet **32** of Fig. 3, or any equivalent means to agitate the path of electronic particles, thereby adding to the path length, increasing the likelihood of molecular impact, and speeding ionized particles to the electrodes, may be employed in the forms of the invention shown in Figs. 4 and 5, having been omitted solely for the sake of simplicity.

While I have illustrated various embodiments of the invention, involving a pair of electrodes in a sealed pump chamber which are externally energized electrically by a direct current voltage source, these electrodes may also be energized by a high frequency alternating current source, with or without further internal or external ion path disturbing provisions such as the radio-active source magnet or coils, with similar, though less thoroughly effective ionization of gaseous molecules. Accordingly, with this in mind, the electrodes **20** and their connected conductors **22** may be considered illustrative of such a high frequency field adaptation. In this alternative respect the electrodes have much the same function as the high frequency coils **24**, **25** of the modification of Figs. 1 and 2.

I claim:

1. An ionization vacuum pump comprising a casing defining a sealed, air-tight pumping chamber, which chamber has a gas intake opening adapted to be connected to a space to be evacuated and a gas discharge opening to the exterior of said casing, a pair of spaced electrodes mounted in said chamber at opposite ends of a path of electron flow therethrough, conductors connected to said electrodes and extending through said casing in sealed relation thereto, which conductors are adapted to connect said electrodes with terminals of an external voltage source and thereby cause ionization of molecules in said chamber by electron flow along said path, followed by attraction of ionized particles to one of the electrodes and electrical discharge thereof, and an independent source of emission of radioactive particles located between said electrodes, said source being sufficiently closely adjacent said electron flow path to supplement the ionization in said chamber created by said electrodes, which independent source becomes the predominant source of ionization under an extremely high degree of evacuation of said chamber.

2. An ionization vacuum pump comprising a casing defining a sealed, air-tight pumping chamber, which chamber has a gas intake opening adapted to be connected to a space to be evacuated and a gas discharge opening to the exterior of said casing, a pair of spaced electrodes mounted in said chamber at opposite ends of a path of electron flow therethrough, conductors connected to said electrodes and extending through said casing in sealed relation thereto, which conductors are adapted to connect said electrodes with terminals of an external voltage source and thereby cause ionization of molecules in said chamber by electron flow along said path, followed by attraction of ionized particles to one of the electrodes and electrical discharge thereof, an independent source of emission of radioactive particles located between said electrodes, said source being sufficiently closely adjacent said electron flow path to supplement the ionization in said chamber created by said electrodes, which independent source becomes the predominant source of ionization under an extremely high degree of evacuation of said chamber, and means creating a field acting to disturb the flow of electrons in said path and to cause turbulence in the movement of radioactive particles emitted by said independent source.

3. An ionization vacuum pump comprising a casing defining a sealed, air-tight pumping chamber, which chamber has a gas intake opening adapted to be connected to a space to be evacuated and a gas discharge opening to the exterior of said casing, a pair of spaced electrodes mounted in said chamber at opposite ends of a path of electron flow therethrough, conductors connected to said electrodes and extending through said casing in sealed relation thereto, which conductors are adapted to connect said electrodes with terminals of an external voltage source and thereby cause ionization of molecules in said chamber by electron flow along said path, followed by attraction of ionized particles to one of the electrodes and electrical discharge thereof, an independent source of emission of radioactive particles located between said electrodes, said source being sufficiently closely adjacent said electron flow path to supplement the ionization in said chamber created by said electrodes, which independent source becomes the predominant source of ionization under an extremely high degree of evacuation of said chamber, and means creating a high frequency field acting to disturb the flow of electrons in said path and to cause turbulence in the movement of radioactive particles emitted by said independent source.

4. An ionization vacuum pump comprising a casing defining a sealed, air-tight pumping chamber, which chamber has a gas intake opening adapted to be connected to a space to be evacuated and a gas discharge opening to the exterior of said casing, a pair of spaced electrodes mounted in said chamber at opposite ends of a path of electron flow therethrough, conductors connected to said electrodes and extending through said casing in sealed relation thereto, which conductors are adapted to connect said electrodes with terminals of an external voltage source and thereby cause ionization of molecules in said chamber by electron flow along said path, followed by attraction of ionized particles to one of the electrodes and electrical discharge thereof, an independent source of emission of radioactive particles located between said electrodes, said source being sufficiently closely adjacent said electron flow path to supplement the ionization in said chamber created by said electrodes, which independent source becomes the predominant source of ionization under an extremely high degree of evacuation of said chamber, and a coil energized at high frequency and surrounding said casing between said electrodes, said coil creating a high frequency field acting to disturb the flow of electrons in said path and to cause turbulence in the movement of radioactive particles emitted by said independent source.

5. An ionization vacuum pump comprising a casing defining a sealed, air-tight pumping chamber, which chamber has a gas intake opening adapted to be connected to a space to be evacuated and a gas discharge opening to the exterior of said casing, a pair of spaced electrodes mounted in said chamber at opposite ends of a path of electron flow therethrough, conductors connected to said electrodes and extending through said casing in sealed relation thereto, which conductors are adapted to connect said electrodes with terminals of an external voltage source and thereby cause ionization of molecules in said chamber by electron flow along said path, followed by attraction of ionized particles to one of the electrodes and electrical discharge thereof, an independent source of emission of radioactive particles located between said electrodes, said source being sufficiently closely adjacent said electron flow path to supplement the ionization in said chamber created by said electrodes, which independent source becomes the pre-

dominant source of ionization under an extremely high degree of evacuation of said chamber, and magnetic means creating a magnetic field acting to disturb the flow of electrons in said path and to cause turbulence in the movement of radioactive particles emitted by said independent source.

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