

Sept. 20, 1966

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3,274,436

ION SOURCE WITH SELECTIVE HOT OR COLD CATHODE

Filed Jan. 23, 1963

Fig. 1.

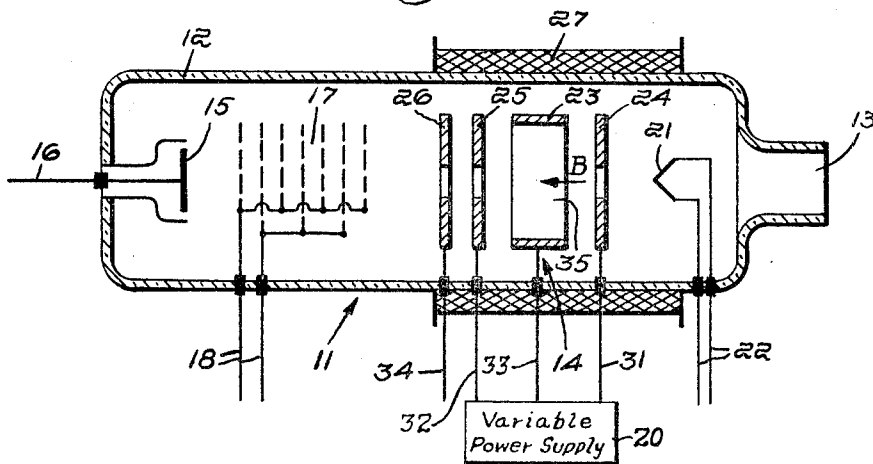
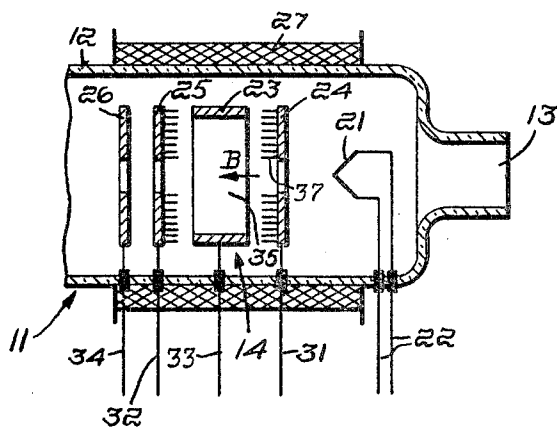


Fig. 2.



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3,274,436
ION SOURCE WITH SELECTIVE HOT OR COLD
CATHODE**Günter Reich, Vochemer Str. 9, Cologne-**
Zollstock, Germany**Filed Jan. 23, 1963, Ser. No. 253,360****Claims priority, application Germany, Jan. 31, 1962,**
L 41,094**3 Claims. (Cl. 315—111)**

This invention relates to ion sources and more particularly to ion sources for use in vacuum equipment such as mass spectrometer partial pressure gauges which operate over large pressure ranges.

Experience has shown that in vacuum equipment of this type the most satisfactory ion sources are those which produce ions as a result of ionizing collisions between electrons and neutral gas molecules. These ion sources require a source of electrons which should be relatively insensitive to changes in operating pressure. The ion source will then provide an ion current bearing a substantially linear relationship to operating pressure which linearity is essential for many vacuum measuring applications.

All of the existing ion sources of the above type have suffered from certain disadvantages and deficiencies. For example, the cold cathode Penning type ion source while being extremely rugged and offering a constant electron discharge current in particular operating pressure regions will also exhibit erratic gas discharge striking behavior after prolonged operation and in the lower pressure regions of desired operation. Another well known ion source is the hot or thermionic cathode type which is usually in the form of a hot filament. This ion source provides the desired linearity between produced ion current and operating pressure but unfortunately, succumbs to filament burnout in the frequently desired higher operating pressure regions.

It is therefore the object of this invention to provide a device for the production of ions which is specifically adapted to maintain a uniform electron flow and corresponding linear ion current to pressure relationship over a large range of operating pressures (for example, between 10^{-3} to 10^{-8} mm. Hg).

One feature of this invention is the provision of an ion source which combines a cold cathode Penning type discharge device with a hot filament thermionic cathode thereby providing an ion source which is useful over a wide operating pressure range.

Another feature of this invention is the provision of an ion source of the above featured type wherein the cold cathode device is positioned between the hot filament thermionic cathode and the device utilizing the produced ion beam thereby permitting the cold cathode device to function as a focusing apparatus for the hot filament electron source.

Another feature of this invention is the provision of an ion source of the above featured type wherein the cathode electrodes of the cold cathode Penning type discharge device possess a plurality of needle points which tend to increase electron discharge current and thereby improve low pressure performance.

These and other important objects and features of the present invention will become more obvious upon a perusal of the following specification taken in connection with the accompanying drawings wherein:

FIG. 1 is a schematic showing of a mass spectrometer partial pressure gauge utilizing the ion source of the instant invention, and

FIG. 2 is a partial enlarged showing of another cold cathode discharge device embodiment of this invention.

Referring now to FIG. 1 there is shown a mass spec-

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trometer device 11 having a vacuum tight, elongated casing 12 with one open end 13 adapted for connection to a vacuum chamber containing gas to be analyzed. Adjacent the open end 13 is the ion source 14 which directs an ion beam to the collector electrode 15 positioned at the opposite end of mass spectrometer casing 12. Attached to ion collector 15 is collector lead 16 which passes through the spectrometer casing 12 and is adapted for connection to a measuring device (not shown). Also positioned within the mass spectrometer casing 12 between the ion collector 15 and the ion source 14 are a plurality of conventional ion separating electrodes 17. Attached to the ion separating electrodes 17 are lead-ins 18 adapted for connection to appropriate power supplies (not shown).

The spectrometer includes a thermionic cathode formed by the hairpin shaped filament 21 positioned between the ion source 14 and the mass spectrometer casing opening 13 and adapted for connection by leads 22 to an appropriate filament current source (not shown). The Penning type ion source 14, including the hollow open ended cylindrical anode electrode 23 and straddling cathode plates 24, 25, is positioned between the thermionic cathode electrode 21 and the ion separating electrodes 17. An ion focusing plate electrode 26 is located between the ion separating electrodes 17 and one of the cold cathode electrodes 25. Each of the plate electrodes 24 and 25 and ion focusing electrode 26 possess central apertures which together with hollow anode cylinder 23 provide a continuous axial passageway between ion separating electrodes 17 and the thermionic cathode electrode 21. The hollow cylindrical permanent magnet 27 is mounted on the external portion of spectrometer casing 12 and provides a magnetic field B within and in the direction of the passageway.

The operation of the invention will normally depend upon the pressure existing within the system being analyzed. For example, with pressures below 10^{-4} mm. Hg the filament electrode 21 operating at ground potential is heated to produce a beam of electrons. At these pressures the thermionic cathode electrode 21 will function effectively with little susceptibility to burnout. The plate electrodes 24, 25 and the hollow cylindrical anode electrode 23 are energized by the conventional variable power supply 20 through lead ins 31, 32, 33 respectively to a relatively low potential of about, for example, 200 volts. The ion focusing electrode 26 is energized through lead in 34 to a slightly more negative potential.

The electron beam emitted by the incandescent thermionic cathode 21 is focused by the combined effect of the magnetic field B and the electric field produced by the plate electrodes into the hollow volume 35 within the anode electrode 23. In this ionization region 35 positive ions are created by collisions between the electrons and neutral gas molecules and are directed through the central aperture of plate electrode 25 under the assisting influence of ion focusing electrode 26. The ion beam then moves into the area of the ion separating electrode 17. In this area certain selected ions of a given mass would be separated and later collected by the ion collector electrode 15 according to well known principles.

At other operating pressures such as, for example, above 10^{-4} mm. Hg the thermionic cathode electrode 21 would remain de-energized while the Penning type device 14 functions as a cold cathode ion source for the mass spectrometer 11. In this case the hollow cylindrical anode 23 is energized by the variable power supply 20 to a relatively high positive potential (for example, at or above 2000 volts) relative to the cold cathode plate electrodes 24, 25 while the ion focusing electrode 26 is again maintained slightly negative with respect to the cold cathode electrodes 24, 25.

The gas discharge produced within hollow anode elec-

trode 23 as a result of the applied voltage and magnetic field B will produce ionization within the anode interior volume 35. The ion beam produced thereby will again be directed through the apertures in cold cathode plate electrode 25 and the ion focusing electrode 26 and pass into the area of ion separating electrode 17.

FIG. 2 shows another embodiment of a cold cathode Penning type ion source according to the present invention. In this case the cold cathode discharge device is constructed similarly to that shown in FIG. 1 except that the cathode plates 24, 25 are provided with a plurality of needle points 37 projecting toward the volume 35 enclosed by the hollow cylindrical anode electrode 23. The needle points 37 serve the purpose of intensifying the discharge current within the hollow anode 23 when the cold cathode device 14 is being utilized as a cold cathode ion source. This embodiment greatly stabilizes performance and enhances the initiation of a gas discharge with the cold cathode device 14 while operating at low pressures such as, for example, below 10^{-6} mm. Hg.

Thus the present invention provides a rugged improved ion source which will produce a relatively constant electron current and a correspondingly linear ion current-pressure relationship over a wide range of operating pressures.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. For example, the showing of the ion source with a mass spectrometer is merely exemplary as the ion source could be used for any application requiring a supply of ions such as vacuum pumps, gauges, etc. It is therefore to be understood that within the scope of the attached claims the invention may be practiced other than as specifically described.

What is claimed is:

1. An ion beam apparatus comprising an ion source having a hollow open ended cylindrical anode electrode, an ion beam utilizing device positioned adjacent one open end of said hollow open ended cylindrical anode electrode and including an ion collector electrode adapted to collect

ions transmitted by said ion source, a thermionic cathode electrode positioned adjacent the opposite open end of said hollow open ended cylindrical anode electrode, said ion source further including a first plate electrode positioned between said ion beam utilizing device and said cylindrical anode electrode and a second plate electrode positioned between said thermionic cathode electrode and said hollow cylindrical anode electrode, said first plate electrode having an aperture adapted to transmit ions passing between said cylindrical anode electrode and said ion beam utilizing device, said second plate electrode having an aperture adapted to transmit electrons between said thermionic cathode electrode and said cylindrical anode electrode, magnetic means adapted to apply a magnetic field through said cylindrical anode electrode, and variable power supply means connected to said ion source and adapted to permit selective energization of said ion source as either an ion focusing anode for said thermionic cathode electrode or as a cold cathode ion source.

2. The apparatus according to claim 1 wherein at least one of said plate electrodes possess a plurality of needle points which project toward the volume enclosed by said hollow cylindrical anode electrode.

3. The apparatus according to claim 1 including an apertured ion focusing electrode positioned between said ion source and said ion beam utilizing device.

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