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IONIZATION VACUUM GAUGE

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Fig. 1.

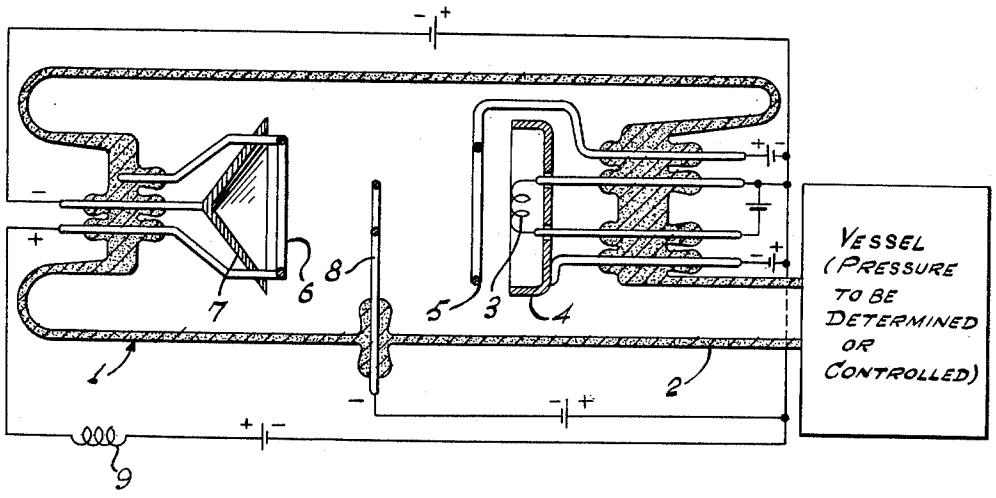
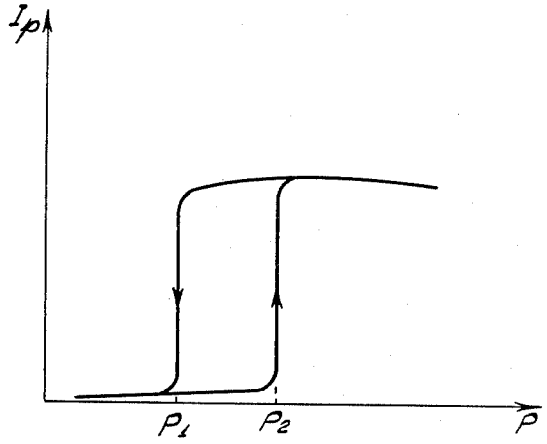


Fig. 2.



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IONIZATION VACUUM GAUGE

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This invention relates to an ionization vacuum gauge, and more particularly to an ionization vacuum gauge which is especially suitable for automatc control of a vacuum system.

It has been possible to attain a comparatively high accuracy of vacuum measurement by means of a conventional ionization vacuum gauge. The conventional gauge determines pressure from the ratio of beam current caused to flow through the gauge, to the current of ions formed by ionization due to the beam current. Inasmuch as the ion current is very small, it has often been necessary to amplify the ion current in order to utilize the ionization vacuum gauge for maintaining a vacuum system under a pressure less than a certain value. This has resulted in many defects such as the lowering of accuracy in detected values, hazards in the amplifiers, etc.

It is, therefore, the general object of this invention to eliminate the above-mentioned shortcoming in an ionization vacuum gauge.

Another object of the invention is to obtain an ionization vacuum gauge which is excellent for use in the automatic control of a vacuum system.

Still another object of the invention is to obtain an ionization vacuum gauge wherein the apportionment of the electric current abruptly changes in accordance with the pressure change.

According to the invention, there is provided an ionization vacuum gauge wherein charged particles are made to ionize the residual gas, and wherein the apportionment of the electric current is arranged so as to be varied by the space charge formed by the ionization.

By way of example, an embodiment of the invention will be described with reference to the accompanying drawing in which:

FIG. 1 schematically shows an ionization vacuum gauge made in accordance with the invention; and

FIG. 2 shows a typical characteristic of the ionization vacuum gauge shown in FIG. 1, wherein the variation of the collector current I_p is plotted against the change in pressure P.

Referring now to FIG. 1, the ionization vaccum gauge of the invention comprises an envelope 1 having a tube 2 for communication with a vacuum system (not shown), the pressure of which is to be measured.

In the envelope 1, there are provided the following elements: a filament 3 adjacent one end thereof, a reflector 4 for the electrons emitted from the filament 3, a ring-shaped accelerating electrode 5 disposed in front of the filament 3, a collector electrode 6 adjacent the other end of the envelope 1, a reflector 7 for reflecting the electrons back to the collector 6, and a retarding electrode 8 disposed between the filament 3 and the collector 6.

In operation, after the vacuum system is pumped out to a certain appropriate pressure, the filament 3 is heated. The accelerating electrode 5 and the collector 6 are supplied with positive voltages relative to the filament 3. The reflector electrodes 4 and 7 and the retarding electrode 8 are connected to negative voltages relative to the filament 3. By adjusting the filament current, the sum of the electric current I_a flowing through the accelerating electrode 5 and I_p flowing in the collector 6 is maintained at a predetermined value. If so adjusted, the electrons emitted by the filament 3 will move between the accelerating electrode 5 and the collector 6 and ionize the residual gas molecules within the envelope 1. It will be understood by those skilled in the art that this adjustment of total current (I_a+I_p) is an initial adjustment rather than an operating adjustment. In other words, it is not necessary to change the filament current while the device is operating; it is only necessary to determine the filament current which is required, with the particular filament employed, to produce the desired total current. This can be done most simply by placing current meters in series with the accelerating electrode and the collector electrode and then adjusting the filament voltage until the desired total current is observed on the meters. The filament voltage which produces the desired total current is noted, and the desired operating condition can then be obtained by simply applying this voltage to the filament when the device is placed in operation. In some embodiments of the invention it might be desirable to include a variable resistor in series with the filament circuit so that the device can be easily changed from one operating condition to another. In other embodiments it might be desirable to regulate the filament voltage to improve the accuracy of the device. This can be done with any suitable voltage regulating device, many of which are known to those skilled in the art. In general, however, it is only necessary to determine the filament voltage which will produce the desired total current and to apply that voltage to the filament.

When the pressure is higher than P_1 shown in FIG. 2, positive ions produced by the ionization will form a positive space charge mainly in the neighborhood of the accelerating electrode 5 and will tend to neutralize the negative voltage of the retarding electrode 8, so that currents will flow in the accelerating electrode 5 and the collector 6. As the pressure lowers, the above-mentioned positive space charge decreases. When the pressure lowers to P_1, the collector current I_p, which may be indicated by a meter coil 9 for example, also decreases because of the negative voltage of the retarding electrode 8. The decrease of the collector current I_p further decreases the positive space charge which in turn is accompanied by a further decrease of the collector current I_p. Thus, there results a steep cut-off characteristic as shown in FIG. 2.

When the pressure rises to P_2, a positive space charge is formed by the action of electrons near the accelerating electrode 5. The collector current, therefore, begins to flow and assists the formation of a greater positive space charge. Thus, the result is a steep build-up characteristic as shown in FIG. 2.

The dimensions of a practical ionization gauge are as follows:

The diameter of the accelerating electrode 5: 35 mm.;
The diameter of the collector (ring-shaped) 6: 35 mm.;
The diameter of the opposing end openings of the reflectors 4 and 7: 40 mm.;
The distance between the accelerating electrode 5 and the collector 6: 75 mm.;
The distance between the opposing ends of the reflectors 4 and 7: 80 mm.;
The reflectors 4 and 7; the accelerator 5 and the collector 6: disposed symmetrically with respect to the retarding electrode 8, and the voltage (relative to the filament 3) applied to the accelerator 5: +450 v.;
The voltage of the collector 6 relative to the filament 3: +450 v.
The voltage of the reflectors 4 and 7 relative to the filament 3: —150 v.;
The voltage of the retarding electrode 8 relative to the filament 3: —150 v.;
The current I_a flowing in the accelerator 5: 7 ma.;
The current I_p flowing in the collector 6: 13 ma.;

Total current I: 20 ma.;
P_1: 2.2×10^{-5} mm. Hg;
P_2: 4.0×10^{-5} mm. Hg.

By utilizing such collector current, it is possible to operate efficiently, for example, an electromagnetic valve, or control effectively the source of gas so that the pressure in the vacuum system could be maintained within a predetermined range, or be automatically controlled below a desired pressure. Inasmuch as the threshold values P_1 and P_2 of the pressure can be set at any desired values by selecting the voltage of each electrode and the total current I, the vacuum gauge provides means or easily and reliably detecting and controlling the degree of vacuum.

Although in the embodiment a filament, and a ring-shaped electrode are suggested as the emitter electrode, the construction of the emitter electrode can be suitably modified in accordance with the use of the vacuum gauge and the degrees of vacuum to be measured. Further, the beam current may be electrons and in addition charged particles, positive or negative. Also, there is no limitation to the number of collectors and accelerating electrodes.

While the foregoing description sets forth the principles of the invention in connection with specific apparatus, it is to be understood that this description is made only by way of example and not as a limitation of the scope of the invention as set forth in the objects thereof and in the accompanying claims.

I claim:

1. An ionization vacuum gauge for determining the gas pressure within a vessel, comprising a tube having a plurality of serially arranged electrodes, means connecting the interior of said tube with the interior of said vessel, whereby there is communication of gas therebetween, said electrodes comprising in sequence an emitter electrode, an accelerating electrode, a retarding electrode an a collector electrode, means for biasing said accelerating and collector electrodes with a positive polarity relative to said emitter electrode and said retarding electrode with a negative polarity relative to said emitter electrode, whereby electrons emitted by said emitter electrode are attracted to said accelerating and collector electrodes and are repelled by said retarding electrode, and means connected to said collector electrode responsive to changes in the collector current for providing an indication of the gas pressure in said vessel.

2. The gauge according to claim 1, wherein said emitter electrode is adapted to emit electrons when heated in amounts corresponding to the temperature thereof, and also including heater means adapted to heat said emitter electrode to a temperature which corresponds to some predetermined level of electron emission, said predetermined level of electron emission being selected such that at a first relatively high level of gas pressure positive ions are produced by ionization to form a positive space charge in the region of the accelerating electrode, tending to neutralize the negative biasing voltage on said retarding electrode, thereby increasing the current at said collector electrode, and conversely, at a second relatively low level of gas pressure the positive space charge is diminished and the amount of current flowing in said collector electrode is decreased, whereby the current in said collector electrode is an indication of the gas pressure in said vessel.

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