Dec. 17, 1957 A. H. W. BECK ET AL 2,817,030

IONISATION MANOMETERS

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FIG. 1.

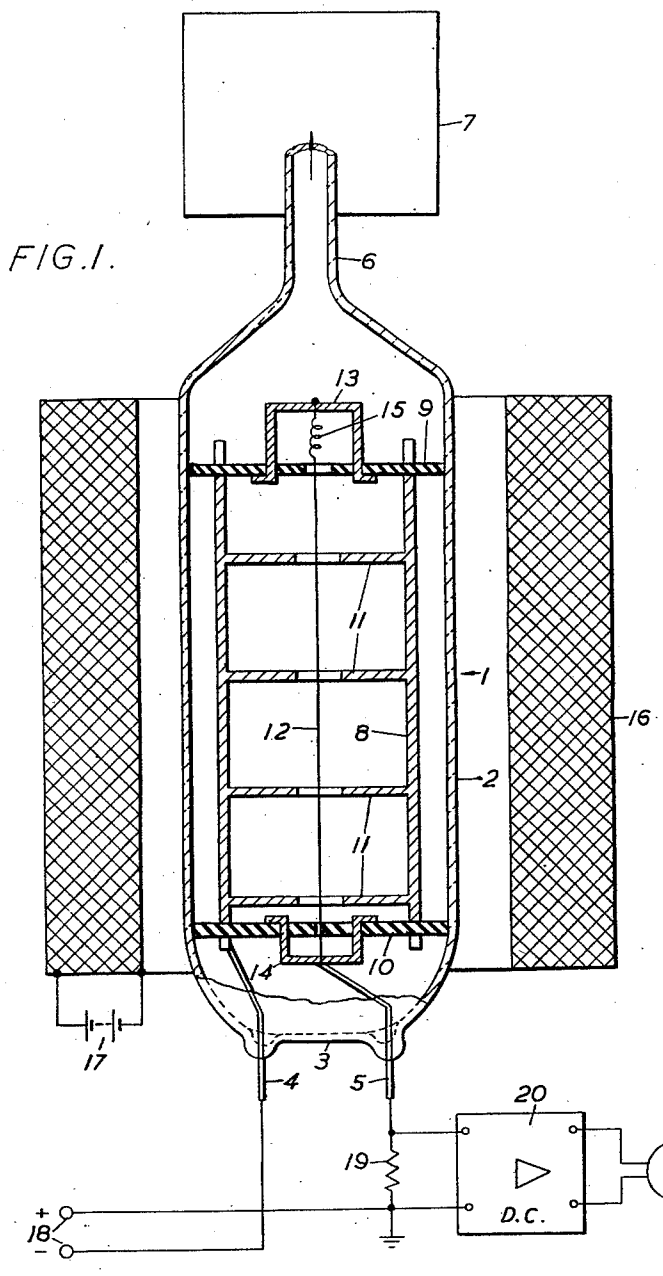

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FIG. 2.

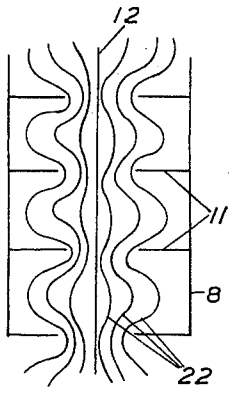
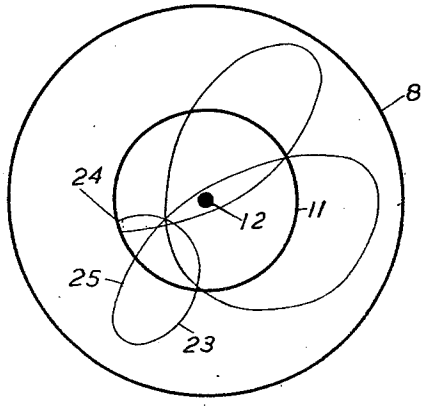


FIG. 3.



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United States Patent Office 2,817,030 Patented Dec. 17, 1957

2,817,030

IONISATION MANOMETERS

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Application March 25, 1952, Serial No. 278,466

Claims priority, application Great Britain April 20, 1951

3 Claims. (Cl. 313—7)

The present invention relates to ionisation manometers.

Ionisation manometers commonly employed in the thermionic valve industry as comparison instruments for estimating the degree of vacuum in a low pressure system rely upon electrons taking part in an electric discharge forming ions in the residual gas. In some arrangements positive ions are collected and the current flowing through the collector electrode gives an estimate of the number of gas molecules and hence of the gaseous pressure within the system; one of the most widely used devices of this kind is an ordinary thermionic triode electrode structure in which the grid is used as the ion collector. In other arrangements the strength of the primary discharge current is arranged to be dependent upon the degree of ionisation induced thereby and hence upon the gaseous pressure; for these arrangements a cold cathode discharge can be utilised.

It will be evident that the longer the electron path in an ionisation manometer the more chance there is of an electron colliding with a molecule and thus producing ionisation. We are aware that in order to improve the sensitivity of a cold cathode ionisation manometer, arrangements have been proposed wherein the electrons are subject to a magnetic field and hence travel along helical paths within the manometer tube.

According to the present invention there is provided an arrangement for estimating the degree of vacuum in a low pressure system comprising a vessel in communication with the said system; an elongated anode and a surrounding cold cathode electrode within the vessel; field emission surfaces protruding inwardly from the cathode electrode; means, including the provision of a magnetic field axially of the anode and cathode electrodes, for causing electrons emitted from the said surfaces to follow helicoidal paths about the said axis; and means for measuring changes of current flowing between the said anode and cathode electrodes.

From the point of view of the manometer tube per se, the invention provides an ionisation manometer tube comprising an elongated anode electrode surrounded by a non-magnetic (cold) cathode electrode and transverse metallic baffle plates, joined to the said cathode electrode, dividing the enclosure within the cathode into chambers communicating one with one another through respective central orifices surrounding the anode electrode.

An embodiment of the invention will be described with reference to the accompanying drawings in which—

Fig. 1 shows in part section an ionisation tube according to the invention together with a diagrammatic indication of its mode of use.

Fig. 2 is a diagram illustrating the distributing of potentials in the manometer tube of Fig. 1 and

Fig. 3 illustrates the nature of a typical electron path in the said tube.

In the embodiment shown in Fig. 1 a manometer tube **1** comprises a cylindrical glass envelope **2** having at one end a glass base **3** provided with leads **4** and **5** sealed therethrough and at the other end a tubulation **6** communicating with a system **7** being evacuated. Inside the envelope

2 a cylindrical cathode electrode **8** of non-magnetic material is located between mica washers **9** and **10**. The washers **9** and **10** are apertured so as not to impede the evacuation of the tube; the upper washer **9**, in particular should present a low impedance to the flow of gas and may be formed, for example, as an annular ring having a diametral web integral therewith. The interior of the cathode cylinder is divided by baffle plates **11** projecting from the internal cylinder wall into chambers communicating with one another through central orifices in the baffle plates. A fine wire anode **12** is supported in tension along the axis of the tube by means of the bridge members **13** and **14** secured to the washers **9** and **10** respectively, the wire being tensioned at its upper end by means of the spring **15**. The leads **4** and **5** are connected respectively to the cathode **8** and to the anode wire **12**. In operation the tube is surrounded by a coil **16** energised from a source indicated at **17**. The leads **4** and **5** are connected through the terminals **18** to a power supply providing a voltage of between 2.5 and 5 kv. adjusted according to the pressure range to be measured. The cathode lead **4** is taken to the negative terminal while the positive terminal of the power supply is connected to the anode through a resistor **19**, the positive terminal being grounded. The resistor **19**, which may have a value of the order 2 mω, is connected across the input terminals of a D. C. amplifier **20** feeding an output meter **21**.

In a typical embodiment of the invention for measuring pressures in the range 10^{-3} to 10^{-7} mm. Hg the tube is some three inches long, the cathode diameter is three quarters of an inch and four baffle plates, spaced three quarters of an inch apart, are provided. The baffle plates are .008 inch in thickness and the apertures are $\frac{3}{16}$ inch in diameter and the anode is a length of 0.002 inch diameter tungsten wire. The cathode and baffle plates may conveniently be fabricated from the copper-nickel alloy known in the industry under the registered trademark "Ferry." The H. T. voltage may conveniently be supplied by rectification of the output of a 100 kc./s. source in the same manner as is sometimes used for the high tension supply for the cathode ray tube in commercial television receivers; we have found the actual high voltage power supply of a television receiver to be adequate for our purposes. With the dimensions of tube quoted and a field from the coil **16** of the order of 300 gauss on the axis of the coil, we have found the manometer arrangement described to be some hundred times more sensitive than the conventional triode instrument, a hundred microamperes or more being injected through the resistor **19** when an exciting voltage of 3 kv. is used and the gas pressure is of the order of 10^{-5} mm. Hg.

It should be noted that it is not necessary to arrange the ionisation manometer tube as a side tube branching from the vacuum system; such an arrangement is usually adopted to avoid resistance to the flow of gas through the systems and the embodiment of Fig. 1 has a single tubulation in accordance with the normal practice. The electrode structure of the present invention, particularly of the embodiment described, offers little resistance to the flow of gas and, therefore, if desired, a manometer tube according to the present invention may be inserted in series with a main gas path of the vacuum system; suitable modification to the envelope and lead-out arrangements of the embodiment of Fig. 1 for such use will be obvious to those skilled in the art.

While the theory of operation of the invention has not yet been fully investigated, it is evident that the baffles **11** are effective as sources of field emission of primary electrons and serve to provide the necessary axial components of electric field for electrons to drift along the axis of the tube. In Fig. 2 we have indicated roughly at **22** equipotentials within the cathode **8**. The baffles **11**

form protrusions projecting inwardly from the surface of cathode 8; the equipotentials are thus distorted and crowd together between the inner edges of the baffles and the anode wire 12. Hence there are axial components of electric force tending to cause electrons to drift towards transverse planes equidistant from adjacent baffles.

A plan view of part of a typical electron trajectory is shown at 23 in Fig. 3. The electron is assumed to have been drawn off at 24 from the sharp edge of a baffle 11. The joint radial electric and axial magnetic fields at this point cause the electron to turn away from the anode towards the cathode, from which it is repelled, so tracing a loop such as 25. Only a small number of electrons will be emitted with zero axial velocity into a plane of zero axial electric field, so our typical electron will have travelled slightly along the axis towards the next adjacent baffle. Since the electron, in the absence of collision with gaseous molecules, slowly moves into regions where the equipotentials are further apart, the loops in the trajectory become increasingly larger until the electron reaches the transverse plane between adjacent baffles in which it is no longer subject to an axial force.

From the above discussion it will be appreciated that electrons of the primary discharge not only have very long paths in the absence of collision with gaseous molecules but any one electron will tend to sweep out a large volume so as to have a greater probability of collision with gaseous molecules than if it were confined to a single plane. Furthermore, although in this invention the protrusions on the cathode surface need not necessarily be in the form of annular baffles, the arrangement of the embodiment described has the advantages that there are successive regions, namely the planes intermediate successive baffles, in which numbers of electrons tend to congregate, thus forming effective ionising layers which gaseous molecules must cross during the evacuation of the vessel. We believe, therefore, that the arrangement of the embodiment described provides greater sensitivity than other forms of the invention.

While the principles of the invention have been described above in connection with specific embodiments and particular modifications thereof, it is to be clearly understood that this description is made only by way of example, and not as a limitation on the scope of the invention.

What we claim is:

1. An ionisation manometer tube comprising an elongated anode electrode surrounded by a non-magnetic cathode electrode, transverse metallic baffle plates extending from, electrically in contact with, and mechanically joined with, the said cathode electrode, dividing the enclosure within the cathode into a plurality of chambers communicating one with one another through respective orifices surrounding the anode electrode, and means for producing a magnetic field axially of the anode and cathode electrodes for causing electrons emitted from said cathode to follow helicoidal paths about said axis.

2. A tube according to claim 1 comprising a cylindrical glass envelope adapted to communicate with an enclosure whose degree of vacuum is to be measured, lead wires, connected respectively to the anode and cathode, sealed through the envelope and insulating washers at either end of the said cathode electrode locating the same within the envelope and apertured to permit passage of gas during evacuation, the cathode electrode being cylindrical and the anode being a fine wire supported axially in tension between the said insulating washers.

3. A tube according to claim 2 in which the said envelope comprises at one end a base through which the said leads are sealed and at the other a tubulation for connection to the said enclosure.

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