

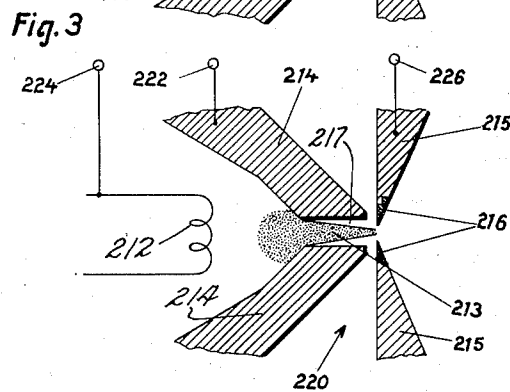
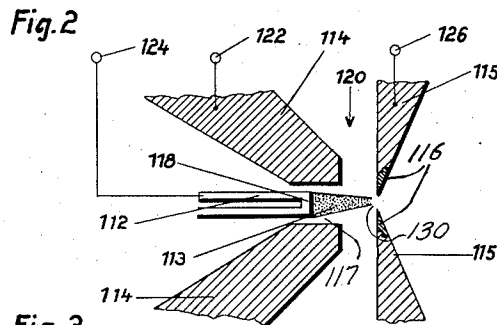
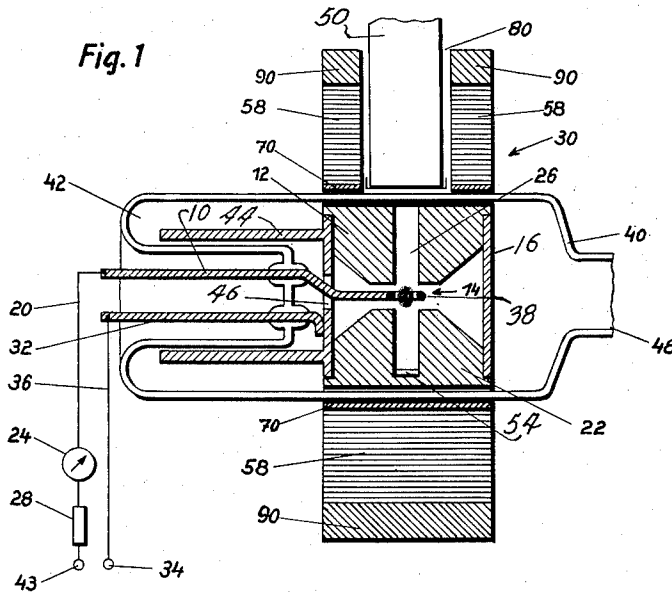
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ARRANGEMENT FOR GLOW DISCHARGE TUBES

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1

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ARRANGEMENT FOR GLOW DISCHARGE TUBES

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9 Claims. (Cl. 313—7)

The present invention relates to glow discharge tubes, and more particularly to an arrangement for such tubes providing a high plasma density at low pressures of neutral gas therein.

It is an object of the present invention to increase considerably the plasma density of such tubes.

It is another object of the present invention to increase the intrinsic brilliance of the luminous surface of such tubes.

It is a further object of the present invention to reduce the pressure of the neutral gas in glow discharge tubes.

It is still another object of the present invention to enable an analysis of the residual gas in the tube to be carried out by simple means such as by use of a pocket spectroscope.

Other objects and advantages of the present invention will become apparent from the following detailed description when read with reference to the accompanying drawings showing, by way of example, some embodiments of the present invention. In the drawings

Fig. 1 is a side elevation, partly shown in section, of a first embodiment of the present invention,

Fig. 2 is a diagrammatic section of part of a second embodiment of the present invention, and

Fig. 3 is a diagrammatic section of part of a third embodiment of the present invention.

Referring now to the drawings in detail, and first to Fig. 1, a densimeter is shown for high vacuum tubes with light spectroscopic gas indication and operating with, for example, hydrogen as test gas. The apparatus shown in Fig. 1 operates with a gas discharge from a cold cathode in the manner of the well known Penning discharge with pendulum motion of the electrons.

A glass vessel or tube 40 is evacuated so that the residual gas, for instance hydrogen, has a pressure amounting, for instance to 10^{-5} millimeters of mercury.

A magnetic lens generally denoted by the reference numeral 30 includes two pole pieces 12, 22 having inner walls forming a bore 26. The pole pieces are arranged within the glass tube 40 and separated from each other by a gap 14. The pole pieces 12, 22 serve as cathodes and are connected with a metal tube 16 which in turn is connected with a connecting piece or bus bar 32 sealed into the wall of the glass tube 40. The terminal 34 connected to ground is connected by a conductor 36 to the bus bar 32.

A ring-shaped anode 38 is arranged symmetrically to the walls thereof pieces 12, 22 in the gap 14 of the pole and connected by a conductor 10 with another conductor 20 and through an ammeter 24 and a resistor 28 to a terminal 43. The terminals 43 and 34 are connected, respectively, with the positive and negative terminals (not shown) of a direct current source.

The glass tube 40 is formed with an annular end portion 42 which serves to accommodate a metal cylinder 44 connected to the metal tube 16 and in heat conductive contact with the pole pieces 12 and 22 so as to efficiently cool the same through said end portion. The

2

metal tube 16 is provided with a bore 46 for passage of the conductor 10 connected with the anode 38.

The glass tube 40 is provided with a neck portion 48 being adapted for connection to the vacuum apparatus (not shown).

A hollow cylindrical iron part 70 is arranged on the glass tube 40 so as to form a continuation of the pole pieces 12, 22. A permanent magnet 58 and an iron stirrup 90 are arranged outside the cylindrical iron part 70. On one side of the permanent magnet 58 and the iron stirrup 90 an opening 80 is provided for the reception of a simple pocket size spectroscope 50 in alignment with the boring 26, allowing observation of the spectral lines emitted by the gas filling the bore 26 and the gap 14 in the neighborhood of the ring-shaped anode 38.

A reflecting mirror 54 is preferably arranged at one end of the bore 26 between the pole pieces 12, 22.

The operation of this device is as follows:

A cold gas discharge is caused by the potential difference applied by the voltage source (not shown) to the ring-shaped anode 38 and the cathode 12, 22. The tube 16 operates as a Penning vacuumometer in which under the influence of the magnetic field of the permanent magnet 58 the otherwise very extended volume of the discharge is concentrated by 2-3 orders of magnitude. The concentration of the discharge in the plasma filling the bore 26 and the gap 14 follows substantially the following equation

$$j_{ea} \approx j_{ec} \frac{H_a}{H_c}$$

where j_{ea} is the current density in the anode space, j_{ec} the current density in the cathode space, and where H_a and H_c are the magnetic field intensities, respectively, in the anode and cathode spaces. It should be noted that the magnetic field is inhomogeneous in such a manner that the field H_a in the anode space is very strong in comparison to the field H_c in the cathode space. By the diminution of the volume of the effective gas discharge by 2-3 orders of magnitude the excitation luminescence of the Penning discharge is very much increased, and beyond that almost doubled by the reflecting mirror 54 arranged at the bottom of the bore 26. In consequence thereof the density of the luminescence is so increased in the axial bore at reduced pressures of the gas such as 10^{-5} millimeters of mercury that an analysis of the gas may be carried out with a simple spectroscope 50.

Thus the electrons of the plasma of a gas discharge and also the primary electrons originating from the cathode drop may be magnetically condensed, the effectiveness of this method being only slightly affected by collisions of the electrons with the gas provided a relatively low pressure of the neutral gas amounting to less than 1 millimeter of mercury and a small discharge volume below about 5 cubic cm. are applied. Just gas discharges in a gas having an as low as possible neutral gas density and an as small as possible volume are of great technical importance for special discharges such as spectroscopic vacuum densimeters and ion sources.

Very inhomogeneous magnetic fields may be produced in different ways as is well known in the art, especially as axially symmetrical and asymmetrical fields. The pole piece lens described hereinabove allows obtaining an axially symmetrical field shape particularly suitable for the present invention at a field volume rendered small owing to the gas collisions.

For these reasons this arrangement is suitable for replacing known helium densimeters in which a leaky container is scanned by means of a gas jet of helium, the helium gas in the container being detected by means of a mass spectrometer. The elimination of the helium densimeter and its replacement by a simple sturdy ar-

3

rangement constitutes an important problem of modern vacuum technics because the helium densimeters are complicated, unreliable in operation, expensive, and often the helium gas necessary for the operation thereof is not available. Finally, hydrogen gas as a means for spraying the leaky container has the advantage, that owing to its low molecular weight, it penetrates the fine pores more quickly than helium gas.

The embodiment shown in Fig. 1 is not limited to this application but may be further developed in any desired manner.

A further application in which it is of great importance to obtain a dense plasma at as low as possible a pressure of the neutral gas is found, for instance, in the field of ion sources. Here high plasma density is desirable in order to emit the ion current from the ion emitting opening at a high ion current density. In this connection a low density of the neutral gas is desired so that from the ion emitting opening as small as possible a quantity of neutral gas diffuses into the jet space, so that the source has a high efficiency.

For the application of the fundamental principle of the present invention it does not matter whether the electrons are emitted in the discharge to be condensed by a cold cathode as shown in Fig. 1 or by a heated cathode as shown in Figs. 2 and 3.

Referring now to Fig. 2 of the drawings a thermal cathode 112 shaped as a stirrup is arranged with the front part 118 thereof in the bore 117 of a magnetic pole piece lens generally denoted by 120 in a range of a low magnetic field intensity. The pole piece 114 of the magnetic lens 120 is maintained by a terminal 122 at the same negative potential as that at which the thermal cathode 112 is maintained by the terminal 124. The other pole piece 115 of the magnetic lens 120 forms the anode of the condensed discharge and is connected by the terminal 126 to a source of positive potential. The other pole piece or anode 115 of the magnetic lens 120 is provided with an annular insert 116 consisting of a high melting temperature material such as molybdenum or tungsten, the annular insert 116 having an opening 130 forming an extension of the bore 117. The glass vessel containing the rarefied gas and the electrodes is not shown in Figs. 2 and 3.

The electrons are emitted as a cone 113 from the front part 118 of the thermal cathode 112. The cone 113 extends as far as the bore of the annular insert 116 of the anode 115.

In Fig. 3 the thermal cathode 212 is helical and connected by the terminal 224 to a source of negative potential which is also applied by the terminal 222 to the pole piece 214 of the magnetic lens 220. The pole piece 214 is milled on the side thereof facing the helical thermal cathode 212 and the source of electrons is formed by the plasma 213 in front of the cathode 212 so as to coincide for the greater part of its length with the bore 217 of the pole piece 214. The cathode 212 is situated substantially outside the bore 217 in a space practically free of the magnetic field produced by the pole piece 214, and the plasma of the positive column sends the electrons in the shape of the cone 213 into the space of high magnetic field intensity defined by the end of the bore 217. Arranged in a plane near the end of the bore 217 is an annular insert 216, consisting preferably of molybdenum or tungsten which forms part of the anode 215 and which is connected by the terminal 226 with a source of positive potential.

I have described hereinabove some embodiments of an arrangement for glow discharge tubes. However, it should be understood that my invention extends also to changes, modifications, and equivalents of the elements described hereinabove which will be obvious to those skilled in the art.

I claim:

1. A device for producing a high density plasma in a

4

low pressure neutral gas atmosphere comprising, an evacuated envelope containing a residual neutral gas under low pressure, a source of electrons in said envelope, anode means spaced from said source of electrons operative to attract electrons from said source along a discharge path, and means for producing a magnetic field the lines of force of which extend along the discharge path between said source and said electron attracting means, the field strength of said magnetic field being relatively weak in the zone of said source as compared with its strength in the zone of said anode means.

2. The discharge device as defined in claim 1 wherein said electron source comprises a cathode and a portion of the discharge plasma adjacent to said cathode.

3. A device for producing a high density plasma in a low pressure neutral gas atmosphere comprising, an evacuated envelope containing a residual neutral gas under low pressure, a source of electrons in said envelope, anode means spaced from said source of electrons operative to attract electrons from said source along a discharge path, and means for producing a magnetic field the lines of force of which extend along the discharge path between said source and said electron attracting means, said magnetic field being inhomogeneous and relatively weak in the zone of said source of electrons.

4. The discharge device as defined in claim 3 wherein said inhomogeneous magnetic field producing means comprises a magnetic pole shoe lens.

5. The discharge device as defined in claim 4 wherein said magnetic pole shoe lens comprises a magnetic lens member comprising said anode means, and wherein said lens member is provided with an axial bore for permitting suction therethrough of ions in said discharge plasma.

6. The discharge device as defined in claim 1 wherein the axial bore of said lens member is defined by an annular insert of high melting temperature metal fixed in said lens member.

7. A device for producing a high density plasma in a low pressure neutral gas atmosphere comprising, an evacuated envelope containing a residual neutral gas under low pressure, a magnetic lens in said envelope comprising a pair of spaced pole shoes having aligned axial bores, spaced cathode and anode means in said envelope and within said magnetic lens operative to produce an electron current flow therebetween, said magnetic lens being operative to produce an inhomogeneous magnetic field the lines of force of which are of greater strength in the vicinity of said anode means than in the vicinity of said cathode means.

8. The discharge device as defined in claim 7 including a magnet arranged outside of said envelope and having a pair of pole members disposed in closely spaced relation with respect to one each of said pole pieces, and transverse openings in one of said pole members and the adjacent one of said pole pieces to allow inspection of the plasma in said lens by means of a pocket spectroscope.

9. The discharge device as defined in claim 8 including a second opening in the other of said pole pieces in alignment with the opening of said first pole piece, and a mirror seated in said second opening for reflecting additional light from the plasma being observed by the spectroscope.

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