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2,417,797

MASS SPECTROMETER

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Fig. 1.

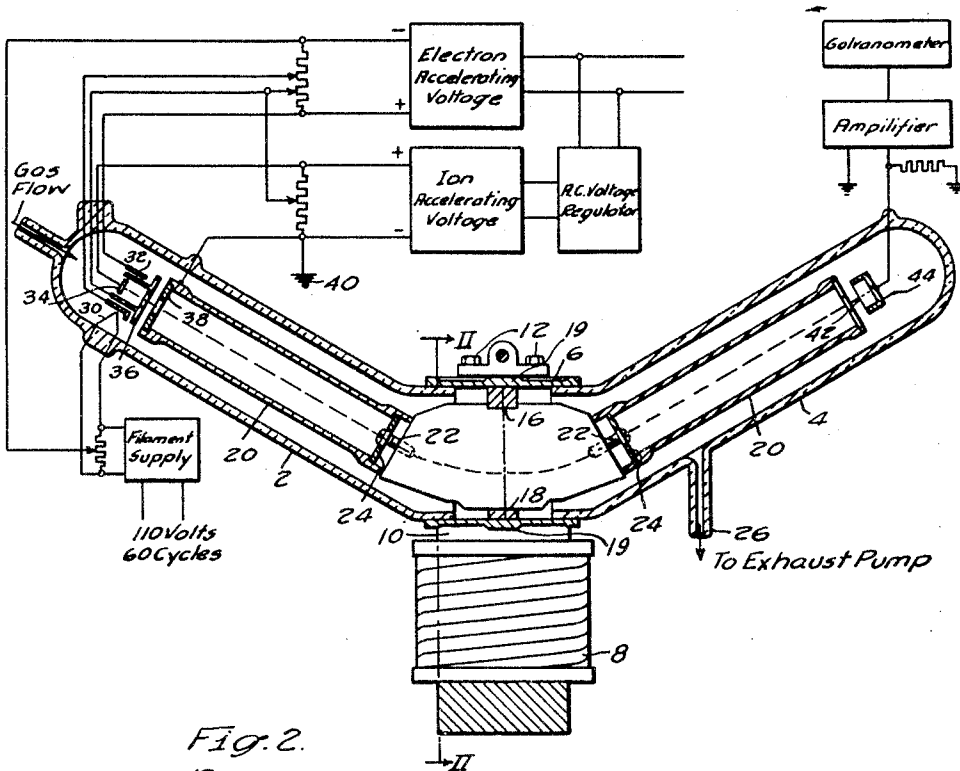


Fig. 2.

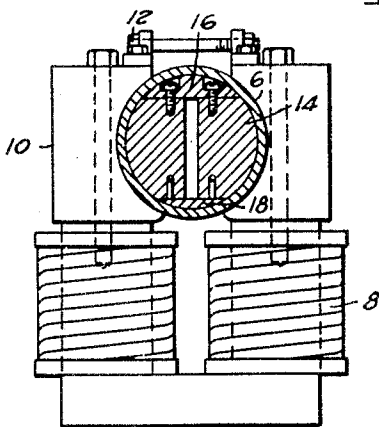
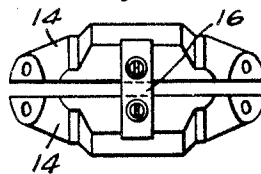


Fig. 3.



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MASS SPECTROMETER

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2 Claims. (Cl. 73—18)

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The present invention relates generally to vacuum tubes but more particularly to a tube construction for a mass spectrometer.

Spectrometers of the usual type employ an evacuated tube for defining an ion path, which path is bent by a magnetic field to focus ions of a given mass-to-charge ratio upon an exit slit within the tube. Upon leaving such slit the ion beam impinges a suitable collector plate. The charge on the plate is then amplified and measured to give a quantitative measurement of the constituent of the material, such as a gas, being investigated. In prior practice the magnetic field has been produced by electromagnets of substantial size and weight because of the necessity of a high strength field and the substantial spacing between the pole pieces which must be sufficient to receive the spectrometer tube.

It is an object of the present invention to substantially decrease the dimensions of the spectrometer and particularly the size of the electromagnet required for the desired magnetic field strength.

More specifically, it is an object of the invention to provide a mass spectrometer tube in which the pole pieces of the field producing magnet are themselves in the direct path of the ion stream.

It is a further object of the invention to provide a spectrometer construction of such character that the proper alignment of parts is maintained and the assembly of the parts into proper position is assured.

Other objects of the invention will be apparent from the following description taken in connection with the accompanying drawing, in which:

Figure 1 is a view in lateral section, partially schematic, of a mass spectrometer in accordance with the present invention,

Fig. 2 is a view in section taken on the line II—II of Fig. 1, and

Fig. 3 is a plan view of the pole pieces of the assembled electromagnet.

Referring to Fig. 1, the spectrometer comprises, generally, an evacuated envelope comprising glass sections 2 and 4 joined at their inner ends by a metal sleeve 6. The metal sleeve 6 is preferably of a material having substantially the same coefficient of expansion as glass and is fused to the arms 2 and 4. Such material may be that commonly sold under the trade name Kovar.

Associated with the collar or cylinder 6 is an electromagnet 8 having, in the present instance, two windings which are energized from a constant source of direct current. The pole portions 10 of the electromagnet closely embrace the sleeve 6

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and may be clamped in position by bolts such as 12. Instead of an electromagnet a permanent magnet may be used if desired. It will be noted that the pole portions 10 of the magnet are removable, so that the magnet may be readily removed for repair or replacement.

The pole pieces for the magnet 8 comprise two semicylindrical members 14 rigidly mounted inside the collar 6. Referring more particularly to Figs. 2 and 3, the pole faces are clamped together by means of a yoke 16 secured by screws, and a lower yoke 18 which is pinned in position, as indicated. Prior to assembly of these pieces a suitable jig or spacer may be placed between the pole faces to insure the accuracy of the width of the slot between them. After securing the yokes 16 and 18 in place, the assembly including the spacer or jig, is inserted into the sleeve 6 with a tight fit. The sleeve and pole pieces 14 are then spot-welded together at points disposed on the annular ridge 19 (Fig. 1) of the sleeve, and the spacer or jig is removed.

A pair of tubes 20 of non-magnetic material, such as copper, are then secured to the ends of the magnet pole pieces as by screws 22 extending through a plate secured in the base of each tube. Such plates 24 are of course, provided with an opening or slit through which the ions may enter into the field defined by the pole pieces 14 and emerge therefrom.

The glass tubes 2 and 4, which are open at both ends at this stage of the assembly are then fused to the ends of the sleeve 6 in hermetically sealed relation.

As is usual in devices of this kind, a beam of electrons is set up between a filament 30 and an anode 32, and is suitably accelerated by electrodes, with suitable apertures, disposed therebetween and energized from the electron accelerating voltage source, as indicated.

When a gas sample passes the electron beam the molecules thereof become ionized and the ions formed just below the electrode 34 are driven by a small potential difference between the electrodes 34 and 36 through a very narrow slit in the latter. This ion beam is then accelerated by a much larger potential difference between the electrode 36 and an electrode 38 at the end of tube 20, the tube 20 being at ground potential, as indicated at 40. The ion beam thereafter continues into the field of the electromagnet 8, as defined by the pole pieces 14. Depending upon the mass-to-charge value of the ions, some will be deflected up through the copper tube 20 and its narrowly defined exit slit 42, to be collected upon a Fara-

day cup 44, amplified and impressed upon a galvanometer as indicated. Other ions of different mass-to-charge values will be deflected into contact with the grounded tubes 20, and will not, therefore, affect the measurement of the ions focused on the exit slit 42.

The ion source assembly and the ion charge collector 44 may be mounted at the positions shown, in any convenient and well understood manner, by inserting them respectively through the open ends of the glass tubes 2 and 4. Such tube ends are then sealed off to complete the spectrometer tube. In the cap on glass tube 2 a gas inlet is provided for connection to a flow-restraining device, or stop-cock according to usual practice, and tube 4 is provided with a tubular extension 26 for connection to evacuating and degassing equipment.

The ion source equipment is largely schematic and any of the well known types of devices may be employed. In fact a spark source could be used for analyzing solid materials. Also the collecting device 44 need not be of the shape or type shown.

It is believed unnecessary to discuss in detail the various voltage sources, amplifiers, etc., as they are well-known in the art.

By reason of the construction described, a mass spectrometer has been produced which is readily portable and highly efficient, in that the pole pieces of the field magnet are directly in the ion path; the ion path is accurately defined by the pole pieces and the copper tubes 20 which are attached thereto with machine accuracy, and the overall weight of the device is only a fraction of those used heretofore.

Quite obviously, variations may be made in the structure described, and it is expected that the scope of the invention will be limited only by the appended claims.

I claim as my invention:

1. In a mass spectrometer, a magnetic field producing magnet having two pole portions, a cylindrical collar embraced between said pole portions, a pair of pole pieces of substantially semi-cylindrical shape mounted in said collar for cooperating with said pole portions and spaced to provide a slot therebetween, a pair of non-

magnetic metallic tubes each having an end secured respectively to the ends of said pair of semi-cylindrical pole pieces to define a path communicating with said slot, a pair of open-ended tubes of insulating material enclosing said non-magnetic metallic tubes, and means for sealing the open ends thereof to the respective ends of said collar.

2. In a mass spectrometer, means for defining an ion path comprising a pair of magnetic pole pieces mounted in a tubular metallic sleeve in spaced relation to form an airgap therebetween, a tubular nonmagnetic member rigidly secured to the adjacent edge faces of said pole pieces with its axis intersecting said air-gap and substantially perpendicular to any flux lines bridging said air-gap and a second tubular nonmagnetic member secured in like manner to the opposite adjacent edge faces of said pole pieces, and closures for the free ends of said members having slits therein for the passage of ions there-through.

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