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MASS SPECTROMETER TUBE ION SOURCE ASSEMBLY

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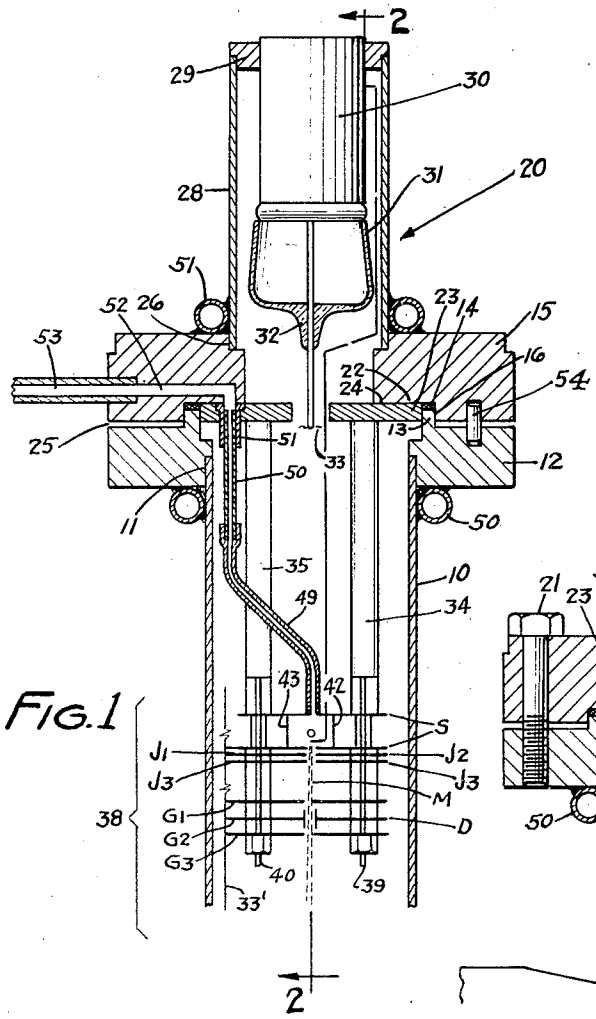


FIG. 1

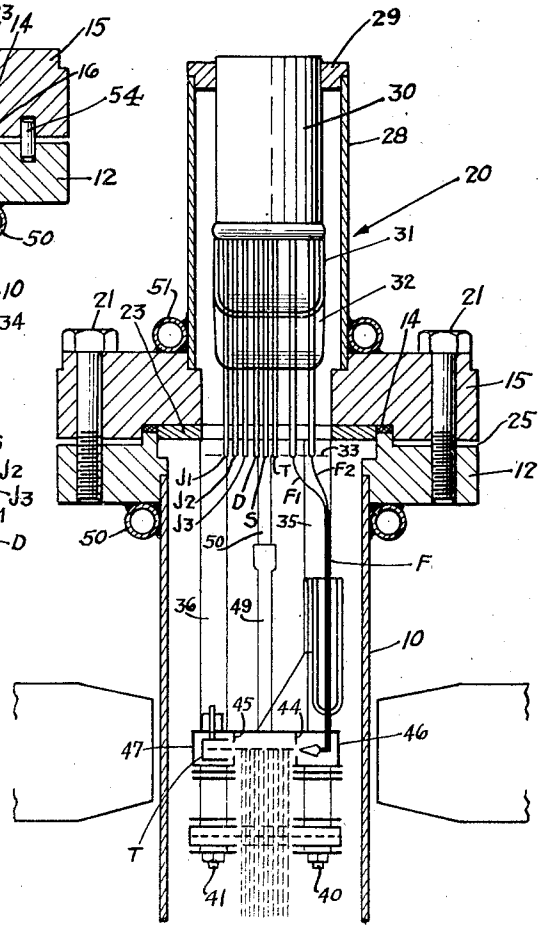


FIG. 2

INVENTOR
ALFRED O.C. NIER
By Paul, Paul & Moore
ATTORNEYS

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MASS SPECTROMETER TUBE ION SOURCE ASSEMBLY

Alfred O. C. Nier, Minneapolis, Minn., assignor to Regents of the University of Minnesota, Minneapolis, Minn., a corporation of Minnesota

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This invention relates to improvements in mass spectrometer tubes and the like and particularly to improvements in the ion source portion thereof. Heretofore, mass spectrometer tubes have been so constructed that the ion source is not readily removable once the tube is completed for this portion of the tube must, in common with the remainder of the tube, be de-gassed by application of heat and pumping before the tube is set into operation. Hence, the constructions heretofore used have not been readily accessible, and such opening provisions as have been made are cumbersome to a degree that servicing the ion source has been a difficult and time consuming operation.

It is an object of the invention to provide an improved mass spectrometer overcoming these objections of prior constructions and to provide an ion source which is readily accessible, easily serviced and easily put into operation.

Other objects of the invention include the provision of an improved unit construction of an ion source for a mass spectrometer tube, capable of assembly or disassembly from the tube proper.

Other and further objects of the invention are those inherent in the apparatus herein illustrated, described and claimed.

The invention is illustrated in the drawings in which

Figure 1 is a vertical transverse sectional view of the apparatus of the present invention;

Figure 2 is a vertical transverse sectional view taken in the direction of arrows 2—2 of Figure 1.

Throughout the drawings corresponding numerals refer to the same parts.

In the drawings certain of the lead wire connections within the tube proper have been omitted for purposes of clarity.

Referring to the drawings the mass spectrometer tube proper is composed of a metallic tube, such as Inconel or other nonmagnetic tubing 10 which is sweat soldered at 11 into a terminal flange 12. The flange is recessed at the joint 11 so as to present a tight fit to the external surface of the tube to which it is soldered. The upper portion of the flange is provided with a flange 13 which seats in a groove 16 in the mating flange 15 of the ion source assembly generally designated 20. The ion source includes the flange 15 which serves as an assembly base for all of the remaining elements of the ion source. The flange 15 has the same external diameter as the flange 12 and is apertured so that it can be fastened to the flange 12 by means of a plurality of cap screws 21 evenly spaced around the periphery of the flange. A locating pin 53 mounted on one of the flanges

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and a cooperating hole in the other flange insures re-assembly in one position only. The flange 15 is provided with an internal step 22 upon which a plate 23 is centrally fastened and attached by soldering at the surface 24. The outer diameter of the plate 23 is such as to leave an internal groove in which a peripheral gasket 14 which is capable of maintaining a gas-tight high vacuum joint is seated. The tongue flange 13 of the mass spectrometer tube flange 12 is adapted to reach into the groove and seat upon the gasket 14 when the two flanges 12 and 15 are drawn together by the screws 21 and thus provide an exceedingly tight joint. The tongue 13 has a sufficient axial dimension so that when it is seated upon the gasket 14 a space remains between the two flanges as at 25. This facilitates the separation of two flanges for servicing.

The flange 15 has a central aperture and has a step 26 milled in the upper surface so as to receive the end of a tube 28 which is soldered to the flange 15 at the step 26. The tube 28 is capped at 29, and cap 29 carries the internally extending metallic tube 30 which is sealed in gas-tight relation to the glass squash 31 through which eight lead-in wires pass in gas-tight relationship at the squash portion 32. The lead wires are, respectively, J_1, J_2, J_3, D, S, T, F_1 and F_2. In the drawings these are shown broken off at the line 33 for purposes of clarity, but it will be understood that they extend downward to the corresponding connections at breaking line 33'. The plate 23 also serves to support four stainless steel posts, of which posts 34, 35 and 36 are shown in the drawings. The four posts are spaced in rectangular configuration and are fastened by screws or brazing to the plate 23. When the ion source is assembled as shown in Figures 1 and 2, the posts 34 extend into the tube 10 of the mass spectrometer tube and serve to support the elements of the ion source which are shown generally opposite the bracket 38.

The ion source consists of a plurality of spaced plates S, S, J_1, J_2, J_3, D and ground plates G_1, G_2 and G_3, together with a deflection plate D. Plates S and S (which are connected together) and plates J_1, J_2, J_3 and D are mounted on wire posts 39, 40 and 41 which extend from the stainless steel posts 34, 35, 36 etc. All of these plates are insulated from each other and from the posts. Plates G_1, G_2 and G_3 are likewise mounted on the posts but are not insulated therefrom since they are all at ground potential, the same as the posts. The spacing of the plates S—S, J_1, J_2, J_3, G_1, G_2, G_3, and D is by means of glass washers

and the assembly is held in place by nuts on the end of the wire posts 39, 40, 41 etc. The plates S—S are spaced apart and between them there are provided walls 42 and 43 which form a rectangular pocket which has division walls 44 and 45 and end walls 46 and 47 therein as shown in Figure 2. The filament F is situated in the pockets between walls 44 and 46 and the filament lead wires F_1 and F_2 extend upwardly from this pocket and are connected to the corresponding lead wires F and F entering through the squash of the tube.

The filament F is hair pin shaped and its apex, which is most intensely heated, is adjacent an aperture in wall 44 so that a beam of electron emitted by the filament passes through the aperture in the direction of a corresponding aperture in the wall 45 and after passing therethrough enters an antrum formed by the U-shaped channel T which is insulated from but mounted on wire 41 and connected by a suitable insulated lead wire, not illustrated, to the correspondingly numbered wire T entering through the squash. A potential is maintained between the filament F and the antrum plate T (which is known as the trap) and the electrons are accordingly drawn across the space between walls 44 and 45.

In the space between walls 44 and 45 there is a rectangular pocket which is connected by a tube 49, thence through the couplings 50 and 51 and through the hole 52 to the inlet capillary tube 53 through which the gas sample to be analyzed is introduced into the spectrometer tube. The molecules of gas in the sample to be analyzed are thus conducted directly to the space defined by the walls 42, 43, 44 and 45 and the molecules in this space are subjected to a beam of electrons from the filament F which passes through the aperture in plate 44, thence across the space and through the aperture in the plate 45 to the trap T. The electrons bombard the molecules and cause them to be ionized, hence to be subject to acceleration potentials.

The lower plate S in Figures 1 and 2 has an aperture slit at its central portion and below the lower plate S are a plurality of plates J_1, J_2 and J_3. Potential supplies of gradually increasing value (more positive) are connected to the plates J_1—J_3, respectively. Ground potential is applied to plates G_1, G_2 and G_3. Plates J_1 and J_2 are half plates and define a slit between them. Plate J_3 is a full plate and has a slit in the center. The potentials so applied to plates J_1, J_2 and J_3 form a field which reaches through the slit in the lower plate S and the ionized and hence charged molecules are accelerated by the potential gradient and pass through the slits defined by the plate S and by the plates J_1 and J_2 and by plate J_3, the ionized molecules attain a gradually increasing velocity and upon leaving the slit defined by the full plate G_1, the molecules continue to move along (or coast) at a velocity determined by the potential gradient through which they have fallen. Thus, in a specific installation ground potential is applied to plates G_1, G_2 and G_3 and positive potentials applied to the plates J_1, J_2, J_3 and S as follows: J_3=1700 volts plus; J_1 and J_2=1800 volts plus; and S=2000 volts plus. The stream of ionized molecules is indicated by the dotted line M and is subject to some focusing action due to the particular potentials applied to the plates J_1 through J_3.

The ionized molecules move towards the first ground plate G_1, and after passing through a slit therein, pass through the space formed by the T-shaped ground plate G_2 and the T-shaped deflector plate D. Normally the plate D is connected to ground and hence normally (during the operation of the mass spectrometer tube), the ionized molecules continue in their movement through the slit plate G_3 and thence on through the mass spectrometer tube. When it is desired to "turn off" the mass spectrometer tube, this is conveniently done by applying a positive potential to the plate D which causes the ionized molecules to be deflected and miss the slit in the plate G_3 and hence are collected on the plate G_3. It will be understood that the plates S—S, J_1, J_2, J_3, G_1, G_2, G_3, D and the filament terminals are connected to the correspondingly designated lead-in wires entering through the squash 32.

At the junction of the mass spectrometer tube 10 and the flange 12 there is soldered a full turn of copper tubing 50 and similarly at the junction of the flange 15 and the tube 28 there is soldered another full turn of tubing 51. These tubes 50 and 51 may be connected in series and cooling water is run through them when the assembly has been made and the mass spectrometer tube is being pumped out. During the pumping operation it is necessary to degas. This is accomplished by vigorously heating the entire assembly by a gas torch or by a high frequency furnace applied around the ion source assembly or by other types of electric furnaces. The heating thus accomplished would seriously deteriorate the gasket 14 were it not for the fact that during the heating the local area most adjacent the gasket is cooled by the passage of cooling water through the tubes 50 and 51.

The entire assembly of the ion source is mounted upon the flange 15 which, as previously described, is usually removable from the flange 12. Therefore, for purposes of constructing the ion source, flange 15 forms a handy mounting plate upon which the delicate elements supported by the posts 34, 35, 36 etc. can be mounted, fastened and adjusted. When the entire ion source assembly is completed, it is readily attached to the flange 12 of the mass spectrometer tube proper and once the cap screws 21—21 are pulled down tight a gas-tight junction is perfected at the sealing gasket 14. The pin 54 provided in one or the other of the flanges 12 or 15 seats in a corresponding aperture of the opposite flange. This permits assembly of the flange 15 in only one position of the flange 12, and hence the ion source may be readily removed and as readily re-mounted upon the mass spectrometer tube without fear that adjustment of the ion source axially of the mass spectrometer tube will be lost. The easy removability of the ion source assembly permits replacement of the filament F in a few minutes' time in the event it burns out and readily permits adjustment of the remaining elements of the ion source should this be necessary.

Plate D, J_1 or J_2 can be used for interrupting the beam in order to change the ion current from a steady D. C. to a pulsating D. C. current. In some cases it is more desirable to use A. C. amplifiers to measure the analyzed currents, and deflecting plates such as D, J_1 or J_2 may be used to modulate the beam if an alternating or pulsating potential is applied to one of the three.

As many apparently widely different embodiments of this invention may be made without departing from the spirit and scope thereof, it is to be understood that I do not limit myself to

the specific embodiments herein except as defined by the appended claims.

What I claim is:

1. In a mass spectrometer having an elongated tube portion terminating at the ion source, the improvements comprising a first flange mounted in gas-tight relationship on said tube, a unitary ion source and gas inlet structure including a thick second flange for removable attachment in gas-tight relationship to the first flange, a plurality of mounting posts on the second flange and positioned and spaced so as to extend axially into the elongated spectrometer tube when the flanges are coupled together, a filament, sample bombardment chamber, electron trap and ionized molecule accelerating and focusing plates mounted as an assembly on said posts, all of said parts being thereby carried on the second flange, a squash inlet also mounted in gas-tight relation on the second flange, and a sample inlet extending axially through said thick second flange and connected by a sample inlet conduit to the sample bombardment chamber.

2. The apparatus of claim 1 further characterized in that one of the flanges is provided with a subsidiary circumferential tongue and the other flange is provided with a cooperating mating groove in which a gasket is seated.

3. The apparatus of claim 2 further characterized in that said gasket is formed of a material which deteriorates upon the application of heat thereto and a circular cooling fluid tube is soldered to the exterior surface of each flange, said tubes being in thermal communication with the gasket retained between said flanges whereby said flanges and gasket may be cooled during general heating of the assembly for degassing.

ALFRED O. C. NIER.

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