July 2, 1963 C. E. BURDG 3,096,435

ION GENERATING AND FOCUSING MECHANISM

Filed Dec. 9, 1960 2 Sheets-Sheet 1

FIG. 1

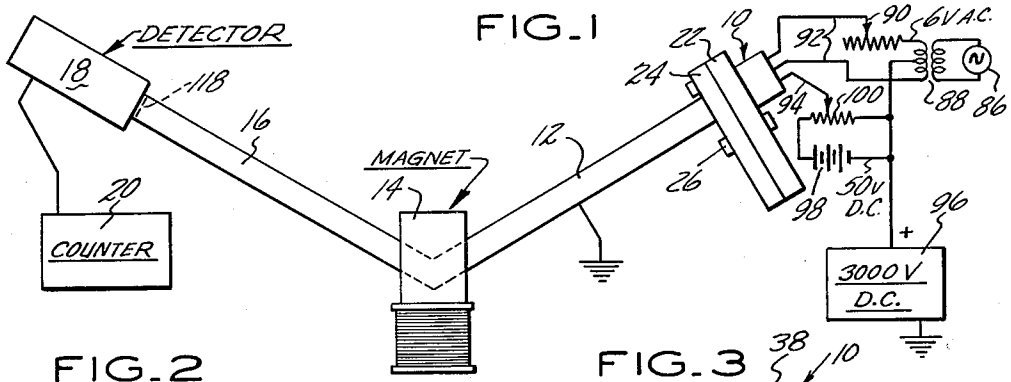


FIG. 2

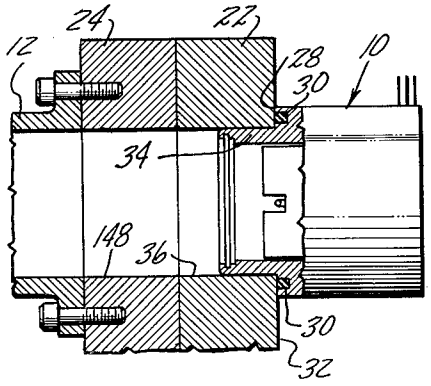


FIG. 3

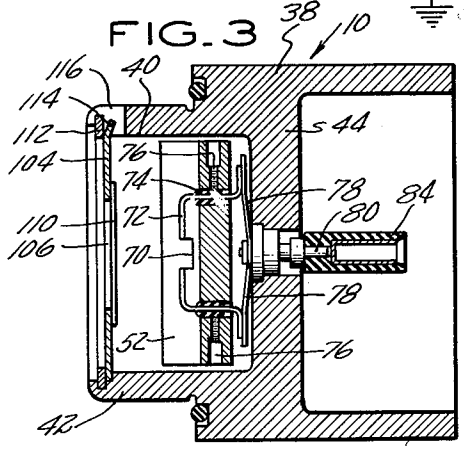


FIG. 4

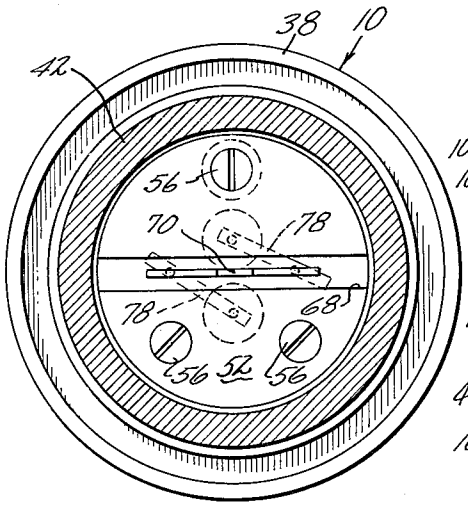
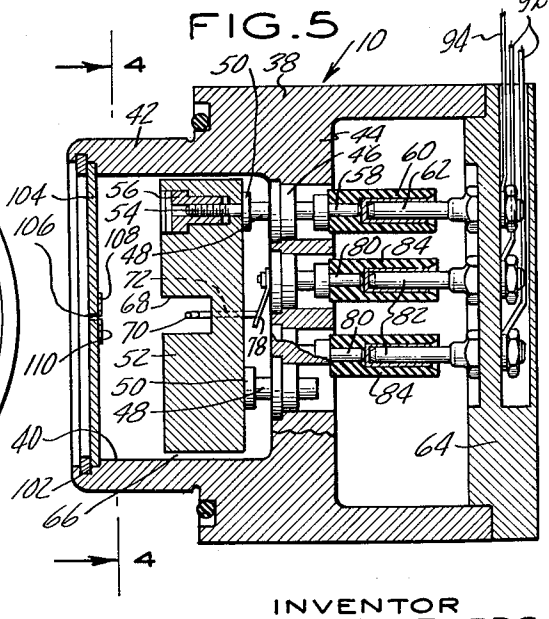


FIG. 5



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July 2, 1963 C. E. BURDG 3,096,435

ION GENERATING AND FOCUSING MECHANISM

Filed Dec. 9, 1960 2 Sheets-Sheet 2

FIG. 6

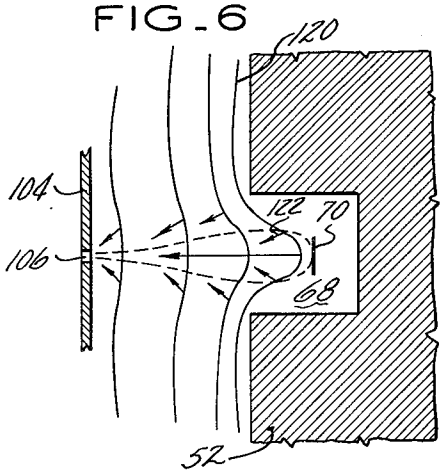


FIG. 7

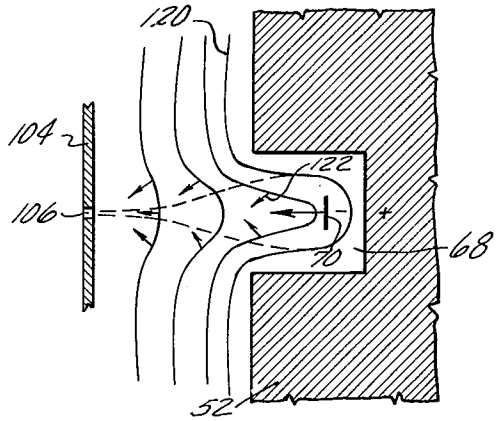


FIG. 8

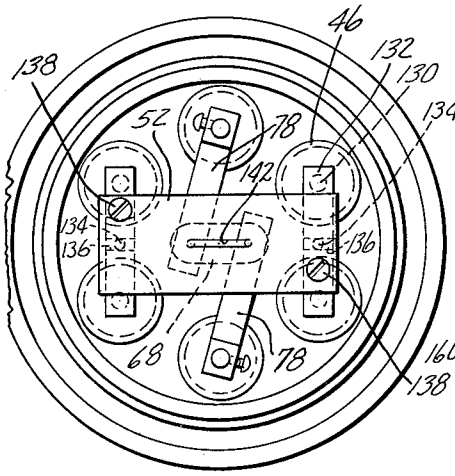


FIG. 10

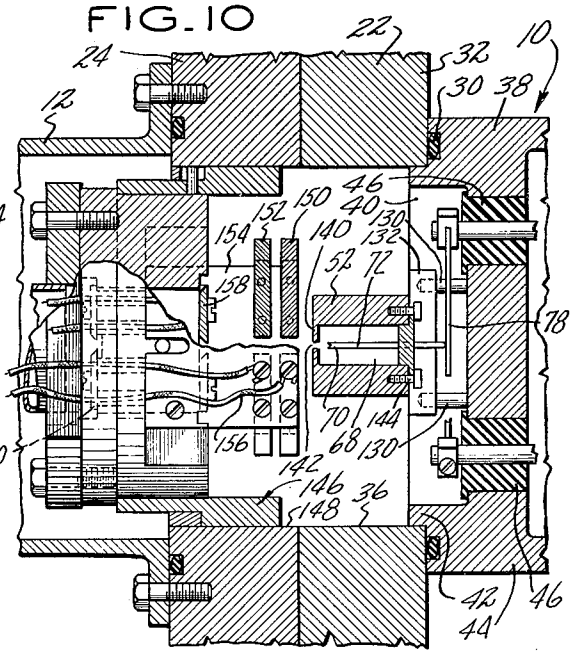


FIG. 9

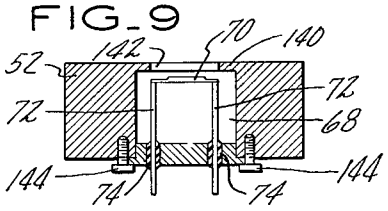
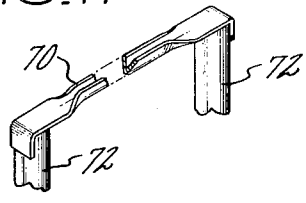


FIG. 11



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ION GENERATING AND FOCUSING MECHANISM

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Filed Dec. 9, 1960, Ser. No. 74,826
6 Claims. (Cl. 250—41.9)

This invention relates to ion generating and focusing mechanism and particularly to a readily removable and adjustable unit for use in a mass spectrometer.

An object of this invention is a unit for supporting a sample to be analyzed in a mass spectrometer and including means for generating and focusing the ion beam.

Another object is a unit carrying the ion generating and focusing means which may be readily assembled with and removed from the mass spectrometer.

A still further object is mechanism in which the sample carrying means and the focusing mechanism may be readily assembled with and removed from the assembly unit.

Other and additional objects will be apparent from the following specification and the accompanying drawings in which:

FIG. 1 is a schematic representation of a mass spectrometer incorporating the present invention.

FIG. 2 is an enlarged view showing the removable unit partly in section assembled with its support on the spectrometer.

FIG. 3 is a cross section of the unit showing the sample ribbon and its electrical feed throughs.

FIG. 4 is a section on line 4—4 of FIG. 5 of the unit showing the sample carrying block in assembled position.

FIG. 5 is cross section of the assembly unit with portion broken away.

FIG. 6 is an enlarged schematic graph illustrating the focusing effect of the channel.

FIG. 7 is an enlarged graph similar to FIG. 6 but showing the effect of a bias on the sample.

FIG. 8 is a plan view of a modified sample carrying block in assembled position.

FIG. 9 is a section through the modified sample carrier block.

FIG. 10 is a cross section of the modified structure with portions broken away, showing the sample carrier and a lens system.

FIG. 11 is an enlarged perspective of the sample carrying ribbon.

In a mass spectrometer in which an analysis may be rapidly made it is desirable to change from one sample to be analyzed to another, rapidly and with a minimum of inconvenience. It is also desirable to be able to prepare samples in advance so that they may be readily inserted in the machine without delay.

A mass spectrometer incorporating the present invention is schematically shown in FIG. 1, in which an ion beam from a source indicated generally at 10 is propelled through a highly evacuated tube 12 to a position where the beam is deflected by the magnet 14 to continue its path along the tube 16 to a detector 18 in which each ion will produce a voltage pulse which is counted by the counter 20 to give an indication in a manner known in the art of the number and nature of ions being released. The tube 12 and its associated mechanism is evacuated by any suitable means such as diffusion or mechanical vacuum pumps, not shown. The ion source unit assembly 10 is mounted in a support 22 which in turn is rotatably mounted upon a mating plate 24 for rotation about an axis 26 to bring the ion source into line with the tube 12. As explained in my application Serial No. 45,891, filed on July 28, 1960 for vacuum

lock mechanism to which reference may be made for further details of the support 22 and its associated mechanism, the support receives a plurality of the units 10 and presents them successively to pumping stations before presenting them in a testing position in alignment with the tube 12. Provision is also made for venting the area under the unit 10 so as to permit its ready removal. The present invention relates primarily to the unit 10 and its mounting in the support 22.

As seen in FIG. 2 the unit 10 is a cylindrical cup-shaped member having a shoulder 28 incorporating an O-ring seal 30 which cooperates with the surface 32 of the support 22 when the unit 10 is in assembled relation with the support 22. A pilot 34 cooperates with an aperture or passageway 36 in a member 22 to guide the unit 10 in assembling the same, and align the unit 10 in the support 22. The pilot 34 being cylindrical permits rotation of the unit 10 to provide proper alignment of the ion beam when the unit 10 is aligned with tube 12 as will be described. Referring to FIGS. 3, 4, and 5, and also FIGS. 8, 9, and 10, which will be explained in more detail later, the unit 10 comprises a housing member 38 having a cup-shaped recess 40 in one end, and defined by upstanding walls 42 and a bottom 44. The bottom 44 is provided with a plurality of apertures and each aperture is sealed by an electrical insulating member 46. Three of the insulating members carry stand-off devices 48, the flanges 50 of which act as the support and locating means for a block 52. Each stand-off device has a threaded projection 54 receiving a nut 56 which when tightened will hold the block 52 in aligned position on the stand-off devices 48. One of the stand-off devices is provided with a second projection 58 extending from an end opposite to projection 54 and is received in a receptacle 60 by means of which it may be electrically connected with a prong 62 carried by a plate 64 which will permit ready connection of the projection 58 and the block 52 with a source of electricity. The block 52 is thus supported adjacent the bottom of the cup-shaped recess 40 and at the same time electrically insulated from the housing 38. The block 52 is supported to provide a substantially uniform space 66 between the interior of the wall 42 and the periphery of the block 52. This space is made sufficiently large so as to prevent electrical flashover from the block 52 to the housing 38 but is made sufficiently small so as to prevent contamination of the electrical feed-throughs in the bottom of the cup.

The block 52 is provided with a channel or trough 68 extending diametrically there-across and of suitable geometry, generally somewhat deeper than it is wide, to assist in focusing the ion beam generated from a sample located in the trough. A U-shaped ribbon 70 is provided for carrying the sample to be analyzed and it is supported by wires 72 passing through insulators 74 in the bottom of the slot and held in position by screws 76. When the block is positioned in the housing 38, the wire 72 will make contact with spring contacts 78, electrically connected with electrical feed-throughs 80 similar to the electrical feed-through 58. The electrical feed-throughs 80 are adapted to be electrically connected with the prongs 82 by insertion of the prongs 82 into the receptacles 84 so as to pass electric current through the sample 70 and heat the same to generate the ions.

As shown in FIG. 1, this source of heating current may be a source of alternating current 86 fed through a transformer 88 and a rheostat 90 to wires 92 leading to the prongs 82. In order to provide a suitable accelerating force for the ions, the block 52 is connected by means of the feed-through 58 and the prongs 62 and the wire 94 with a suitable source of direct high voltage, say 3,000 volts direct positive voltage. Under some con-

ditions it may be found that the focusing effect of the slot 68 may be somewhat improved by making the block 52 positive with respect with the sample 70. This may be accomplished by placing a direct current source 98, of say 50 volts, across a potentiometer 100 whose slider is arranged in series with the line 94 leading to the high voltage source 96.

The interior of the wall 42 of the cup 40 is provided with a ledge 102 receiving a disc or plate 104 with a diametrically extending collimating slit 106 therein. The slit 106 itself may be used for collimating the beam of ions generated by the heated sample 70 or the slit 106 may be left wider than required to focus the ion beam, and the collimating slit may be formed between two plates 108 and 110 secured by spot welding to the face of the plate 104. The plate 104 may be held in position by a snap ring 112 and located by a prong or projection 114 received in a slot 116 in the wall 42.

From the above it will be seen that I have provided a unit including a source of ions and means for focusing the ions into a strong beam or ribbon of ions including a structure which may be readily inserted into and removed from its support and which may be rotated on its own axis which is also the beam axis while observing the intensity of the received beam to align the driven beam with the slit 118 FIG. 1 usually accompanying the detector 18. The unit 10 when inserted in position in the support 22 is held in position by the difference in pressure created by the vacuum in the cup-shaped recess 40 on one side and the atmospheric pressure on the opposite side of the unit 10.

As shown in FIGS. 6 and 7, the channel 68 in the block 52 in addition to providing excellent mechanical protection to the sample ribbon 70 located in the slot or channel, materially assists in focusing or directing ions driven off of the ribbon 70 into a path through the slit 106 in the plate 104. The lines 120 represent lines of equal potential, and the arrows 122 represent the force exerted on those ions at those equal potential lines, which force is at substantially right angle to the equal potential line. Due to the dip in this equal potential line in the neighborhood of the slot, it will be appreciated that the ions in that region are urged in a direction which tends to bring them into a central path in the unit 10 aligned with the slit 106. As shown in FIG. 7 by making the ribbon somewhat negative with respect to the block 52 including the sides and bottom of channel 68, the equal potential lines 120 dip further into the channel 68 and have a greater focusing effect causing more ions to pass through the slot 106.

While the unit has been described above, as combined with a collimating slit directly, it will be understood that the unit may be combined with an ion lens system as indicated in FIG. 10 which shows a modification of the above described structure. While the above structure provides a simple, rugged and reasonably accurate mechanism which is simple and rapid to use, and in which the collimating slit is removed each time the sample is changed so that it may be thoroughly cleaned to help preserve good resolution in the instrument and eliminate any "memory" effect or may be replaced with a plate of different slit geometry, and in which the cover plate having only a narrow slit virtually precludes accidental contamination of the main system by trash, loose parts, or broken ribbons, originating in the sample area, and therefore is to be preferred where the greatest sensitivity is not required, greater sensitivity may be obtained by using an ion lens system between the sample and the collimating slits as shown in FIG. 10.

The modification shown in FIG. 10 utilizes a similar cup-shaped member 38 for the unit 10, but uses a block 52 of somewhat different geometrical proportions and uses a different support for the block. A modified sample support is also used. In the FIGS. 8, 9, and 10 modification, pins 130 supported by insulating devices 46 extend into and locate a pair of square metal rods 132, the tops of which are machined off to provide a support for the block 52, which is located by dowels 134 in the block 52 and received in slots 136 in the rods 132. Block 52 is secured to rods 132 by screws 138. The open end of the trough 68 may be left open as shown in FIG. 5 or it may be partially restricted by an overhang or plate member 140 providing a reduced opening 142 for the trough. The ribbon used to support the element or sample to be tested is a separate assembly as shown in FIGS. 9 and 11 and is inserted into the block from the side opposite the trough opening to in effect form the metallic bottom of the trough and is held in position by the fit in the trough and the screws 144. Electricity is conducted to the supporting wires 72 thru the spring 78 and other connections in the same manner as described for the FIG. 5 construction. The ribbon 70 which is a flat wire is connected or welded to the wire 72 and the central portion of the wire 70 is doubled on itself (FIG. 11) to bring the edges of the wire or ribbon closer together and form an elongated V-shaped groove for receiving the sample which is usually placed on the ribbon in liquid form and evaporated. Samples may thus be prepared in advance of the testing and stored either as units such as shown in FIGS. 9 and 11 or in combination with blocks 52 if sufficient blocks are available. The electrical connections for the FIG. 10 construction are the same as those for the FIG. 5 construction, and the same reference numerals are used to indicate the same or equivalent parts. FIG. 10 shows the sample carrier in combination with a suitable lens system. Briefly, the lens system comprises a unit 146 which is supported in an aperture 148 in the stationary plate 24. Two sets of lens members 150, 152, are supported between insulating plates 154 and supplied with accelerating and focusing voltages through wires 156. The unit also supports two sets of collimating plates 158 and 160, down stream of the lens members, 150, 152.

Although I have described one specific structure and one specific modification thereof to illustrate my invention, it is obvious that various changes can be made which would come within the scope of the invention which is limited only by the appended claims.

I claim:

1. In a mass spectrometer adapted to be provided with a vacuum, a support subjected on one side to said vacuum, a housing supporting an ion beam source and focusing mechanism for said beam, said housing comprising a shouldered cylindrical member having a closed end supporting said source and focusing mechanism and having sealing means associated with said shoulder, a cylindrical receptacle in said support receiving, aligning and adjustably supporting said housing with the shoulder seating on said support and with the sealing means forming a seal between said housing and said support, said housing including said closed end being subjected to said vacuum on one side and atmospheric pressure on the other side to retain said housing in said support.

2. In an ion generating and focusing device, a cup-shaped housing unit, insulating means supporting electrical feedthroughs extending through the base of said unit, spring contact means connected with said feedthroughs, other insulating means in the base of said unit, a ribbon adapted to support an ion source, a block, insulating means supporting said ribbon in said block, conducting means connected with said ribbon and extending through said insulating means and said block, means supporting said block on said other insulating means, one of said other insulating means supporting an electrical feed-through and including means connecting said feed-through to said block, said conducting means adapted to contact said spring contact means upon assembly of said block and its supporting means in said unit.

3. In a mass spectrometer having a support with one side subjected to vacuum, a removable cup-shaped mem-

ber receivable in telescoping relation in a socket extending through said support and retained in position by said vacuum, sealing means between said member and said support urged into sealing position by said vacuum, insulating means extending through the bottom of said cup, a sample carrier, a block supported on said insulating means and having a recess receiving said sample carrier, means retaining said carrier in a selected position in the recess in said block and means supported by, and removable from said support with, said member and having a slit aligned with said carrier for shaping an ion stream emitted by said sample, and means supplying an electric current and an ion accelerating voltage to said carrier.

4. A sample carrier for use in a mass spectrometer comprising a flat ribbon supported between two electrically conducting posts and having a central portion folded along a longitudinally extending central line to form a longitudinally extending V-shaped trough for receiving a sample to be tested.

5. A sample carrier as claimed in claim 4 in combination with a block having a trough with the carrier located in the trough with the open side of the V of the ribbon facing the open side of the trough in the block.

6. An ion generating and focusing device, comprising a ribbon adapted to be heated to provide a source of ions, a block having a trough therein, means supporting

said ribbon in said trough, a cup-shaped member, electrical insulating means supporting said block in said member, a plate having a slit therethrough, means supporting said plate with the slit aligned with said ribbon and trough for shaping the path of ions projected from said source, a support for said cup-shaped member mounted for movement transversely of said ion path and means rotatably supporting said cup-shaped member in said support for rotation about an axis substantially coaxial with the axis of said ion path.

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