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ION PRODUCING MECHANISM

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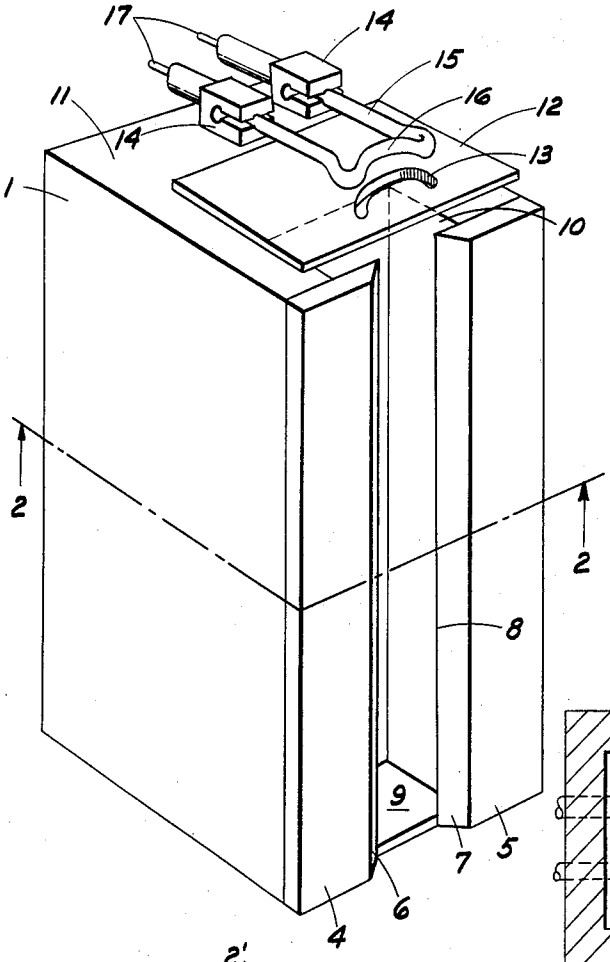


FIG. 1.

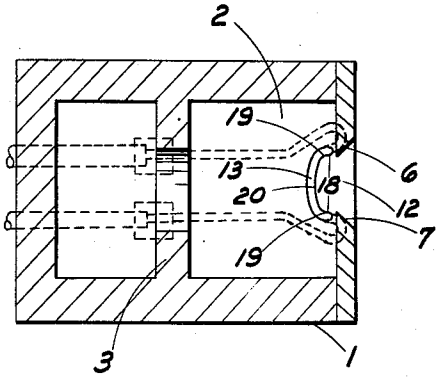


FIG. 2.

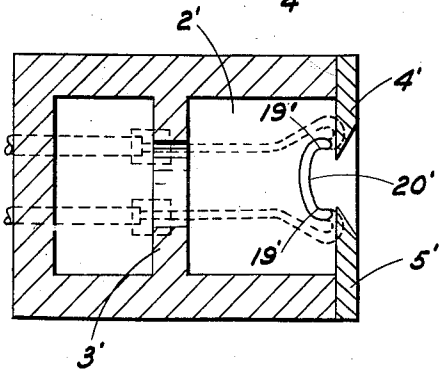


FIG. 3.

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ION PRODUCING MECHANISM

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8 Claims. (Cl. 313—63)

My invention relates to ion sources, and more particularly to ion producing mechanisms for electromagnetically operated equipment for the separation of isotopes or elements.

It is the practice in the separation of isotopes or elements to vaporize a charge material through heating, subject the vapors to electron bombardment in an ionizing chamber to ionize them, eject the ions from the chamber into a magnetic field, accelerate them through the field in arcuate paths whose radii correspond to their respective masses, and then collect the ions at or near the focal points of the ion beams. The ionizing source usually takes the form of an electric arc parallel to the magnetic field of the equipment between a hot filamentary cathode and a plate anode. This arc is comprised of ions and electrons in equilibrium forming a plasma in vapor containing the desired type of atom. The defining slot is formed in a separate plate next adjacent to the cathode, separating the cathode from the main part of the arc. Since the electrons in such a system can move essentially only parallel to the magnetic field, if the slot in the defining slot plate is smaller than the cathode, and opposite the cathode with respect to the magnetic field, the shape of the defining slot effectively defines the cross section of the arc beyond it. The defining slot and plate also perform the additional function of reducing the vapor in the region of the cathode and reducing the ion bombardment.

As originally conceived the conventional ion source employed a rectangular defining slot opposite a straight section of cathode. The electrons passing through the defining slot then formed an arc of rectangular cross section of the same shape as the slot itself. It was from the plasma surrounding this arc column that the ions forming the beam were accelerated by the accelerating voltages of the equipment. By this action these accelerating voltages effectively push the plasma region back toward the arc core, producing a concave surface or meniscus on the plasma facing the accelerating electrodes, and defining the limit of the field of the accelerating voltages in the ionizing chamber. This concave surface on the plasma is necessary for proper focusing of the ion beam, and its shape is critical for successful operation of the unit.

If pushed back too far by the action of the accelerating voltages, the arc becomes so thin that insufficient ions are produced to effectively supply the equipment for proper operation, or the arc may entirely break down at one or more points.

In order to aid in the formation and the proper positioning of this concave portion, the use of cathodes and defining slots curved on a radius were proposed. However, the space between the ends of the arc and the accelerating electrodes permitted the escape of neutral vapors from the ionizing chamber. This reduced the charge efficiency of the system and as the operation proceeded, the escaped vapors would condense upon the walls and parts of the equipment, and, if permitted to accumulate to any appreciable degree, might disintegrate and create a dangerous situation. As a consequence, the equipment must be closed down and cleaned periodically, and must be treated and scrubbed to remove the contamination.

To overcome this leakage of neutral vapors from the ionizing chamber, the curve of the arc might be extended in uniform curvature at its ends until they reach the accelerating electrodes. However, if the correct distance and the curvature of the central portion of the arc were maintained with respect to the ion exit slit, the ends of the arc would not terminate adjacent to the edges of the slit in the ionizing chamber through which the ions are ejected, but portions of the ends of the arc, approaching the walls of the ionizing chamber, would be shielded from the high voltage, looking in through the slit, by the walls of such chamber. By hiding portions of the arc from the ejecting voltage, ions in these portions would not be acted upon or ejected, thereby eliminating a portion of the arc as a supply source, and lowering the efficiency of the operation.

Applicant with a knowledge of these problems in the prior art has for an object of his invention the provision of a curved defining slot in the plate controlling the filamentary flow of electrons across the ionizing chamber so that an arc of curved cross section conforming closely to the outline of the meniscus, may be provided to inclose the ion exit passage or slit of the ionizing chamber to permit maximum operating efficiency and prevent the leakage of neutral vapors from the ionizing chamber.

Applicant has as another object of his invention the provision of a defining slot having a compound curve configuration to provide an arc across the exit slit of the ionizing chamber of concave cross section so that the ends of the curve approach the edges of the exit plates and the whole arc is exposed to the action of the ejecting voltage, while loss of neutral charge vapor between the ends of the arc and the edges of the exit slit of the ionizing chamber is effectively prevented.

Applicant has as a further object of his invention the provision of a curved filament for cooperation with a collimating slot of compound curvature to provide an arc with a face of concave or curved cross section, and with the curvature of the central portion being less than that on either side thereof.

Applicant has as a still further object of his invention the provision of an electron producing filament of curved form to coact with a curved defining slot, the curvatures of the filament and slot being compound curves whose ends are of different curvature than the intermediate portions to produce more efficient operation.

Other objects and advantages of my invention will appear from the following specification and accompanying drawings, and the novel features thereof will be particularly pointed out in the annexed claims.

In the drawings, Fig. 1 is a perspective of a box construction inclosing an ionizing chamber with my improved filament and defining slot associated therewith. Fig. 2 is a cross section of the same construction taken along the line 2—2 of Fig. 1. Fig. 3 is a cross section of a modified form showing the cathode and defining slot.

Referring to the drawings in detail, 1 designates a box of substantially parallelepiped configuration whose walls define an ionization chamber 2. Charge in an adjacent or an adjoining chamber (not shown) is heated, and the vapors are allowed to flow from the charge chamber to the ionization chamber. The size and shape of the charge chamber may be conventional or of characteristic type, and vapors may be fed to the ionizing chamber 2 through a controlled port or orifice in the rear wall 3 of the box 1 in conformity with usual practice. The forward end of the box 1 may have plates 4, 5, with tapered edges or lips 6, 7 mounted thereon in spaced relation to define a slit 8. The lower end 9 of box 1 may be in the form of a plate and serve as the anode. The upper end 11 of box 1 is cut away at 10 and a plate 12 with a defining slot 13 therein may be mounted over the cutaway portion. Carried by the plate 11 are insulators 14, 14 which serve to mount the filament 15 over plate 12 so that the intermediate portion 16 thereof is in alignment with the defining slot 13 in the plate 12. Leads 17, 17 supply the filament with heater current.

The curvatures of the slot 13 and the filament 16 are not uniform, the intermediate portion 20 thereof being of flatter curvature than the curved portions 19, 19 on either side thereof in order to bring the edges of the arc set up in chamber 2, between cathode 16 and anode 9, into close proximity with the edges of the plates 4, 5 and cover the slit 8. Fig. 2 shows how the curvature of the intermediate portion 16 of the filament brings it into close proximity with the edges of the plates 4, 5 thereby controlling the configuration of the arc so that the edges of the arc approach the plates 4, 5 and substantially seal the slit 8. If desired, the ends 18, 18 of the slot 13 may

either be of substantially flat curvature or the same curvature as portions 19, 19.

In its operation, cathode 15 is at a negative potential with respect to plates 9, 12 and electrons are emitted therefrom. They are accelerated through defining slot 13 across chamber 2 to anode 9. Neutral gases are fed into ionizing chamber 2 from the charge chamber (not shown). The box 1 is disposed within the usual magnetic field of the instrument so that the electron path from cathode 15 to anode 9 is substantially parallel thereto. Electrons in this path bombard the atoms of the neutral gas in chamber 2 and ionize it. As ions are formed some of them float back toward cathode 15, neutralizing the space charge about the cathode and permitting a rush of electrons from the cathode to the anode. Under these conditions the flow of the charged particles strikes an arc, and this arc forms a plasma where the particles are in dynamic equilibrium. The ions formed in this plasma are withdrawn through the slit formed by the edges of plates 4, 5. The plates 4, 5 thus serve to define the ion beam and to permit the application of an accelerating potential to the ions forming the beam.

The arc between cathode 15 and plate 9, due to the shape of the portion 16 of the filament, and/or the shape of the defining slot 13, is concave in cross section, the curve being in the shape of a partial horseshoe or compound curve wherein the ends may be of greater curvature than the central portion. In this connection it may be observed that the plate 12 acts as a grid element shaping the arc to conform to the defining slot. The edges of the defining slot are preferably brought to a point about $\frac{3}{64}$ of an inch from the slit 8, and about $\frac{1}{32}$ of an inch from their edges, while maintaining the correct curvature and position of the center of the arc core. The use of collimating slots of this character with suitable cathodes have shown as much as a 10% increase in the output over normal operations.

In the modification of Fig. 3, the ends 19', 19', of the defining slot serve to bring the arc defined by the central portion 20' into close proximity with the meniscus and to terminate the ends of the arc adjacent the edges of the exit slit. In this way ions from the whole arc may be subjected to the action of the accelerating voltage and efficiency of operation may be improved. While the ends 19', 19', for convenience in illustration, are shown in somewhat exaggerated curvature in relation to the curvature of the central portion 20', one form of such construction employs a central portion with a radius of .343 inch and end portions with radii of .094 inch. The cathode may take the same general form as the collimating slot so long as it is larger than the slot and covers it.

While the partial horseshoe and semi-elliptical types of curves disclose preferred embodiments of my invention, it will be understood that any slot and/or cathode curvature designed to move the edges of the arc core close to the edges of the exit slit, while maintaining the appropriate shape and position of the center of the arc core, will fall within the spirit of my invention.

Having thus described my invention, I claim:

1. An ion producing mechanism of the character described comprising an ionizing chamber for the reception of gaseous vapor, a cathode of substantially horseshoe configuration for supplying a stream of electrons for ionizing said vapor, a barrier having an arcuate slot therein for disposition between said cathode and said chamber to define the path of electron flow therein and produce an arc across the chamber, and means defining an exit slit adjacent said path for removal of ions from the said chamber, said exit slit extending along the arc with its edges in close proximity to the ends thereof.

2. An ion producing mechanism of the character described comprising an ionizing chamber for receiving gaseous vapors, a cathode of substantially horseshoe configuration for supplying a stream of electrons for ionizing said vapors, an opening in the ionizing chamber extending along and adjacent said stream for removing ions therefrom, and means providing a barrier with an arcuate electron stream defining slot of substantially horseshoe configuration therein between said cathode and said ionizing chamber to bring the ends of said stream into close proximity with said opening for reducing the escape of gaseous vapors from said chamber.

3. An ion producing mechanism of the character described comprising an ionizing chamber for receiving gaseous vapors, a cathode of compound curved configu-

ration for supplying a stream of electrons of curved cross section across said chamber to ionize said vapors, an opening in the ionizing chamber adjacent said stream, means for setting up a field extending through the opening for ejection of ions from the chamber, and means providing a barrier with a slot for the passage of electrons therethrough providing an arc of concave configuration facing said opening with ends along the edges of said opening to reduce the escape of gaseous vapors from said chamber.

4. An ion producing mechanism of the character described comprising an ionizing chamber adapted to receive gaseous vapors, a cathode positioned outside of said chamber for striking an arc across it to ionize said vapors, an opening in the ionizing chamber extending along and adjacent to the arc for removal of ions therefrom, and means providing a barrier with an arc defining slot of compound curve configuration therein positioned between the cathode and the ionizing chamber with the ends of the slot directed towards the exit slit to bring the ends of said arc into close proximity with the edges of the opening for reducing the escape of said vapors.

5. An ion producing mechanism of the character described comprising an ionizing chamber adapted to receive gaseous vapors, a cathode of compound curve configuration for supplying a stream of electrons to ionize said vapors and produce an arc of curved configuration, an opening in said ionizing chamber adjacent the stream, charged plates positioned on either side of said opening for setting up a field through said opening for the ejection of ions from said ionizing chamber, and means providing a barrier having an electron beam and arc shaping slot therein positioned between the cathode and the ionizing chamber for directing the ends of the arc along and in close proximity to the edges of said plates to reduce the escape of vapors from said chamber.

6. An ion producing mechanism of the character described comprising an ionizing chamber for the reception of gaseous vapors, a cathode of compound curvature for supplying a stream of electrons of arcuate cross section for ionizing said vapors, an opening in said chamber adjacent the path of said stream for extension of a field into the chamber to remove ions therefrom, and a barrier with a slot therein having an intermediate portion of flatter curvature than the portions on either side thereof and with the ends of the slot directed towards said opening interposed between said cathode and said ionizing chamber for co-action with said cathode to produce an arc with a concave face directed along said opening and bring the ends of the ion stream into close proximity with the edges of the opening and reduce the escape of said vapors.

7. An ion producing mechanism of the character described comprising an ionizing chamber for the reception of gaseous vapors, a cathode having a compound curve configuration with ends of flatter curvature than the intermediate portion for supplying a stream of electrons of arcuate cross section to ionize said vapors, an elongated opening in said chamber adjacent said stream and extending there along for passage of an ion ejecting field, and a slotted barrier interposed between said cathode and said ionizing chamber for co-action with said cathode to direct the concave portion of the arc towards the opening and bring the ends of the electron stream into close proximity with the edges of the opening and reduce the escape of said vapors.

8. An ion producing mechanism of the character described comprising an ionizing chamber for the reception of gaseous vapors, an exit opening in the chamber for removal of ions, an electron emitting cathode of arcuate configuration with its ends directed towards said opening for ionizing the vapor in the ionizing chamber and setting up an arc extending along the exit opening, and a barrier positioned adjacent the cathode and having an arcuate shape slot of substantially horseshoe configuration therein with its ends directed towards said exit opening for co-action with the cathode to shape the arc and bring the ends thereof into close proximity with the edges of the exit opening to reduce the escape of gaseous vapors.

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