Sept. 2, 1958 J. G. BACKUS 2,850,636
ION PRODUCING MECHANISM
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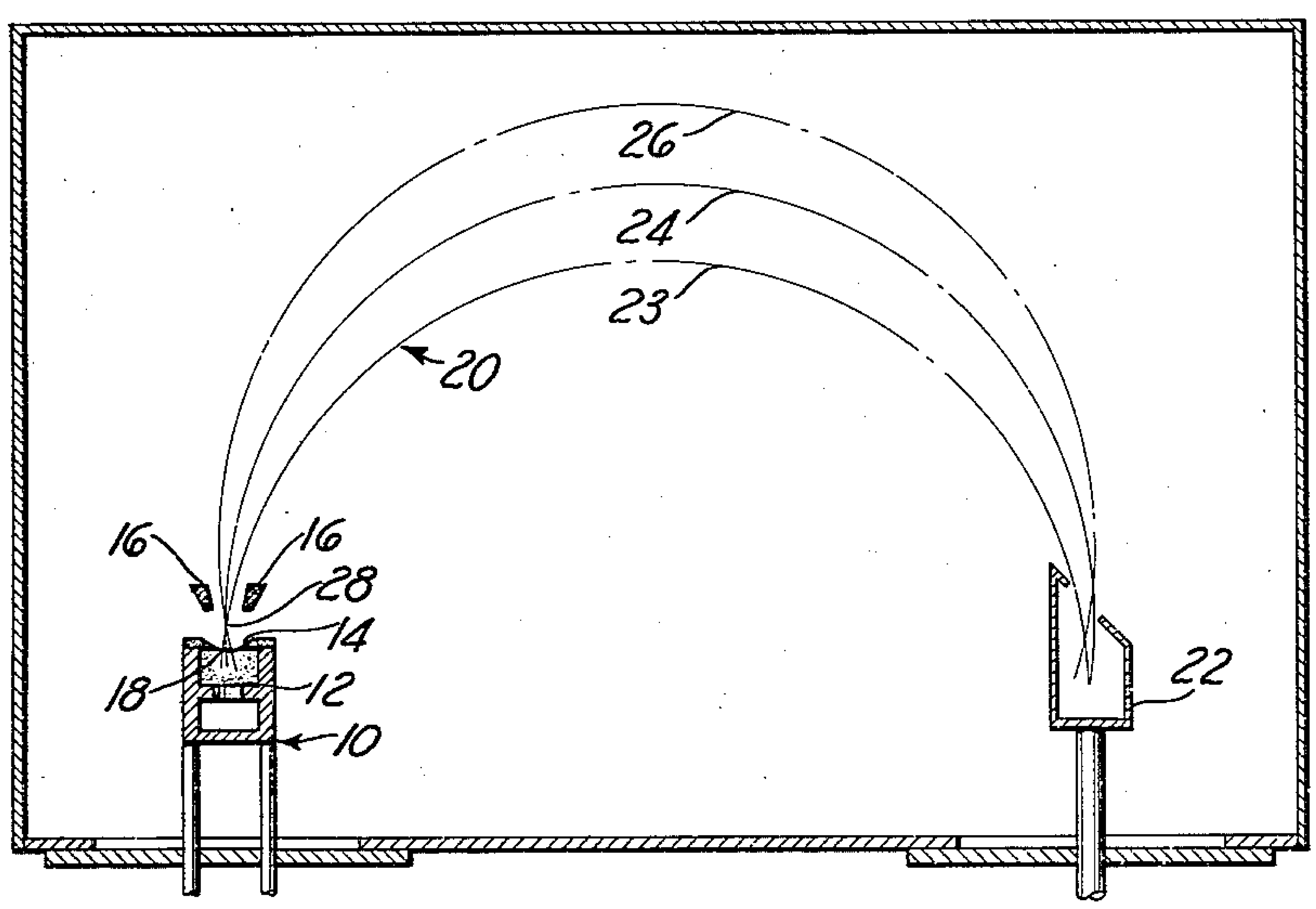

FIG. 1.

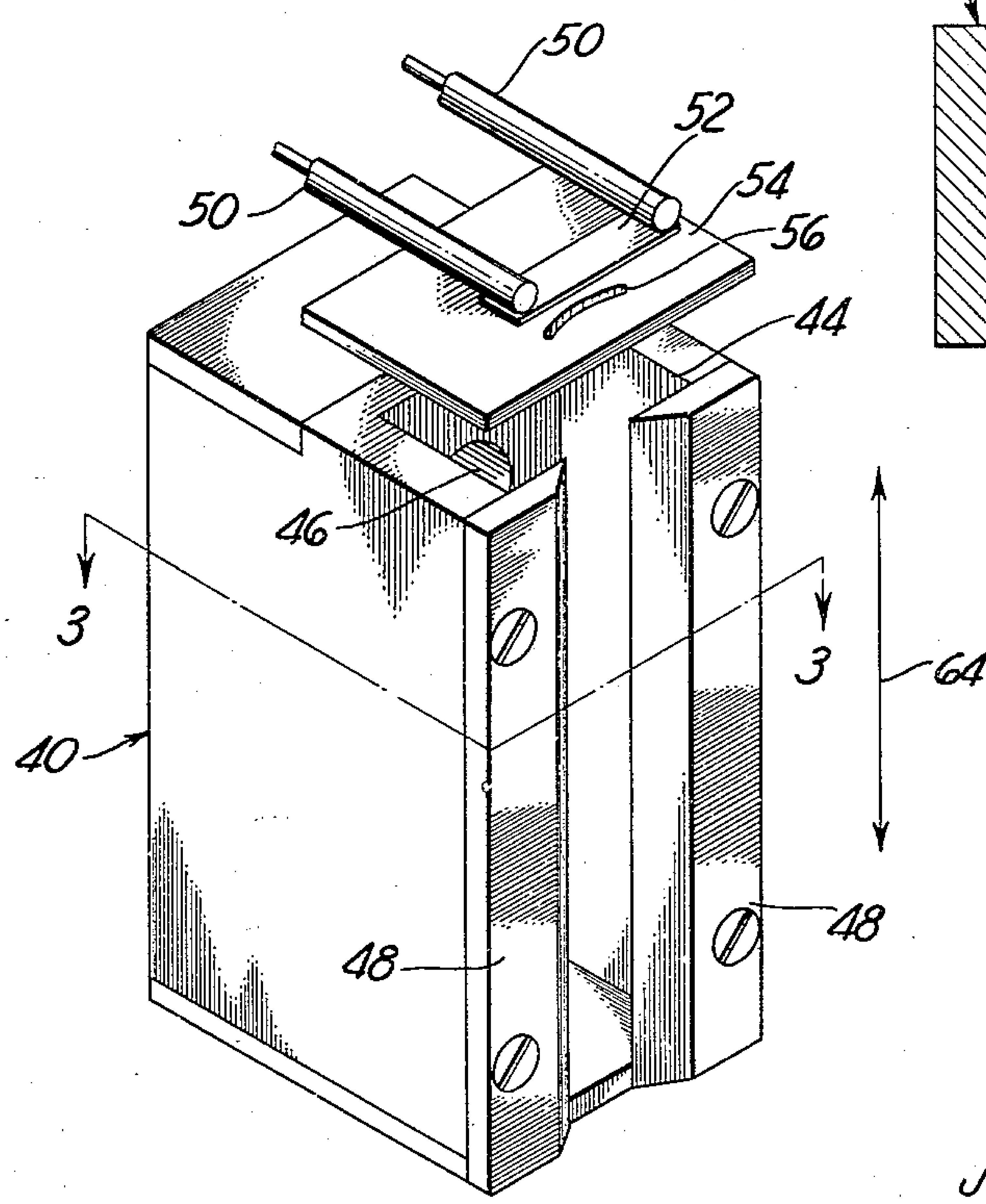

FIG. 2.

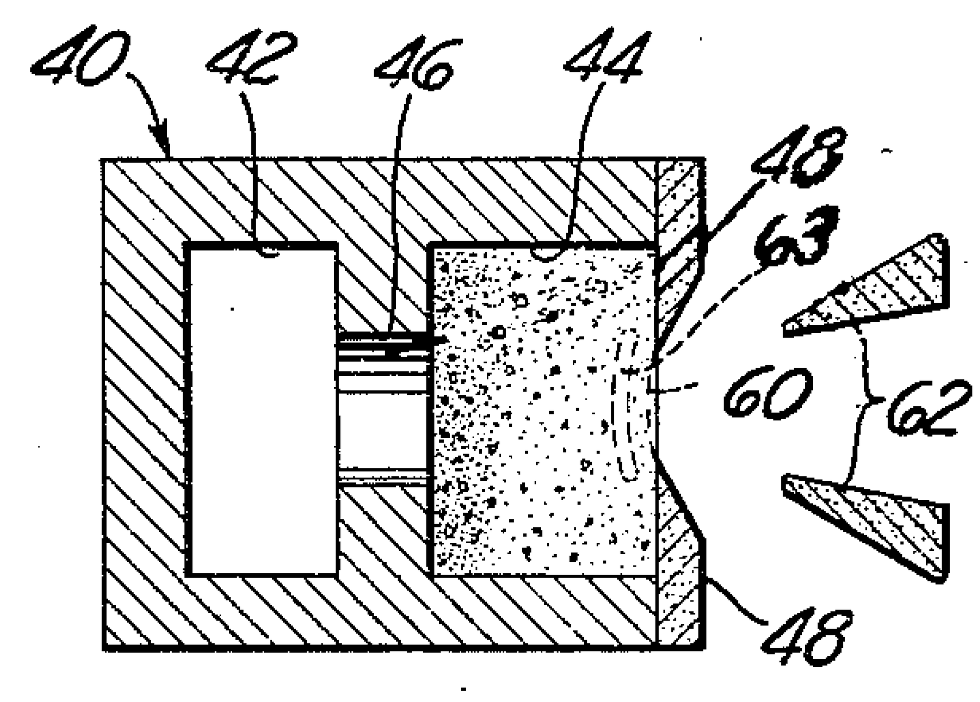

FIG. 3.

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ION PRODUCING MECHANISM

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Application August 29, 1945, Serial No. 613,360

6 Claims. (Cl. 250—41.9)

My invention relates to the art of separating a polyisotopic substance into segregable masses in each of which the naturally occurring distribution of the constituent isotopes has been radically altered so that at least one of the segregable masses obtained is enriched with respect to one of the isotopes. More particularly, my invention relates to the transmitter of a calutron.

The construction and theory of a calutron has been completely disclosed and set forth in an application for Letters Patent of the United States Serial No. 557,784, filed October 9, 1944, by Ernest O. Lawrence, and issued as U. S. Patent No. 2,709,222 on May 24, 1955, and it would serve no useful purpose to repeat here the details of construction of a calutron. In passing, however, it may be stated that a calutron consists of an evacuated tank or vessel disposed between the poles of a powerful magnet and containing means for ionizing a vaporized polyisotopic substance and transmitting ions thereof in the form of a beam which follows an arcuate path within the tank. The action of the magnetic field upon the beam of ions is to cause ions of lighter isotopes to concentrate along the inner periphery of the beam, whereas ions of heavier isotopes congregate along the outer portion of the beam and follow a somewhat longer path. The beam of ions debouches into a collector which includes at least two compartments or pockets for the reception of segments of the beam. When the ions enter the collector they are neutralized. A mass richer in the concentration of the heavier isotope or isotopes than was the case with the original material will build up in the compartment receiving the outer portion of the beam.

The most important object of the present invention is to increase the density of the beam of ions in a calutron and thereby to increase the yield therefrom.

Another object of the invention is to increase the percentage of charge material ionized and projected through the calutron.

An important feature of my invention resides in a trimmer, or collimating plate, so disposed in the transmitter of a calutron as to intercept and block the emission of electrons from the filament except through a concave path or ribbon extending through the ionizing chamber of the calutron transmitter. The trimmer serves to direct the electron stream closely adjacent and parallel to the boundary of the plasma in the ionizing chamber adjacent the exit slit.

These and other objects and features of my invention will be more readily understood and appreciated from the following detailed description of a preferred embodiment thereof selected for purposes of illustration and shown in the accompanying drawings, in which:

Figure 1 is a diagrammatic view of portions of a calutron;

Fig. 2 is a view in perspective of the calutron transmitter; and

Fig. 3 is a view in cross section along the line 3—3 of Fig. 2.

Referring now to Fig. 1, there are shown, diagrammatically, the major elements of a calutron; namely, an arc block **10** provided with an internal ionizing chamber **12**, and an exit slit **14** formed in one wall of the ionizing chamber **12**. Adjacent the exit slit **14** there is disposed a pair of opposed accelerating electrodes **16**. When the calutron is operated, there is formed within the ionizing chamber **12** a "plasma." For purposes of the present discussion, a "plasma" may be defined as a region electrically neutral but containing copious quantities of ions and electrons. The shape of the boundary of the plasma adjacent the exit slit **14** depends somewhat upon the character of the electric field between the accelerating electrodes **16** and the arc block **10**. The voltage drop between thse two elements may be as great as 30 k. v., the accelerating electrodes **16** being negative with respect to the arc block **10**. Under these conditions, the boundary of the plasma is concave with respect to the accelerating electrodes **16**, the boundary being represented in Fig. 1 by the line **18**.

It is to be understood that there is provided an electron-emissive element which projects a stream of electrons through the ionizing chamber at right-angles to the plane of the paper. Inasmuch as the calutron is interposed between the poles of a powerful magnet, there is also present a strong magnetic field in which the direction of the flux is also perpendicular to the plane of the paper upon which the drawing has been made. One function of the magnetic flux is to bend the ion beam until it follows the curved path shown in Fig. 1, but another function of the magnetic flux is to collimate the electron stream so that the electrons emitted by the cathode do not fly off at random but are projected in straight lines across the ionizing chamber. The beam of ions is denoted generally by the reference numeral **20** and, as will be seen, terminates in a collector **22** which functions in the manner above described.

It is obvious that the source of the beam cannot be a mathematical line since the ions which compose the beam are derived from several points across the face of the plasma boundary **18**. Consequently, the beam **20** is really composed of a number of individual rays, three of which are diagrammatically represented by the lines **23**, **24**, and **26**. Measurements have established, however, that the beam **20**, or the individual rays composing the beam **20**, passes through a virtual focus point **28** disposed between the accelerating electrodes **16** and the arc block **10**. When the rays **23**, **24**, and **26** are magnetically projected through the point **28**, they appear to become asymptotic, which correlates with the concave configuration of the boundary of the arc plasma. It has also been established that the majority of the ions leaving the plasma do so at right-angles to the plasma boundary.

In view of the foregoing factors, I deemed it advantageous to devise a calutron transmitter in which the electron stream would be concentrated along the boundary of the plasma, since the ion density is always greatest in the immediate vicinity of the electron stream. By so directing the electron stream that it would correspond to the configuration of the plasma boundary, I increased the ion density in the plasma at the concave boundary thereof.

To achieve the desirable result referred to in the foregoing paragraph, I constructed a calutron transmitter of the type shown in Figs. 2 and 3. I provided an arc block **40** consisting of an elongated casting having a chamber **42** for the reception of the charge material of polyisotopic substance, and an ionizing chamber **44** communicating with the charge chamber **42** by means of a conduit **46** formed by boring a hole through the wall separating the chambers **42** and **44**. The ionizing chamber **44** is open at one end and the opening is partially restricted by means of a pair of face plates **48** of carbon or graphite, which form between them a relatively narrow exit slit. Supported above the arc block **40** is a pair of stiff, water-cooled leads **50**, across the ends of which is mounted a flat ribbon cathode or filament **52** of thoriated tungsten or other suitable electron-emissive material. Supported beneath the filament **52** (by means of structure not shown in the drawing) is a flat metal plate **54** insulated from the arc block **40** and provided with a through-and-through crescent shaped aperture or slit **56**. The filament **52** and the plate **54** are so disposed that the crescent slit **56** lies directly beneath the ribbon filament **52**, and it should be emphasized that the filament is both longer and broader than the slit **56**. The slit **56** is also disposed directly above the ionizing chamber **44** and located just behind the plane of the exit slit formed by the face plates **48**.

The arc block **40** itself serves as an anode with respect to the cathode **52**. The elements are so arranged in the calutron tank that the slit formed by the face plates **48** is parallel to the direction of the flux. In Fig. 2 the flux direction is indicated by the arrow **64**. The magnetic field collimates the electron stream leaving the filament **52** so that all electrons traveling away from the filament do so along paths parallel to the magnetic flux. The plate **54** intercepts and blocks off all electrons leaving the filament **52** in downward direction with the exception of those which travel through the slit **56**, and it will be evident that the combination of the slit **56** and the action of the magnetic flux is to form an electron stream across the ionizing chamber **44**, which has the same cross section as the contour of the slit **56**. As will be seen from the relative position of the elements of the invention, the above-described cross section of the electron stream is determined primarily by the configuration of the plate **54** and the familiar interference resulting from a negative charge building up on the plate may be prevented by the impression of a suitable potential upon such plate by any appropriate means, such as that shown in the patent to Taylor, No. 2,373,151, the precise means so employed forming no novel portion of this invention. In Fig. 3 the plasma present in the ionizing chamber **44** is designated by the stippled area and the boundary of the plasma adjacent the exit slit is indicated by the dotted line **60**. Adjacent the exit formed by the face plates **48** there is also shown, in Fig. 3, a pair of accelerating electrodes **62** disposed in advance of the arc block **40**. The relative dispositions of the plasma boundary **60** and the electron stream is shown in Fig. 3 wherein the dotted lines **63** represent a cross section through the electron stream.

In view of the discussion of Fig. 1, it will be evident that I have succeeded in directing through the arc chamber **44** a stream of electrons which closely parallels the boundary of the arc plasma and thereby greatly increases the ion density in the region closely adjacent the boundary of the plasma. It has been found that by so increasing the ion density, a much greater number of ions is withdrawn from the plasma by the attraction of the accelerating electrodes **62**, consequently increasing the density of the ion beam projected through the calutron. Furthermore, the combination of the crescent-shaped slit **56** beneath the filament, the accelerating electrodes, and the juxtaposition of the plasma boundary and the electron stream increases the percentage of the charge material which is ionized and projected through the calutron.

It is to be understood that in normal practice the charge chamber **42** is to be filled with polyisotopic material capable of being vaporized by means of heating elements (not shown). The vapor passes into the ionizing chamber **44** where ionization of the vapor is accomplished by the impact of the electrons from the filament upon the particles of the vapor, as well as by collision and consequent secondary emission of electrons within the ionizing chamber.

Having now described and illustrated a preferred embodiment of my invention, what I claim as new and desire to secure by Letters Patent of the United States is:

1. A calutron transmitter comprising walls defining a chamber having an elongated exit slit in one wall thereof, an electrode disposed outside said chamber in position to withdraw ions through said slit, a flat ribbon cathode disposed adjacent one end of said chamber, and a plate having a crescent shaped slit therethrough, said plate being disposed between the said chamber and said cathode in such position that access from the cathode to the chamber is blocked save through said crescent shaped slit.

2. An ion producing mechanism comprising a housing defining a chamber having an opening, an electrode disposed adjacent the opening for withdrawing ions therethrough, an electron emitting surface adjacent one end of said chamber, and a plate disposed between the electron emitting surface and said chamber and having a crescent shaped aperture therein to define an electron stream in said chamber adjacent said opening and having a concave cross section with respect to said electrode.

3. An ion producing mechanism comprising walls defining a chamber, a flat electron emissive cathode disposed adjacent one end of said chamber, and a trimmer plate disposed between said cathode and said chamber and having a crescent shaped slot therethrough smaller in area than the area of the cathode for defining the shape of an electron stream projected from said cathode across said chamber.

4. A calutron transmitter comprising walls defining a chamber having an elongated exit slit, an electrode disposed adjacent said slit for withdrawing ions from said chamber, a cathode disposed adjacent one end of said chamber, and a trimmer plate disposed between said chamber and said cathode and having therein a crescent shaped slot, said trimmer plate being disposed in such position that the slot therein provides access for electrons leaving said cathode, whereby electrons are projected from said cathode through said chamber in a crescent shaped stream traveling along a path lying closely adjacent said exit opening.

5. An ion producing mechanism comprising a housing defining a chamber having an opening, an electrode disposed adjacent the opening for withdrawing ions therethrough, an electron emitting surface adjacent one end of said chamber, a plate having a crescent-shaped aperture therein for producing a crescent-shaped arc through said chamber, and means for maintaining said plate at the potential of said electron emitting surface.

6. Ion producing mechanism disposed in a uniform magnetic field and comprising a source block defining a chamber therein, said source block having an elongated slit formed therein parallel to said magnetic field and communicating between said chamber and the exterior of said source block, said source block further having an aperture therein communicating between said chamber and the exterior of said chamber adjacent one end of said slit, a pair of ion accelerating electrodes disposed on opposite sides of said slit exterior to said source block, a ribbon-like filament disposed adjacent said aperture outside of said chamber for producing an arc discharge through said chamber parallel to and adjacent said slit, and a trimmer plate disposed intermediate said filament and source block and having a crescent shaped aperture therein with the concavity thereof facing said slit whereby the arc discharge is constrained to assume a crescent shaped cross section and to lie immediately adjacent and parallel to said slit, thereby producing an intensified and controlled ion distribution within the influence of said ion accelerating electrodes.

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