May 8, 1956 F. F. OPPENHEIMER 2,745,017

ION PRODUCING MECHANISM

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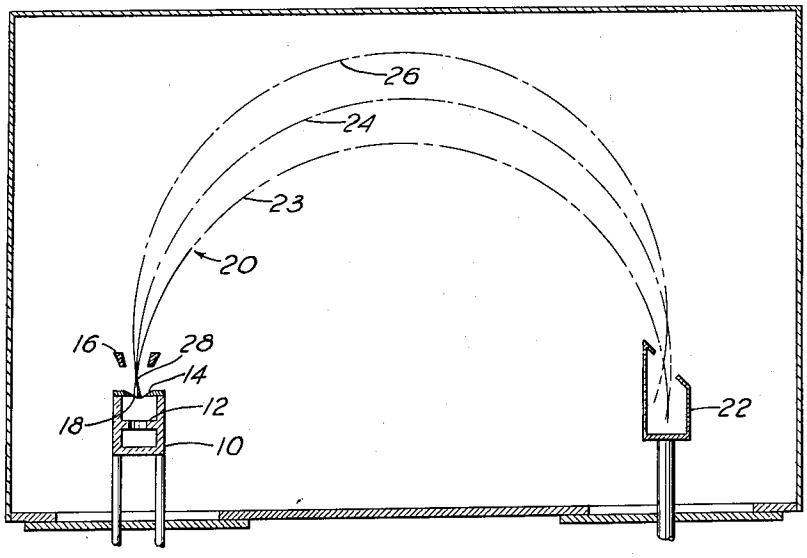


FIG. 1.

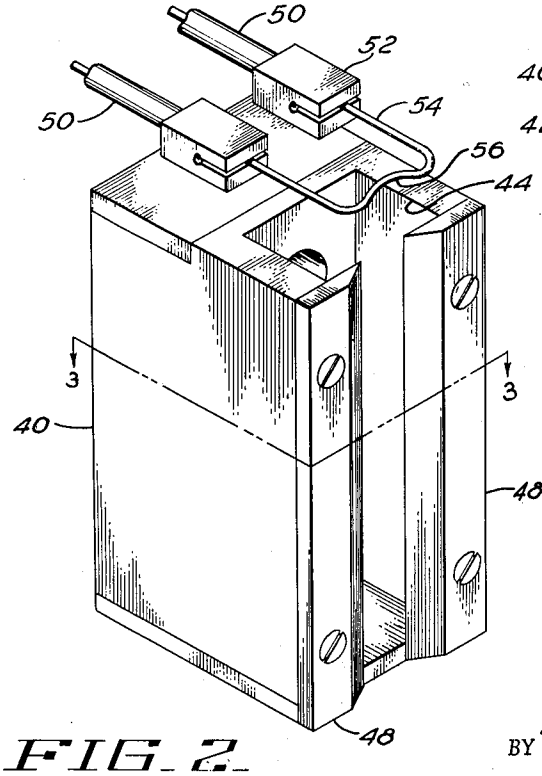


FIG. 2.

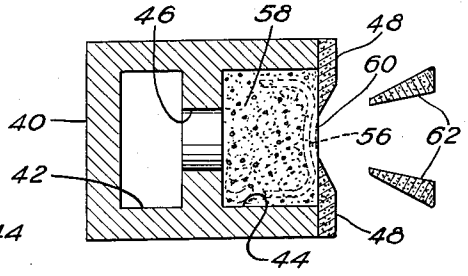


FIG. 3.

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ION PRODUCING MECHANISM

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Application November 28, 1945, Serial No. 631,418

4 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, now Patent No. 2,709,222 granted 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 in 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 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 the combination of an ionizing chamber having an exit opening, a pair of accelerating electrodes disposed without the ionizing chamber and closely adjacent the exit therefrom, and a crescent-shaped electron-emissive filament disposed adjacent one end of the ionizing chamber, the crescent-shaped filament being so disposed as to project a concentrated stream of electrons across the ionizing chamber behind the exit.

Another feature of the invention resides in a calutron transmitted wherein the ionizing electron stream is caused to travel close to the boundary of the arc plasma present in the ionizing chamber.

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 these two elements may be as great as 30 kv., 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 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 electrically projected through the point **28**, they appear to intersect, 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** communi-

cating 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**, each of which terminates in a clamp block **52** provided with sockets for the reception of the legs of a substantially U-shaped electron-emissive filamentary cathode **54**. The legs of the filament **54** are connected by a concaved or crescent-shaped cross member **56** which is disposed directly above the ionizing chamber **44** and located just behind the plane of the exit slit formed by the face plates **48**. By means of apparatus not shown, the leads **50** may be reciprocated to adjust the filament back and forth across the top of the ionizing chamber **44**. The stippled portion **58** of Fig. 3 indicates the plasma within the ionizing chamber **44** and the dotted line **60** represents diagrammatically the boundary of the plasma. 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 arrow **64** in Fig. 2 indicates the direction of the flux in the magnetic field.

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 arch 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 projecting through the calutron. Furthermore, the combination of the crescent-shaped segment **56** of 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 exit, a pair of accelerating electrodes disposed outside said chamber adjacent said exit, and an electron-emissive cathode disposed adjacent one end of said chamber, said cathode having a portion concave with respect to said electrodes for forming an electron stream having a concave cross-section adjacent said exit.

2. An ion producing mechanism comprising a housing defining a chamber having an elongated exit opening, an electrode disposed adjacent said opening for withdrawing ions therethrough, and an electron emitter disposed to discharge across said chamber adjacent said opening, said emitter having a portion concave with respect to said electrode for forming an electron stream having a concave cross-section adjacent said opening.

3. A calutron transmitter comprising walls defining an elongated chamber having an exit slit, an electrode disposed adjacent said exit slit for withdrawing ions therethrough, and an electron-emissive cathode disposed adjacent one end of said chamber, said electron-emissive cathode being concave with respect to said exit slit.

4. In a calutron transmitter which includes in its structure a block having a chamber therein provided with an exit slit, and accelerating electrode structure disposed adjacent said block in advance of said exit slit; a filamentary cathode supported in position to overlie one end of said chamber and having a portion thereof concave with respect to said exit slit, and means establishing a magnetic field having its flux direction parallel to said exit slit, whereby electrons emitted from said cathode will be projected through said chamber along a crescent-shaped path within said chamber behind said exit slit.

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