

May 15, 1956

E. J. LOFGREN
CALUTRON RECEIVERS

2,745,965

Filed May 28, 1945

5 Sheets-Sheet 1

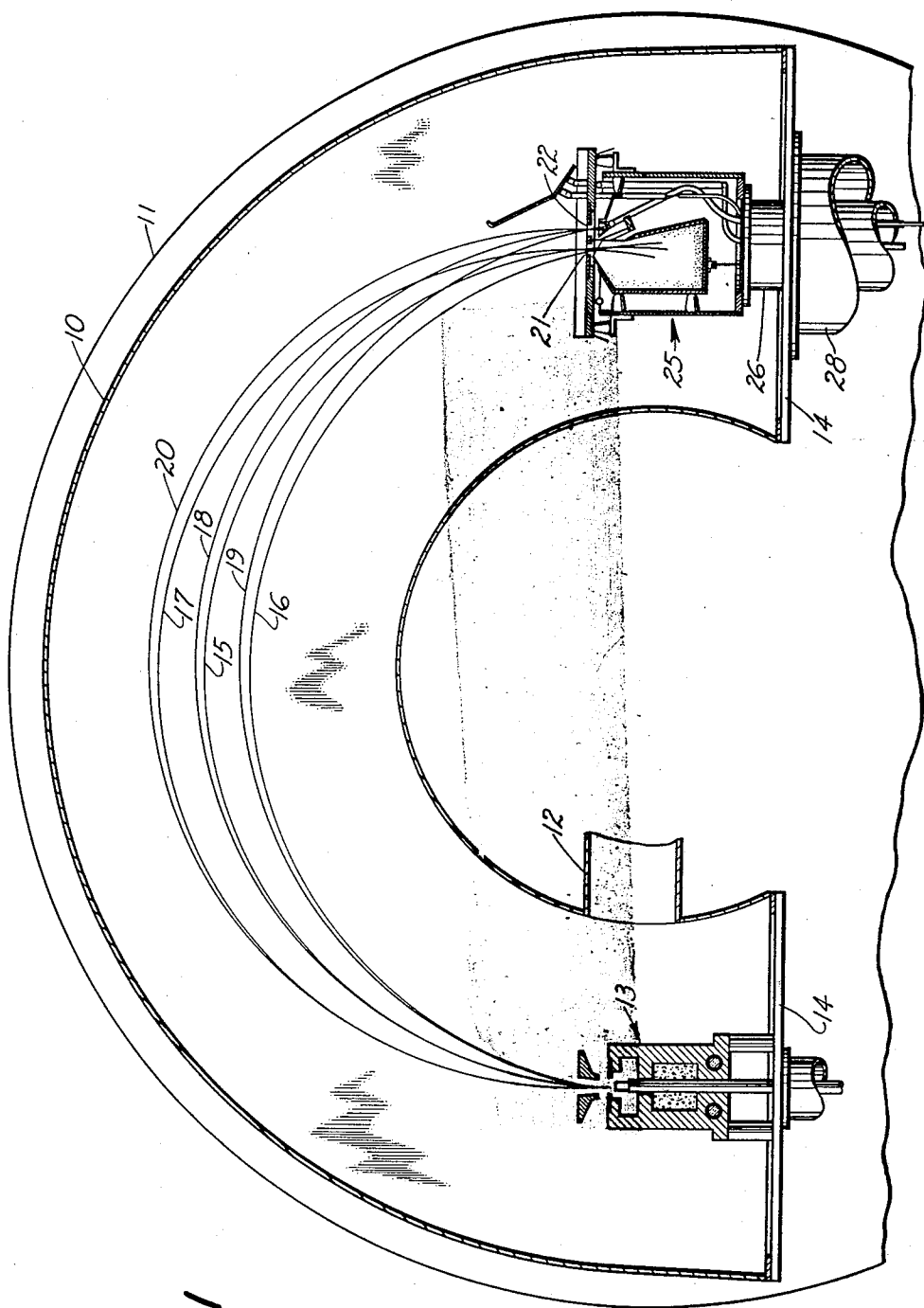


Fig. 1

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5 Sheets-Sheet 2

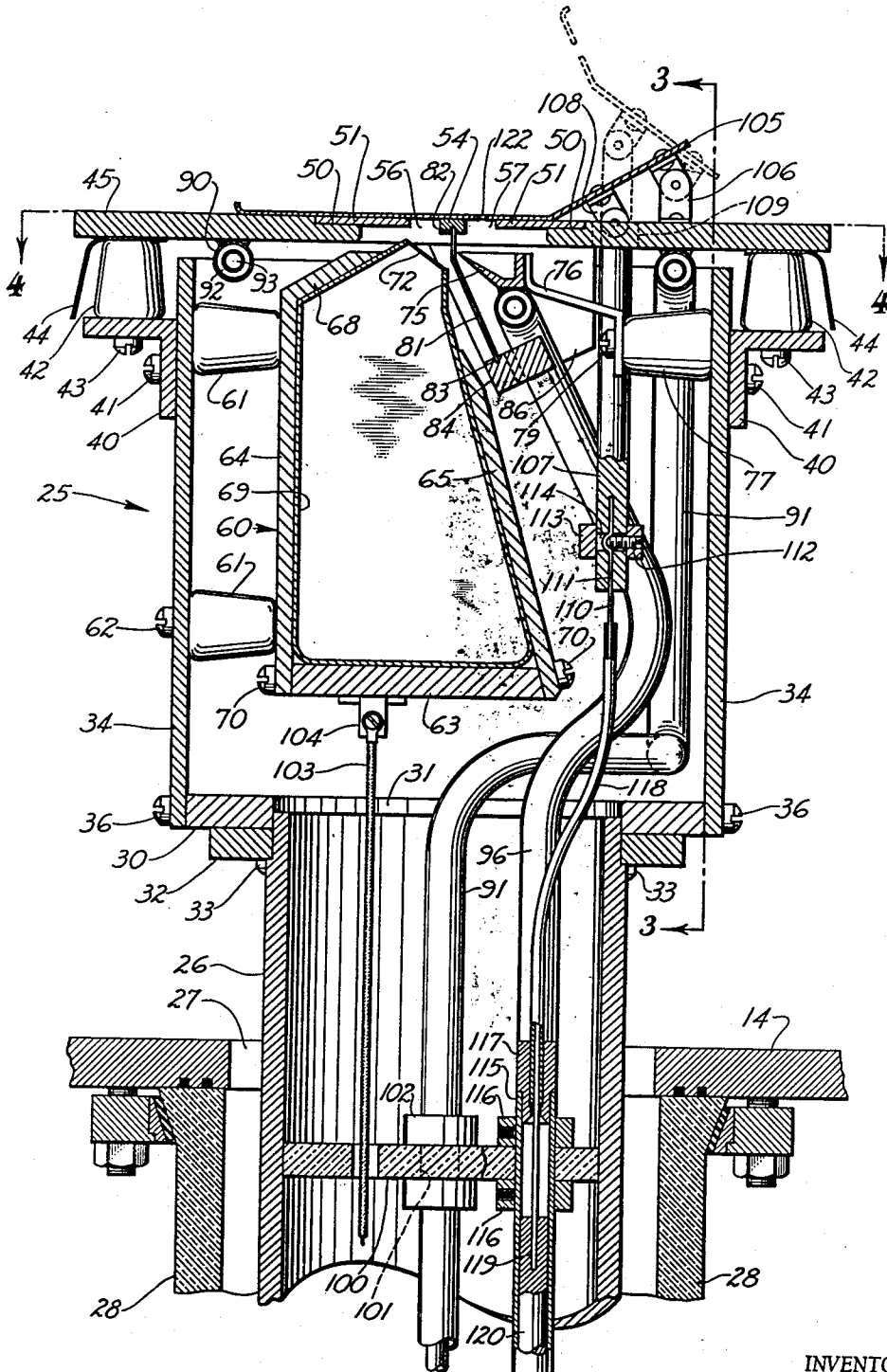


FIG. 2

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5. Sheets-Sheet 3



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5 Sheets-Sheet 4

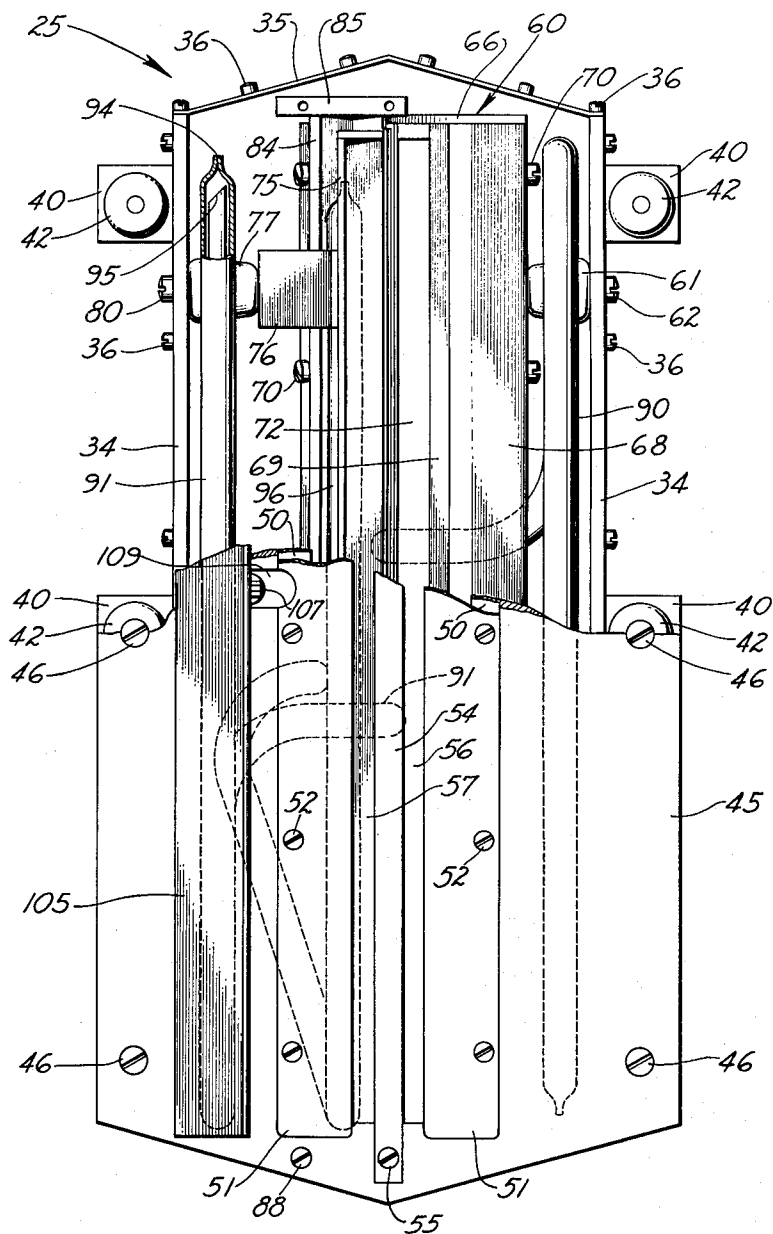


FIG. 4

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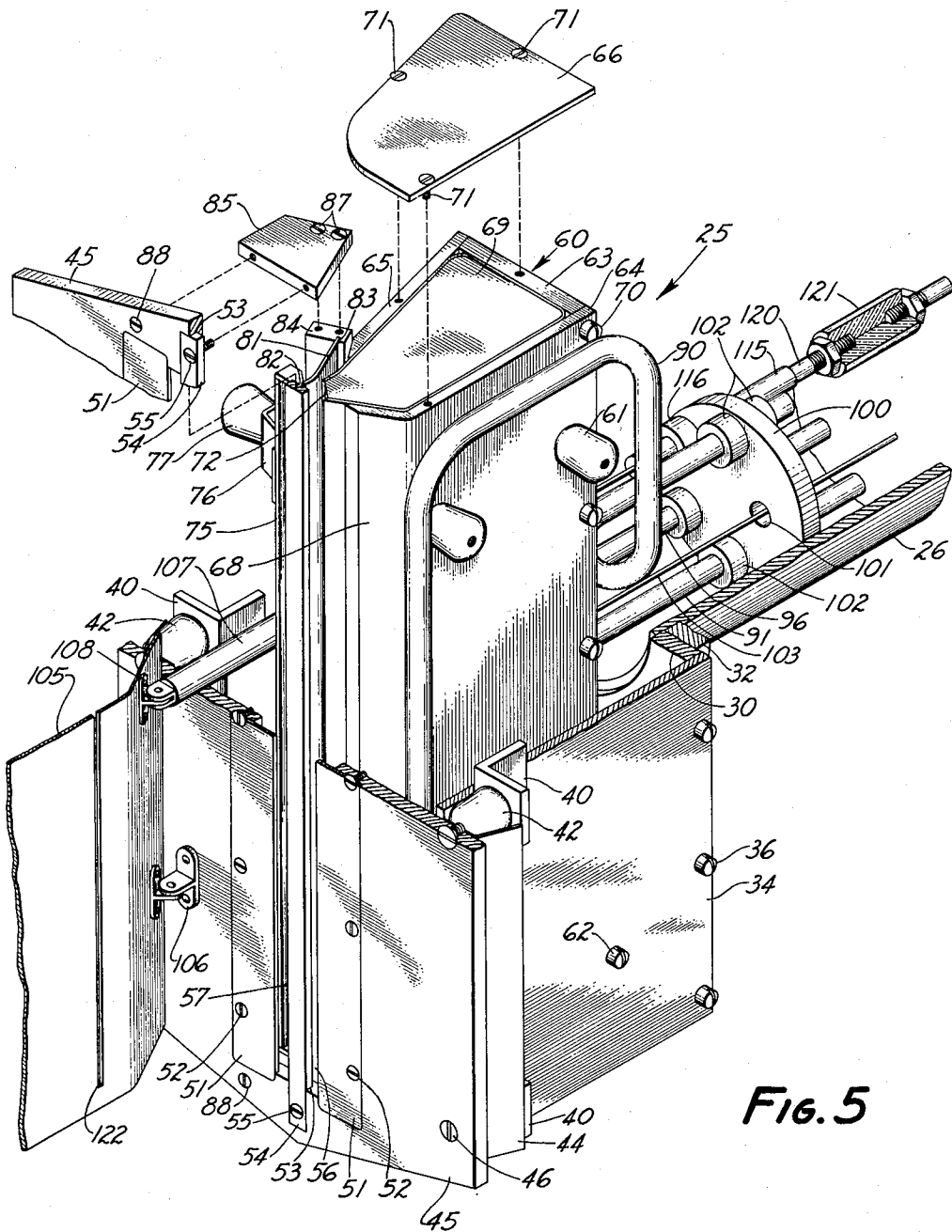


FIG. 5

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1

2,745,965

CALUTRON RECEIVERS

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Application May 28, 1945, Serial No. 596,222

12 Claims. (Cl. 250—41.9)

The general subject of this invention involves the separation, based on difference in mass, of minute particles, such as atoms, and especially the separation of isotopes of an element, or the separation of a portion of an element enriched with respect to a particular isotope on a scale yielding commercially useful quantities of the collected material.

The type of means or mechanism to which the invention relates is known as a "calutron," and correspondingly the method or process is known as a "calutron" method or process. The essential basic elements of a calutron include an evacuated chamber mounted in a magnetic field and containing apparatus for ionizing a polyisotope to be treated, apparatus for projecting a beam of ionized particles of the polyisotope along paths determined by the masses of the respective ions, and a target apparatus for deionizing the particles of the beam and for retaining at least one selected isotope component in a separated region from which it can be recovered.

In its presently preferred form, the calutron comprises an evacuated tank placed between the poles of an electromagnet so that the evacuated space within the tank is pervaded with a magnetic field of high flux density. Within the tank there is provided a "source unit" that includes means for supplying the polyisotope as a vapor or gas to an ionizing region, ionizing apparatus for producing positively ionized particles from the vapor, and an accelerating device maintained at a high negative electrical potential with respect to the ionizing apparatus for withdrawing the positive ions and imparting to each of them a predetermined energy in the form of substantially uniform velocities along paths generally normal to the direction of the magnetic field toward a beam defining slit in the accelerating device disposed generally parallel to the direction of the magnetic field.

The accelerated ions move transversely to the magnetic field and are constrained to travel along arcuate paths having radii that vary with the masses of the particles. By virtue of the accelerating slit construction, the paths for the ions of a given mass diverge from a median path to an extent determined by the geometry of the ionizing and accelerating devices. This divergence of the paths of travel of the ions of a given mass continues through the first 90° of arcuate travel, and then the paths converge during the next 90° and cross each other in a region of focus approximately 180° from the source unit. Thus, in effect, geometrical focusing of a ribbon-shaped stream of ions of a given mass is accomplished adjacent the 180° point, even though there is a relatively wide angle of divergence of the ions at their source.

Similarly, the ions of any other given mass travel along paths that define a ribbon-shaped stream coming to a focus at approximately 180° from the accelerating apparatus. Being composed of ions of different masses, the streams of ions of different isotopes have radii of curvature that differ by an amount dependent solely upon the mass difference of their respective constituent ions. As

2

a result, the centers of the foci of the streams of different isotopes are spaced apart by an amount approximately equal to the difference in the diameters of their respective median paths. In the case of the heavier elements, such as uranium, the difference in mass between the isotopes is not sufficient for accomplishing complete separation of the streams in which the ions of the different isotopes respectively travel, while employing a practical minimum divergence of the beam at the beam defining slit, and a plurality of overlapping streams having overlapping regions of focus are created.

A receiver is disposed within the vacuum tank adjacent the 180° foci of the isotope ions to be separated, for deionizing them and for separately collecting one or all of them as may be desired. Because of the necessary overlapping of the streams at their foci, it is impractical in one operation to separate completely the isotopes of the heavier elements, and, in practice, the separated quantities of material collected at the receiver are merely enriched with respect to a particular isotope.

The degree of isotopic enrichment that may be achieved in practice is also limited by a phenomenon known as "scattering." Probably as a result of collisions between ions, or between ions and neutral gas particles, a certain number of ions of one mass that should reach the receiver entirely outside the region of focus of the ions of a lesser mass, lose energy during their travel. After losing energy these ions of greater mass are caused to continue along arcuate paths of increased curvature, and some of them arrive at the receiver within the portion of the beam richest in a lighter component, thus increasing the contamination of the lighter component by the heavier component.

In the case of the heavier elements, the close proximity of the centers of the 180° foci of different isotope components of the beam presents still another complication affecting the isotopic enrichment obtainable in practice. The particles reaching the receiver are traveling at high speeds and tend to rebound from the surfaces they first strike, a phenomenon referred to as "scattering." Because the particles do not necessarily rebound from a surface at an angle therewith equal to the angle of collision, scattered material is showered in many directions from those surfaces of the receiver subjected to direct ion bombardment. As a result, the problem of retaining separated material in a region of a receiver where it first strikes, and of preventing contamination of separated material with scattered particles from another region of the receiver, present serious difficulties. Failure adequately to handle these difficulties may result in a substantial decrease in the separation and retention efficiencies of a receiver.

For a complete disclosure of a calutron and its mode of operation, reference is made to the copending application of Ernest O. Lawrence, Serial No. 557,784, filed October 9, 1944, for "Methods of and Apparatus for Separating Materials," now Patent No. 2,709,222. Only such parts of a calutron will be described herein as are necessary to an understanding of the present invention.

The present invention relates to that part of a calutron referred to as the "receiver," and the illustrated embodiment is designed particularly for separating a portion of uranium enriched with respect to the U²³⁵ isotope. Throughout the following description, the U²³⁴ isotope will be ignored, as it comprises too small a proportion of normal uranium to be of any importance as a contaminant of the product separated by the particular receiver illustrated.

An object of the invention is to provide a calutron receiver adapted separately to collect and retain a maximum percentage of the ions traveling in a selected portion of an ion beam.

3

Another object of the invention is to provide a calutron receiver having a single ion receiving pocket for collecting one isotopic component of an ion beam and having an electrode for intercepting another adjacent isotopic component for beam control purposes.

Another object of the invention is to provide a calutron receiver of the type described, so constructed that material striking the electrode positioned in the path of one isotopic beam component cannot scatter therefrom into the pocket positioned in the path of another closely adjacent beam component.

Another object of the invention is to provide a calutron receiver of the type described in which a maximum of space is available to accommodate the single ion receiving pocket, whereby the pocket may be shaped most effectively for retaining the ions received thereby.

Another object of the invention is to provide a pocket for a calutron receiver that is so constructed and disposed within the receiver that a high percentage of the ions entering the pocket will be retained therein.

Another object of the invention is to provide a calutron receiver of the type described having means for selectively closing the ion receiving pocket to the admission of ions when beam conditions are unsatisfactory for the collection of material, and for simultaneously restricting the cross-sectional area of the beam intercepted by the electrode positioned adjacent the pocket, whereby more accurate beam current measurements may be made for beam control purposes.

Still further objects of the invention will appear from the following description of a preferred embodiment thereof and from the accompanying drawings, in which:

Figure 1 is a horizontal sectional view of a calutron tank, showing the arrangement of the source and receiver within the tank and the relation of the tank to the magnet, certain parts being shown somewhat schematically for simplicity;

Fig. 2 is a horizontal sectional view on an enlarged scale of the receiver shown in Fig. 1, the plane of the section being taken horizontally through the center of the receiver with certain parts broken away;

Fig. 3 is an elevational view of the receiver, shown partly as a section taken along a plane indicated by the line 3—3 in Fig. 2;

Fig. 4 is an elevational view of the receiver, shown partly as a section taken along a plane indicated by the line 4—4 in Fig. 2; and

Fig. 5 is a partially exploded isometric view of the receiver, looking generally toward the beam receiving face from one side thereof, certain parts being broken away in order to show the relation of other parts in the interior of the receiver.

Referring to the drawings, Fig. 1 illustrates a calutron of the general character disclosed in the Lawrence application, mentioned above, but embodying certain modifications including, among other features, a receiver constructed in accordance with the present invention. The calutron comprises a C-shaped tank 10 that is supported midway between a pair of horizontally disposed, vertically spaced-apart, pole faces 11 (only one being shown) of a calutron magnet, whereby a substantially uniform magnetic field may be created throughout the interior of the tank with the flux paths passing upwardly therethrough. The tank 10 is adapted to be evacuated through a pump-out conduit 12 to reduce the interior pressure, in a manner disclosed in the Lawrence application.

A source unit, generally designated 13 and illustrated schematically in Fig. 1, is mounted within the tank 10 at one end thereof on one of a pair of removable end walls 14 for producing, from a polyisotopic charge material, a beam of singly ionized positive ions traveling along arcuate paths to regions of focus approximately 180° along said paths toward the opposite end of the tank. As hereinafter indicated, the source unit may be designed to project the ions along paths that are initially divergent to

4

either side of a median path by various angles between predetermined maxima and that later converge toward and diverge beyond a region of focus at angles on either side of a median path equal to their respective initial angular divergences. This beam is schematically and somewhat ideally illustrated in Fig. 1 by two sets of three lines each, one set representing a median path 15 and two extreme paths 16 and 17 of a stream of ions of one isotope, and the other set representing a median path 18 and two extreme paths 19 and 20 of a stream of ions of another heavier isotope. The stream of ions represented by the first-mentioned set of lines 15, 16, and 17 converges toward and diverges beyond a region of focus 21 located approximately 180° from the source unit 13 toward the opposite end of the tank 10, and, similarly, the stream of ions represented by the second-mentioned set of lines 18, 19, and 20 converges toward and diverges beyond a second region of focus 22 that is laterally spaced from the region of focus 21 of the ions of a lesser mass. A source unit capable of producing such an ion beam is disclosed in detail in the Lawrence application mentioned above.

As explained previously herein, it is impractical from a production standpoint to obtain a beam in which adjacent foci of two isotope ion streams are completely separated, when dealing with the heavy elements such as uranium, and the unattainable ideal beam illustrated has been shown only in order to disclose more clearly the relationships between the trajectories of ions comprising a polyisotopic beam.

A receiver, generally designated 25, is mounted on a removable wall 14 of the C-shaped tank 10, at the opposite end thereof from the source unit 13, for collecting and deionizing ions arriving at one of the regions of focus 21 separately from those arriving at the adjacent region of focus 22, and for trapping ions reaching the first-mentioned region of focus 21 in such manner that they can be separately removed from the calutron.

The receiver 25 is mounted on a tube 26 that projects outwardly through an aperture 27 in the adjacent end wall 14 of the tank 10. The tube 26 is preferably supported in the aperture 27 on apparatus carried by a cylindrical insulator 28 secured in an air-tight manner around the aperture, the tube being preferably mounted for rotary movement about its own axis, for pivotal movement in both a horizontal and a vertical direction, and for longitudinal movement along its axis, with the outer end of the tube 26 and the space between the tube and the surrounding walls of the aperture 27 and insulator 28 suitably sealed against leakage of air into the tank 10. The apparatus for supporting the tube 26 forms no part of the present invention, and one example of suitable apparatus is disclosed in detail in the above-mentioned Lawrence application. With such apparatus, the inner end of the tube 26 may be rotated and translated in any direction for aligning the receiver 25 with the beam to be received thereby.

The receiver 25 comprises a back plate 30 of hexagonal outline having a centrally disposed aperture 31 therein. The inner end of the supporting tube 26 is secured in the aperture 31 for ready removal by means of a flange 32 that may be soldered to the tube, and a cooperating series of cap screws 33 that pass through the flange 32 and are tapped into the back plate 30.

A housing projects forwardly from the back plate 30 and comprises a pair of oppositely disposed side plates 34 and a pair of oppositely disposed end plates 35, each of the end plates being bent to form two angularly related portions adapted to conform to the contour of two angularly related adjacent edges of the hexagonal back plate 30. The side plates 34 and end plates 35 are mounted on the back plate 30 and are secured thereto and to each other at adjoining edges by series of cap screws 36. To facilitate the removal of air molecules from the interior of the receiver when evacuating the calutron tank, an

5

aperture 37 may be provided through each of the angularly related portions of both of the end plates 35.

Adjacent and parallel to the forward edges of the two side plates 34 respectively, there are mounted two rows of three angle brackets 40 that are secured to the associated side plates by cap screws 41. Each angle bracket 40 carries a forwardly projecting stand-off insulator 42, of ceramic material or the like, that is mounted on the associated bracket by a cap screw 43. A shield 44 extends along each row of insulators 42 with one portion of the shield disposed to protect the insulators from scattered particles traveling in the calutron tank and with an angularly related portion disposed along the forwardly projecting ends of the insulators between the insulators and a receiver face plate 45. The face plate 45 is carried by the two rows of insulators 42 and is secured thereto by a number of screws 46 that pass through the face plate, through one of the shields 44, and into the forward ends of the insulators 42, respectively.

The face plate 45 is provided with a large, centrally disposed, generally rectangular opening therethrough that is rabbeted along a pair of opposed side edges to provide seats 50 for a pair of similar, oppositely disposed, beam defining plates 51. The beam defining plates 51, preferably formed from graphite sheets, are secured to the face plate 45 by a number of screws 52 and extend the full length of the opening. The face plate 45 is also rabbeted at opposite ends of the opening therethrough to provide seats 53 for the ends of a central beam defining strip 54, also preferably made of graphite; and the beam defining strip 54 is secured in the seats 53 by a pair of screws 55. The beam defining plates 51 and the beam defining strip 54 restrict the opening in the face plate 45 and define two, parallel, spaced-apart, rectangular slots 56 and 57 that are adapted to pass predetermined portions of an ion beam into the interior of the receiver. When the beam comprises ions of the several uranium isotopes, one of the slots 56 is adapted to pass a portion of the beam of maximum U^{235} ion current density, and the other of the slots 57 is adapted to pass a portion of the beam of maximum U^{238} ion current density.

The radial distance between the centers of the 180° foci for any two isotopes of an element varies from device to device, for it is dependent not only upon the mass difference between the two isotopes, but also upon the radius of the beam, which is dependent in turn upon the strength of the magnetic field and the kinetic energy imparted to the ions. In a given device employing given operating conditions, however, this distance depends only upon the mass difference of the two isotopes. For the uranium isotopes of 235 and 238 mass units, this difference is three mass units, and the radial distance between the respective foci of these isotopes of uranium in any given device and under any given set of operating conditions is referred to for convenience as three slugs. In the embodiment of the invention illustrated herein, the centers of the slots 56 and 57 are spaced three slugs apart.

The proper width of each slot in any particular receiver is dependent upon a number of considerations, including the angle of divergence of the beam at the source 13, the extent to which quantity of material collected is to be sacrificed for maximum isotopic enrichment, and the distribution of scattered material in the beam. In the illustrated embodiment of the invention, both slots are 1½ slugs wide. Since the centers of the slots are three slugs apart, the central beam defining strip 54 is also 1½ slugs wide. These dimensions may be altered considerably according to the collection characteristics desired.

A pocket, generally designated 60, for receiving and retaining U^{235} ions admitted through the U^{235} slot 56, is positioned inside the receiver and is supported in place by two pairs of stand-off insulators 61 that are mounted on one of the housing side plates 34 by cap screws 62. The pocket comprises a bottom or back wall 63, a pair of side plates 64 and 65, and a pair of end plates 66 and

6

67, one of the side plates 64 being bent longitudinally to provide a partial front wall 68 that extends generally forwardly toward the U^{235} slot 56. An opening is left between one edge of the front wall 68 and the adjacent edge of the opposite side wall 65 of the pocket to accommodate a projecting portion of a pocket liner 69. The side walls 64 and 65 and the end walls 66 and 67 of the pocket are secured together and to the back wall 63 thereof by a number of cap screws 70 and flat head screws 71. The end walls 66 and 67 of the pocket are substantially parallel and are normal to the back wall 63, while the side walls 64 and 65 diverge from their forward edges adjacent the U^{235} slot 56 toward the back wall 63, with one of the side walls 64 disposed generally normal to the back wall and the opposite side wall 65 inclined thereto so as to form an acute interior angle therewith. The liner 69, preferably made of copper, is in the form of a compartment having a single opening 72 disposed behind the U^{235} slot 56 and adapted to admit all of the ions passing through the slot; and the size and shape of the liner are such that it fits snugly in the pocket 60 in surface-to-surface contact with the walls thereof over substantially their entire area.

Because of space limitations imposed by the close proximity of the U^{235} and U^{238} slots 56 and 57, the portion of the side wall 65 of the pocket 60 adjacent the face plate 45 cannot readily be disposed entirely out of the path of ions passing through the U^{235} slot 56. However, by inclining the side wall 65 of the pocket in the manner described above, most of the inner surface of the corresponding portion of the liner 69 is disposed out of the path of ions entering the pocket, and the scattering of material from this surface out of the pocket through the opening 72 is thereby substantially eliminated. At the same time, this surface of the liner is disposed so as to be effective for intercepting material scattered from the back wall of the liner in the general direction of the opening 72. The opposite side wall 64, on the other hand, may be disposed far enough to one side of the U^{235} slot 56 to be substantially completely out of the path of ions passing therethrough.

A strip type deionizing electrode 75, that is slightly longer than the U^{238} slot 57, is disposed inside the receiver in a position behind the U^{238} slot for intercepting substantially all of the ions passing therethrough; and the ion intercepting face of the electrode is shaped so as to deflect away from the U^{238} slot the majority of the deionized particles scattering therefrom. The electrode is spaced from the U^{238} slot about the same distance that the opening 72 in the pocket liner 69 is spaced from the U^{235} slot 56, and is supported in position by a pair of brackets 76 and a pair of stand-off insulators 77. The brackets 76 may be secured to the electrode 75 by a pair of flat head screws 78, and to the associated insulators 77 by a pair of cap screws 79, and the insulators 77 may be mounted on the adjacent side wall 34 of the receiver housing by a pair of cap screws 80.

In order to prevent ions passing through the U^{238} slot 57 and striking the electrode 75 from scattering from the electrode into the U^{235} pocket 60, a baffle 81 is positioned between the electrode and the pocket. The forward edge of the baffle is fitted into a groove 82 that extends longitudinally into the back side of the central defining strip 54, and the rearward edge of the baffle is fitted into a similar groove 83 in a brace 84 that is positioned behind the electrode 75. Both the baffle 81 and the brace 84 are longer than the electrode 75 and project beyond the opposite ends thereof, the brace 84 extending slightly further in both directions than the baffle. A pair of similar end blocks 85 and 86 are secured to opposite ends of the brace 84 by two pairs of screws 87, and each end block is secured to the back side of the face plate 45 by a pair of screws, including the screw 55 that holds the adjacent end of the central defining strip 54 in place and a second screw 88 positioned to one side thereof.

Since the receiver absorbs a considerable amount of energy as a result of bombardment by ions traveling in the ion beam, it is highly desirable to cool the parts most heavily bombarded. When a uranium ion beam is projected from the source unit 13 to the receiver 25, for the purpose of separately collecting U^{235} , the parts of the receiver most heavily bombarded are the face plate 45 that intercepts all of the beam falling outside of the limits of the two slots 56 and 57, and the electrode 75 that intercepts the portion of the beam of maximum U^{238} ion intensity. The heating effect on the pocket 60 is relatively small in view of the large area of its heat radiating surface and the relatively low intensity of the U^{235} portion of the beam received thereby; and direct cooling thereof has been found not to be essential with the construction disclosed herein.

To cool the face plate 45, two independent cooling fluid lines 90 and 91 are employed, each of the lines consisting of a pair of concentric copper tubes that define a pair of parallel passages 92 and 93 for respectively conducting a cooling fluid to the area to be cooled and drawing it off again. Within the receiver, each of the cooling fluid lines 90 and 91 terminates in a squirt-tube type of interconnection between its concentric passages 92 and 93, this interconnection being formed by pinching and sealing the end 94 of the outer tube and by terminating the inner tube in an open end 95 short of the pinched end of the outer tube. Thus a cooling fluid can flow to the ends of the lines 90 and 91 through the outer passageways 92 and return through the inner passageways 93.

One of the cooling fluid lines 90 is soldered to the back surface of the face plate 45 for substantially the full length thereof between the pocket 60 and the adjacent side plate 34 of the receiver housing. From there, this cooling fluid line extends out of the receiver housing through the aperture 31 in the back plate 30 and into the receiver supporting tube 26. The other cooling fluid line 91 for the face plate 45 is similarly secured in heat conducting relation to the opposite side of the back surface of the face plate and also extends out of the receiver housing through the aperture 31 and into the supporting tube 26.

To cool the electrode 75, a cooling fluid line 96, structurally similar to the other two cooling fluid lines 90 and 91, is soldered to the back surface of the electrode for substantially its entire length and is also led out of the receiver housing through the aperture 31 into the supporting tube 26. The brace 84, positioned below the electrode 75, has a side portion cut away adjacent one end thereof to provide a notch 97 through which the cooling fluid line 96 may pass with clearance to prevent electrical contact between the brace and the cooling fluid line.

All three of the cooling fluid lines 90, 91, and 96 pass out of the tank 10 through the receiver supporting tube 26 and into communication with suitable fittings (not shown) for connecting the outer passageways 92 to a source of cooling fluid and the inner passageways 93 to a return fluid receptacle (also not shown). The three cooling fluid lines are maintained out of electrical contact with each other and with all parts of the receiver except those parts to be respectively cooled thereby. Within the supporting tube 26 and adjacent the receiver end thereof, the cooling fluid lines are brought into parallel, spaced-apart relation with each other and are held in position by an insulator disk 100 that is forced with a snug fit into the supporting tube. The disk 100 is provided with a number of apertures 101 therethrough, one for each cooling fluid line and two others for purposes described hereinafter. Two collars 102 surround each cooling fluid line on opposite sides of the disk 100 for holding the cooling fluid lines against longitudinal movement, the collars being secured to their associated cooling fluid lines in any convenient manner, such as

by soldering or by means of set screws. From the disk 100, the cooling fluid lines project on through the supporting tube 26 and through appropriate insulated seals in the closed outer end thereof (not shown) for preventing air from leaking into the tank 10 and for maintaining electrical separation of the cooling fluid lines, all in a well-known manner as disclosed, for example, in the above-mentioned Lawrence application.

The use of an electrically nonconducting cooling fluid, such as distilled water, permits the cooling fluid lines to serve as electrical leads for separately measuring the quantity of ions striking the face plate 45 and the electrode 75. A suitably insulated electrical lead 103 may be attached to the pocket 60, by means of a terminal bracket 104, and may be brought out of the tank 10 through the supporting tube 26 by way of one of the openings 101 in the insulated disk 100, and out of the closed outer end of the supporting tube through an appropriate seal in an obvious manner (not shown).

In order to prevent contamination of the interior of beam has become stabilized and has been focused for reception, a door 105 is mounted on the front of the face plate 45 by a pair of hinges 106. The door is slightly greater in length than the U^{235} and U^{238} slots 56 and 57 and is adapted to swing about the hinges 106 from a closed position against the face plate and covering the U^{235} and U^{238} slots, to an open position (shown in Fig. 1 and again by dotted lines in Fig. 2) out of the paths of the U portions of the beam.

For operating the door between its open and closed positions, a rod 107 is pivotally connected to the door by means of a bracket 108 and projects into the interior of the receiver through an aperture 109 in the face plate 45. One end of a length of heavy wire 110, such as music wire, is mounted in a centrally disposed aperture 111 in the opposite end of the rod 107, and a set screw 112, carried by a collar 113, projects into a transverse aperture 114 in the rod 107 and against the wire 110 to anchor it in place.

The wire 110 extends from the rod 107 through a guide mechanism mounted in the insulating disk 100. This guide mechanism includes a tubular sleeve 115 that passes through one of the apertures 101 in the insulating disk and is secured against longitudinal movement with respect thereto by means of two collars 116 that surround the sleeve 115 and are suitably secured thereto on opposite sides of the insulating disk. A plug 117, soldered in the end of the sleeve 115 on the receiver side of the insulating disk, is longitudinally bored to permit the wire 110 to pass therethrough and to accommodate one end of a length of copper tubing or the like 118 that is soldered to the plug 117 and surrounds the wire 110 for a considerable portion of its length. The tube 118 is bent to conform to a desired path of travel for the wire 110 whereby electrical contact between it and other parts of the receiver may be avoided.

Inside the sleeve 115, at a point spaced from the plug 117 when the door 105 is closed, the wire 110 is suitably anchored, as by soldering, in an opening 119 centrally disposed in an end of a control shaft 120 that projects a short distance into the sleeve 115. The control shaft 120 extends in the opposite direction through the outer closed end of the supporting tube 26 where it passes through a suitable seal (not shown) that permits longitudinal movement of the control shaft. At some convenient point along its length between the sleeve 115 and the outer end of the supporting tube 26, the control shaft 120 includes an interposed insulator portion 121 adapted to withstand the stresses imposed on the control shaft and to prevent grounding of the face plate 45 through the door control mechanism.

By pushing the control shaft 120 further into the sleeve 115, the wire 110 is moved a corresponding distance in the same general direction through the plug 117 and the

tube 118, thereby moving the rod 107 in a direction to cause the door 105 to swing about its hinges 106 into the open position illustrated in Figs. 1 and 2. To close the door again, the control shaft 120 is merely pulled back into the starting position.

To facilitate determining when the beam is properly focused for most efficient reception, a narrow slot 122 is provided in the door 105, the slot preferably being coextensive in length with the electrode 75. For receiving a uranium ion beam to collect U^{235} , the width and spacing of the slots 56 and 57 in the face plate 45 are so chosen that the center of the U^{238} component of the beam (the component of greatest ion intensity) will be focused on the longitudinal center line of the U^{238} slot 57 when the center of the U^{235} component of the beam is focused on the longitudinal center line of the U^{235} slot 56. With the slot 122 in the door 105 located so that its longitudinal center line will be aligned with the longitudinal center line of the U^{238} slot 57, when the door is in its closed position, an accurate focus can be obtained by varying the accelerating voltage of the source unit 13 until the current to the electrode 75 is maximized. The door can then be opened for admitting the focused U^{235} component of the beam through the U^{235} slot 56 into the pocket 60 and for permitting a corresponding portion of the U^{238} component of the beam to pass through the U^{238} slot 57 to the electrode 75.

Within limits, the narrower the slot 122 is made, the more sensitive the current to the electrode 75 becomes as an indication of the accuracy of focus during the initial setting of the accelerator voltage at the source unit. However, since the overall output of the source unit may vary substantially during the subsequent period of reception, the intensity of the small cross section of the beam that can pass through the slot 122 is an unreliable indication of the accuracy of focus over an extended period of time. For this reason, it is desirable that the U^{238} slot 57 be of a substantial width so that, when the door 105 is opened for reception, the current to the electrode 75 will be useful as a check on the total output of the source unit and on the sharpness of the focus, as well as on the accuracy with which the U^{235} and U^{238} foci are aligned with the slots 56 and 57. Moreover, the more U^{238} ions admitted through the U^{238} slot 57, the less is the amount of sputtering of contaminating U^{238} particles from the face plate 45 into the U^{235} portion of the beam and into the U^{235} pocket 60.

With the receiver 25 mounted in the evacuated tank 10, with cooling fluid circulating through the cooling fluid lines 90, 91, and 96, and with the door 105 in its closed position, the beam is created and focused in accordance with the indicator current to the electrode 75. When a proper focus of the beam has been achieved, the door 105 is opened, and subsequent readings of current to the electrode 75, to the face plate 45, and to the pocket 60 may be observed as a check on general beam conditions and on the rate at which ions are entering the pocket 60. The door 105 may be closed during a run in the event the condition of the beam should become unfavorable, in order to prevent contamination of the material in the pocket 60 until the condition of the beam is corrected; or the door may be closed at regular intervals during a run to obtain a more reliable check on the accuracy of focus and to carry out any required refocusing operation.

At the conclusion of a run, the beam is cut off, the circulation of cooling fluid through the receiver is stopped, the pressure in the tank is brought up to atmospheric pressure, and the receiver is removed from the tank by removing the tank wall 14 on which it is mounted. After removing one of the end plates 35 of the receiver housing, one of the end walls 66 of the pocket 60, and one of the baffle supporting end blocks 85, the pocket liner 69 may be withdrawn for recovering the material collected therein during the run.

While I have described in detail a specific embodiment of my invention, it is to be understood that this has been done for illustrative purposes and that the scope of my invention is not limited thereby except as required by the appended claims.

What is claimed is:

1. In a calutron having means for establishing an ion beam and for causing divergence of beam components of different mass during travel of said components to respective regions of focus, an ion receiver comprising a collecting pocket having an opening therein for admitting one beam component, a removable liner for said pocket, and an electrode having a surface for intercepting another beam component, said opening and the entire ion intercepting surface of said electrode being respectively positioned in side-by-side relation adjacent the regions of sharpest focus of the beam components to be received thereby.

2. In a calutron having means for establishing an ion beam and for causing divergence of beam components of different mass during travel of said components to respective regions of focus, an ion receiver comprising a collecting pocket having an opening therein for admitting a beam component of one mass, a removable liner for said pocket, and an electrode having a surface for intercepting a beam component of a different mass, said opening and the entire ion intercepting surface of said electrode being respectively positioned adjacent the regions of sharpest focus of the beam components to be received thereby.

3. In a calutron having means for establishing an ion beam and for causing divergence of beam components of different mass during travel of said components to respective regions of focus, an ion receiver comprising a collecting pocket having an opening therein for admitting a beam component of one mass, a removable liner for said pocket, an electrode having a surface for intercepting a beam component of a different mass, and means for delimiting the portions of the beam respectively reaching said opening and the ion intercepting surface of said electrode, said beam delimiting means being disposed adjacent the regions of sharpest focus of the portions of the beam to be passed thereby, and said opening and the entire ion intercepting surface of said electrode being respectively disposed adjacent the regions of focus of the beam components to be received thereby and substantially equidistant from said beam delimiting means.

4. In a calutron having means for establishing an ion beam and for causing divergence of beam components of different mass during travel of said components to respective regions of focus, an ion receiver disposed adjacent said regions of focus and comprising a supporting framework, a face plate carried by said framework and provided with a pair of spaced-apart beam defining slots for passing delimited portions of said beam, a collecting pocket carried by said framework and having an opening therein for admitting ions passed by one of said slots, a removable liner for said pocket, and an electrode carried by said framework for intercepting ions passed by the other of said slots, said opening and said electrode being disposed substantially equidistant from their respectively associated beam defining slots.

5. In a calutron having means for establishing an ion beam and for causing divergence of beam components of different mass during travel of said components to respective regions of focus, an ion receiver disposed adjacent said regions of focus and comprising a supporting framework, a face plate carried by said framework and provided with first and second spaced-apart slots for passing delimited portions of said beam, a collecting pocket carried by said framework and having an opening therein disposed to admit ions passed by said first slot, an electrode carried by said framework and disposed to intercept ions passed by said second slot, and means carried by said

framework selectively operative completely to close said first slot.

6. In a calutron having means for establishing an ion beam and for causing divergence of beam components of different mass during travel of said components to respective regions of focus, an ion receiver disposed adjacent said regions of focus and comprising a supporting framework, a face plate carried by said framework and provided with first and second spaced-apart slots for passing delimited portions of said beam, a collecting pocket carried by said framework and having an opening therein disposed to admit ions passed by said first slot, an electrode carried by said framework and disposed to intercept ions passed by said second slot, and means carried by said framework selectively operative completely to close said first slot and simultaneously partially to close said second slot.

7. In a calutron having means for establishing an ion beam and for causing divergence of beam components of different mass during travel of said components to respective regions of focus, an ion receiver disposed adjacent said regions of focus and comprising a supporting framework, a face plate carried by said framework and provided with first and second spaced-apart slots for passing delimited portions of said beam, a collecting pocket carried by said framework and having an opening therein disposed to admit ions passed by said first slot, an electrode carried by said framework and disposed to intercept ions passed by said second slot, and a door carried by said framework and having a third slot therein, said door being selectively operative for movement into the path of said beam with said third slot aligned with said second slot to permit a predetermined portion of said beam to pass therethrough to said electrode and with an unslotted portion of said door aligned with the said first slot to close the same for preventing ions from entering said pocket.

8. In a calutron having means for establishing an ion beam and for causing divergence of beam components of different mass during travel of said components to respective regions of focus, an ion receiver positioned adjacent said regions of focus and comprising an electrode for intercepting ions from a first selected portion of the ion beam, and a collecting pocket having an opening therein disposed adjacent said electrode to one side thereof for admitting a second selected portion of the ion beam, said pocket having a side wall that defines a side of said opening closest to said electrode and that is inclined away from the paths of ions entering said opening so as to be substantially free from direct bombardment thereby.

9. In a calutron having means for establishing an ion beam and for causing divergence of beam components of different mass during travel of said components to respective regions of focus, an ion receiver positioned adjacent said regions of focus and comprising an electrode for intercepting ions from a first selected portion of the ion beam, and a collecting pocket having an open-

ing therein disposed adjacent said electrode to one side thereof for admitting ions from a second selected portion of the ion beam, said pocket extending to a considerable depth behind said opening in the general direction of travel of said beam at its regions of focus and having a side wall disposed adjacent said electrode and extending behind the electrode at an angle to said general direction of travel such that the interior surface of the side wall is substantially free from direct bombardment by ions entering said opening.

10. In a calutron having means for establishing an ion beam and for causing divergence of beam components of different mass during travel of said components to respective regions of focus, an ion receiver positioned adjacent said regions of focus and comprising a collecting pocket having an opening therein for admitting ions from a first selected portion of an ion beam, said pocket having a bottom wall disposed opposite said opening and spaced a substantial distance therefrom and a pair of side walls that diverge from said opening toward said bottom wall, whereby an electrode may be positioned closely adjacent said opening at one side thereof for intercepting ions from a second selected portion of the ion beam and the interior surfaces of the side walls of said pocket may be so disposed that they are substantially free from direct bombardment by ions entering said opening.

11. In a calutron having means for establishing an ion beam and for causing divergence of beam components of different mass during travel of said components to respective regions of focus, an ion receiving pocket comprising a front wall having an opening therein positioned adjacent the region of focus of one beam component for admitting a selected portion thereof, a back wall disposed opposite said opening and spaced a substantial distance therefrom, and a pair of side walls that diverge continuously from said top wall toward opposite edges of said bottom wall, at least one of said side walls being inclined at an acute angle to the bottom wall.

12. In a calutron having means for establishing an ion beam with ions traversing paths initially divergent to either side of a median path by predetermined maximum angles and later converging toward and diverging beyond a region of focus at angles on either side of a median path equal to their respective initial angular divergences, a collecting pocket having an opening therein positioned adjacent said region of focus for admitting a selected portion of the beam and a side wall extending beyond said opening in the general direction of travel of the beam, said side wall being inclined with respect to the ion paths of maximum angular divergence so that it is substantially free from direct bombardment by ions entering said opening.

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