

March 6, 1956

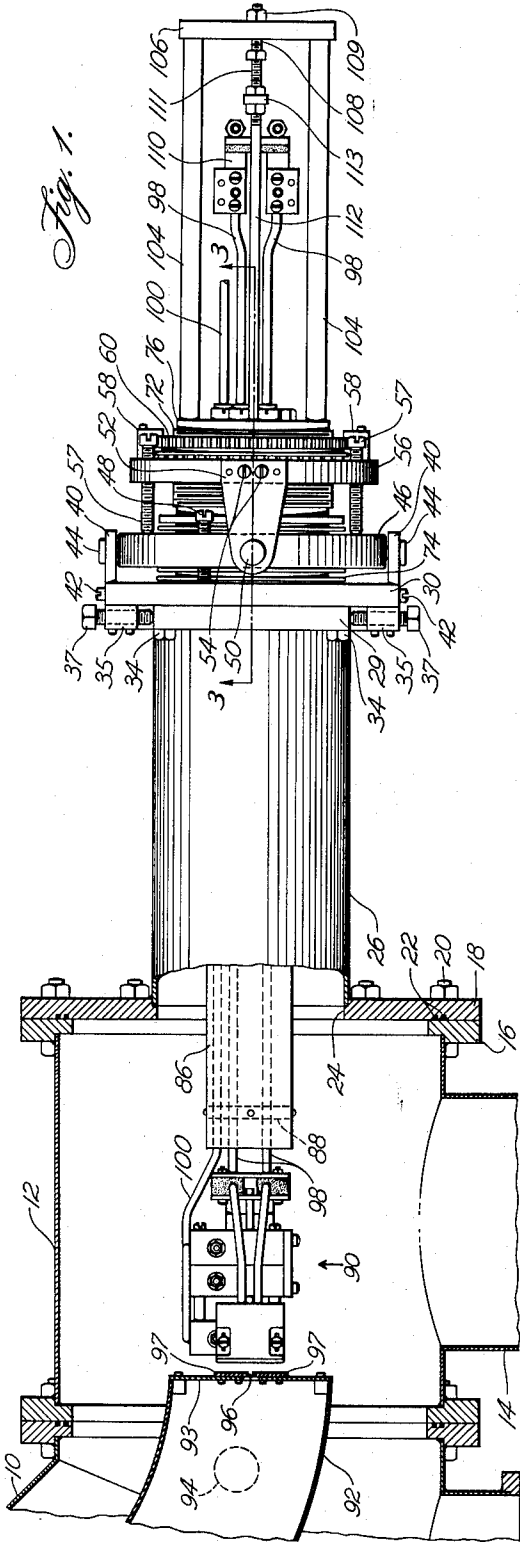
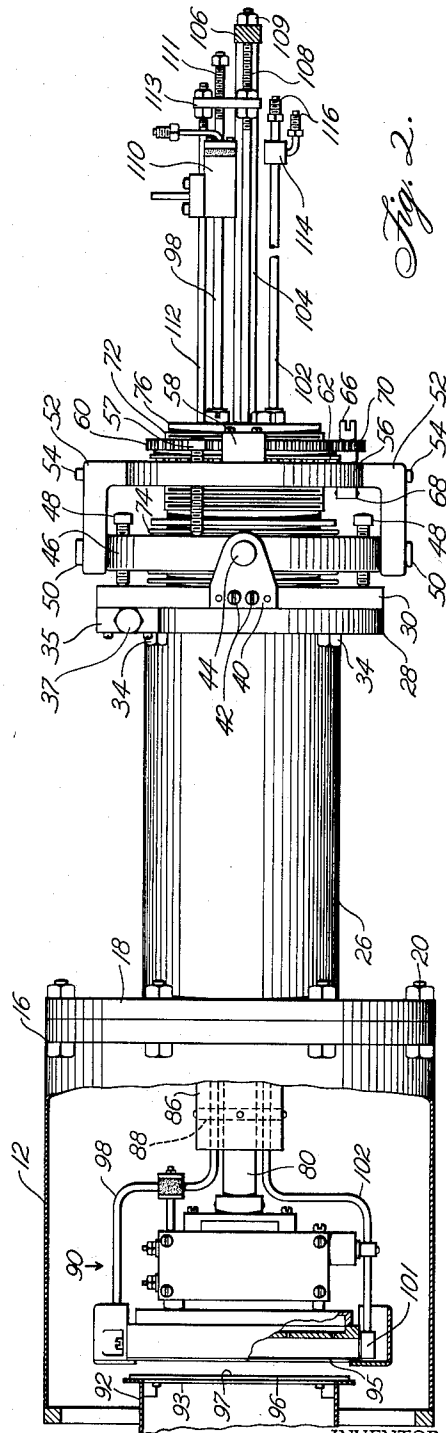
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2,737,590

ION SOURCE FOR A CALUTRON

Filed March 13, 1945

3 Sheets-Sheet 1



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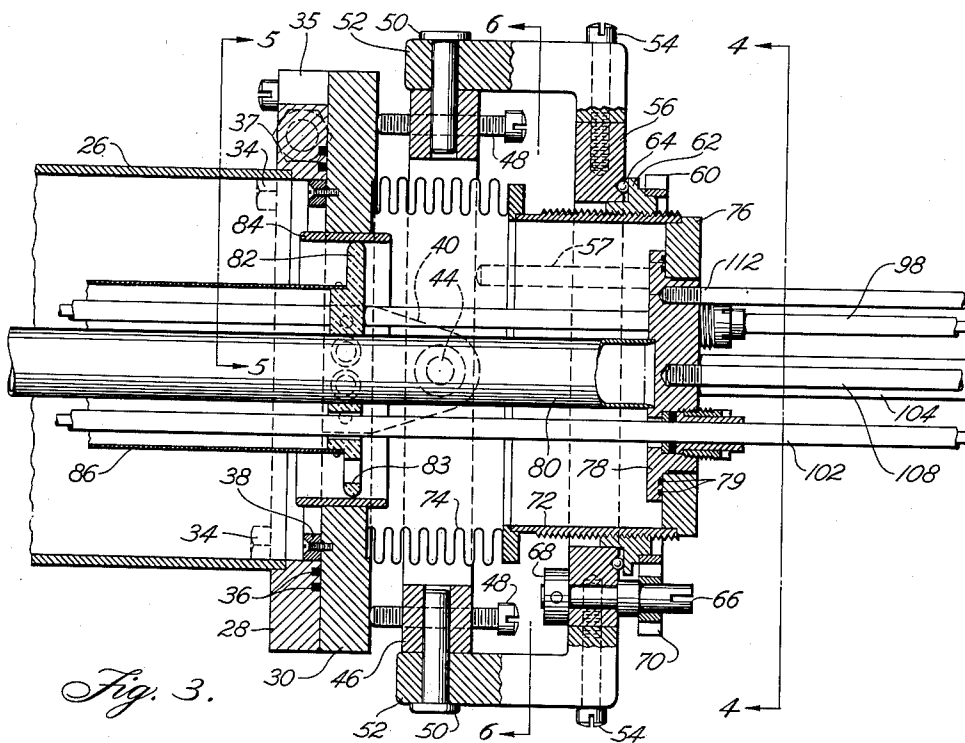
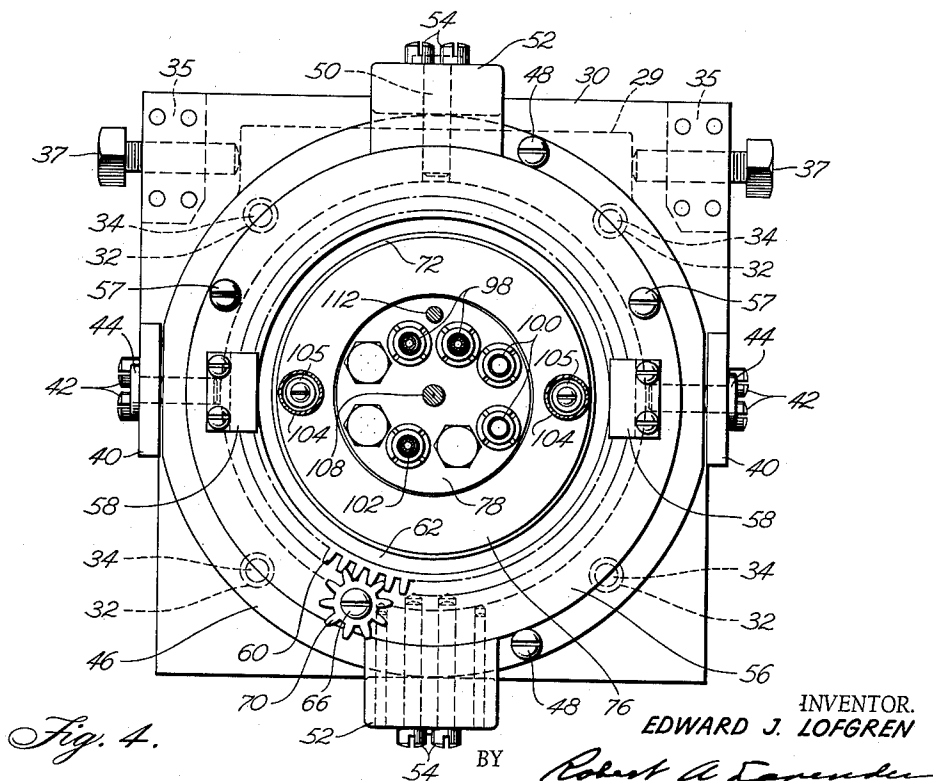
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3 Sheets-Sheet 2



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3 Sheets-Sheet 3

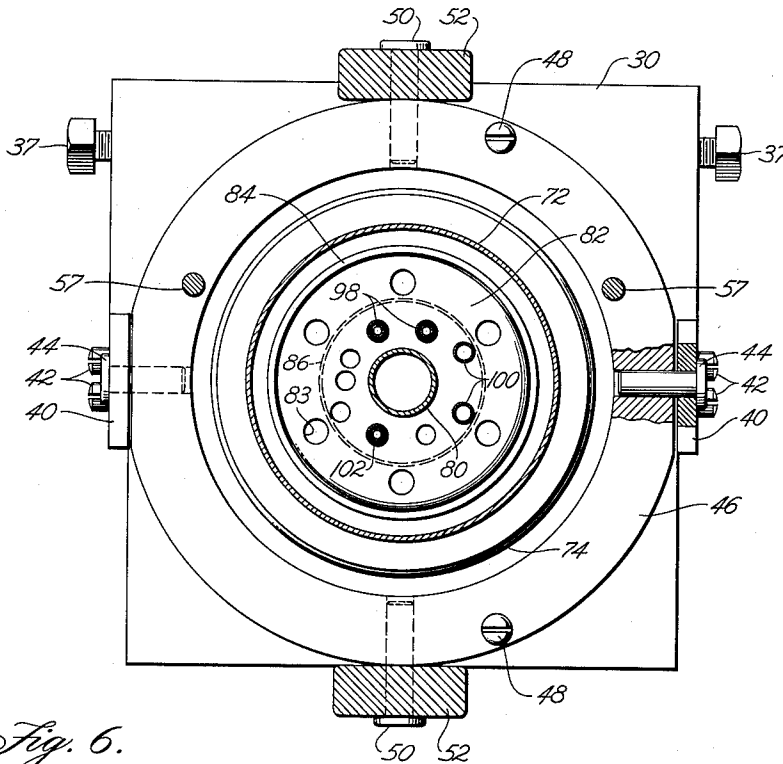


Fig. 6.

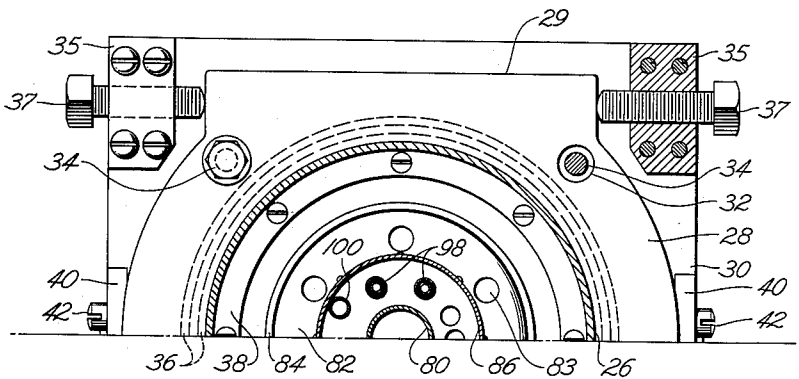


Fig. 5.

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1

2,737,590

ION SOURCE FOR A CALUTRON

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Application March 13, 1945, Serial No. 582,431

12 Claims. (Cl. 250—41.9)

The present invention relates to the art of treating a polyisotopic substance to produce a plurality of segregable masses wherein the distribution of the constituent isotopes has been altered so that one of the masses produced is enriched with respect to at least one isotope. The purpose of such treatment is to obtain a product characterized by an enhancement of the percentage of a selected isotope. More specifically, the invention relates to the device known in the art as a "calutron," a term which has been defined as "any apparatus or machine wherein isotope separation or enrichment is achieved on a large scale yielding commercially useful quantities of one or more isotopes, by appropriate separative action on gaseous ions with electrostatic or electromagnetic means or combinations of them."

The foregoing definition has been taken from an application for Letters Patent of the United States, Serial No. 557,784, filed on October 9, 1944, by Ernest O. Lawrence, now Patent No. 2,709,222. In that application, the theory of isotopic separation and the principles of operation of a calutron are so fully treated and thoroughly explored that no useful purpose would be served by here repeating the discussion contained therein.

It may be stated in passing, however, that by projecting a beam of positive ions of a vaporized or gaseous polyisotopic substance through a magnetic field acting normally to the path of the beam, the beam is caused to follow a curve wherein the ions of the heavier isotope tend to concentrate in the region adjacent the outer periphery and the ions of the lighter isotope congregate in the region adjacent the inner periphery. In other words, ions of greater mass travel along a curve of greater radius than the ions of lesser mass. By disposing suitable pockets or collectors in the path of the beam, preferably 180° from the source of the beam, it is possible to collect at least two masses, one of which is enhanced with respect to one isotope while the other is correspondingly impoverished with respect thereto.

The present invention consists essentially in an improved mount for the ion producing mechanism or "source" of the type disclosed in an application filed for Letters Patent of the United States, Serial No. 578,791, filed February 19, 1945, by William M. Brobeck. In assembling the elements of a calutron it has been found that the relative positions of the exit slit from the arc chamber, the passage between the accelerating electrodes, and the pockets of the receiver mechanism must be precisely fixed. Consequently, it is advantageous to provide a mechanism by which these elements can be given various adjusting motions, which though small in physical extent, considerably enhance the efficiency with which a calutron can be operated.

The most important object of the present invention is to provide an ion source mechanism capable of being adjusted through several different planes with respect to the other elements of the calutron.

A further object of the invention is to provide a simple, rugged mount for an ion source.

2

Still another object of the invention is to increase the efficiency with which the calutron separates a polyisotopic substance into a plurality of substantially monoisotopic masses.

5 An important feature of the invention resides in the combination of gimbals, in which an ion source support stem is suspended, with mechanism constructed to provide both axial translation and rotation of the support stem.

10 Another feature of the invention resides in a novel combination of gimbal rings and set screws by means of which the relative positions of the gimbal rings and a supporting plate for the ion source may be locked in a desired condition of adjustment.

15 These and other objects and features of the invention will more readily be 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:

20 Figure 1 is a plan view showing an improved mount constructed according to the invention and assembled in a calutron;

Figure 2 is a view in side elevation of the construction shown in Fig. 1;

25 Figure 3 is a view in cross section taken along the line 3—3 of Fig. 1;

Figure 4 is a view in cross section taken along the line 4—4 of Fig. 3;

30 Figure 5 is a view in cross section taken along the line 5—5 of Fig. 3; and

Figure 6 is a view in cross section taken along the line 6—6 of Fig. 3.

Although, as will later be discussed, there are many forms in which the invention may be embodied, it has been successfully operated in conjunction with a calutron constructed as shown schematically in Figs. 1 and 2.

35 An airtight substantially arcuate tubular vacuum vessel or tank 10 of stout metal is secured at one end to a terminal section 12 from which leads a vent 14 adapted to be coupled to a vacuum pumping system (not shown).

40 The end wall of the terminal section 12 comprises a flanged rim 16 to which is bolted a heavy metal face plate 18, a pair of ring gaskets 22 being interposed between the flanged rim 16 and the face plate 18; bolts 20,

45 spaced at intervals around the face plate, are tightened to secure the face plate 18 to the rim 16 and to compress the gaskets 22 in order to form a vacuum seal. The face plate 18 is provided with a large centrally disposed aperture 24 about the periphery of which is welded

50 a hollow cylindrical support tube 26 of medium gauge steel or other suitable material. At its outer end the support tube 26 is welded to a flat annular member 28 having an upwardly projecting shoulder 29 with flat side walls. A rectangular member 30 is secured to the

55 member 28 by four bolts 34 which pass through oversize holes 32 drilled in the machine 28 and are received in holes tapped in the plate 30. A pair of ring gaskets 36

are interposed between the faces of the members 28 and 30 in order to provide a vacuum seal therebetween. Secured to the inner face of the plate 30 on either side of

60 the projecting portion 29 of the member 28 is a pair of blocks 35 provided with tapped through-and-through holes for the reception of a pair of bolts or cap screws 37 which pass through the blocks and bear against the

65 flat side walls of the projection 29. The relative position of the members 28 and 30 may be adjusted by loosening the bolts 34 and manipulating the bolts 37. The result is to rotate the member 30 with respect to the member 28, the movement being limited by the dimensions of

70 the holes 32. When the desired condition of adjustment has been obtained, as will later be discussed, the bolts 34 are tightened to lock the members 28 and 30 in fixed

relation. Screwed to the inner face of the member 30 is a copper ring 38 dimensioned to fit snugly within the annulus 28. The function of the ring 38 is to provide a bearing surface on which the member 30 rotates and to supplement the gaskets 36 in providing an effective vacuum seal.

Secured to opposite sides of the member 30 is a pair of diametrically opposed ears or lugs 40 held in place by screws 42 and extending outwardly from the member 30. The lugs 40 serve as journals for a pair of pivot pins 44 upon which is suspended a gimbal ring 46. By reference to Fig. 2 it will be seen that the gimbal ring 46 may be rotated about the horizontally disposed pivot pins 44. In order that the position of the gimbal ring 46 may be fixed with relation to the member 30, a pair of set screws 48 are threaded through the ring and bear upon the outer surface of the member 30. The set screws 48 are disposed opposite each other at the top and bottom of the ring 46, and adjustment may be obtained by loosening one of the set screws as the other is tightened. Secured in the top and bottom of the gimbal ring 46 is a pair of diametrically opposed pins 50 pivotally supporting a pair of lugs 52 which in turn are secured to a second gimbal ring 56 by a plurality of screws 54. From an inspection of Figs. 1 and 2 it will be evident that the second gimbal ring 56 is adapted to swing about a vertical axis and to be adjusted angularly with respect to the first gimbal ring 46. In order to provide for fixing the relative positions of the gimbal rings, a pair of oppositely disposed set screws 57 are threaded through the ring 56 and bear against the outer surface of the gimbal ring 46. A desired adjustment between the gimbal rings may be obtained by loosening one of the set screws 57 as the other is tightened.

The gimbal ring 56 carries a pair of oppositely disposed L-shaped lugs 58 which extend from the outer surface of the gimbal ring and serve as retaining members or keepers for a ring gear 60 provided with external gear teeth and welded to an internally threaded bushing 62 working against a race of ball bearings 64 disposed in a circular slot cut into the outer face of the gimbal ring 56. Journaled in the bottom portion of the gimbal ring 56 is a stub shaft 66 to which is keyed a pinion 70 in mesh with the teeth of the ring gear 60. A collar 68 is pinned to the shaft 66 at its inner end and serves to anchor the shaft 66 against axial displacement.

Threaded into the bushing 62 is a cylindrical metal sleeve 72 welded at its inner end to a flexible airtight metal bellows 74 which in turn is welded to the outer face of the plate 30. At its outer end the sleeve 72 is welded or otherwise suitably secured to a centrally apertured disk 76. A circular disk or plug 78 fits into the aperture in the disk 76 and has an integral flanged portion at its inner end which is larger in diameter than the aperture in the disk 76 and bears against the inner surface thereof. A pair of ring gaskets 79 are interposed between the faces of the disk 76 and the plug 78 in order to effect a vacuum seal when the plug is pulled outwardly by tensioning mechanism later to be described. The inner surface of the plug 78 is recessed to receive one end of a hollow tubular stem member 80, and the two are permanently secured together by welding or other suitable means of connection. The stem 80 extends through the tubular support 26 and into the interior of the terminal section 12 of the tank 10 and carries at its inner end ion-producing mechanism later to be discussed. Secured to the inner surface of the plate 30 is a short cylindrical sleeve 84 within which is disposed a ceramic plug 82 apertured to receive the stem 80 and provided with other apertures to receive the various leads and cooling tubes usually associated with an ion source. Ports 83 serve to equalize the pressure on both sides of the ceramic plug 82. The plug 82 fits loosely within the sleeve 84 in order that the stem 80 may be moved through a small degree of arc when the set screws 48 or 57 are manipulated to vary

their condition of adjustment. The ceramic plug 82 has on its inner face an annular shouldered portion providing a support for a tubular metal shield 86 disposed in concentric relation with the stem 80 and extending along the greater portion of the length of the stem. Within the section 12 of the tank 10 and adjacent the inner end of the stem 80 is a brass disk 88 apertured to receive the stem 80 and providing another support for the shield 86. It will be seen that the ceramic plug 82 and the disk 88 serve to render the stem 80 and the shield 86 substantially stiff and rigid.

The plug 78 is tensioned against the disk 76 by means of a pair of hollow tubular arms 104 supported at their inner ends by a pair of lugs 105 screwed to the outer face of the disk 76. The arms 104 carry at their outer ends a cross head or bridge member 106 in the central portion of which is an aperture freely receiving a threaded tension rod 108 screwed into the plug 78. A nut 109 threaded on the outer end of the rod 108 may be tightened against the bridge member 106, thus exerting an outward pull on the plug 78 which is balanced by the pressure exerted against the disk 76 by the arms 104. The result is to draw the plug 78 outwardly so that its inner flanged portion bears against the inner surface of the disk 76 and compresses the ring gaskets 79 to effect a vacuum seal. A pair of rigid water-cooled conductors 98 carry at their inner ends a filamentary cathode (not shown) for the ion source 90 and pass through the shield 86, the disk 88, the ceramic plug 82, and the plug 78. At their outer ends the cathode leads 98 are received in a block 110 which is mounted for sliding adjustment on a rod 111 secured in a bracket 113 which is carried by the rod 108 and by a second rod 112 which is secured to the plug 78. The block 110 may be adjusted in and out in order to move the cathode leads 98 and provide for a slight adjustment of the cathode. A rigid water-cooled conductor 102 is secured at its inner end to an anode 101, and passes through the interior of the shield 86, the disk 88, the ceramic plug 82, and the plug 78. The outer end of the anode lead 102 is received in a block 114 to which water inlet and outlet connections 116 are secured.

The ion source 90 which is carried on the inner end of the stem 80 in itself forms no part of the present invention and will not be described in detail. A source suitable for use with the construction of my invention is clearly described and explained in the copending application of William M. Brobeck, and it will be sufficient here to state that the source 90 may conveniently comprise a block containing a chamber for the reception of a charge of polyisotopic vaporizable material, and an arc chamber in which the vapor is ionized by an arc discharge from a filamentary cathode disposed at the top of the chamber to an anode disposed adjacent the bottom of the chamber. The arc chamber is provided in its inner wall with an exit slit shown at 95 in Fig. 2. The source 90 may be cooled, when necessary, by flowing a liquid coolant through a conduit 100 which is supported in parallel relation to the stem 80 and loops about the source 90. Disposed within the tank 10 and supported in spaced relation from the walls thereof by suitable insulators 94 is a tubular metal liner 92. The end of the liner 92 adjacent the ion source 90 is closed by a wall 93 except for a narrow slit 96 formed by a pair of accelerating electrode plates 97 suitably secured to the wall 93. By rendering the accelerating electrode plates 97 highly negative with respect to the arc chamber, ions formed in the arc chamber are drawn through the exit slit 95 at high velocity in the form of a narrow ribbon or beam which passes between the plates 97 and into the interior of the liner 92. As fully explained in the copending applications above referred to, the ion source 90 and the tank 10 with the liner 92 are interposed between the pole pieces of a powerful magnet (not shown), the arrangement being such

that the flux acts through a plane perpendicular to the plane of the drawing in Fig. 1.

It has been found highly necessary that the exit slit 95 be aligned with the direction of the flux between the pole pieces of the magnet; otherwise the beam of ions may be highly unstable. Consequently, the axial rotation of the stem 80 which is obtained by manipulation of the set screws 37 is effective to provide the adjustment necessary in order to align the slit 95 with the magnetic flux.

It has also been found that the spacing between the exit slit 95 of the arc chamber and the accelerating electrode plates 97 is highly critical. The spacing may be adjusted by rotating the stub shaft 66 with a screw driver. The ring gear 60 turns as a result of the rotation of the pinion 70, but since the ring gear 60 and the bushing 62 are held against axial displacement by the keepers 58, the threaded sleeve 72 is forced to move axially, inasmuch as it is in threaded engagement with the bushing 62. This axial movement is, of course, transmitted to the disk 76 and the plug 78 which carries the stem 80.

It is desirable when assembling the calutron to adjust the ion source 90 so that the exit slit 95 is disposed exactly parallel to the accelerating electrode plates 97, a condition of adjustment which frequently requires that the ion source 90 be tilted either up or down or from side to side. These adjustments are provided by the gimbal rings 46 and 56, and the desired condition of adjustment may be maintained by setting the screws 48 and 57 to lock the gimbal rings in fixed relation to each other and to the plate 30 which, as has been previously explained, is locked to the annular member 28 fixed on the outer end of the support tube 26.

It will now be evident that I have described an improved mount for a calutron ion source, which has the important advantage of providing practically universal adjustment of the ion source. The gimbal ring combination affords angular adjustment of the entire source in two planes at right angles to each other, the ring gear and sleeve combination makes it possible to translate the entire source axially to adjust the spacing between the arc chamber and the accelerating electrodes, and the source 90 may also be rotated on axis by loosening the bolts 34 and manipulating the set screws 37. It should also be noted that accompanying each combination of elements affording an adjustment is a corresponding means for locking the members in their adjusted relation. To those skilled in the art it will be apparent that there are many other ways in which the present invention could be carried out, and that the structure herein described is only one embodiment of the invention defined in the appended claims.

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

1. A calutron comprising a support tube, a first gimbal ring, means for mounting said ring on said tube for limited rotation about a first axis located diametrically of said tube, a support stem passing through said tube, a second gimbal ring for mounting said stem on said first ring for limited rotation about a second axis located diametrically of said tube and at right angles to said first axis, means for adjusting and securing the angular position of said gimbal rings, means for moving said stem substantially axially of said tube independent of said gimbal rings, and means for connecting said stem and said tube by a flexible air-tight member accommodating the several degrees of motion afforded by said gimbal rings and said moving means.

2. A calutron comprising a support tube, a first gimbal ring, means for mounting said ring on said tube for limited rotation about a first axis located diametrically of said tube, a support stem passing through said tube, a second gimbal ring for mounting said stem on said first ring for limited rotation about a second axis located diametrically of said tube and at right angles to said first axis, means

for moving said stem substantially axially of said tube, and a plug surrounding and supporting said stem, said plug having curvilinear surfaces bearing upon the interior of said tube and accommodating the several degrees of motion afforded by said gimbal rings and said moving means.

3. A calutron comprising a support tube, a stem disposed within said tube, means for rotating said stem about its axis, means for moving said stem axially within said support tube, means for tilting said stem through two planes disposed at right angles to each other, and air-tight means for flexibly connecting said stem and said tube.

4. A calutron comprising a support tube, a stem disposed within said support tube, means for rotating said stem about its axis, gimbals mounting said stem on said tube, and air-tight means for flexibly connecting said stem and said tube.

5. A calutron comprising a tank, a support tube mounted on one wall of said tank, a stem extending through said tube and into said tank, means secured to said tube mounting said stem for rotation about its axis, axial translation, and for tilting motion in two planes at right angles to each other, and air-tight means for flexibly connecting said stem and said tube.

6. A calutron comprising a tank, a support tube secured to one wall of said tank, a first gimbal ring secured to said tube, means for rotating said ring about said tube, a second gimbal ring pivotally mounted on said first ring, a disk movably supported by said second gimbal ring, means for translating said disk axially of said ring, a stem secured to said disk, and air-tight means for flexibly connecting said stem and said tube.

7. A calutron comprising a tank, a support tube secured to one wall of said tank, a first gimbal ring secured to said tube, means for rotating said ring about said tube, a second gimbal ring pivotally mounted on said first ring, a disk movably supported by said second gimbal ring, means for translating said disk axially of said ring, a stem secured to said disk, means for adjustably positioning said rings with respect to said tube and to each other, and air-tight means for flexibly connecting said stem and said tube.

8. A calutron comprising a tank, a support tube secured to one wall of said tank, a first gimbal ring secured to said tube, means for rotating said ring about said tube, a second gimbal ring pivotally mounted on said first ring, a disk movably supported by said second gimbal ring, means for translating said disk axially of said ring, a stem secured to said disk, means including a plurality of set screws for adjustably positioning said rings with respect to said tube and to each other, and air-tight means flexibly connecting said stem and said tube.

9. A calutron comprising a vacuum vessel, walls forming a tubular member disposed within said vacuum vessel, means supporting said tubular member in fixed spaced relation from the walls of said vessel, an accelerating electrode disposed at one end of said tubular member, a support tube secured to a wall of said vessel, a stem extending through said support tube, an ion producing mechanism carried on the end of said stem adjacent said accelerating electrode, gimbal rings secured to said support tube and to said stem for adjusting the position of said ion producing mechanism with respect to said accelerating electrode through two planes at right angles to each other, means for angularly displacing said stem and gimbal rings about the axis of said stem, means for translating said stem and ion producing mechanism axially to vary the distance between said ion producing mechanism and said accelerating electrode, and air-tight means for flexibly connecting said stem and said tube.

10. A calutron comprising a vacuum vessel, walls forming a tubular member disposed within said vacuum vessel, means supporting said tubular member in fixed spaced relation from the walls of said vessel, an accelerating electrode disposed at one end of said tubular member, a support tube secured to a wall of said vessel, a stem

7

extending through said support tube, an ion producing mechanism carried on the end of said stem adjacent said accelerating electrode, gimbal rings secured to said support tube and to said stem for adjusting the position of said ion producing mechanism with respect to said accelerating electrode through two planes at right angles to each other, means for rotating said stem and gimbal rings about said tube, and air-tight means for flexibly connecting said stem and said tube.

11. A calutron comprising a vacuum vessel, walls forming a tubular member disposed within said vacuum vessel, means supporting said tubular member in fixed spaced relation from the walls of said vessel, an accelerating electrode disposed at one end of said tubular member, a support tube secured to a wall of said vessel, a stem extending through said support tube, an ion producing mechanism carried on the end of said stem adjacent said accelerating electrode, gimbal rings secured to said support tube and to said stem for adjusting the position of said ion producing mechanism with respect to said accelerating electrode through two planes at right angles to each other, means for translating said stem and ion producing mechanism axially to vary the distance between said ion producing mechanism and said accelerating electrode, and air-tight means for flexibly connecting said stem and said tube.

12. A calutron comprising a tank, a support tube secured to one wall of said tank, a first gimbal ring secured to said tube, a second gimbal ring pivotably mounted on said first ring, a disc movably supported by said second gimbal ring, a stem secured to said disc and entering said tube, an externally threaded cylindrical sleeve rigidly secured to said disc and extending therefrom toward said

8

tube, a plurality of threaded bushings engaging the external threads of said cylindrical sleeve and slidably engaging said second gimbal ring, a ring gear rigidly secured to said bushings and said disc, a pinion gear rotatably mounted upon said second gimbal ring and engaging said ring gear whereby angular displacement of said pinion gear produces axial displacement of said stem and disc relative to said tube and gimbal rings, and flexible air-tight connecting means secured to said tube and said cylindrical sleeve.

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