July 26, 1955 C. STARR 2,714,166

CALUTRON STRUCTURE

Filed Oct. 27, 1947 3 Sheets-Sheet 1

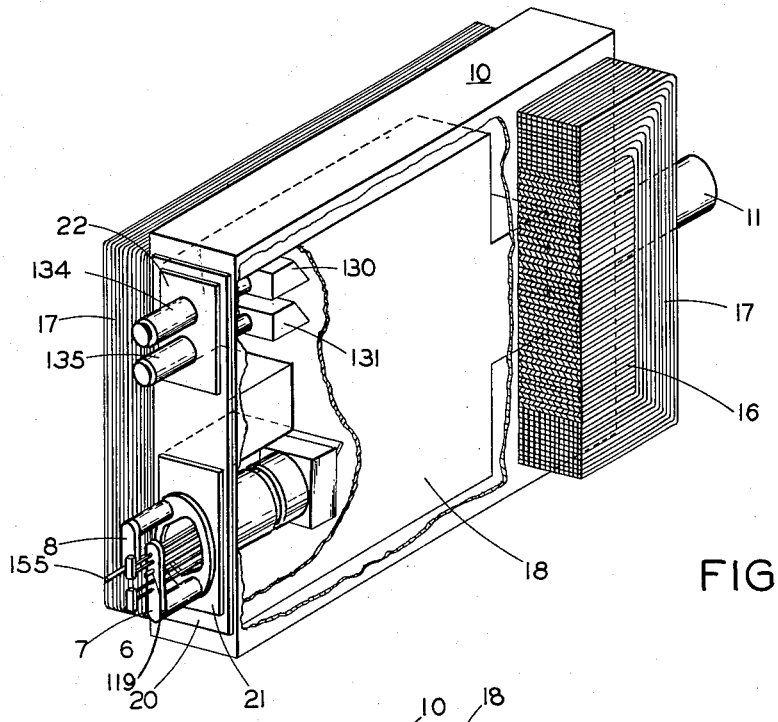

FIG 1

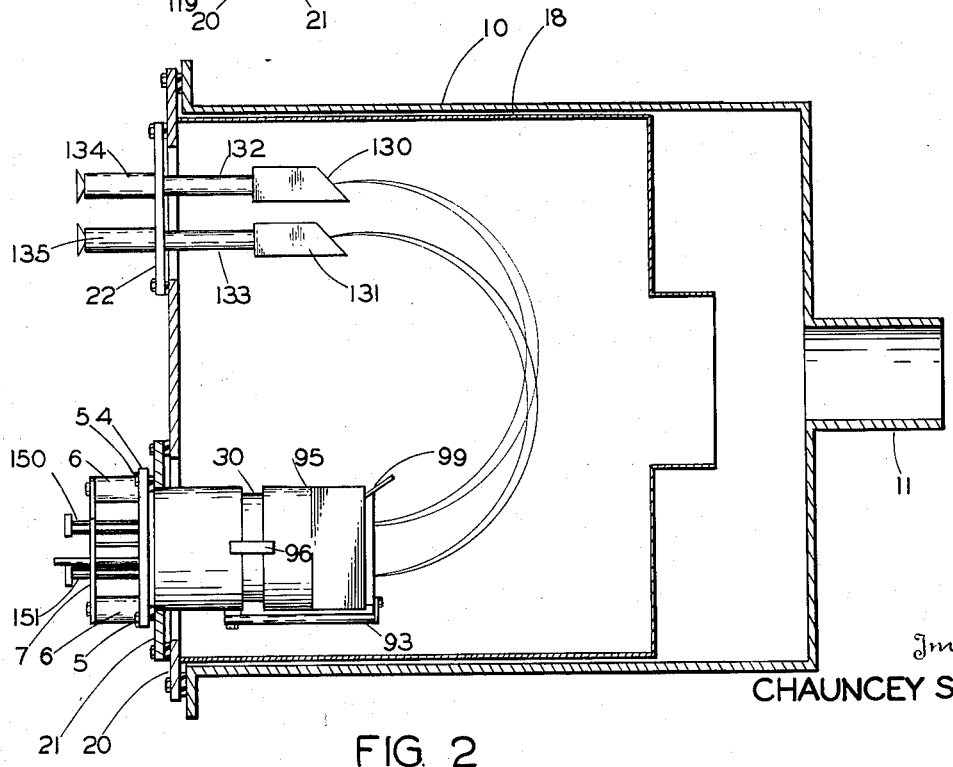

FIG. 2

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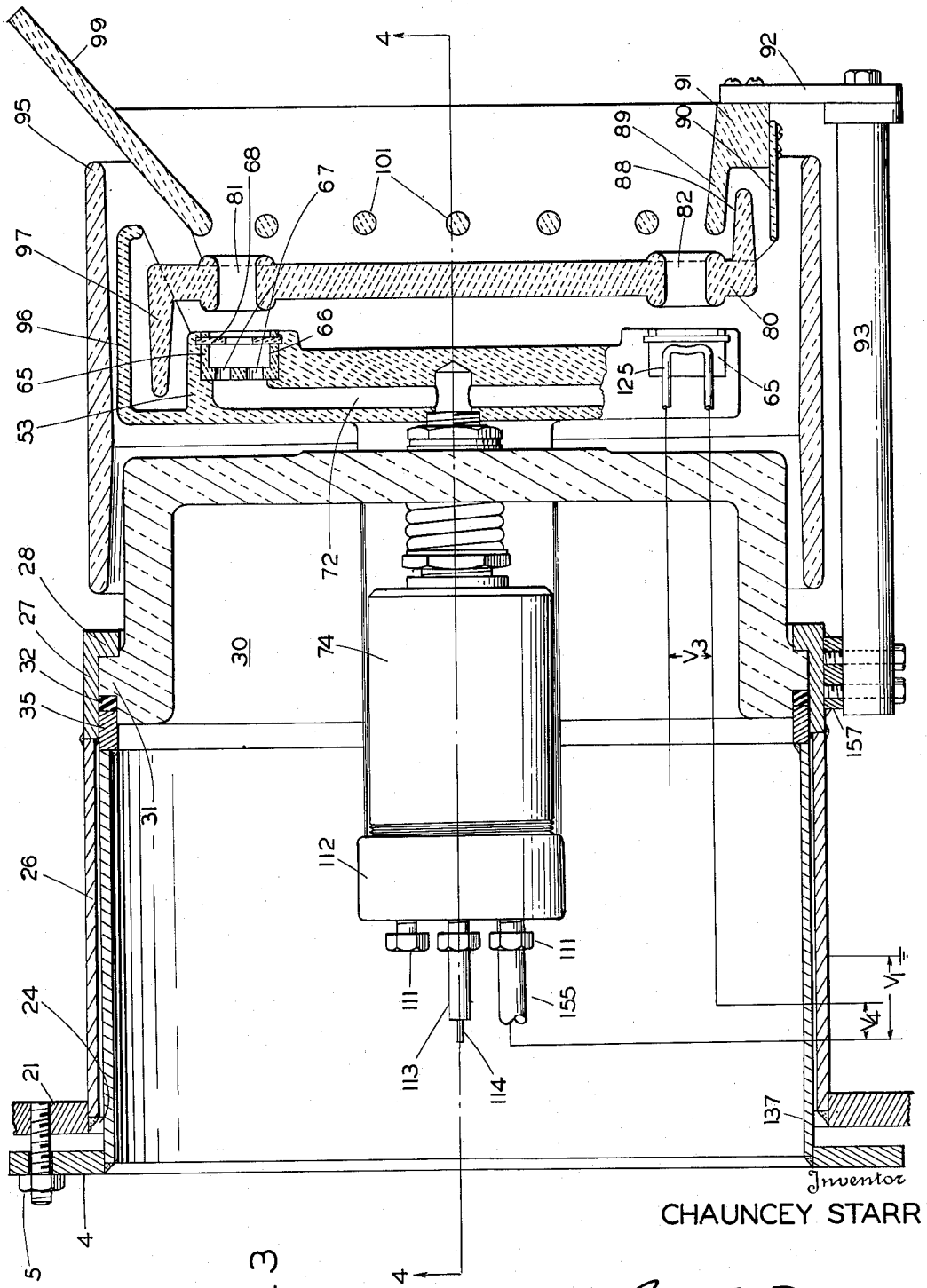

FIG. 3

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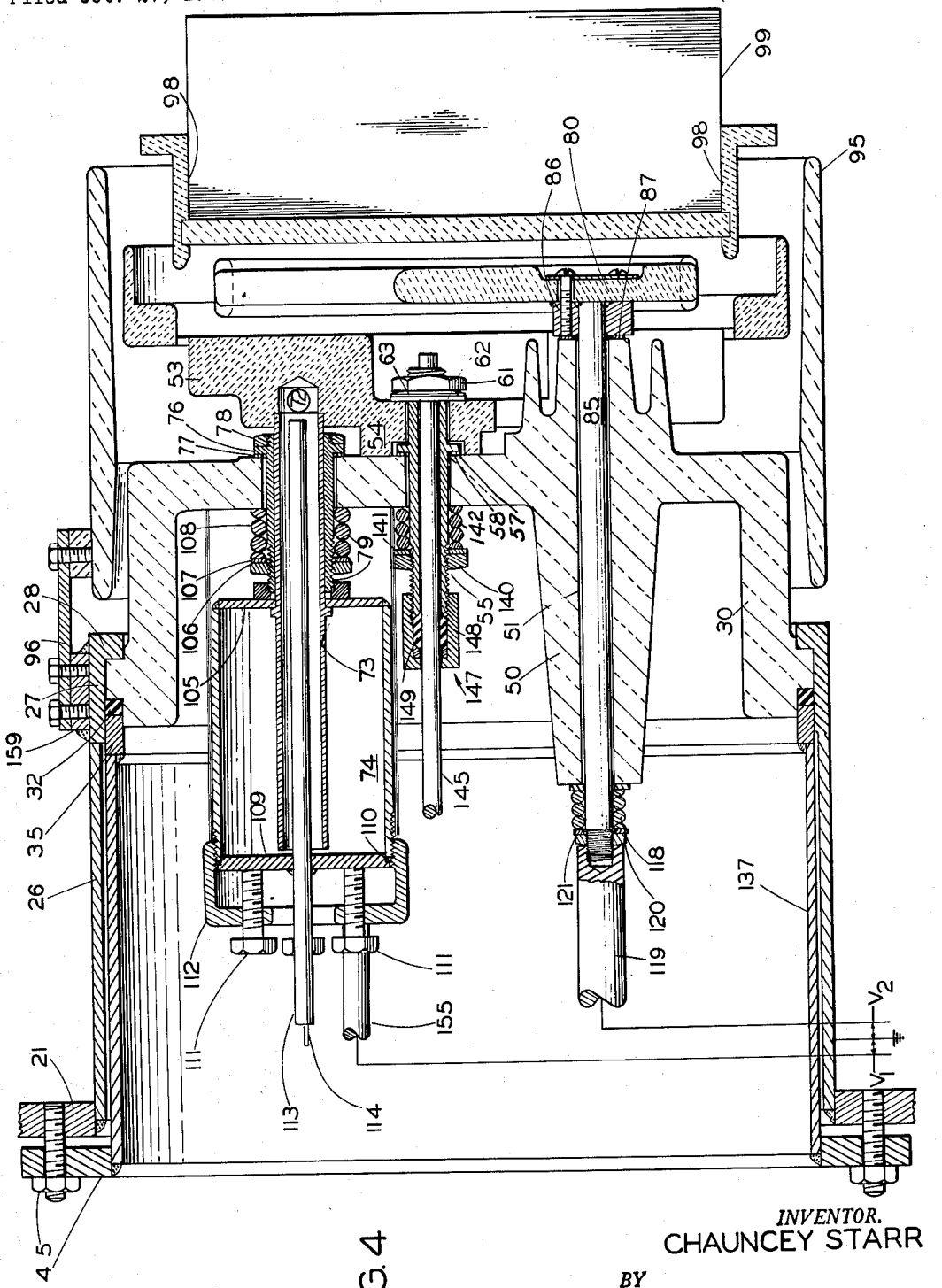

FIG. 4

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2,714,166

CALUTRON STRUCTURE

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Application October 27, 1947, Serial No. 782,442

14 Claims. (Cl. 250—41.9)

The present invention relates to improvements in calutrons of the type disclosed in the application of Ernest O. Lawrence, Ser. No. 557,784, filed October 9, 1944, the invention being concerned principally with improvements relating to the transmitter, that is the ion source and related apparatus for transmitting a ribbon or beam of positive ions.

The calutron structure customarily involves an ion source unit which is customarily referred to as the transmitter in calutron terminology, and in this type of apparatus, especially in the type which is referred to as the "hot source" type, the transmitter itself is at a high potential; thus, the situation is that of a high potential body disposed in a relatively intense magnetic field and in a vacuum, which are the conditions prevailing in calutron apparatus.

The process of ionization which takes place at the ion source unit, of course, gives rise to considerable numbers of free electrons resulting in a large amount of undesirable electron oscillation in the vicinity of the high potential body within the magnetic field. This electron drain has been a serious problem throughout the history of calutron operation. It gives rise to very undesirable and destructive heating and bombardment effects which are very deleterious to the equipment and very prone to give rise to failure of various parts of the equipment. The electron drain tends to circulate around that side of the transmitter unit corresponding to the direction of the ion beam transmitted by the unit and with prior known structure it has been possible for the electron drain, that is the oscillating volume, to circulate completely around the high potential body, that is, the transmitter. This phenomenon was possible inasmuch as the conventional type of structure involved the transmitter, that is the high potential body, being supported from a side wall of the evacuated tank, that is from a removable face plate, by means of a relatively large insulator bushing, the bushing however having a maximum transverse dimension less than the maximum transverse dimension of the high potential body such that there was space on the sides of the bushing support permitting the existence of oscillating volumes of electrons completely surrounding the high potential body.

It is the principal object of my invention to provide improved constructional arrangements calculated to overcome the foregoing described objections, principally that is, to prevent the circulation of electron drain, that is the existence of oscillating volumes of electrons completely around the high potential body, that is the transmitter unit.

It is furthermore a specific object of my invention to accomplish the purpose set forth in the preceding object by substantially filling the space between the high potential body and the supporting wall so that the said space cannot be occupied by oscillating volumes of electrons.

A further object of my invention is to eliminate the need for the conventional insulator bushings used in calutrons for supporting the transmitter and the accelerating electrode slits by providing a single structure of

insulating material having substantially the same transverse dimensions as the transmitter unit itself for supporting the transmitter unit.

Further objects and many additional advantages of my invention will become apparent from the following detailed description and annexed drawings wherein Fig. 1 is a diagrammatic illustration of the manner in which a calutron unit may be set up showing the relative position of the transmitter thereof. Fig. 2 is a cross sectional view of the calutron tank showing the transmitter and receiver units. Fig. 3 is a cross sectional side elevation of a transmitter unit embodying the principles of my invention. Fig. 4 is a view taken along line 4—4 of Fig. 3.

Referring now more particularly to Fig. 1 of the drawings, there is shown schematically a calutron, that is an electromagnetic type of isotope separation apparatus, and in Fig. 1 numeral **10** designates a rectilinear evacuated tank in which the calutron process is carried out. The tank has an outlet **11** at the back which may be connected to a suitable evacuating system, not shown, consisting ordinarily of a diffusion pump backed up by a rotary mechanical pump. On opposite sides of tank **10** are laminated iron cores or pole pieces as designated at **16**, and wound around these pole pieces are electrical windings **17**. The cores and windings produce an intense magnetic field which is in a direction perpendicular, that is transverse with respect to the tank.

Within the tank **10** is a liner structure **18** having the general shape and configuration as shown in Fig. 1, and the interior of the liner is evacuated as well as the remainder of the interior of the tank. Tank **10** has a relatively large vertical face plate **20** at the front which is attached to the tank in a manner to form a seal between the tank and the face plate, and it supports the liner structure **18** within the tank. Numerals **21** and **22** designate lower and upper sub-face plates, respectively, attachable to the main face plate **20** in a sealing manner, and cooperating respectively with the lower and upper portions of the liner portion **18**. The upper subface plate **21** carries and supports the ion beam transmitter as will presently be described in detail, and the upper sub-face plate **22** supports the collector structure, the transmitter being operable to project a pair of beams of ions into the structure **18** which beams are bent into arcs of a circle under the influence of the magnetic field whereby the separated components of the beam may be separately collected by the collector structure carried by sub-face plate **22**. This is shown diagrammatically in Fig. 2 which shows the tank **10** and the liner **18** in cross section with the transmitter unit and receivers or collectors in their relative position within the liner structure **18**.

The collectors include boxes or compartments **130** and **131** supported from sub-face plate **22** by extending numbers **132** and **133** which pass through sub-face plate **22** and are sealed thereto as is well known in the art. The members **132** and **133** have portions **134** and **135** exterior of the sub-face plate **22** which provide for various adjustments of the boxes **130** and **131**.

As shown in Fig. 2, there is attached to the sub-face plate **21**, a ring member **4** by bolts **5**. Numerals **6** diagrammatically represent insulator members suitably attached to ring member **4** which serve to support and space from the transmitter unit, panel, or bracket elements **7** and **8** which support the ends of various electrical and water leads extending into the transmitter unit as also shown in Fig. 1 and as will be referred to more in detail hereinafter.

Referring more particularly now to Fig. 3 of the drawings which shows in cross section the details of the transmitter unit, my invention may be more specifically under-

stood. The sub-face plate 21 has a cylindrical opening 24 therein and fitting in this opening and extending therefrom inwardly as respects the calutron tank is a metal ring or cylinder 26 which is attached to the face plate 21 by welding as shown. At the inner end of the ring 26 is another metal ring 27 of slightly greater thickness and having an annular shoulder or flange 28, this ring being attached to the inner end of the ring 26 by welding as shown. Numeral 30 designates a relatively large dome-shaped structure of insulating material such as ceramic and this dome-shaped structure has an annular ring or flange portion 31 which engages within the ring 27 with the flange portion abutting against the shoulder 28 of the ring 27. Interposed between the flange 31 of the dome-shaped structure 30 and another ring member 35 within the ring 27 is a ring of sealing material 32. Ring member 35 is welded to the end of a cylinder or barrel member 137 within member 26 which is welded at its end to previously described ring 4 which as described is attached to sub-face plate 21 by bolts 5. As may be observed, tightening of bolts 5 compresses sealing ring 32.

Referring now to Fig. 4 of the drawings, the structure 30 as shown in this figure includes an integrally formed portion 50 which forms what corresponds to an insulator bushing as normally used for carrying a high voltage lead from the exterior to the interior of an evacuated space as in calutrons. The portion 50 involves a round tapering portion extending to the left from the end of the dome structure 30 and a shorter generally cylindrical portion having a relatively deep annular depression or flute in its end as shown. The portion 50 has a longitudinal bore 51 extending internally therethrough as shown and as will be referred to again.

Referring again to Fig. 3 of the drawings, numeral 53 designates generally a structure involving two elongated chambers in which the ionization takes place, and a manifold whereby a vapor of the medium to be ionized is conducted to the ionizing chambers. The structure 53 is conventionally made of graphite and as may be seen more particularly on the view of Fig. 4, it has an integral portion 54 which fits against the face of the dome structure 30 and which is attached thereto by means of a lug 55 which involves a bolt passing through an opening in the face of the dome structure 30 and through an opening in the portion 54 of the housing structure 53. The lug or bolt 55 has a flange 57 disposed in a similarly shaped recess in the portion 54 of the housing structure 53, and interposed between this flange and the adjacent face of dome structure 30 is a sealing ring or gasket 58 so as to provide a vacuum-tight seal. The lug or bolt 55 secures the bracket portion 54 by a nut 61 on its inner end, there being a spacer 62 and a compressible washer 63 interposed between the nut and the portion 54 of housing structure 53. Bolt 55 is screw threaded at its opposite end, as shown, having a nut 140 and a washer 141 thereon with a coil spring 142 interposed between washer 141 and dome structure 30. Tightening of nut 140 compresses gasket 58 and secures bolt 55 to the dome structure 30. Bolt 55 has a longitudinal bore extending through it and extending through this bore is a rod 145 which extends through stuffing box or packing gland 147 comprising a gland member 148 engaging the bolt 55 in screw threaded relationship and having packing material 149 therewithin which is normally urged against the end of bolt 55 and is compressed to form a seal as well known in the art.

Referring again to Fig. 3 of the drawings, the structure 53 forms two elongated recesses which form the ionization chambers, these recesses being parallel to the face of the dome structure 30 and being horizontally disposed. These recesses are designated by the numerals 65—65, and each of them is lined with material as shown at 66 which may preferably be graphite, this material having longitudinal slots or openings 67 at the bottom part of the recess to permit entrance of material to be ionized into

the chamber formed. At the outer side of each of the ionization chambers, that is at the top of the chamber, are relatively thin strips preferably of graphite as designated by the numeral 68, these strips fitting in slots formed in the structure 53 and their inner edges being adjacent so as to form a slit-like opening from the ionization chamber. Referring to Fig. 3, the two ionization chambers are in communication by means of a manifold 72 in the member 53 and this manifold is in communication with a supply of the vapor of the material to be ionized as will be described. The manifold 72 communicates by way of a tube 73 (see Fig. 4) with a charge container 74 disposed within the cylindrical members 26 and 137 and the dome structure 30, and within the container a charge of solid material to be ionized is vaporized by the application of heat thereto. The details of construction of the charge container and the manner of vaporizing the material are in themselves no part of my invention. The tube 73 is sealed in relation to the face of the dome structure 30 by means of a flange 76 and a sealing ring or gasket 77 interposed between the said flange and the face of the dome structure 30, the flange 76 being urged against the sealing ring by a nut 78 which engages the end of a sleeve 79 through which the tube 73 passes as shown, the sleeve extending through an opening in the end of dome 30. The sleeve 79 engages in screw-threaded relationship with a collar attached as shown to a head 105 forming the end of the charge container 74. Also engaged on sleeve 79 is a nut 106 and a washer 107 with a coil spring 108 interposed between washer 107 and the end of dome 30. The assembled parts as described hold the charge container 74 and tube 73 in position and in sealing engagement with dome 30.

The left end of charge container 74 is closed by a disc 109 having an annular shoulder as shown having a gasket ring 110 therein which is interposed between disc 109 and the end of the charge container 74. Disc 109 is urged against the end of the container 74 by cap screws 111 engaged in a screw cap 112 which engages the end of container 74 in screw-threaded relationship. By tightening screws 111 disc 109 is sealed against container 74. The screw cap 112 has a central opening as shown, and extending through it is an electrical heating element 113 which extends through disc 109 into the interior of container 74 being disposed within tube 73, the end of which is spaced from disc 109. The arrangement provides for vaporizing solid charge material in container 74, the vapor passing through tube 73 to the manifold 72. The heating element 113 is a well known commercial type of heater involving a central wire 114 which is connected to a suitable power source, the outer tube of the unit being grounded, and there being a powdered material between the rod and tube.

During operation regulated potentials are maintained on various of the parts. In the particular embodiment disclosed, the face plate structure and cylinders 26 and 137 are at ground potential as indicated on Fig. 3 and Fig. 4. The ion source unit is maintained at positive 35 kilovolts as indicated by the character V_1 on Fig. 4 the connection being through a rod 155 attached to the charge vaporization chamber 74 and shown broken away on Fig. 4 and extending through bracket 8 on Fig. 1.

Disposed adjacent one end of each the ionization chambers 65 are electron emitters of generally U-shaped construction (see Fig. 3), only one of these being shown as at 125 to avoid obscuring the showing of other parts. The emitters are arranged as is conventional in calutrons to emit a stream of electrons along the ionization chamber to bombard the vapor therein to cause ionization thereof, the operation being well known to the art. A suitable potential V_3 is impressed across the leads to the emitter 125 as shown diagrammatically on Fig. 3, and the leads in practice are sealed at the point where they pass through the end of dome 30. The leads

may be in the form of water tubes as shown at **150** and **151** in Fig. 2.

As is known in the art, an arc is struck within the ionization chambers and a suitable potential for sustaining this arc is maintained between emitter **125** and structure **53** as represented by character V_4 on Fig. 3, structure **53** as described being at the potential of chamber **74**.

Referring again to Fig. 3 of the drawings, the housing **53** in which is formed the ionization chambers, has adjacent thereto a structure designated by the numeral **80** which forms accelerating electrode slits cooperating with the ion sources in the housing **53**. The structure **80** is rectangular in configuration and has two elongated slit-like formations designated at **81** and **82**, the structure having shoulder or rib-like formations forming the periphery of these slits, the slits being parallel and aligned with the slit-like openings in the ionization chambers formed in the housing **53**. The structure **80** is supported by means of a rod **85** (see Fig. 4) which extends longitudinally through the bore **51** in the portion **50** of the dome structure **30**. The rod **85** has a spacer member **86** attached to its end by welding or the like, and the structure **80** is attached to the spacer member **86** by screws as shown. The spacer member **86** is spaced from the portion **50** by a sealing member **87** as shown so as to make the arrangement vacuum tight.

Rod **85** at its other end beyond portion **50** extends through a coil spring **118** and screws into a tapped hole in the end of conductor rod **119**. A nut **120** engages rod **85** adjacent the end of rod **119** and a washer **121** is between the nut and coil spring **118**. The coil spring is normally under compression retaining the parts securely in assembled sealing relationship. The accelerating electrode slit structure **80** is maintained at a negative potential of 15 kilovolts as represented by the character V_2 on Fig. 4, the connection being through rod **119** shown broken away on Fig. 4 and supported by bracket **7** on Fig. 1.

Referring to Fig. 3 of the drawings, numeral **96** designates a baffle structure which is formed integrally with the housing **53**, extending upwardly and outwardly from the upper part thereof, and interleaved between the horizontal portion of this structure and the structure **53** is a rib or leaf **97** extending inwardly from the structure **80**, it being formed integrally therewith for purposes which will be described. At the lower part of the structure **80** is a similar rib or leaf **88** extending in the opposite direction and interleaving between comparable leaves or ribs **89** and **90**; the rib or leaf **89** is above the rib **88** and is formed integrally with the lower part of a funnel or throat-like structure designated generally at **91**. This structure is attached to and supported from a vertical bracket **92** which is attached by cap screws as shown to tubular horizontal bracket **93** which in turn is attached by cap screws through its end to a spacer member **157** welded to ring member **27** as shown. The throat structure **91** has vertical sides **98**, as may be seen on Fig. 4, and a flat inclined upper part or top **99** (see Fig. 3), and between the side walls is formed a grill work comprising the horizontal rods as may be seen at **101** on Fig. 3. As will be presently described more in detail, positive ions are drawn from the ionization chambers by the accelerating electrodes which are maintained at a negative potential of 15 kv. as described above; the ionization produces considerable numbers of free electrons which in turn produce additional ionization in the vicinity of the accelerating electrodes on both sides thereof. The structure just described tends to dump the electrons constituting drain on either side of the accelerating electrode structure **80**. The drain tends to circulate upwardly on the left side of the structure **80** and downwardly on the right side thereof looking at Fig. 3, and the rib **97**, interleaved as shown and described, tends to cause the first-mentioned drain to dump as it traverses the tortuous passageway around this rib. Similarly the drain on the opposite side of the structure **80** tends to be dumped passing around the rib **88**.

Surrounding the entire transmitter unit is a sleeve-like structure **95** which is preferably formed of ceramic material; the left end of this structure is circular and is around the dome structure **30**, and the right end of this structure is square (see Figs. 1 and 2), forming a "cuff" so to speak which incloses and is spaced from the structure **80** and is also around part of the throat or nose structure **91**. The structure **95** is supported from ring **27** by means of a bracket **96** which is attached at one end to the structure **95** by cap screws as shown, and at the other end by additional cap screws to a spacer member **159** which is welded as shown to ring **27**.

As has been previously set forth, in heretofore known calutron transmitters, there was opportunity for electron drain to circulate completely around the transmitter unit in a direction at right angles to the magnetic field. As will be observed, in my arrangement, the transverse dimension of the dome structure **30** is substantially coextensive with the entire transmitter unit itself so that space which might otherwise be occupied by electron drain, that is oscillating volumes of electrons circulating completely around the unit, is wholly occupied, thus eliminating the possibility of the existence of such oscillating volumes. The dome structure **30**, of course, must be protected against the destructive bombardment effects of the drain which would otherwise circulate around the unit, and in order to thus protect the dome structure **30**, the dumping arrangement comprised in part of the ribs **97** and **88** on the accelerating electrode structure **80** is provided. This arrangement tends to cause the free electrons to be dumped in a plane parallel to the outlet of the ionization chambers to minimize the destructive effect of this drain tending to bombard the structure **30**. Further protection in this respect is provided by the ceramic member **95**.

From the foregoing, those skilled in the art will observe that I have provided an arrangement whereby the objections to previously known calutron structures permitting circulation of drain current completely around the transmitter unit have been obviated. The need for individual insulator bushings for supporting the transmitter unit, and for individually supporting the accelerating electrode structure has been eliminated since the entire apparatus is supported by and insulated by the dome structure **30**.

The foregoing illustrates a preferred form of my invention, and since it may be practiced in various modifications of the preferred form, it is intended that the disclosure be interpreted as illustrative only, and that the boundaries of the invention be determined in accordance with the scope of the claims appended hereto.

I claim:

1. In a calutron wherein a body including an ion source at high potential is disposed in a magnetic field and in a high vacuum, in combination, an evacuated tank having a generally dome-shaped structure formed of insulating material extending inwardly from a side wall of the tank and forming part of the tank and having the ion source supported therefrom, a slit-forming accelerating electrode adjacent the ion source, and interleaving baffle members disposed at the top and bottom of the ion source adjacent the accelerating slit, and generally parallel thereto, providing a tortuous passageway for electron drain so as to cause dumping of free electrons.

2. The structure as in claim 1 wherein the tortuous passage at the top is at one side of the accelerating electrode and the tortuous passageway at the bottom is at the other side of the accelerating electrode.

3. In a calutron wherein a body including an ion source at a high potential is disposed in a magnetic field and in a high vacuum, in combination, an evacuated tank having said body therein, a slit-forming accelerat-

ing electrode adjacent the ion source, interleaving baffle members disposed at the top and bottom of the ion source adjacent the accelerating slit and generally parallel thereto providing a tortuous passageway for electron drain, and a member made of insulating material disposed adjacent the side of the ion source opposite the accelerating slit and having a transverse dimension substantially coextensive with said ion source to avoid the existence of a closed path for electron flow around the ion source.

4. The structure of claim 3 wherein the tortuous passageway at the top is at one side of the accelerating electrode and the tortuous passageway at the bottom is at the other side of the accelerating electrode.

5. In a calutron wherein a body including an ion source at a high potential is disposed in a magnetic field and in a high vacuum and has accelerating means to accelerate positive ions from said source at right angles to the magnetic field, in combination, an evacuated tank having said body supported therein, means comprising a member made of insulating material disposed adjacent the side of said body opposite from said accelerating means, said member having a dimension in the direction of the magnetic field substantially coextensive with that of the ion source and having substantial depth transversely to the magnetic field whereby a closed path for electron drain completely around the ion source is eliminated, said member being substantially cylindrical in shape and having an integral portion of generally round elongated configuration, said integral portion having the general shape and configuration of an insulator bushing and having a longitudinal bore therethrough providing for passage of an electrical conductor.

6. In a calutron wherein a body including an ion source at a high potential is disposed in a magnetic field and in a high vacuum and has accelerating means to accelerate positive ions from said source at right angles to the magnetic field, in combination, an evacuated tank having said body supported therein, means comprising a member made of insulating material disposed adjacent the side of said body opposite from said accelerating means, said member having a dimension in the direction of the magnetic field substantially coextensive with that of the ion source and having substantial depth transversely to the magnetic field whereby a closed path for electron drain completely around the ion source is eliminated, and an open ended sleeve-like member made of insulating material and disposed around the ion source and around said first mentioned member.

7. In a calutron wherein a body including an ion source at a high potential is disposed in a magnetic field and in a high vacuum and has accelerating means to accelerate positive ions from said source at right angles to the magnetic field, in combination, an evacuated tank having said body supported therein, a member of insulating material formed generally in the shape of a hollow cylinder closed at one end, the closed end of said cylindrical member being disposed adjacent the side of said body opposite said accelerating means, said closed end having an area substantially coextensive with said ion source, and means forming a vacuum-tight mechanical supporting connection between the open end of said cylindrical member and an interior surface of said tank.

8. In a calutron wherein a body including an ion source at a high potential is disposed in a magnetic field and in a high vacuum and has accelerating means to accelerate positive ions from said source at right angles to the magnetic field, in combination, an evacuated tank having said body supported therein, a member of insulating material formed generally in the shape of a hollow cylinder closed at one end, the closed end of said cylindrical member being disposed adjacent the side of said body opposite said accelerating means, said closed end having an area substantially coextensive with said ion source, and means forming a charge containing and vaporizing device disposed within said cylindrical member and supported from the closed end thereof, the closed end of said cylindrical member having a passageway therethrough through which the charge vapor may pass from said vaporizing device to said body.

9. In electromagnetic isotope separating apparatus, in combination, a closed tank, means for evacuating said tank to a high vacuum, means for forming a high intensity magnetic field traversing said tank from one side thereof to the other, said tank having at one end thereof a generally cylindrical hollow open ended re-entrant portion, a generally cylindrical hollow member of insulating material having one end open and the other end substantially closed, means forming a vacuum-tight connection between the inner end of said re-entrant portion and the open end of said cylindrical member, and an ion source supported by said cylindrical member and disposed exteriorly thereto adjacent the closed end thereof, said ion source and said cylindrical member being substantially coextensive in transverse area.

10. Apparatus, as claimed in claim 9, wherein the closed end of said cylindrical member has a passageway extending therethrough for the introduction of vapor to said ion source.

11. Apparatus, as claimed in claim 9, wherein the closed end of said cylindrical member has a first passageway extending therethrough for the introduction of vapor to said ion source and also has a second passageway extending therethrough for accommodating a high potential electrical conductor.

12. In electromagnetic isotope separating apparatus, in combination, a closed tank, means for evacuating said tank to a high vacuum, means for forming a high intensity magnetic field traversing said tank from one side thereof to the other, said tank having at one end thereof a generally cylindrical hollow open ended re-entrant portion, a generally cylindrical hollow member of insulating material having one end open and the other end substantially closed, means forming a vacuum-tight connection between the inner end of said re-entrant portion and the open end of said cylindrical member, an ion source supported by said cylindrical member and disposed exteriorly thereto adjacent the closed end thereof, and means forming a charge containing and vaporizing device disposed within said cylindrical member and supported from the closed end thereof, the closed end of said cylindrical member having a passageway extending therethrough through which the charge vapor may pass from said vaporing device to said ion source.

13. In electromagnetic isotope separating apparatus, in combination, a closed tank, means for evacuating said tank to a high vacuum, means for forming a high intensity magnetic field traversing said tank from one side thereof to the other, said tank having at one end thereof a generally cylindrical hollow open ended re-entrant portion, a generally cylindrical hollow member of insulating material having one end open and the other end substantially closed, means forming a vacuum-tight connection between the inner end of said re-entrant portion and the open end of said cylindrical member, an ion source supported by said cylindrical member and disposed exteriorly thereto adjacent the closed end thereof, slotted accelerating electrode means disposed adjacent said ion source on the side away from said cylindrical member for accelerating positive ions from said source in a direction at right angles to the magnetic field, the closed end of said cylindrical member having an elongated protuberance extending both inwardly and outwardly therefrom, said ion source having an opening therein disposed to accommodate the outward extension of said protuberance, said protuberance having a central bore therethrough, and a metal rod extending through said bore and connected electrically and mechanically to said accelerating electrode means.

14. In electromagnetic isotope separating apparatus, in

combination, a closed tank, means for evacuating said tank to a high vacuum, means for forming a high intensity magnetic field traversing said tank from one side thereof to the other, said tank having at one end thereof a generally cylindrical hollow open ended re-entrant portion, a generally cylindrical hollow member of insulating material having one end open and the other end substantially closed, means forming a vacuum-tight connection between the inner end of said re-entrant portion and the open end of said cylindrical member, an ion source supported by said cylindrical member and disposed exteriorly thereto adjacent the closed end thereof, slotted accelerating electrode means disposed adjacent said ion source on the side away from said cylindrical member for accelerating positive ions from said source in a direction at right angles to the magnetic field, the closed end of said cylindrical member having an elongated protuberance extending both inwardly and outwardly therefrom,

said ion source having an opening therein disposed to accommodate the outward extension of said protuberance, said protuberance having a central bore therethrough, a metal rod extending through said bore and connected electrically and mechanically to said accelerating electrode means, an open ended sleeve-like member of insulating material disposed around said accelerating electrode means, said ion source, and at least a portion of said cylindrical member, and means forming a supporting connection between said re-entrant portion and said sleeve-like member.

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