CALUTRON RECEIVERS

Filed Feb. 21, 1946 4 Sheets-Sheet 1

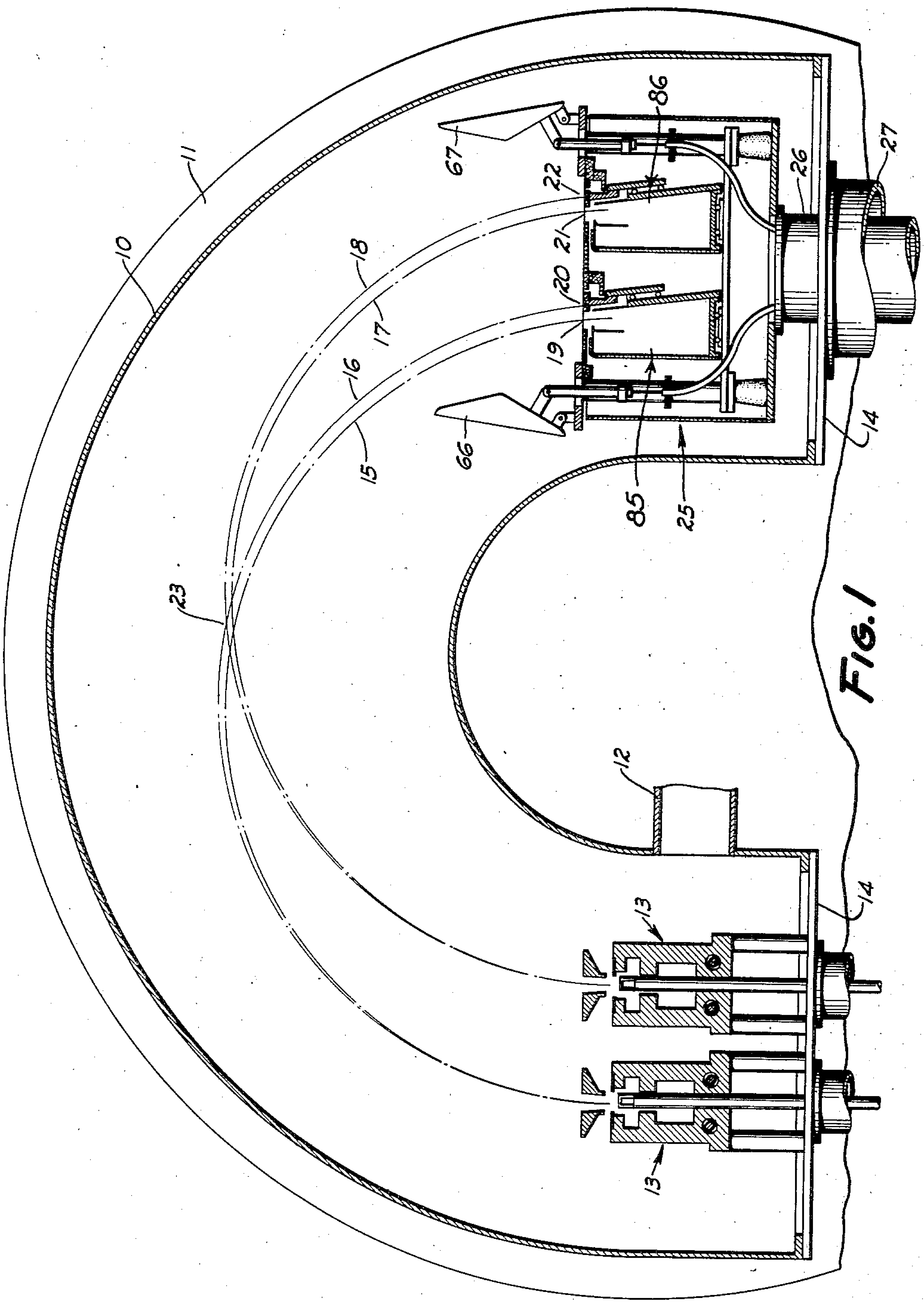

FIG. 1

INVENTOR.
FRED H. SCHMIDT
KENNETH F. STONE
BY
Robert A. Lavender
ATTORNEY.

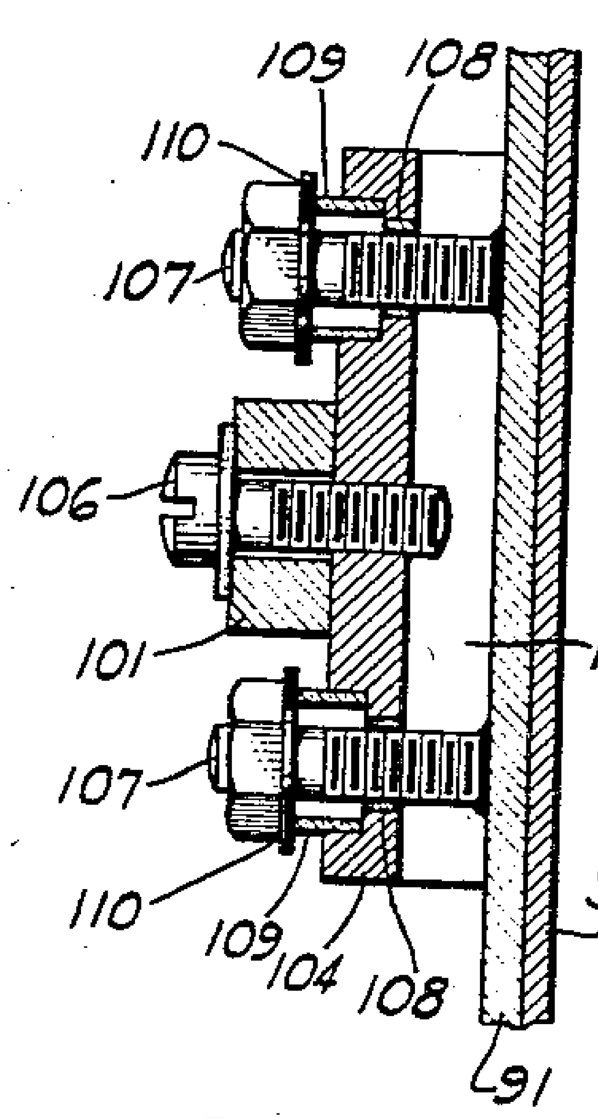

FIG.4

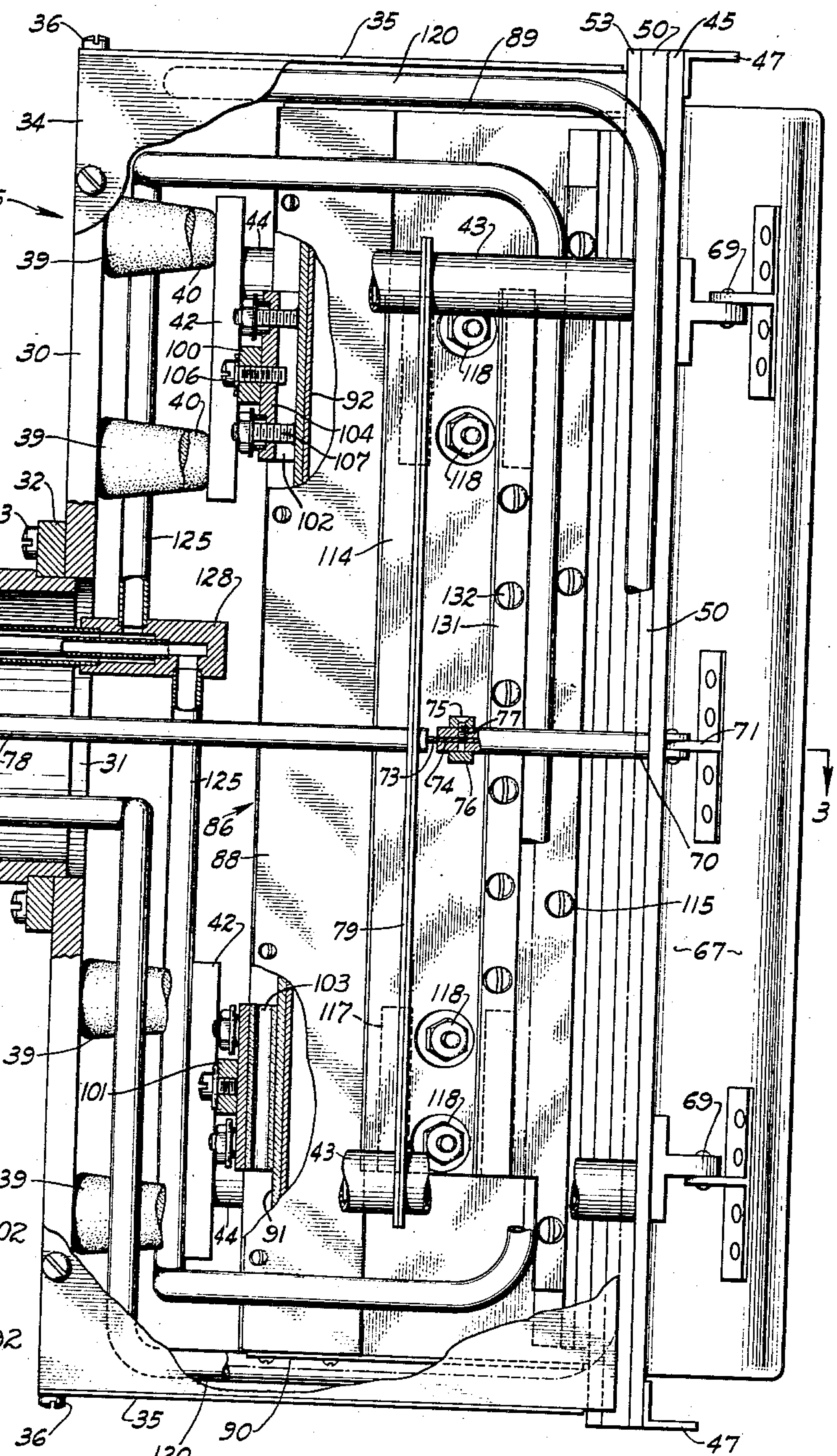

FIG.2

INVENTOR.
FRED H. SCHMIDT
KENNETH F. STONE

BY Robert A. Lavender

ATTORNEY.

Sept. 2, 1958 F. H. SCHMIDT ET AL 2,850,639

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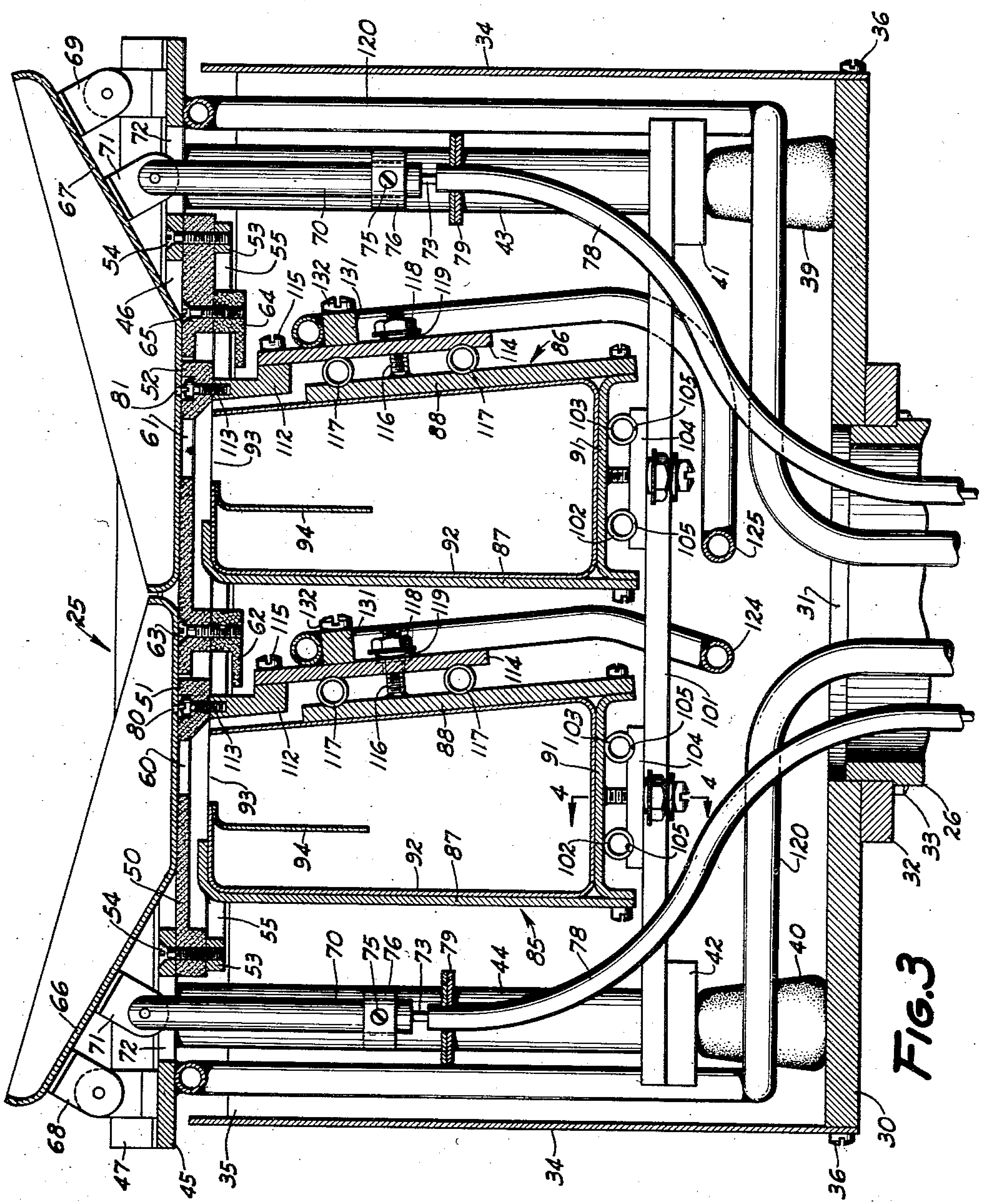

FIG. 3

INVENTOR.
FRED H. SCHMIDT
KENNETH F. STONE

BY Robert A. Lavender
ATTORNEY.

Sept. 2, 1958 F. H. SCHMIDT ET AL 2,850,639

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Filed Feb. 21, 1946 4 Sheets-Sheet 4

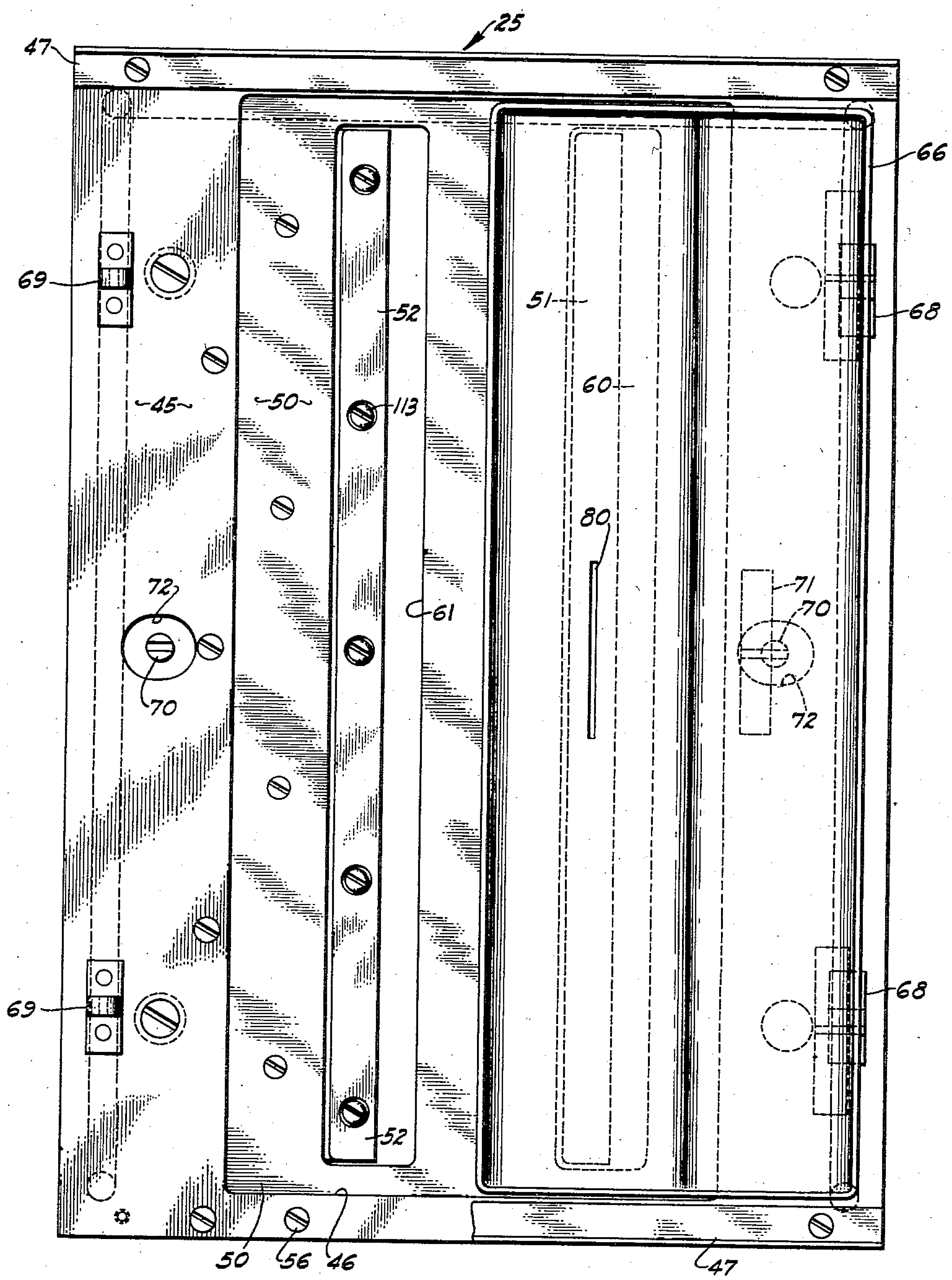

FIG. 5

INVENTOR.
FRED H. SCHMIDT
KENNETH F. STONE

BY

Robert A. Lavender
ATTORNEY.

United States Patent Office

2,850,639

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2,850,639

CALUTRON RECEIVERS

Fred H. Schmidt, Berkeley, Calif., and Kenneth F. Stone, Long Branch, N. J., assignors to the United States of America as represented by the United States Atomic Energy Commission

Application February 21, 1946, Serial No. 649,400

11 Claims. (Cl. 250—41.9)

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. In its presently preferred form, a calutron includes an evacuated chamber mounted in a magnetic field and containing apparatus for ionizing a polyisotope to be treated, apparatus for projecting one or more beams 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 or beams and for retaining at least one selected isotope component thereof in a separated region from which it can be recovered.

For a complete disclosure of the essential features of a preferred form of calutron, and of its mode of operation, reference is made to United States Patent No. 2,709,222 issued May 24, 1955 to Ernest O. Lawrence for "Methods of and Apparatus for Separating Materials." The form of calutron disclosed in that patent comprises an evacuated tank placed between the poles of an electromagnet so that the evacuated space within the tank is pervaded with a substantially uniform 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 having a rectangular pattern 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 a result, corresponding points within the foci of the streams of different isotopes are spaced apart by an amount approximately equal to the difference in the diameters of the respective paths of the constituent ions. 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 foci 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.

In another United States patent to Ernest O. Lawrence, No. 2,714,644, issued August 2, 1955, for "Calutrons," a number of forms of a calutron are disclosed in which a plurality of ion beams are transmitted in the evacuated space within a single tank. Several of these forms (Figures 15, 16 and 30) involve a source unit for transmitting a plurality of ion beams in noninterfering, intersecting relation through the interior of the evacuated tank to respective, closely adjacent regions of focus and a single receiver disposed in the paths of the plurality of beams at their regions of focus for collecting desired material therefrom.

The present invention relates to that part of a calutron referred to as the "receiver," and the illustrated embodiment is designed particularly to receive a plurality of non-interfering, intersecting, uranium ion beams, of the general type disclosed in the last-mentioned Lawrence patent, for separating a portion of each beam enriched with respect to the U^{235} isotope. Throughout the following description, the U^{234} 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 each of a plurality of closely adjacent ion beams.

Another object of the invention is to provide a calutron receiver having a plurality of ion receiving pockets for respectively collecting and retaining a maximum percentage of the ions traveling in a selected portion of each of a corresponding plurality of closely adjacent ion beams.

Another object of the invention is to provide an improved unitary calutron receiver for a plurality of closely adjacent ion beams.

Another object of the invention is to provide a calutron receiver having a plurality of ion receiving pockets for respectively collecting and retaining the maximum percentage of the ions traveling in a selected portion of each of a corresponding plurality of closely adjacent ion beams, the pockets being contained in a single housing adapted to be mounted as a unit in a calutron tank.

Another object of the invention is to provide a unitary calutron receiver adapted to be disposed in a calutron tank at the 180° regions of focus of a plurality of closely adjacent, non-interfering, intersecting ion beams with a face plate of the receiver disposed in the paths of the beams, the face plate being provided with a corresponding plurality of apertures for respectively passing selected delimited portions of the beams to respectively associated ion receiving pockets contained in a unitary housing.

Another object of the invention is to provide a calutron receiver having an ion receiving pocket for separately collecting and retaining ions traveling in a selected portion of one isotope component of an ion beam and an electrode for intercepting ions traveling in a corresponding contiguous portion of another isotope component of the ion beam.

Another object of the invention is to provide a calutron receiver having an ion receiving pocket for separately collecting and retaining ions traveling in a selected portion of an ion beam and an electrode for intercepting ions traveling in another selected portion of the ion beam, the electrode being disposed so as to delimit one side of the portion of the ion beam admitted into the ion receiving pocket.

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

Fig. 1 is a horizontal, sectional view of a calutron tank, showing the arrangement of a double source unit, or pair of source units, and a double 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 side elevational view on an enlarged scale of the receiver shown in Fig. 1, certain parts being broken away to show the interior of the receiver;

Fig. 3 is a horizontal sectional view on an enlarged scale of the receiver shown in Fig. 1, the plane of the section being indicated by the line 3—3 in Fig. 2;

Fig. 4 is a fragmentary, vertical sectional view of a portion of the interior of the receiver, the plane of the section being indicated by the line 4—4 in Fig. 3; and

Fig. 5 is an elevational view of the receiver, looking toward the beam viewing face thereof, with one of a pair of doors for one beam in a closed position and the other of the pair of doors removed to show more clearly the posterior structure of the beam viewing face.

Referring to the drawings, Fig. 1 illustrates a calutron of the general character disclosed in the Lawrence Patent No. 2,709,222, mentioned above, but embodying certain modifications including, among other features, apparatus for transmitting a pair of ion beams in noninterfering, intersecting relation through the interior of an evacuated tank to respective, closely adjacent regions of focus and a unitary receiver disposed in the paths of both ion beams at their regions of focus for collecting desired material therefrom. The calutron comprises a C-shaped tank **10** 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 above-mentioned Lawrence Patent No. 2,709,222.

A pair of identical source units, both designated **13** and illustrated schematically in Fig. 1, are 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 pair of beams of singly ionized positive ions traveling along similar, intersecting, arcuate paths to respective regions of focus approximately 180° along said paths toward the opposite end of the tank. As hereinbefore indicated, each source unit **13** may be designed to project ions of a given mass along paths that are initially divergent to 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 with respect to a median path (path of 0° divergence) equal to their respective initial angular divergences. Streams of ions of different mass transmitted as a single beam by such a source unit follow similar paths except that the paths of the ions of greater mass have a somewhat greater radius of curvature, so that the median paths of two streams of ions of different mass transmitted from a single source unit arrive at spaced-apart 180° regions of focus.

In Fig. 1, the two beams transmitted by the source units **13** are schematically and somewhat ideally illustrated by two sets of two lines each. One set represents a median path **15** and another median path **16** for streams of ions of the U^{235} and U^{238} isotopes, respectively, that are transmitted from one of the pair of source units; and the other set represents a median path **17** and another median path **18** for streams of ions of the U^{235} and U^{238} isotopes, respectively, that are transmitted from the other of the pair of source units. The two streams of ions represented by the median paths **15** and **16** from one source unit pass through respective 180° regions of focus **19** and **20**, and the two streams of ions represented by the median paths **17** and **18** from the other source unit pass through respective 180° regions of focus **21** and **22**. The beam represented by the median paths **15** and **16** cross the beam represented by the median paths **17** and **18** in a region **23** without interference, as disclosed in the second mentioned Lawrence Patent No. 2,714,644. A single source unit capable of producing an ion beam such as those described herein is disclosed in detail in the first mentioned Lawrence Patent No. 2,709,222.

A receiver, generally designated **25**, is mounted on a removable end wall **14** of the C-shaped tank **10**, at the opposite end thereof from the source units **13**, for collecting and deionizing ions arriving at the U^{235} region of focus **19** separately from those arriving at the adjacent U^{238} region of focus **20** and for collecting and deionizing ions arriving at the other U^{235} region of focus **21** separately from those arriving at the adjacent U^{238} region of focus **22**, and for trapping ions reaching the U^{235} regions of focus **19** and **21** in different regions within the receiver in such a manner that they can be removed from the calutron separately from the ions arriving at the U^{238} regions of focus **20** and **22**.

The receiver **25** is mounted on a tube **26** that projects outwardly through an aperture (not shown) in the adjacent end wall **14** of the tank **10**, the tube **26** being mounted on the adjacent end wall **14** and insulated therefrom in any desired manner, as by a cylindrical insulator support **27** secured to the end wall and surrounding the tubular support **26**.

The receiver **25** comprises a back plate **30** of rectangular configuration 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 fastening elements **33** that pass through the flange **32** and into the back plate **30**.

The back plate **30** forms part of a housing that projects forwardly from the back plate and includes a pair of oppositely disposed side plates **34** and a pair of oppositely disposed end plates **35**, the side plates **34** and end plates **35** being mounted on the back plate **30** and secured thereto by fastening elements **36**. The end plates and side plates may be secured together along their adjoining edges in any desired manner, as by soldering.

The entire interior structure of the receiver and of the face plate therefor and associated parts, presently to be described, are mounted on four pairs of standoff insulators, two pairs of insulators **39** being respectively secured in any suitable manner in spaced apart relation along one side of the back plate and the other two pairs of insulators **40** being similarly disposed on the opposite side of the back plate. One pair of insulators **39**, located adjacent the bottom of the back plate, supports a metal plate 41; and the other pair of insulators 39, located adjacent the top of the back plate, supports an identical metal plate. Similarly, a lower pair of the insulators 40 supports a metal plate 42, and the other pair of insulators 40 supports another identical plate 42. Two pairs of tubular members 43 and 44 are respectively soldered to and project forwardly from the four plates supported by the insulators 39 and 40 and provide a relatively rigid supporting structure to which a metal face plate 45 may readily be secured, the insulators 39 and 40 serving to insulate the face plate from the receiver housing.

The face plate 45 is provided with a large, centrally disposed, rectangular opening 46 therethrough, the opening being large enough to pass the entire U^{235} and U^{238} portions of both beams, except for scattered material arriving entirely outside the normal regions of focus for the two beams. To prevent warping of the face plate 45, a pair of angle members 47 are respectively soldered along opposite ends of the face plate.

A beam defining structure comprising a generally rectangular graphite plate 50 having a pair of elongated rectangular openings therein, and a pair of graphite U^{238} electrodes 51 and 52 respectively disposed within the rectangular openings of the graphite plate 50, is mounted in alignment with the aperture 46 in the face plate 45 with the forward surface of the graphite plate 50 abutting the rearward surface of the face plate 45 around the entire perimeter of the aperture 46 therein. A pair of metal bars 53 respectively extend adjacent the side edges of the graphite plate 50 along the back side thereof, and fastening elements 54 pass through the face plate and through the graphite plate into the bars 53 to hold the graphite plate in place and to reinforce it against warping. Another pair of metal bars 55 respectively extend adjacent the end edges of the graphite plate along the back side thereof and are fastened in place similarly to the metal bars 53 by fastening elements 56 to provide additional support for the graphite plate 50.

One of the U^{238} electrodes 51 in one of the elongated rectangular openings of the graphite plate 50 extends the length of this opening and about one half the width thereof and is mounted therein, in a manner described hereinafter, so as to define one side of a U^{235} slot 60 for passing a predetermined cross sectional area of the U^{235} portion of one of the beams; and the other U^{238} electrode 52 is similarly disposed in the other elongated rectangular opening of the graphite plate 50 and defines one side of a second U^{235} slot 61 for passing a predetermined cross sectional area of the U^{235} portion of the other beam. On the opposite side of the U^{238} electrode 51 from the adjacent U^{235} slot, the electrode is spaced slightly from the adjacent edge of the surrounding opening in the graphite plate 50; and an elongated graphite baffle member 62 is secured to the graphite plate 50 by fastening elements 63 and extends partially behind this U^{238} electrode 51 along its entire length so as to intercept ions passing through the small space between the electrode and the adjacent edge of the surrounding opening in the graphite plate 50. The other U^{238} electrode 52 is similarly disposed in the other opening of the graphite plate 50, and a second graphite baffle member 64 is secured to the graphite plate 50 by fastening elements 65 and extends behind this U^{238} electrode along its entire length for intercepting ions passing between this electrode and the adjacent edge of the surrounding opening in the graphite plate 50.

With this arrangement of the U^{238} electrodes and respectively associated U^{235} slots in the beam viewing face of the receiver, each electrode actually defines one side of the U^{235} portion of the beam passed by the adjacent U^{235} slots, and the necessity for employing an intermediate beam defining strip is eliminated, thus permitting the use of wider slots and the collection of a larger portion of the beam. Moreover, the ion intercepting face of each electrode may be of a size and shape and may be so disposed that it intercepts a segment of the U^{238} portion of the beam corresponding exactly to the U^{235} portion of the beam passed by the adjacent U^{235} slot. Thus, knowing the ratio of U^{235} ions to U^{238} ions in the beams to be received, the quantity of ions entering the U^{235} slots may be obtained simply by multiplying the U^{238} current readings by this ratio.

In order to prevent the passage of ions through the two U^{235} slots 60 and 61 during the warmup period, before the beams have become stabilized and have been focused for reception, a pair of doors 66 and 67 are respectively mounted in front of the face plate 45 on two pairs of hinges 68 and 69. Each door is slightly greater in length than the U^{235} slot to be opened and closed thereby and is adapted to swing about its hinges from a closed position against the face plate and covering the two U^{235} slots (as shown in Fig. 3) to an open position out of the paths of the U^{+} portions of the beam (as shown in Fig. 1).

For operating the doors 66 and 67 between their open and closed positions, two substantially identical mechanisms are respectively associated therewith. Referring either to the door 66 or the door 67 and its associated operating mechanism, a rod 70 is pivotally connected to the door by means of a bracket 71 and projects into the interior of the receiver through an aperture 72 in the face plate 45. One end of a length of heavy wire 73, such as music wire, is mounted in an aperture 74 that extends axially into the rearward end of the rod 70, and a set screw 75 carried by a collar 76 projects into a transverse aperture 77 in the rod 70 and against the wire 73 to anchor it in place. The wire 73 extends generally rearwardly from the rod 70 into the receiver supporting tube 26, where it is connected to a suitable push-pull type of control for moving it and the associated rod 70 longitudinally to open and close the associated door.

A tubular sleeve 78 surrounds the wire 73 along most of its length and is anchored at both ends against longitudinal movement. Within the receiver housing, the sleeve 78 may be secured against longitudinal movement by means of any suitable bracing structure 79, that may be soldered or otherwise fastened to one end of the sleeve and to the adjacent pair of tubular members 43 or 44. The sleeve is bent to conform to a desired path of travel for the wire 73, whereby electrical contact between it and other parts of the receiver may be avoided. A suitable push-pull control for the wire 73 and anchor for the rearward end of the sleeve 78 are disclosed in United States Patent No. 2,745,965 to Edward J. Lofgren, which issued May 17, 1956.

To facilitate determining when the beams are properly focused for most efficient reception, a pair of narrow slots 80 and 81 are respectively provided in the doors 66 and 67, the slots being so disposed in the associated doors that they are respectively aligned with the longitudinal center lines of the two U^{238} electrodes 51 and 52 when the doors are in their closed positions. Though the lengths of the slots 80 and 81 are not of critical importance, it is preferred that they extend only a short distance parallel to the longitudinal center lines of the respectively aligned U^{238} electrodes and that they be centrally disposed with respect to the midpoints of these longitudinal center lines. The widths of the slots 80 and 81 are likewise not of critical importance, as disclosed in the above-mentioned Lofgren patent, but are preferably only a fraction of the widths of the respectively aligned U^{238} electrodes.

Thus, with the doors 66 and 67 in their closed positions, a segment of greatest ion intensity of the U^{238} portion of each of the two beams will pass through the associated slot 80 or 81 to the aligned U^{238} electrode 51 or 52 when the U^{238} portion of the beam is properly focused upon its associated electrode. For each beam, the spacing between the longitudinal center line of the associated U^{238} electrode and the longitudinal center line of the contiguous U^{235} slot is chosen equal to the spacing between the lines of maximum U^{238} and U^{235} ion intensity in the beam. With this arrangement, focusing of the beams so that the maximum quantities of ions pass through the door slots **80** and **81** to the respectively aligned electrodes **51** and **52** serves to center the U^{235} foci of the beams on their respective U^{235} slots **60** and **61**. After the beams are properly focused, the doors may be opened to permit reception.

A pair of identical ion receiving pockets, generally designated **85** and **86**, are disposed inside the receiver housing behind the two U^{235} slots **60** and **61** respectively for receiving and retaining ions passing through those slots. Referring either to the pocket **85** or the pocket **86**, a pair of side walls **87** and **88**, a pair of end walls **89** and **90**, and a rear wall **91** are secured together to define an enclosure having an opening adapted to be disposed behind an associated U^{235} slot for admitting ions passing through the slot. A pocket liner **92**, preferably made of sheet copper, is shaped to conform to the interior dimensions of this enclosure so that the exterior surface of the liner will be in contact with substantially the entire area of the interior surfaces of the enclosing plates. The liner **92** is provided with an opening **93**, slightly larger in each dimension than the U^{235} slot with which it is to be associated, for admitting into the interior of the liner ions passing through the associated slot; and a baffle **94**, that extends the full length of the pocket liner **92**, is secured thereto adjacent one side of the opening **93** and projects inwardly a substantial distance in a direction generally parallel to the paths of travel of ions entering the pocket in order to assist in trapping ions that might otherwise rebound out through the opening **93**.

In order to provide a suitable mounting for the two pockets **85** and **86**, a pair of bars **100** and **101** are disposed in spaced apart parallel relation and are secured at their opposite ends to the plates **41** and **42** in any suitable manner, as by welding. Referring to the pocket **85**, a pair of tubular insulators **102** and **103** and a plate **104** are disposed between the supporting bar **101** and the adjacent end of the rear wall **91** of the pocket, the plate **104** being provided with a pair of grooves **105** conforming to the cylindrical contour of the tubular insulators **102** and **103** to provide seats therefor. As best shown in Fig. 4, the plate **104** is secured to the bar **101** by a fastening element **106** that passes through the bar and is threaded into the plate; and the insulators **102** and **103** are clamped between the plate **104** and the rear wall **91** of the pocket by a pair of studs **107** that are soldered at one end to the rear wall of the pocket and project between the two insulators and through the plate **104**, from which they are electrically insulated by ceramic sleeves **108** and **109**. Each stud **107** is provided with a nut and washer combination **110** that bears against the associated insulating sleeve **109** to clamp firmly together the assembly comprising the plate **104**, the tubular insulators **102** and **103**, and the rear wall **91** of the pocket. An identical support is provided between the opposite end of the rear wall of the pocket **85** and the bar **100**, and a pair of identical supports are provided between opposite ends of the pocket **86** and the bars **100** and **101**. With this arrangement, a rigid mounting for each pocket is provided while maintaining the pocket out of electrical contact with the receiver housing.

The two U^{238} electrodes **51** and **52** are identically mounted on the side plates **88** of the respectively associated pockets **85** and **86** in insulated relation thereto. The structure supporting each U^{238} electrode comprises a bracket **112** secured at its forward end to the electrode by a number of fastening elements **113** and adjacent its rearward end to a plate **114** by a number of fastening elements **115**. The plate **114** is secured adjacent its opposite ends to the side wall **88** of the pocket by two sets of electrically insulating mountings, each comprising a pair of studs **116** that are welded at one end to the pocket side wall **88** and project, with clearance, through apertures in the plate **114**. A pair of tubular insulators **117** are disposed on opposite sides of the studs **116** between the pocket side wall **88** and the plate **114**, and the assembly is clamped together by a pair of nuts **118** and a pair of ceramic insulator washers **119** on the projecting ends of the studs. With this arrangement, the plates **114** and associated electrodes **51** and **52** are maintained out of electrical contact with the side walls **88** of the pockets to which they are respectively secured.

For cooling the face plate **45**, a copper tube cooling fluid line **120** is led into the receiver housing through the supporting tube **26**, and thence partially around the interior structure contained within the housing and forwardly into contact with the face plate **45** adjacent one corner thereof. The portion of the cooling fluid line **120** in contact with the face plate **45** extends substantially the full length thereof adjacent one side edge, thence around the interior structure contained within the receiver housing to a point on the opposite side of the face plate adjacent its upper end, and finally downwardly the full length thereof, after which the line is led partially around the interior structure contained within the receiver housing and out of the receiver again through the supporting tube **26**. Heat conducting relation between the cooling fluid line **120** and the face plate is preferably maintained throughout the portion of the line in contact with the face plate by soldering that portion of the line directly thereto.

The cooling fluid line **120** is maintained out of electrical contact with all parts of the receiver except the face plate with which it is associated and is mounted within the supporting tube **26** by means of an insulating disk **121** in a manner disclosed and described in some detail in the above-mentioned Lofgren patent. With this arrangement, and by employing an electrically nonconducting cooling fluid, the cooling fluid line **120** may be employed as an electrical lead for reading currents to the face plate **45**.

For cooling the two U^{238} electrodes **51** and **52**, a pair of independent cooling fluid lines **124** and **125** are employed. Referring to the cooling fluid line **125** for the electrode **52**, the cooling fluid supply is brought into the receiver through a conduit formed between a pair of concentric copper tubes **126** and **127** that are led into the receiver housing through the supporting tube **26** and through the insulating disk **121** to a fitting **128** disposed within the receiver housing adjacent the opening **31** in the back plate **30**. The passageway between the two concentric tubes **126** and **127** is connected with one end of the cooling fluid line **125** through the fitting **128**; and the opposite end of the cooling fluid line **125** is connected through the fitting with an interior passageway defined by the inner one of the concentric tubes **127** in order to provide a return line for the cooling fluid for conducting it back out of the receiver.

The two ends of the cooling fluid line **124** for the U^{238} electrode **51** are respectively connected with the two passages formed by a second pair of concentric tubes **129** and **130**, through a second fitting (not shown) that may be identical with the fitting **128** associated with the above-described cooling fluid line **125**. The two cooling fluid lines **124** and **125** respectively form cooling fluid circuits in heat conducting relation with the two electrode supporting plates **114**, each of these cooling fluid lines being partially supported against its associated electrode supporting plate by means of an elongated block **131** and fastening elements **132**. To obtain an adequate flow of heat from the plates **114** to the associated cooling fluid lines, the lines may be soldered directly to the plates.

The cooling fluid lines **124** and **125** and their associated fittings and supply and return lines are maintained out of electrical contact with all parts of the receiver except the plates 114 to which they are respectively connected. With this arrangement, and by employing a nonconducting cooling fluid, the cooling fluid lines 124 and 125 may respectively be employed as electrical leads for reading currents to the U^{238} electrodes 51 and 52.

With the receiver 25 mounted in the evacuated tank 10, with cooling fluid circulating through the cooling fluid lines 124 and 125, and with the doors 66 and 67 in their closed positions, the two beams may be created and focused in accordance with the indicator currents to the U^{238} electrodes 51 and 52. When both beams have been properly focused, the doors 66 and 67 are opened, and subsequent readings of current to the electrodes 51 and 52 may be observed as a check on general beam conditions and on the rate at which ions are entering the pockets 85 and 86.

Either or both of the doors 66 and 67 may be closed during a run in the event the condition of one or both of the beams should become unfavorable, in order to prevent contamination of the material in the pockets 85 and 86 until the condition of the beam or beams is corrected; or the doors may be closed at regular intervals during a run to obtain a more reliable check on the accuracy of focus of the beams and to carry out any required refocusing operations.

At the conclusion of a run, the beams are 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 end wall 14 on which it is mounted. After removing one of the end plates 35 of the receiver housing, and one of the end walls 89 of each of the pockets 85 and 86, the two pocket liners 92 may be withdrawn for recovering the material collected therein during the run.

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

What is claimed is:

1. In a calutron including a tank and means for transmitting a plurality of ion beams within the tank, a receiver for said beams comprising a frame structure having an apertured viewing face presented to said beams for passing selected portions thereof, and a plurality of pockets mounted on said frame structure in cooperative relation with apertures in said face plate for receiving ions passing through said apertures.

2. In a calutron having means for establishing a plurality of ion beams and for causing divergence of beam components of different mass within each beam during travel of said components to a region of focus, a unitary ion receiver comprising a pair of collecting pockets respectively associated with said beams, each pocket having an opening therein disposed adjacent the region of focus of the associated beam for admitting a selected delimited portion thereof.

3. In a calutron having means for establishing a plurality of ion beams and for causing divergence of beam components of different mass within each beam during travel of said components to a region of focus, a receiver comprising a housing containing a pair of collecting pockets respectively associated with said beams, each of said pockets having an opening therein disposed adjacent the region of focus of the associated beam for admitting a selected delimited portion thereof.

4. In a calutron having means for establishing a plurality of ion beams and for causing divergence of beam components of different mass within each beam during travel of said components to a region of focus, a receiver comprising a housing, a face plate mounted on said housing in the paths of said beams adjacent the regions of focus thereof, a pair of apertures in said face plate for respectively passing selected delimited portions of said beams, and a pair of collecting pockets mounted within said housing and respectively aligned with said apertures, each of said pockets having an opening for admitting to the pocket ions passing through the aligned aperture in the face plate.

5. In a calutron having means for transmitting an ion beam, an ion receiver comprising means for passing a selected delimited portion of the beam to an ion receiving pocket, said means including an electrode for delimiting one side of the portion of the beam passed to the ion receiving pocket.

6. In a calutron having means for transmitting an ion beam, an ion receiver comprising an ion receiving pocket for separately collecting ions travelling in a selected portion of the ion beam, and an electrode for intercepting ions travelling in a selected contiguous portion of the ion beam.

7. In a calutron having means for transmitting an ion beam, an ion receiver comprising an ion receiving pocket for separately collecting ions travelling in a selected portion of the ion beam, and an electrode for intercepting ions travelling in a selected contiguous portion of the ion beam, the electrode being disposed so as to delimit one side of the portion of the ion beam admitted into the ion receiving pocket.

8. In a calutron having means for transmitting 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 an ion receiving pocket having an opening therein for admitting a selected delimited portion of the ion beam, means disposed in the path of said beam for delimiting one side of the portion thereof admitted through the opening of the pocket, and an electrode disposed in the path of said beam for delimiting another side of the portion thereof admitted through the opening of the pocket.

9. In a calutron having means for transmitting 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 viewing face disposed in the path of the ion beam adjacent said regions of focus and having an aperture therein for passing a selected delimited portion of the beam to an ion receiving pocket, and an electrode disposed within said aperture for delimiting one side of the portion of the beam passed to the ion receiving pocket.

10. In a calutron having means for transmitting 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 viewing face disposed in the path of the beam at said regions of focus and having an aperture therein for passing a delimited portion of the beam, an electrode disposed within said aperture for delimiting one side of the portion of the beam passed thereby, and an ion receiving pocket aligned with the aperture in said viewing face for receiving the delimited portion of the beam passed thereby.

11. In a calutron having means for transmitting 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 viewing face disposed in the path of the beam at said regions of focus and having an aperture therein for passing a delimited portion of the beam, an electrode disposed within said aperture for delimiting one side of the portion of the beam passed thereby, and an ion

receiving pocket having an opening therein aligned with the aperture in said viewing face for receiving the delimited portion of the beam passed thereby.

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