

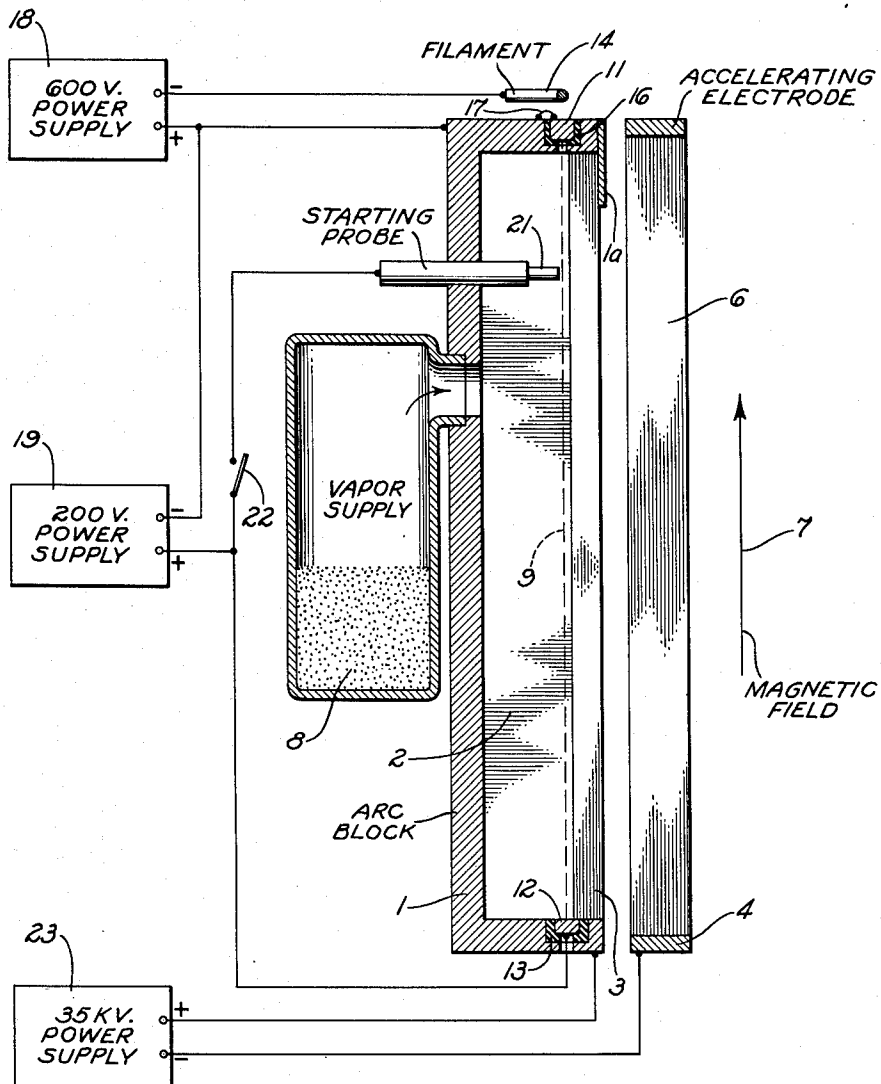
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ION SOURCE UNITS

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ION SOURCE UNITS

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This invention relates to calutrons and more particularly to the electrode arrangement in the arc block of a calutron ion source.

Calutrons are described in general in "Atomic Energy for Military Purposes" by H. D. Smyth, and are described in great detail in the copending application of Ernest O. Lawrence, Serial No. 557,784, filed October 9, 1944, now Patent No. 2,709,222. Calutrons are commercial isotope separators, separating large quantities of material compared to laboratory instruments which separate only microscopic amounts of material. They have been principally used, and very successfully used, in separating the isotopes of uranium, the isotope U^{235} being separated from the other isotopes of uranium.

In general, the material to be separated in a calutron is placed in an ion source unit and therein converted to ionic form, whereupon it is projected by electrical means into a magnetic field. Thereafter, the ions travel in curved paths due to the magnetic forces, the heavier ions traveling in paths of greater radius than lighter ions. Ion collectors are placed across these paths at some convenient point, such as the 180° point of travel of the ions along their curved paths. The entire apparatus is evacuated so as to reduce the number of collisions that the ions encounter in travelling through the magnetic field to the collector.

Various electrode arrangements have been devised for the arc block of a calutron, particularly in the cathode structure. The most common type of cathode has been in a directly emitting filament heated by resistance to a conductive current. Filaments are prone to weaken due to metallic alloying with uranium metal derived from uranium atoms that strike the filament. A plate was believed to be less subject to this alloying action, and consequently a plate cathode was employed. The plate was heated to emissivity by an external source of heat, which may take the form of a stream of bombarding electrons. The present invention relates to such a plate type cathode heated indirectly by electron bombardment.

In the past, it has been common to space the cathode, whether directly heated filaments or indirectly heated plates, from the arc block. An electric field was established between the two so that the arc block was the anode, and electrons were attracted to it. Inasmuch as considerable quantities of charge vapor escaped if the end of the arc block toward cathode were open, it was finally closed, except for a small slot. The magnetic field passing through the cathode and the slot collimated the electrons so that they followed the lines of magnetic flux through the slot into the arc chamber, rather than follow the lines of the electric field. The shape of the slot was found to be important to the stability of the slot, and in general trimmed the electron stream so that only the most desirable portion was passed.

The electron trimming aperture or slot still permitted quantities of vapor to escape and thus reduce the efficiency of the ion source as this vapor could not be converted into ions that would be projected into the magnetic field for

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separation. The present invention removes this difficulty, by making the cathode a structural part of the arc chamber enclosure. Since it is difficult to insulate the cathode from the arc block, an insulated anode is used to set up the necessary electric field for the arc.

It is therefore an object of the invention to provide a calutron ion source wherein the arc cathode is a structural part of the arc block.

A more general object is to provide an improved ion source for a calutron.

These and other objects and advantages of the invention will be apparent in the following description and claims considered together with the drawing forming a part thereof and showing a sectional elevation view of a calutron arc block taken along the magnetic field.

Referring to the drawing, there is provided an arc block 1 in the form of a housing that provides an interior arc chamber 2 having an elongated exit slit 3. Ions are formed in the arc chamber 2 and are withdrawn through the exit slit 3 by an accelerating electrode 4 having a slit 6 therethrough that matches the exit slit 3 and is elongated similarly. The entire calutron is placed in a magnetic field indicated by the flux line 7. The exit slit 3 and the accelerating slit 6 are elongated along the direction of this magnetic field.

An arc discharge takes place in the arc chamber 2 in an atmosphere of charge gas containing ions or molecules containing the substance desired to be ionized. This charge gas is supplied by a reservoir 8 containing a suitable solid or liquid that will vaporize or containing a charge gas under pressure. The gas is led into the left side of the arc chamber 2 and is bombarded by an electron stream 9 emanating from a cathode block 11 and terminating at an anode 12. The anode 12 is insulated from the arc block 1 by a nonconductor block 13, and when a suitable positive potential is applied to the anode, the requisite electric field is set up to establish the electron stream. The cathode block 11 is heated to emissivity by heat derived from electron bombardment from a filament 14. The filament 14 may be heated by any suitable means such as a conductive current therethrough from a current source (not shown). The cathode block 11 is thermally insulated from the arc block 1 by sheet material 16, such as mica. The potential of the cathode block 11 and the arc block 1 are preferably the same and a pig tail lead 17 maintains this relationship.

A power supply 18 which may be from 600 to 800 v. is connected between the filament 14 and the arc block 1 to set up the necessary electric field for bombarding the cathode block 11. The insulated anode 12 is connected to the positive terminal of a second power supply 19 which may be about 200 volts. Preferably, this power supply should deliver 300 volts for initiating the arc and there be changed to 100 volts for maintaining the arc. Inasmuch as the starting electric field at the cathode block 11 is weak, a starting probe 21 is provided that is closely adjacent to the cathode block 11. This probe is operated by a switch 22 connected to the anode voltage, and the switch is opened as soon as an arc is initiated. The positive ions are withdrawn from the arc by a negative voltage impressed on the electrode 4 by a power supply 23 which may be at typical calutron accelerating voltages such as 35 kv.

In operation, vapor is supplied by the reservoir 8 to the arc chamber 2 and there bombarded by an electron stream 9 emanating from a cathode 11 and striking an anode 12. An arc plasma is thereupon formed in the chamber 2 and the positive ions therein are withdrawn through to ion exit slit 3 by the negative potential impressed on the accelerating electrode 4. The ions pass through the elongated slit 6 in this electrode and form the typical calutron ion ribbon that curves and splits up

in the magnetic field in accordance with the respective masses of the ions. Also, a suitable metallic strip 1a is secured to the front wall of the arc block 1 across the upper end of the elongated ion exit slit 3 adjacent to the top wall and below the cathode block 11 thereby to prevent the escape of vapor from the upper end of the arc chamber 2 through the ion exit slit 3.

The cathode block 11 is heated to emissivity by electron bombardment from the filament 14. The arc is initiated by a starting probe 21 placed closely adjacent to the cathode block 11. The use of a cathode block in accordance with the present invention eliminates the use of an electron entrance aperture heretofore present in calutron arc chambers. The vapor consumption is therefore improved and cathode fouling eliminated in calutron structures made in accordance with the present invention.

Although this invention has been described with reference to a particular embodiment thereof, which is by way of example only, it is not limited to this embodiment, nor otherwise, except by the terms of the following claims.

What is claimed is:

1. An ion source unit comprising a hollow arc block defining an arc chamber and provided with a wall constituting a principal cathode, means including an auxiliary cathode disposed exteriorly of said arc block and adjacent to said principal cathode for bombarding said principal cathode in order to render the same electron emissive, means including a principal anode disposed in said chamber remote from said principal cathode for sustaining an arc between said principal cathode and said principal anode, means including a starting anode disposed in said chamber adjacent to said principal cathode for striking an arc between said principal cathode and said principal anode, means for supplying a gas to be ionized to said chamber, and means for withdrawing ions from said chamber.

2. In an ion source for use in a magnetic field, the combination comprising a hollow arc block defining an elongated chamber having an aperture at each end and a slit extending along one elongated wall thereof, an electron emissive block disposed in the aperture at one end of said block and forming a closure therefor, a plate electrode disposed within the aperture at the opposite end of said block and forming a closure therefor, said electron emissive block and plate electrode lying along a path parallel to and along the inner portion of said block defining said slit, a probe electrode piercing a wall of said block and extending into said chamber in the region of said electron emissive block to a point adjacent the path between said block and plate electrode, means associated with said electron emissive block to raise the temperature thereof, means for introducing an ionizable vapor into said chamber, means connected between said electron emissive block and said plate electrode for rendering the latter sufficiently positive relative to the former to sustain an arc therebetween, and means connected between said plate electrode and said probe electrode to

render said probe temporarily positive relative to said electron emissive electrode to start said arc.

3. In an ion source for use in a magnetic field, the combination comprising a hollow arc block defining an elongated chamber having an aperture at each end and a slit extending along one elongated wall thereof, a cathode disposed in the aperture at one end of said block and forming a closure therefor, a plate electrode disposed within the aperture at the opposite end of said block and forming a closure therefor, said cathode and plate electrode lying along a path parallel to and along the inner portion of said block defining said slit, a probe electrode piercing a wall of said block and extending into said chamber in the region of said cathode to a point adjacent the path between said cathode and plate electrode, means associated with said cathode to raise the temperature thereof, means for introducing an ionizable vapor into said chamber, a power supply having a positive and a negative terminal with the negative terminal connected to said cathode and the positive terminal connected to said plate electrode to sustain an arc therebetween, and a switch connected between said plate electrode and said probe electrode whereby said probe electrode may be rendered positive with respect to said cathode to start said arc.

4. In an ion source for use in a magnetic field, the combination comprising a hollow arc block defining an elongated chamber having an aperture at each end and a slit extending along one elongated wall thereof, a cathode disposed in the aperture at one end of said block and forming a closure therefor, said cathode being electrically connected to said block, a plate electrode disposed in insulated relation with said block within the aperture at the other end thereof and forming a closure therefor, said cathode and plate electrode lying along a path parallel to and along the inner portion of said block defining said slit, a filament disposed externally of said chamber and spaced from said cathode, a probe electrode piercing a wall of said block and extending into said chamber in the region of said cathode to a point adjacent the path between said cathode and plate electrode, an accelerating electrode disposed externally of said block in alignment with said slit, means for introducing an ionizable vapor into said chamber, a first power supply having a negative electrode connected to said filament and a positive electrode connected to said arc block, a second power supply having a negative terminal connected to said arc block and a positive terminal connected to said plate electrode, a double pole-single throw switch connected between said plate electrode and said probe electrode, and a third power supply having a negative terminal connected to said accelerating electrode and a positive terminal connected to said arc block.

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