Jan. 31, 1956

K. R. MacKENZIE ET AL

2,733,350

CALUTRON CONTROL CIRCUIT

Filed Aug. 15, 1946

2 Sheets-Sheet 1

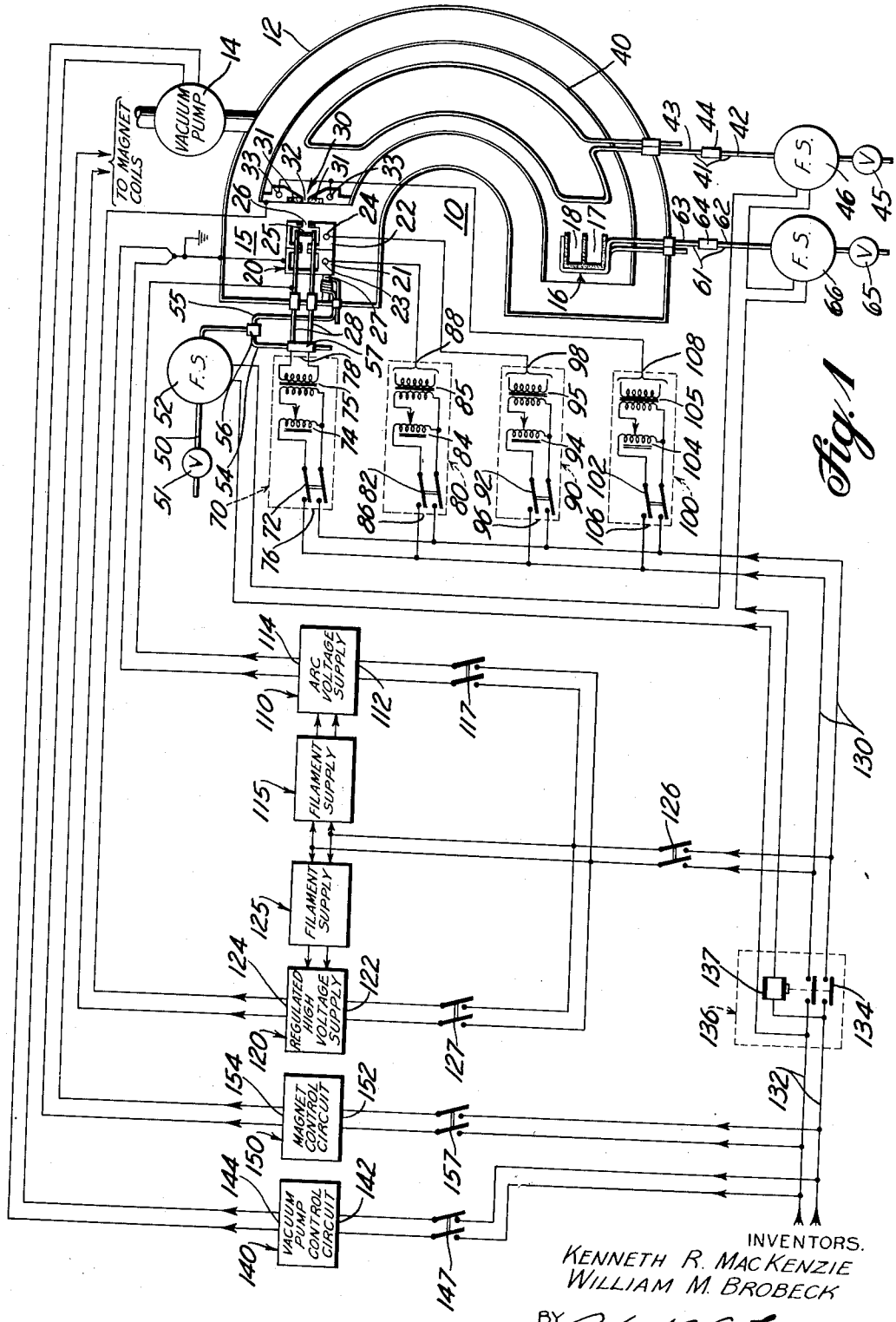


Fig. 1

INVENTORS.
KENNETH R. MACKENZIE
WILLIAM M. BROBECK
BY Robert A. Lavender
ATTORNEY

Jan. 31, 1956 K. R. MacKENZIE ET AL 2,733,350

CALUTRON CONTROL CIRCUIT

Filed Aug. 15, 1946

2 Sheets-Sheet 2

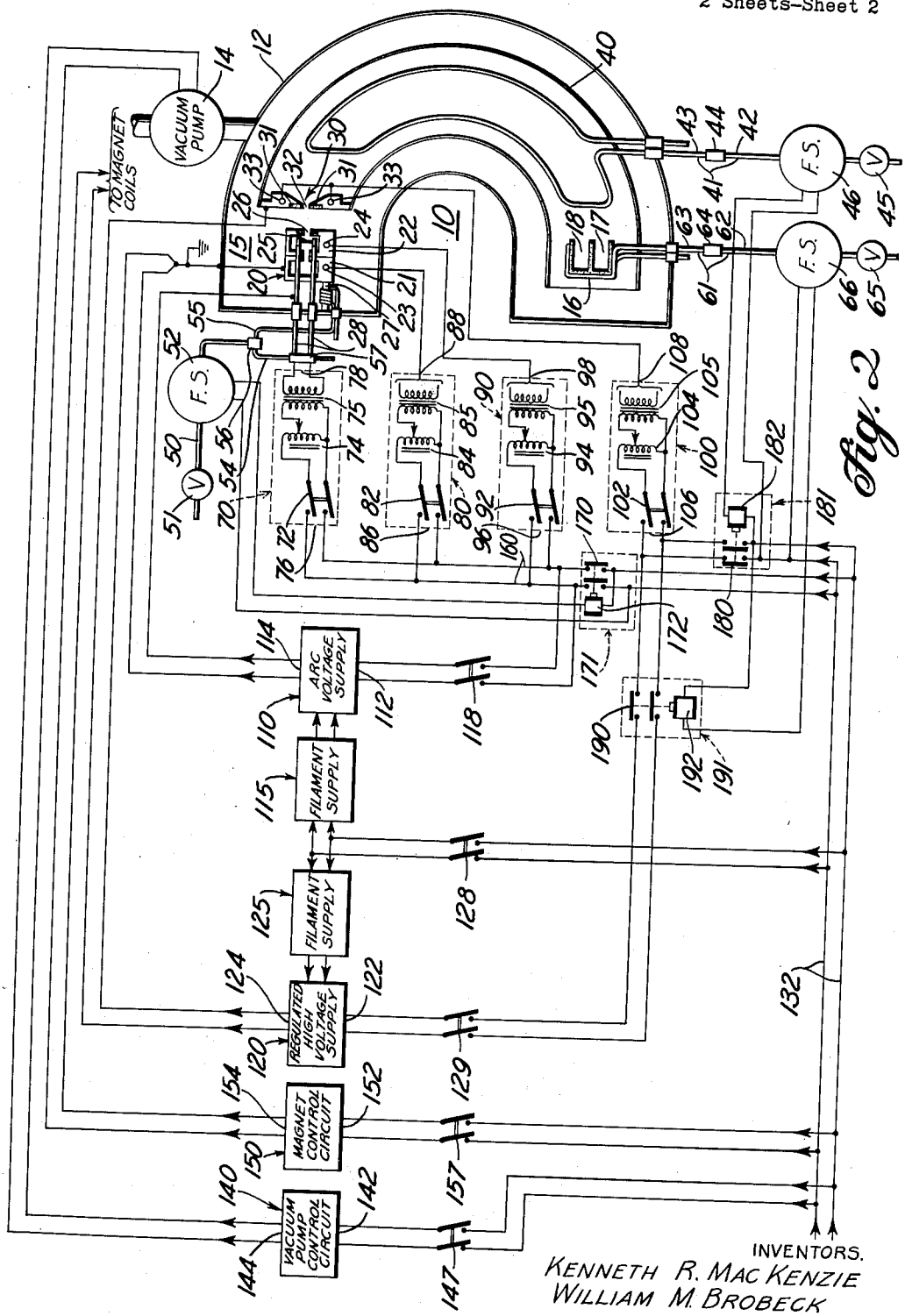


Fig. 2

INVENTORS.
KENNETH R. MAC KENZIE
WILLIAM M. BROBECK

BY Robert G. Lavender
ATTORNEY

United States Patent Office 2,733,350 Patented Jan. 31, 1956

2,733,350

CALUTRON CONTROL CIRCUIT

Kenneth R. MacKenzie, Richmond, and William M. Brobeck, Berkeley, Calif., assignors to the United States of America as represented by the United States Atomic Energy Commission

Application August 15, 1946, Serial No. 690,803

7 Claims. (Cl. 250—41.9)

This invention relates to a protective arrangement for a calutron to prevent inadvertent overheating of water-cooled structure of the calutron.

A calutron is an electromagnetic mass separation apparatus of the type disclosed in the application, Serial No. 557,784 of Ernest Orlando Lawrence, filed October 9, 1944, for Calutrons and now Patent No. 2,709,222 issued May 24, 1955.

An object of this invention is to provide a calutron with apparatus for preventing the inadvertent overheating of the water-cooled structure of the calutron, said apparatus consisting of interlocking devices connected to the electric current and voltage supplies of the calutron so that none of the electrical supplies can be operated unless cooling water is flowing to all of the structures that are to be water cooled.

Another object of this invention is to provide an interlock between the electrical supplies of the calutron and the conduits carrying the cooling water to the various structures of the calutron.

Still another object of this invention is to provide individual interlocks between the various water-cooled parts of the calutron and the electrical supplies thereto.

Other and further objects of this invention will be apparent to those skilled in the art to which it relates from the following specification, claims, and drawing.

Referring to the drawing briefly,

Figure 1 is a schematic wiring diagram of an embodiment of this invention; and

Fig. 2 is a schematic wiring diagram embodying a modified form of this invention.

In order to prevent inadvertent overheating of water-cooled structure of a calutron, the water supplies associated with these structures are interlocked with the electrical supplies which heat these structures.

In one modification of the invention all of the water supplies of the calutron are interlocked with all of the electrical supplies by means of a single relay so that none of the electrical supplies can be operated unless cooling water is flowing to all of the structures that are to be water-cooled. In another modification of the invention, the water supplies associated with the various water-cooled parts of the calutron are individually interlocked with the electrical supplies which cause heating of the respective parts.

Referring to Fig. 1, there is diagrammatically illustrated a typical calutron 10 of the type to which the present invention has been applied, together with the associated electrical networks. This calutron includes a C-shaped tank 12 which is arranged in the air gap of an electromagnet (not shown) and which is maintained at a low pressure by means of a vacuum pump 14. This calutron 10 comprises an ion beam transmitter 15, and an isotope collector 16 arranged within the tank at opposite ends thereof in the general manner described in the application of Ernest O. Lawrence, Serial No. 557,784, filed October 9, 1944, for Calutrons. The ion transmitter 15 illustrated here includes an ion source 20 and an ion accelerating electrode structure 30. The collector 16 is provided with two pockets 17 and 18 in which monoisotopically enriched material is to be collected.

The ion source 20 comprises a charge chamber 21 and an arc chamber 22 communicating therewith, two corresponding electrical heaters 23 and 24 respectively associated therewith and a thermionically emissive cathode 25 operatively associated with the arc chamber 22. The arc chamber 22 includes an upstanding slit 26 at the side thereof adjacent the ion accelerating structure 30. The charge chamber 21 and arc chamber 22 are supported from the wall of the tank by means of an arm 27 such as an insulating bushing. The thermionically emissive cathode 25 is supported above the arc chamber by means of two rigid leads 28, 28 extending through and insulated from the wall of the tank 12.

The ion accelerating structure 30 includes two spaced-apart electrodes 31, 31 forming a beam defining slit 32 disposed adjacent and parallel to the slit 26 in the arc chamber 22. Two heaters 33, 33 are arranged in heat exchange relation with the electtrodes 31, 31 to prevent condensation of charge material on these electrodes 31, 31 during operation.

A C-shaped liner 40 is arranged within the tank 12, the axis of the liner 40 and the axis of the tank 12 being substantially parallel. One end of the liner 40 is arranged in electrical contact with the ion accelerating structure 30 and the other end terminates adjacent the collector 16. This liner 40 serves to maintain an electric-field-free region in the space between the transmitter 15 and the collector 16 in which ions travel when the calutron 10 is operating.

The leads 28, 28 of the cathode 25 and the arm 27 supporting the source are water-cooled by means of water supplied through a first main conduit 50 including a first valve 51 and a first flow switch 52 and through two branch conduits 54 and 55. The branch conduit 55 is arranged in heat exchange relation with the bushing 27. The two leads 28, 28 are in the form of squirt tubes and water is supplied to them through the other branch conduit 54. To mutually insulate the main conduit 50 the ion source 15 and the cathode 25, from each other electrically, the main conduit 50 enters a central opening of an insulating T junction 56, connected, and the two branch conduits 54 and 55 are attached to opposite ends thereof and the second branch conduit 54 communicates with an insulating block 57 which is connected to the outer ends of the squirt tubes 28, 28. This insulating block 57 is so arranged that cooling water flows through the branch conduit 54 into the block 57, thence through one of the squirt tubes 28 back into the block 57 and thence through the other squirt tube 28 back into the block 57 and thence out of the block 57 into a sump (not shown). In operation the water flows through the valve 51, through the flow switch 52 and into the insulating T junction and there it is divided into two currents one of which flows through one branch conduit 54 through the two squirt tubes 28, 28 into the water sump and the other of which flows through the conduit 55 associated with the bushing 27 and thence into the water sump.

The C-shaped liner 40 is water cooled by means of water supplied through a second main conduit 41 comprising two serially connected sections 42 and 43 joined together by means of an insulating coupling 44. The first section 42 is arranged externally of the tank and includes a second valve 45 and a second flow switch 46. The second section 43 extends through the wall of the tank 12 and is insulated therefrom and is arranged in heat exchange relation with the C liner 40. The discharge end of this section 43 passes out through the wall of the tank 12. When cooling water is flowing through

this section the C liner is cooled from end to end including the end adjacent the electrode structure 30.

The collector 16 is water-cooled by means of water supplied through a third main conduit 61 comprising two serially connected sections 62 and 63 joined together by means of an insulating coupling 64. The first section 62 is arranged externally of the tank 12 and includes a third valve 65 and a third flow switch 66. The second section 63 extends through the wall of the tank 12 and is insulated therefrom and is arranged in heat exchange relation with the collector 16. The discharge end of this section 63 likewise passes out through the wall of the tank 12. When cooling water is flowing through this section the collector 16 is cooled.

In the calutron illustrated here, the ion source 15 is electrically connected to the wall of the tank 12 and is grounded and the accelerating electrode structure 30 and the C liner 40 and the collector 16 are insulated from the tank wall so that they may be maintained at a high negative potential with respect to ground in a manner hereinafter set forth.

In order to strike an arc in the arc chamber 22 and to control it in a suitable manner electrical power is supplied to the heaters 23 and 24 associated with the charge chamber 21, the arc chamber 22, and also to the thermionically emissive cathode 25. The heating of the charge chamber 21 causes a charge of solid material previously placed therein to vaporize and flow into the arc chamber 22 where it becomes ionized and some of the ions formed are withdrawn through the slit 26 into the beam defining slit 32 in the accelerating electrode structure 30 and thence projected along arcuate paths to the collector 16. More particularly, the thermionically emissive cathode 25 and the two electrical heaters 23 and 24 and the two electrical heaters 33, 33 are supplied power through corresponding first, second, third, and fourth power supplies 70, 80, 90 and 100 respectively associated therewith.

The first power supply 70 includes a manually operable switch 72, a variac 74, and an isolation transformer 75 arranged in the order named between the input 76 and the output 78 thereof. The second power supply 80 also comprises a manually operable switch 82, a variac 84, and an isolation transformer 85 operatively connected in the order named between the input 86 and the output 88 thereof. The third power supply 90 also comprises a manually operable switch 92, a variac 94, and an isolation transformer 95 operatively connected between the input 96 and the output 98 thereof. And the fourth power supply 100 likewise comprises a manually operable switch 102, a variac 104, and an isolation transformer 105 operatively connected in the order named between the input 106 and the output 108 thereof.

An arc voltage supply 110 having an input 112 and an output 114 is provided, the output of which is electrically connected between the wall of the arc chamber 22 and the cathode 25 so as to maintain the cathode 25 negative with respect to the arc chamber 22 by means of a suitable voltage of about fifty to two hundred volts.

There is also provided a regulated high voltage supply 120 having an input 122 and an output 124 adapted to produce a high D. C. voltage of the order of about 10,000 to about 20,000 volts. The output 124 of this power supply 120 is connected between the wall of the grounded arc chamber 22 and the accelerating electrode structure 30 so as to maintain the ion source 15 at a positive potential relative to the ion accelerating electrode structure 30.

Two filament supplies 115 and 125 are associated with the arc voltage supply 110 and the regulated high voltage supply 120 respectively.

The inputs 76, 86, 96, and 106 of the first, second, third, and fourth power supplies 70, 80, 90, and 100 mentioned above are all connected to the main busses 130 which are supplied power from the main power line 132 through the contacts 134 of a relay 136. The two filament supplies

115 and 125 are also connected to these busses 130 through a double pole single throw switch 126. The input 112 of the arc voltage supply 110 is connected to these busses 130 through an auxiliary double pole single throw switch 117 and the switch 126. The input 122 of the regulated high voltage supply 120 is connected to these busses 130 through an auxiliary double pole single throw switch 127 and the switch 126. The coil 137 of the relay 136 is connected across the conductors 132 of the main power line through contacts of three serially connected microswitch elements (not shown) arranged in the three flow switches 52, 46, and 66 respectively.

To complete the electrical control network associated with the calutron 10 there is provided a vacuum pump control circuit 140 having an input 142 and an output 144 and a magnet control circuit 150 having an input 152 and an output 154. The inputs 142 and 152 of these two circuits 140 and 150 are directly connected to the conductors 132 of the main power line through corresponding double pole single throw switches 147 and 157. The output 144 of the vacuum pump control circuit 140 is connected to the vacuum pump 14. The output 154 of the magnet control circuit 150 is connected to the coils (not shown) of the electromagnet in the gap of which the tank 12 is mounted.

In operation, in order to effect an isotopic enrichment and a collection of the enriched material, a charge of solid polyisotopic material is placed in the charge chamber 21 and the ion source 15 is mounted in a standard manner within the tank 10. The switches 147 associated with a vacuum pump control circuit 140 is then closed, thus energizing the vacuum pump 14 and initiating evacuation of the tank 12. After the pressure within the tank has been reduced to a suitably low value of the order of 10^{-4} mm. Hg, the switch 157 associated with the magnet control circuit 150 is energized, thereby establishing a magnetic field through the tank 12.

The valves 51, 45, and 65 in the three water conduits 50, 41 and 61 are then opened. When the first valve 51 is opened, cooling water circulates through the squirt tubes 28, 28 and through the section of the conduit 55 arranged on the bushing 27. When the second valve 45 is opened cooling water circulates through the section 43 of the conduit 41 in thermal contact with the C-shaped liner 40. When the third valve 65 is opened cooling water circulates through the section 63 of the conduit 61 in thermal contact with the collector 16. When the rates of flow of cooling water in the three conduits are thus established at rates exceeding selected corresponding predetermined values, the microswitches (not shown) in the three flow switches 52, 46 and 66 are closed thus completing the circuit including the coil 137, thus energizing the relay 136. When the relay 136 is thus energized the contacts 134 close and the busses 130 are electrically connected to the conductors 132 of the main power line, thus preparing the four power supplies 70, 80, 90 and 100 and the arc voltage supply 110 and the regulated high voltage 120 and the filament supplies 115 and 125 for operation. The switches 72, 82, 92, and 102 of these four power supplies 70, 80, 90, and 100 are then selectively closed at will, thereby causing electrical energy to flow to the thermionically emissive cathode 25 and the four heaters 23, 24, and 33, 33, the amount of heat supplied thereto being regulated by adjustment of the corresponding variacs 74, 84, 94, and 104. The switch 125 is then closed thus energizing the filament supplies 115 and 125 and the switch 117 is then closed thus establishing an electron accelerating voltage between the cathode 25 and the arc chamber 22 and causing ionizing electrons to be projected into the vapor in the arc chamber 22. When an arc of suitable strength and stability is thus established in the arc chamber 22, the switch 127 is closed, thus causing the regulated voltage supply 120 to become energized and thus establishing an ion accelerating field between the ion source 15 and the accelerating electrode structure 30. When this field has been established, some of the ions

formed in the arc chamber 22 are withdrawn therefrom and selected ions are projected along arcuate paths through the tank 12 to the collector 16 where monoisotopically enriched materials derived from the polyisotopic charge material are separately collected in the pockets 17 and 18, as more fully explained in copending application of Ernest O. Lawrence, Serial No. 557,784, filed October 9, 1944.

By means of the arrangement hereinabove described, neither the ion source 15 nor the accelerating structure 30 can be heated and no arc can be established in the arc chamber and no ion beam can be transmitted through the C-shaped liner and to the collector unless water is flowing at suitable rates through the various water-cooled structural elements of the calutron.

In an alternative embodiment of the invention illustrated in Fig. 2, another arrangement of the control network is utilized in connection with the same calutron 10 hereinabove described. The electrical units of this network are same as those previously described, the difference in the network residing in the use of three relays instead of the single relay and the manner in which the inputs of some of the voltage supplies and power supplies are connected to the main power line.

More particularly, the inputs 112, 76, 86, and 96 of the arc voltage supply 110 and the first, second and third power supplies 70, 80, and 90 are connected to the busses 160 which are in turn connected to the conductors 132 of the main power line through contacts 170 of a first relay 171. The arc voltage supply 110 is connected to the busses through a double pole single throw switch 118. The coil 172 of the first relay is connected across the conductors 132 of the main power line through contacts of a microswitch element (not shown) in the first flow switch 52.

The fourth power supply 100 which serves to supply electrical energy to the heaters 33, 33 associated with the accelerating electrode structure 30 are connected to the conductors 132 of the main power line through contacts 180 of a second relay 181. The coil 182 of the second relay 181 is connected across the conductors 132 of the main power line through contacts of a microswitch element (not shown) in the second flow switch 46.

The regulated high voltage supply 120 is connected to the conductors 132 of the main power line through a double pole single throw switch 129 and through contacts 190 of a third relay 191 and through contacts 180 of the second relay 181. The coil 192 of the third relay 191 is connected across the conductors 132 of the main control line through contacts of a microswitch element (not shown) in the third flow switch 66.

The two filament supplies 115 and 125 are connected directly across the conductors 132 of the main power line through the double pole single throw switch 128.

In operating the calutron 10 with the network illustrated in Fig. 2, the vacuum pump circuit 140 and the magnet control circuit 150 are first operated in the manner hereinabove described and the switch 128 is closed thus energizing the filament supplies 115 and 125. The valves 51, 45, and 65 in the three water conduits are then opened. When the first valve 51 is opened, cooling water circulates through the squirt tubes 28, 28 and through a portion of the conduit 55 arranged on the bushing 27. When the rate of flow of cooling water through the water-cooled elements associated with the ion source 15 are thus established at a rate exceeding a predetermined rate, the microswitch (not shown) in the first flow switch 52 is closed, thus completing the circuit including the coil 172 of the first relay 171 and thus energizing this relay 171. When this relay 171 is thus energized the contacts 170 close and the conductors 160 are electrically connected to the conductors 132 of the main power line, thus preparing the three power supplies 70, 80, and 90 and the arc voltage supply 110 for operation. When the second valve 45 is opened, cooling water circulates through the section 43 of the conduit 41 in thermal contact with the C-shaped liner 40. When the rate of flow of cooling water through the section 43 of conduit 41 in contact with the C-shaped liner 40 is thus established at a rate exceeding a predetermined rate the microswitch (not shown) in the second flow switch 46 is closed, thus completing the circuit including the coil 182 of the second relay 181 and thus energizing this relay 181. When this relay 181 is thus energized, the contacts 180 close and the input 106 of the fourth power supply 100 is electrically connected to the conductors 132 of the main power line, thus preparing the fourth power supply 100 for operation. When the third valve 65 is opened, cooling water circulates through the section 63 of the conduit 61 in thermal contact with the collector 16. When the rate of flow of cooling water through the section 63 of the conduit 61 in thermal communication with the collector 16 is thus established at a rate exceeding a predetermined rate the microswitch (not shown) in the third flow switch 66 is closed, thus completing the circuit including the coil 192 of the third relay 191 and thus energizing this relay 191. When this relay 191 is thus energized, the contact 190 closes and the regulated high voltage supply 120 is prepared for operation.

When the above-referred to circuits have been prepared for operation, the switches 82, 92, and 102 of the second, third, and fourth power supplies 80, 90, and 100 are closed thereby causing electrical energy to flow to the four heaters 23, 24, and 33, 33. The amount of heat supplied to these four heaters may be regulated by adjustment of the corresponding variacs 84, 94, and 104. When the vapor pressure in the arc chamber 22 is brought to a sufficiently high value the switch 128 is closed if it is open, thereby energizing the filament supplies 115 and 125. The switch 72 of the first power supply 70 is then closed, thereby causing electrical energy to flow to the thermionically emissive cathode 25. When this cathode 25 has been brought to a sufficiently high temperature the switch 118 is closed, thereby energizing the arc voltage supply 110, thus establishing an electron accelerating voltage between the cathode 25 and the arc chamber 22 and causing ionizing electrons to be projected into the vapor in the arc chamber 22. When an arc of suitable strength and stability is thus established in the arc chamber 22 the switch 129 is closed, thus causing the regulated voltage supply 120 to become energized and thus establishing an ion accelerating field between the ion source 15 and the accelerating electrode structure 30. When the ion accelerating field has been established, positive ions formed in the arc chamber 22 are withdrawn therefrom and projected along arcuate paths through the tank 12 to the collector 16 where monoisotopically enriched materials derived from the polyisotopic charge material are separately collected in the pockets 17 and 18.

By means of the arrangement described, no arc can be established in the arc chamber unless water is flowing at a suitable rate through various water-cooled structural elements associated with the ion source. Likewise, the accelerating electrode structure cannot be heated unless water is flowing at a suitable rate through the water cooling conduit on the C-shaped liner to which the accelerating electrode structure is attached. Likewise, no ion accelerating field can be established between the ion source and the accelerating electrode structure unless water is flowing both through the water cooling conduit on the C-shaped liner and through the water cooling conduit which is connected to the collector.

What is claimed is:

1. In a calutron having an evacuated tank disposed in a magnetic field, an ion source and associated structure disposed in said tank, an ion receiver disposed in said tank, ion accelerating means including electrode structure disposed adjacent said ion source adapted to transmit selected ions from said ion source through said magnetic field along predetermined paths to said receiver, liner structure connected to said accelerating electrode structure and disposed in said tank along said paths in

enveloping relationship thereto whereby said paths are electrostatically shielded from said ion accelerating means, ion source cooling means including a conduit arranged in heat exchange relationship with said structure associated with said ion source, liner structure cooling means including a conduit arranged in heat exchange relationship with said liner structure, receiver cooling means including a conduit arranged in heat exchange relationship with said receiver, a voltage supply associated with said ion accelerating means, arc generating means associated with said ion source, and means controlled by flow of a cooling medium through said three conduits at rates in excess of corresponding predetermined rates for preparing said arc generating means and said voltage supply for operation, whereby an arc may be established in said ion source and ions may be withdrawn therefrom and projected along said paths only when the rates of flow of the cooling medium through said conduits exceed said predetermined rates.

2. In a calutron having an evacuated tank disposed in a magnetic field, an ion source and associated structure disposed in said tank, an ion receiver disposed in said tank, an accelerating means including electrode structure disposed adjacent said ion source adapted to transmit selected ions from said ion source through said magnetic field along predetermined paths to said receiver, liner structure connected to said accelerating electrode structure and disposed in said tank along said paths in enveloping relationship thereto whereby said paths are electrostatically shielded from said ion accelerating means, ion source cooling means including a conduit arranged in heat exchange relationship with structure associated with said ion source, liner structure cooling means including a conduit arranged in heat exchange relationship with said liner structure, receiver cooling means including a conduit arranged in heat exchange relationship with said receiver, arc generating means for creating ions in said ion source, a voltage supply associated with said ion accelerating structure, means controlled by flow of a cooling medium through said ion source cooling means at a rate in excess of a predetermined rate for preparing said arc generating means for operation whereby an arc may be established in said ion source only when the rate of flow of cooling medium through the ion source cooling means exceeds said predetermined rate, and means controlled by flow of cooling medium through both said liner cooling means and said receiver cooling means at rates in excess of corresponding predetermined rates for preparing said voltage supply for operation whereby ions may be withdrawn from said ion source and projected along said paths only when the rates of flow of the cooling medium through the conduits arranged in heat exchange relationship with said liner and with said receiver exceed said corresponding predetermined rates.

3. In a calutron having an evacuated tank disposed in a magnetic field, an ion source and associated structure disposed in said tank, an ion receiver disposed in said tank, ion accelerating means including electrode structure disposed adjacent said ion source adapted to transmit selected ions from said ion source through said magnetic field along predetermined paths to said receiver, liner structure connected to said accelerating electrode structure and disposed in said tank along said paths in enveloping relationship thereto, whereby said paths are electrostatically shielded from said ion accelerating means, ion source cooling means including a conduit arranged in heat exchange relationship with structure associated with said ion source, liner structure cooling means including a conduit arranged in heat exchange relationship with said liner structure, receiver cooling means including a conduit arranged in heat exchange relationship with said receiver, arc generating means for creating ions in said ion source, heating means arranged in heat exchange relationship with said ion accelerating structure, a voltage supply associated with said ion accelerating means, means controlled by flow of a cooling medium through said ion source cooling means at a rate in excess of a predetermined rate for preparing said arc generating means for operation whereby an arc may be established in said ion source only when the rate of flow of cooling medium through the ion source cooling means exceeds said predetermined rate, means controlled by the flow of cooling medium through said liner cooling means at a rate in excess of a corresponding predetermined rate for preparing said heating means for operation whereby said ion accelerating structure may be heated only when the rate of flow of cooling medium through the conduit associated with said liner structure exceeds said corresponding predetermined rate, and means controlled by flow of cooling medium through both said liner cooling means and said receiver cooling means at rates in excess of corresponding predetermined rates for preparing said voltage supply for operation, whereby ions may be withdrawn from said ion source and projected along said paths only when the rates of flow of the cooling medium through the conduits arranged in heat exchange relationship with said liner and with said receiver exceed said corresponding predetermined rates.

4. In a calutron having an evacuated tank disposed in a magnetic field, an ion source disposed in said tank, an ion receiver disposed in said tank, ion accelerating means including electrode structure disposed adjacent said ion source adapted to transmit selected ions from said ion source through said magnetic field along predetermined paths to said receiver, liner structure thermally connected to said accelerating electrode structure and disposed in said tank along said paths in enveloping relationship thereto, whereby said paths are electrostatically shielded from said ion accelerating means, liner structure cooling means including a conduit arranged in heat exchange relationship with said liner structure, heating means arranged in heat exchange relationship with said ion accelerating structure, a voltage supply associated with said ion accelerating means, and means controlled by the flow of cooling medium through said liner cooling means at a rate in excess of a predetermined rate for preparing said heating means and said voltage supply for operation whereby said ion accelerating structure may be heated and ions may be withdrawn from said ion source and projected along said paths only when the rate of flow of the cooling medium through said conduit exceeds said predetermined rate.

5. In a calutron having an evacuated tank disposed in a magnetic field, an ion source disposed in said tank, an ion receiver disposed in said tank, ion accelerating means including electrode structure disposed adjacent said ion source adapted to transmit selected ions from said ion source through said magnetic field along predetermined paths to said receiver, liner structure connected to said accelerating electrode structure and disposed in said tank along said paths in enveloping relationship thereto whereby said paths are electrostatically shielded from said ion accelerating means, liner structure cooling means including a conduit arranged in heat exchange relationship with said liner structure, receiver cooling means including a conduit arranged in heat exchange relationship with said receiver, a voltage supply associated with said ion accelerating means, and means controlled by flow of a cooling medium through said two conduits at rates in excess of corresponding predetermined rates for preparing said power supply for operation whereby ions may be withdrawn from said ion source and projected along said paths only when the rates of flow of the cooling medium through said conduits exceed said predetermined rates.

6. In a calutron having an evacuated tank disposed in a magnetic field, an ion source disposed in said tank, an ion receiver disposed in said tank, ion accelerating means including electrode structure disposed adjacent said ion source and adapted to transmit selected ions from

said ion source through said magnetic field along predetermined paths to said receiver, receiver cooling means including a conduit arranged in heat exchange relationship with said receiver, a voltage supply associated with said ion accelerating means, and means controlled by flow of cooling medium through said receiver cooling means at a rate in excess of a predetermined rate for preparing said voltage supply for operation whereby ions may be withdrawn from said ion source projected along said paths only when the rate of flow of the cooling medium through said conduit exceeds said predetermined rates.

7. In a calutron having an evacuated tank disposed in a magnetic field, an ion source disposed in said tank, an ion receiver disposed in said tank, ion accelerating means including electrode structure disposed adjacent said ion source and adapted to transmit selected ions from said ion source through said magnetic field along predetermined paths into said receiver, liner structure connected to said accelerating electrode structure and disposed in said tank along said paths in enveloping relationship thereto whereby said paths are electrostatically shielded from said ion source, liner structure cooling means including a conduit arranged in heat exchange relationship with said liner structure, a voltage supply associated with said ion accelerating means, and means controlled by the flow of cooling medium through said liner cooling means at a rate in excess of a predetermined rate for preparing said voltage supply for operation whereby ions may be withdrawn from said ion source and projected along said paths only when the rate of flow of the cooling medium through said conduit exceeds said predetermined rates.

No references cited.