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B. T. WRIGHT ET AL
AUTOMATIC VAPOR CONTROL

2,735,943

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2 Sheets-Sheet 1

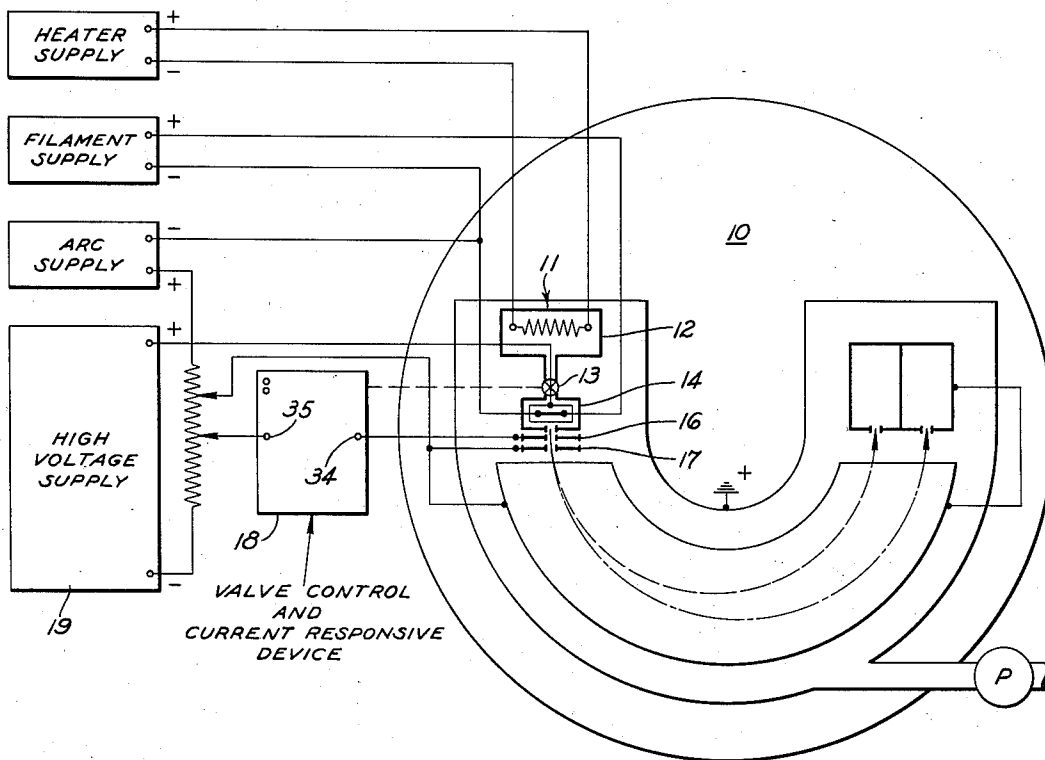


Fig. 1

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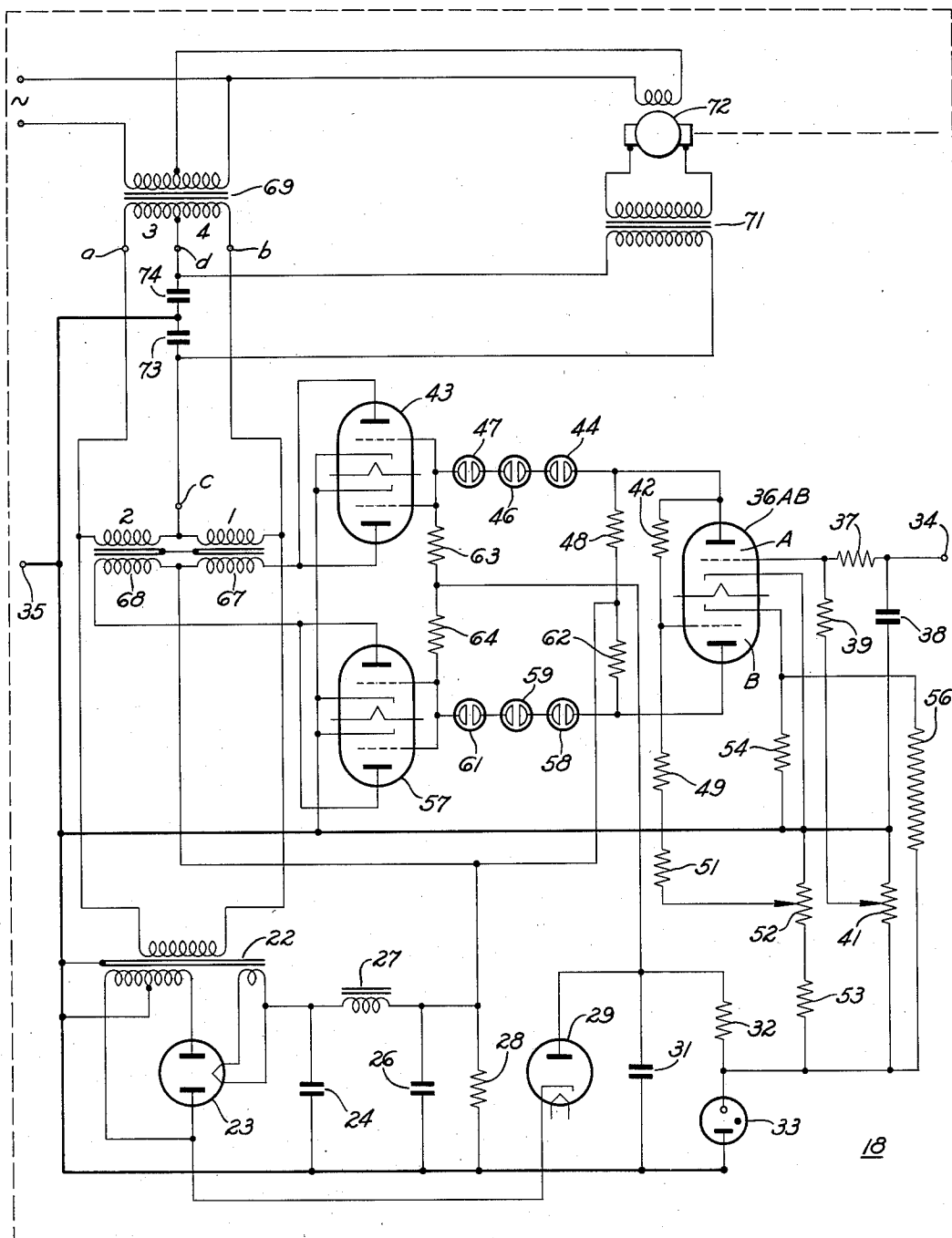


Fig. 2

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AUTOMATIC VAPOR CONTROL

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5 Claims. (Cl. 250—41.9)

This invention relates to an ion source vapor regulator in general. More particularly, this invention relates to an apparatus adapted to insure a stable arc in an ion generator.

An object of this invention is to provide an apparatus adapted to stabilize the arc in an ion generator by regulating the vapor flow thereto.

Another object of this invention is to provide a simple electrical arrangement for automatically regulating a calutron vapor valve so as to maintain a steady flow of vapor from a vapor source to an ionization chamber whereby a more stable arc may be maintained within the ionization chamber.

Still another object of this invention is to provide a simple electrical arrangement for regulating a calutron vapor valve so as to control the flow of vapor to an ionization chamber as a function of the current flow to an acceleration electrode disposed adjacent said ionization chamber.

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

In the accompanying drawings, forming part of this specification, Figure 1 is a schematic view of a calutron embodying the invention and, Fig. 2 is a schematic drawing of the electrical control mechanism instrumental in attaining the objects of the invention.

In Fig. 1 reference numeral 10 designates a calutron having an ion source unit 11 which includes a vaporizing chamber 12 communicating through an adjustable valve 13 to an ionization chamber 14. First and second projecting electrodes 16 and 17 are positioned in front of the ion exit slit communicating with the ionization chamber 14 and are adjustably connected to the negative side of a high voltage power supply 19 as illustrated in the drawing. Further, the electrode 16 is connected through a current responsive device within the valve control mechanism 18, to the high voltage supply 19. This current responsive device supplies a voltage to the valve actuating mechanism, also a part of the valve control mechanism 18, the voltage being of such a value as to reduce the valve opening when the current to the electrode 16, exceeds a predetermined value and as to increase the valve opening when the current to electrode 16 is less than a predetermined value.

The current responsive device and the valve actuating mechanism mentioned above are schematically illustrated in Fig. 2 which is oriented with respect to Fig. 1 by designating the external terminals by the same numbers (34 and 35) in each figure. It is to be noted that the "ground" of the current responsive device is actually some negative potential which is determined by the setting of the high voltage supply rheostat; however, this potential is considered to be ground potential for the purpose of disclosing the circuit of the current responsive device and is referred to as ground in the following description. Considering the present invention with respect to Fig. 2, D. C. plate potential is obtained from a conventional full

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wave rectifier and filter consisting of a power transformer 22, rectifier tube 23, condensers 24 and 26, choke 27 and bleeder resistor 28. The center tap of transformer 22 is grounded, and positive voltage is obtained at the output of the filter, across the bleeder resistor 28.

Bias voltage is obtained from a conventional half wave rectifier employing half the secondary winding of the aforementioned transformer 22, rectifier tube 29 and a regulating net work consisting of a by-pass condenser 31, a resistor 32 and a gaseous voltage regulator tube 33. The negative voltage is developed across the regulator tube 33, the plate being at ground and the cathode at negative potential. A higher but unregulated source of negative grid bias is also available at the plate of rectifier 29.

Input terminal 34 is connected to the control grid of a triode 36A through a resistor 37. A condenser 38 is connected from terminal 34 to ground, condenser 38 and resistor 37 forming an integrating net work in the input circuit.

Grid bias to triode 36A is obtained through a resistor 39 from a sliding contact on a potentiometer 41 connected from ground to the regulated bias voltage supply at the cathode of regulator tube 33. The cathode of triode 36A is grounded, the anode being coupled to the control grid of triode 36B through a high resistance 42 and to the control grids of a double triode 43 through three neon glow lamps 44, 46 and 47. Plate load resistor 48 supplies voltage to triode 36A from the output of the power supply filter. Bias for triode 36B is obtained through series resistors 49 and 51 from the sliding contact of a potentiometer 52 which is connected in series with a resistor 53 across the bias supply. The cathode of triode 36B is returned to ground through a relatively large resistance 54 and to the regulated bias source through a resistor 56. Thus triode 36B is a highly degenerative amplifier and serves as a phase inverter to signals impressed on its grid by triode 36A. The plate of triode 36B is coupled to the control grids of double triode 57 through three neon glow tubes 58, 59 and 61, plate voltage being applied from the power supply through a load resistor 62.

Double triodes 43 and 57 are each connected as single triodes in a push pull circuit, grid bias from the unregulated source at the plate of bias rectifier 29 being applied through very high resistances 63 and 64 respectively.

The cathodes of triodes 43 and 57 are grounded while the plates are connected to primary windings of a pair of saturable core reactors 67 and 68, said primary windings being connected in series and the mid point thus formed returned directly to the plate supply source. The secondary windings of saturable reactors 67 and 68 and a center tapped transformer 69 are connected in the form of a Wheatstone bridge, having as input terminals the ends of the secondary winding of transformer 69 (points a and b) and as output terminals the center tap of the secondary of transformer 69 (point d), and the juncture of secondary windings of saturable reactors 57 and 68 (point c). The input of the bridge is energized by voltage induced into the secondary of transformer 69 from an A. C. source connected to the primary. Energy developed at the secondary of transformer 69 is also connected to the primary winding of the power transformer 22, transformer 69 serving to isolate the power supply from the power line since the entire circuit operates at the high potential of the projecting electrode 16 of Fig. 1 as discussed previously.

The output terminals of the bridge are coupled through transformer 71 to the armature of an A. C. motor 72 of the reversible type, the field being energized from the A. C. power source, connections being made to one line and a tap on the primary of transformer 69. The output terminals c and d are by-passed by condensers 73 and 74.

The operation of the valve actuating mechanism and

current responsive device will be apparent to those skilled in the art by the following discussion. Reference is made to Fig. 2 of the drawings.

The motor 72 controls a calutron vapor valve and is of the reversible type, the direction of rotation depending on the relative phase between the field and armature voltages. Further, windings 1 and 2 of saturable core reactors 67 and 68 and secondary windings 3 and 4 of transformer 69 form a Wheatstone bridge, the input being an alternating voltage between points *a* and *b* which are the terminals of the center tapped secondary of transformer 69, and the output being an alternating voltage of variable phase and amplitude developed between terminals *c* and *d* which are connected by way of the transformer 71 to the armature of the motor 72. The field of motor 72 is connected to the same source of alternating current energizing the bridge. Thus it will be understood that the relative phase of the motor field and armature voltages, and, consequently, the direction of rotation of the motor 72 is determined by the relative impedance of the arms 1 and 2 of the bridge. Moreover, the greater the difference in the impedances of windings 1 and 2, the higher the value of the bridge output and the greater the speed of motor 72.

The impedances of arms 1 and 2 of the bridge are controlled by the magnitude of the current through the primaries of the saturable reactors 67 and 68 which in turn are responsive to the current input to the terminal 34.

The triode 36A has its output directly coupled by way of the glow tubes 44, 46 and 47 to the input of double triode 43 and indirectly coupled by way of a phase inverting triode 36B and glow tubes 58, 59 and 61 to the input of double triode 57.

The input to the triode 36A is the voltage drop across resistor 39 and part of potentiometer 41 due to the current flow to the acceleration electrode 16 via terminal 34.

Thus the input signals to the double triodes 43 and 57 respond in opposite directions as the result of changes in the input current to terminal 34, a rise in said current resulting in drop in the input voltage to the triode 43 and a rise in the input voltage to the triode 57 and similarly, a drop in the input current being followed by a rise and fall respectively in the input voltages to the triodes 43 and 57.

Assuming the bridge is initially balanced so that there is no output to the field of motor 72 and hence no rotation of said motor; the currents through the primaries of the reactors 67 and 68 are equal as are the input voltages to the double triodes 43 and 57. Should there be a rise in the ion source arc current as applied to terminal 34 the voltage input to triode 57 increases thus increasing the current through the primary winding of reactor 68 and decreasing the impedance of the bridge arm 2. The voltage input to triode 43 decreases thereby reducing the current through the primary winding of reactor 67 and increasing the impedance of the bridge arm 1. The resulting unbalance of the bridge is in such a direction that the motor 72 causes the ion source valve 13 Fig. 1 to decrease the vapor flow to the arc, thereby urging the arc current to fall to its original predetermined equilibrium value. Moreover, the arc current may be set to an initial value by adjusting the potentiometers 41 and 52 which vary the grid biases on the triodes 36A and 36B respectively.

By presetting the biases on the double triodes 43 and 57 so that these tubes pass very little current in their equilibrium condition, a small change in input current from the equilibrium value will result in a negligible unbalance of the bridge followed by no resulting rotation of the motor 72. This characteristic is desirable in that it prevents hunting by the motor since an overshoot of the motor will not result in sufficient unbalance of the bridge to cause rotation in the opposite direction. The above result is accomplished when there are only small currents flowing through the control windings of the saturable core reactors, since under these circumstances the impedance sensitivity to changes in currents is small because said reac-

tors are operating at the low slope end of their hysteresis curve.

While I have described the salient features of this invention in detail with respect to one embodiment it will, of course, be apparent that numerous modifications may be made within the spirit and scope of this invention and I do not therefore desire to limit the invention to the exact details shown except insofar as they may be defined in the following claims.

10 What is claimed is:

1. An ion generator comprising a source of vapor, an ionization chamber communicating with said source of vapor, means for establishing an electric arc discharge through said ionization chamber in order to ionize the vapor contained therein, means to expel ions from said ionization chamber, means including a valve for controlling the flow of vapor from said source of vapor into said ionization chamber, and means responsive to the amount of ions expelled from said ionization chamber for adjusting said valve in order to regulate the flow of vapor into said ionization chamber.

2. In a calutron, an ion generator, including a source of vapor, an ionization chamber communicating with said source of vapor and having an ion exit slit formed in the wall thereof; a first means including a valve for providing a continuously variable control of the flow of vapor into said ionization chamber, an ion accelerating electrode disposed adjacent said ionization chamber, and a second means influencing said first means in accordance with the current to said ion accelerating electrode.

3. In a calutron, an ion generator including a source of vapor, an ionization chamber communicating with said source of vapor and having an ion exit slit formed in the wall thereof; a valve providing a continuously variable control of the flow of vapor into said ionization chamber, an ion accelerating electrode disposed adjacent said ionization chamber, and a valve controlling mechanism comprising a current responsive device electrically connected to said ion accelerating electrode in responsive relation to the current thereto, and a valve manipulating element controlled by said current responsive device, whereby said valve is regulated to control the flow of vapor from said vapor source to said ionization chamber in accordance with the current to said ion accelerating electrode.

4. In a calutron an ion generator including a source of vapor, an ionization chamber communicating with said source of vapor and having an ion exit slit formed in the wall thereof, a valve for controlling the flow of vapor into said ion generator, an ion accelerating electrode disposed adjacent said ionization chamber and a valve control mechanism comprising a circuit network including a Wheatstone bridge having an input and an output, a pair of saturable reactors forming adjacent arms of said bridge, means for applying an alternating voltage to said input, a valve actuating element connected to said output and responsive to the phase relationship of the voltages at said output and input, and means for varying the relative impedance of said saturable reactors in order to vary said phase relationship, and thus cause said valve actuating element to operate in such a manner as to regulate the flow of vapor in accordance with the current to said acceleration electrode.

5. In a calutron, an ion generator including a source of vapor, an ionization chamber communicating with said source of vapor and having an ion exit slit formed in the wall thereof, a valve for controlling the flow of vapor into said ionization chamber, an ion accelerating electrode disposed adjacent said ionization chamber and a valve control mechanism comprising a circuit network including a Wheatstone bridge having an input and an output, a pair of saturable reactors forming adjacent arms of said bridge and having subordinate saturating windings, means including a transformer for applying an alternating voltage to said input, a valve actuating means including

an electric motor connected to said output and responsive to the phase relationship of the voltages at said output and input and means including a phase inverter and a push pull amplifier for varying direct currents through the saturating windings of said saturable reactors in accordance with the current to said acceleration electrode, thereby to unbalance the bridge in order to control the relative phase and magnitude of said output and thus cause said valve manipulating means to operate in such a manner as to regulate the flow of vapor in accordance with the current to said acceleration electrode.

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