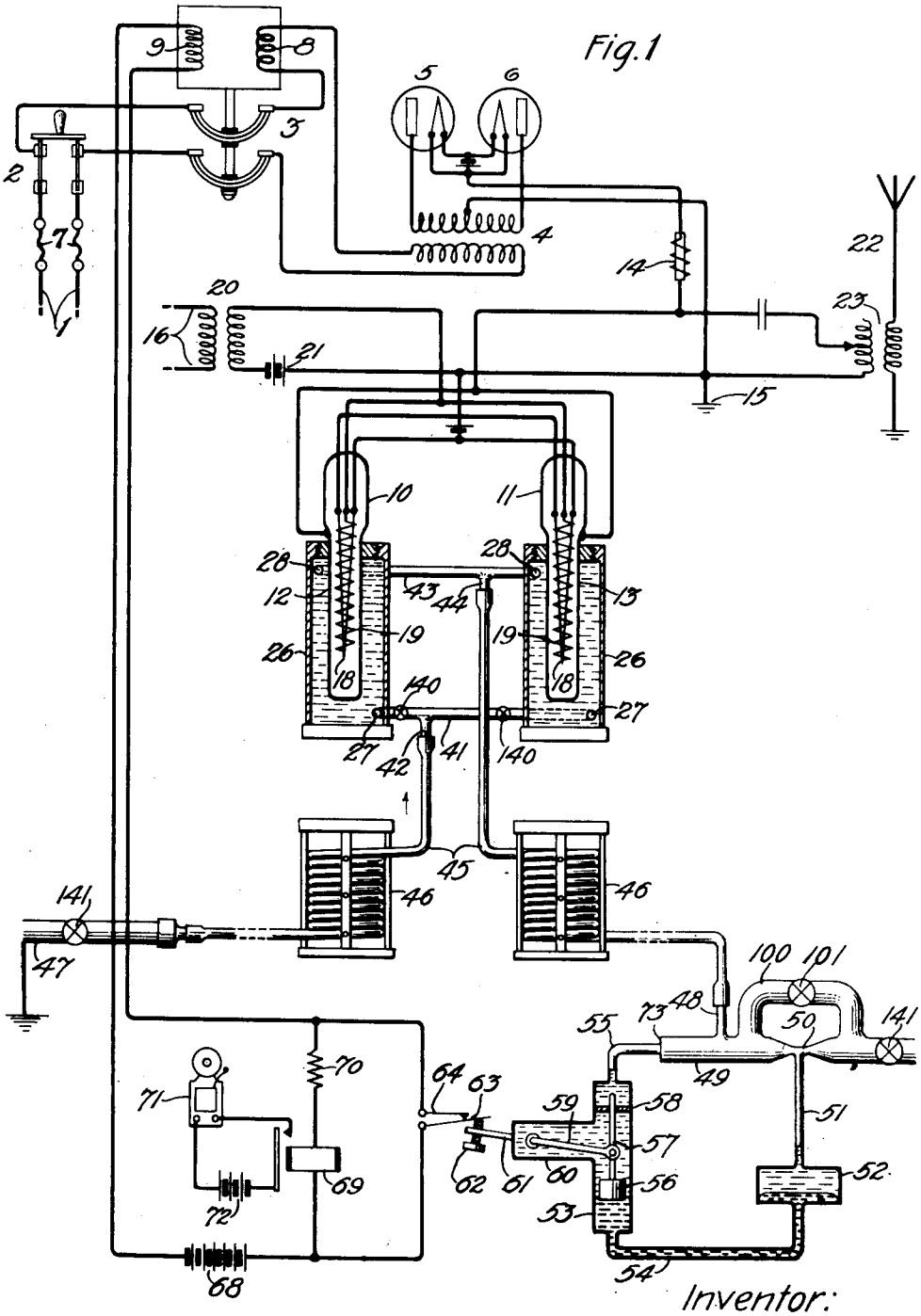
Aug. 30, 1932. A. A. OSWALD 1,874,707

ELECTRIC DISCHARGE APPARATUS

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Fig. 1



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Fig. 2

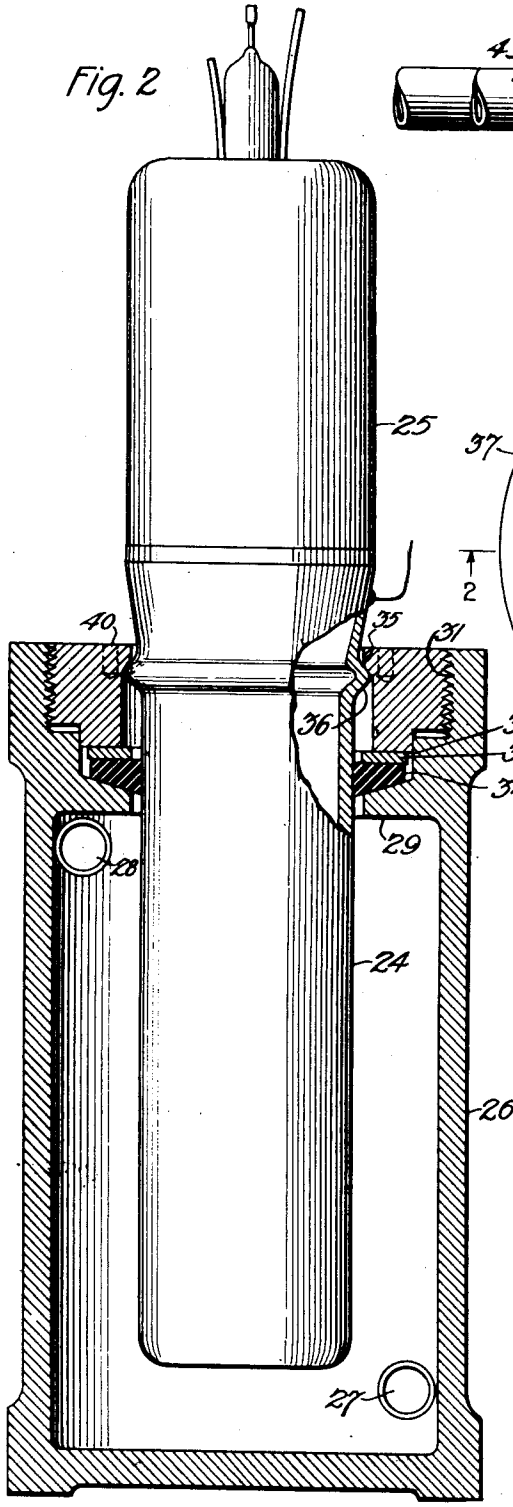


Fig. 3

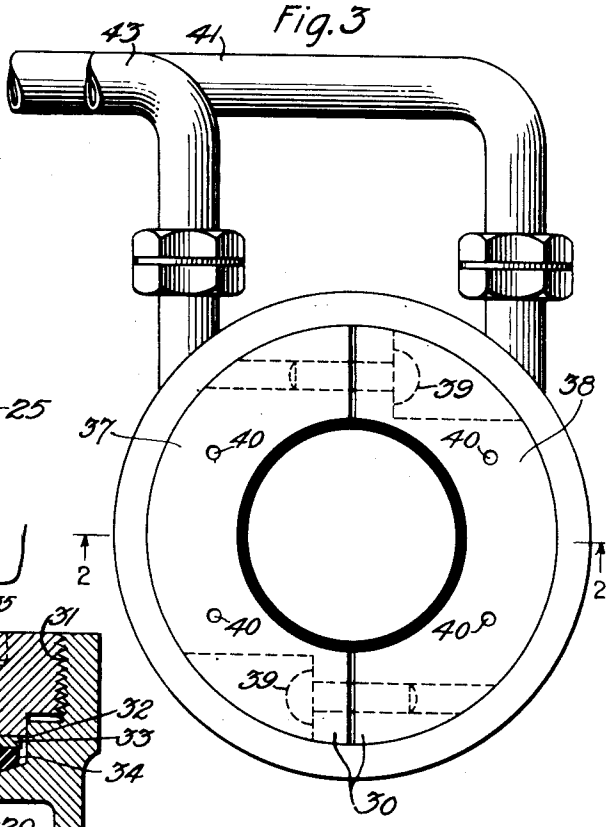
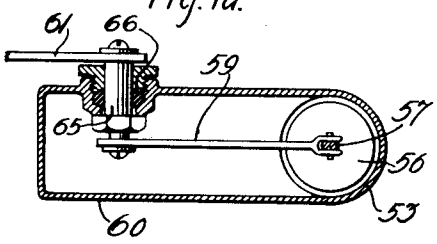


Fig. 1a.



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1,874,707

UNITED STATES PATENT OFFICE

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ELECTRIC DISCHARGE APPARATUS

Application filed May 12, 1922. Serial No. 560,518.

This invention relates to a high power electric discharge device and more particularly to controlling the operation of such a device, including an electron emitter and a cooperating electrode, for use with high voltages.

It has been proposed hitherto to use a discharge device of this character having a water cooled electrode, but, so far as applicant is aware, the power supplied by the discharge device to a load circuit has been relatively small and the potential impressed upon the water cooled electrode relatively low. In certain of these arrangements the water cooled electrode has been grounded, while the potential supplied by an external source has been impressed upon the associated electrode of the device.

The present invention provides an arrangement in which a device of this type has an electrode upon which energy from a high potential source is impressed and cooling water is supplied thereto so as to simultaneously dissipate the heat developed at this electrode, provide a high impedance path to ground, as well as to control the operation of an automatic mechanism which serves to control the connection of the source of electrical supply to this electrode and a signal circuit including an alarm device. In this manner the output electrode of a device of this type may be effectively cooled and insulated from the associated apparatus and ground, while the supply of electrical energy thereto may be regulated and the operator notified of the failure of the water supply, whereby an electric discharge device may be safely used in a high power system adapted to supply high tension energy to a load circuit.

According to this invention, the cathode of the discharge device is grounded, and its anode is operated at a high potential relatively to ground. Water or other cooling medium is introduced into contact with the anode from a grounded supply source and discharged either directly to the earth or to a drain connected to ground through an insulating conveyer for the cooling medium, whereby the medium itself, being of low conductivity and the conveyer of considerable length constitutes a high impedance path between the anode and ground. In this manner all danger of injury to the apparatus itself, the attendant in charge, associated apparatus, or the supply source and discharge means for the cooling medium due to short circuit, shock or discharge is prevented, and also the necessary adjustments for controlling the operation of the device and the supply of cooling medium may be effected without interruption of the service provided, or injury to the attendant. An additional feature of the invention resides in the use of an automatic mechanism adapted to control an alarm circuit and the circuit breaker for connecting the electrical supply source to the anode, whereby upon a predetermined decrease in the amount of the cooling medium supplied to the anode, an alarm device will be operated and the source of electrical supply will be disconnected from the anode.

One object of this invention is to provide an arrangement whereby an electrode of an electric discharge device supplied with high potential may be effectively cooled and simultaneously insulated from ground.

Another object is the provision of means whereby the rate of flow of cooling medium to the high potential electrode of a discharge device is used to control both the supply of electric energy to the electrode and also an alarm circuit to indicate when the rate of flow of the cooling medium decreases below a predetermined normal value.

The novel features which are characteristic of the present invention will be set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation together with additional objects and advantages thereof, will be best understood by reference to the following description taken in connection with the accompanying drawings in which Fig. 1 shows the invention applied to an electric discharge device adapted to supply a load circuit. Fig. 1—A illustrates a detail of the control mechanism, Fig. 2 illustrates a cross-section taken on line 2, 2 of Fig. 3 showing the water jacket applied to the discharge device, the latter being shown in elevation. Fig. 3 is a plan view showing

the closure element or cap for the water jacket.

Referring to Fig. 1 there is shown a circuit 1 adapted to supply alternating current through the switch 2, circuit breaker 3 and step-up transformer 4 to the rectifiers 5 and 6 shown, by way of example, as two element discharge devices. Included in the supply circuit are protective fuses 7. The circuit breaker 3, in addition to the ordinary overload release coil 8, is provided with a holding coil 9 commonly referred to as a no-voltage release coil. As is well known, the armature controlled by the coil 9 is mechanically interlocked with the circuit breaker arms, so that the circuit breaker will only remain closed when this coil is energized.

Both half waves of the high voltage alternating current will be rectified by the devices 5 and 6 and will be impressed upon the output circuits of the high power devices 10 and 11 through a path extending from the common connection for the cathodes of the rectifiers 5 and 6 through the choke coil 14 to the anodes 12 and 13 of the devices 10 and 11 across the space to the filaments 18 and thence to the mid-point of the secondary winding of the transformer 4. The filaments of the high power devices and those of the rectifiers are supplied with heating current from suitable sources, the filaments of the devices 10 and 11 being grounded at 15.

Current to be amplified is supplied by the circuit 16 to the input circuit of the devices 10 and 11, which extends from the filaments 18 to the grids 19 thereof and includes the secondary of the transformer 20, as well as the source 21 which is adapted to impress a control potential upon the grids 19.

As shown in this figure the high power amplified current of radio frequency is supplied to the antenna 22 of a radio transmitting station by the transformer 23. The choke coil 14 serves to provide a low impedance path for the rectified current supplied by the devices 5 and 6 while imposing a high impedance to the alternating current flowing through the common output circuit of the amplifying devices.

As shown in Figure 2, the discharge device consists of an evacuated vessel comprising a conductive portion 24, constituting the anode, and an insulating portion 25, preferably glass, sealed air tight to the anode 24 and adapted to carry the supporting elements for the grid and filament.

Surrounding the anode and spaced therefrom to constitute a cooling chamber, is a casing 26 having an inlet port 27 and an outlet port 28. The casing 26 is provided with an internally extending flange 29 spaced a short distance from the upper end thereof and is screw threaded at its upper open end. A cap or closure 30 for the casing has a threaded portion 31 adapted to engage with the screw threads on the upper open end of the casing and a depending flange 32 adapted to engage a metallic washer 33, which in turn engages with a flexible washer 34. The upper surface of the flange 29 and the lower cooperating surface of the washer 34, which may be of rubber, are inclined inwardly and downwardly so that as the cap 30 is screwed home the washer 33 is compressed and forced into intimate contact with the anode 24. In this manner a water tight seal between the anode and casing is provided. A flange 35 on the cap 30 is adapted to engage an external rib or lip 36 on the anode 24, whereby the discharge device may be securely held in engagement with and having its anode centrally positioned relatively to the jacket 26.

As shown in Figure 3, the cap or closure 30 is made in two sections, 37 and 38, connected together by screws 39, whereby it may be readily attached to and removed from engagement with the anode and casing. The closure is provided with a plurality of recesses or depressions 40 into a pair of which projecting lugs carried by a tool or spanner may be inserted to screw the cap into engagement with the jacket 26. Obviously the cap could be provided with a projecting boss of any well known form adapted to be engaged by a wrench for this purpose.

Referring again to Fig. 1, the anodes of the rectifying devices 5 and 6 may be provided with water jackets as described for devices 10 and 11. The inlet ports 27 of the jacketing element 26 are connected by a tube or pipe 41 provided with a hollow extension 42. Valves 140 are included in the pipe 41 between the extension 42 and the inlet ports 27. In a similar manner the outlet ports 28 are connected by a pipe 43 having a hollow extension 44. Secured to extensions 42 and 44 are insulating flexible tubes 45, portions of which are coiled and mounted on supporting frames 46. A water pipe 47 associated with any suitable source of supply is connected to the opposite end of the left hand tube 45 while the outer end of the right hand tube is secured to a tubular extension 48 carried by the outlet pipe 49 which is provided with a constricted portion 50. Tube 100 including a valve 101 is connected to the discharge pipe 49 on opposite sides of the constricted portion 50 to constitute a by-pass for the cooling water. This feature is provided for use under certain operating conditions to permit of increasing the water supplied to the cooling chambers associated with the anode. Obviously by adjusting the valve 101, a certain quantity of water may be diverted through the tube 100 without varying the quantity of water flowing through the constricted portion 50, and hence the quantity of water supplied to the anode may be thereby increased without affecting the operation of the automatic control mechanism. This arrangement may,

therefore, be used to increase the flow of cooling water to the anode without requiring a readjustment of the operative elements included in the automatic control mechanism.

A tube 51 secured to the outlet pipe at the constriction 50 serves to conduct water to the chamber 52. A pipe 54 connects the chamber 52 with a second chamber 53, the upper end of which is connected to the outlet pipe 49 by a tube 55. Connecting pipe 54 and a portion of the chambers 52 and 53 are filled with mercury. Included in the chamber 53 is a float 56 supported by the mercury and provided with a rod 57 adapted to engage a guide element 58 secured to the walls of the chamber, whereby, as the mercury rises and falls, the float will be constrained to move substantially axially of the chamber 53. Pivotally secured to the rod 57 is a lever 59 enclosed in an extension 60 secured to or formed integrally with the chamber 53 by means of which the movement of the float 56 may be transmitted to an external lever 61 provided with a set-screw 62 adapted to engage a movable contact 63. This contact cooperates with a fixed contact 64 for a purpose to be described later. Any well known mechanical means may be employed for connecting the levers 59 and 61 so that as the inner end of the former rises and falls with the float 56, the outer end of the lever 61 will also be displaced.

As shown in Fig. 1—A, lever 59 is connected to a stub shaft 65 which projects through a packing box 66 mounted in an opening in the side wall of the extension 60, the outer end of the shaft 65 is secured to the lever 61. Thus, as the float 56 is displaced, the shaft 65 will be rotated by means of the lever 59 and the position of the set-screw 62 relatively to the contact 63 will be varied. Obviously any other well known arrangement could be used for this purpose such as, for example, a single lever bent into the form of a crank, one arm of which constitutes the connecting portion 59, a second, the bearing portion enclosed in the packing box 66 while the third is adapted to carry the set-screw 62.

Contacts 63 and 64 are included in a circuit connected to the no-voltage coil 9, a source of current 68, a relay 69, and a resistance 70. Relay 69 is adapted to control a circuit which includes an alarm device, such as a bell 71, or a lamp, or both, and a source of current 72. Under certain conditions to be hereinafter described, the contacts 63 and 64 will be held in engagement to provide a path short circuiting the relay circuit, while under other conditions these contacts will be open and hence the relay will be energized from the source 68 to complete the alarm circuit.

The operation of the arrangement described above will be clear from the following description of an installation which has been tested. The apparatus tested comprised two element rectifiers having water cooled anodes of the design herein shown, upon which a potential of 10,000 volts was impressed. The cooling water was supplied through a distributing system including the insulating arrangement embodying the coiled insulating tubes. The filamentary cathodes of the amplifying devices were grounded as shown in Fig. 1. The potential impressed upon the anodes of the amplifying device was also 10,000 volts and the energy supplied to an artificial load circuit was of the order of 10 kilowatts. Under full load conditions the heat dissipated per square inch of the active anode surface is approximately ½ a kilowatt. In order to effectually transfer this large quantity of heat to the cooling water and at the same time prevent the production of air or vapor bubbles on the external surface of the anodes which would result in overheating them and consequently cause the destruction of the device even if a sufficient quantity of water is being supplied, the cooling water is given a swirling or rotary motion about the external surface of the anodes. This may be effected by providing cylindrical water jackets and discharging the water tangentially into one end of the jackets, the outlet ports are also tangentially arranged relatively to the jacket walls. The rate of flow of water to the anodes of the devices may be regulated by means of a control valve 141 in the inlet or outlet pipe 47 or 49, or it may be controlled separately for the different anodes by the valves 140.

With the filaments grounded, a potential of the magnitude hereinbefore given impressed upon the anodes of the rectifying and amplifying devices and the cooling water supplied by a source connected to ground, it will be apparent that special precautions must be taken to prevent short circuiting of the anode circuits of the devices, as well as to prevent the operator from injury and surrounding property from damage due to the high potentials employed.

In the tests referred to above it was found that by providing the long water columns between the inlet pipe and the anode on the one hand and between the anode and the outlet pipe on the other hand, the cooling water can be introduced from an ordinary water tap and discharged to a city drainage system without endangering the water and sewerage systems, surrounding property, or the attendant in charge of the apparatus. By using a flexible insulating tube and coiling it within the frames as shown at 46, the overall resistance of the ground path through the water column may be made sufficiently high for safe operation of the device, while the space occupied thereby may be reduced to dimensions such that the cooling system may be

mounted with the rest of the apparatus upon a single panel.

The operation of the automatic control arrangement associated with the cooling system will be clear from the following description: When no water is flowing through the discharge pipe 49, the mercury stands at the same level in the chambers 52 and 53, the float 56 is at its highest point and the contacts 63 and 64 are disengaged. With water flowing through the cooling system, the pressure at the points 50 and 73 of the pipe 49, which is a function of the rate of flow, will be different and the mercury level in the chamber 53 and hence the float 56 will be downwardly displaced. By regulating the rate of flow of cooling water to a value slightly greater than that required to effectively cool the anode and adjusting set-screw 62 to maintain the contacts 63 and 64 in engagement, the circuit through the relay 69 and resistance 70 will be short circuited and current will be supplied from the source 68 to the no-voltage release coil 9 to hold its armature interlocked with the arms of the circuit breaker 3. If for any reason the velocity of the cooling water decreases below the amount for which the automatic device is adjusted, contacts 63 and 64 will be disengaged, the shunt path around the relay circuit will be opened, and the relay 69 and resistance 70 will be connected in series with the holding coil 9 and source 68. The value of the resistance 70 is such that the current flowing through the relay branch when the contacts 63 and 64 are open, is less than that required to hold up the armature associated with the holding coil 9. Hence, when the branch circuits included in the contacts 63 and 64 are opened, the armature of the coil 9 will drop back and the circuit breaker 3 will be caused to open, thereby disconnecting the supply main 1 from the rectifiers 5 and 6. However, with the contacts 63 and 64 opened, the current through the relay 69 will be sufficient to energize the relay, whereupon the circuit of the alarm device 71 will be completed to indicate the cause of the trouble.

Obviously by coupling the secondary winding of the transformer 20 and the primary winding of the transformer 23, and associating an adjustable condenser with either or both coils to constitute a frequency determining circuit in a manner similar to that shown in British Patent 13,248 of 1914, or Hartley U. S. Patent 1,356,763, a generator of sustained oscillations may be provided.

From the preceding description it will be apparent that the present invention provides an arrangement whereby an electric discharge device having high energy output may be safely and continuously operated, since a cooling medium is provided for dissipating the heat generated at the anode. A high impedance path between the anode and ground is provided and automatic means for indicating failure of the cooling medium, and for disconnecting the electrical supply source from the anode which are jointly controlled by the flow of the cooling medium to prevent destruction of the discharge device.

It is emphasized that the novel features of this invention are not limited in application to a circuit comprising an amplifier and rectifier, since they may be used with any discharge device having a high energy output, and the automatic control mechanism may be associated with the release coil of an oil switch for controlling any electrical supply source. Again it is noted that the operation of the control system does not depend upon the production of a difference of pressure due to a velocity head, as any other method of producing this difference of pressure, such as, for example, a friction head would be equally satisfactory for the purpose.

While the particular arrangement and specific details have been set forth in this specification for the purpose of completely disclosing the method of the present invention and the principle involved in its operation, it is to be understood that this invention is not limited thereto, but only by the scope of the attached claims.

What is claimed is:

1. In combination a high energy output electric discharge device comprising a plurality of electrodes, one of which is grounded, a high voltage source, means for connecting the high voltage source to another of said electrodes, a grounded water supply source, a grounded discharge outlet for the cooling water, insulated conveying means connecting said water supply source and said discharge outlet with said second mentioned electrode, means associated with one of said conveying means for producing a difference of pressure due to the flow of water therethrough and means controlled by said difference of pressure for controlling the connecting means for the high voltage source.

2. In combination a high energy output electric discharge device comprising a plurality of electrodes, one of which is grounded, a high voltage source, means for connecting the high voltage source to another of said electrodes, a grounded water supply source, a grounded discharge outlet for the cooling water, insulated conveying means connecting said water supply source and said discharge outlet with said second mentioned electrode, means associated with one of said conveying means for producing a difference of pressure due to the flow of water therethrough, means controlled by said difference of pressure for controlling the connecting means for the high voltage source.

3. In combination, a high energy output space discharge device having a cathode and an anode, means for impressing a high voltage on the anode of said device, means for continuously supplying cooling liquid to the anode of said device, and means directly responsive to variation of the instantaneous value of the rate of flow of the cooling liquid for controlling the said voltage impressing means.

4. In combination, a high energy output space discharge device having a cathode and an anode, means for impressing a high voltage on the anode of said device, means for continuously supplying a cooling liquid to the anode of said device, and means directly responsive to variation of the instantaneous value of the rate of flow of the cooling liquid for removing the high voltage from the anode of said device when the rate of flow is less than a predetermined amount.

5. In combination, a high energy output space discharge device having a cathode and an anode, means for impressing a high voltage on the anode of said device, means including a conduit for continuously supplying cooling liquid to the anode of said device, and means directly responsive to change in velocity of the liquid in said conduit for controlling said voltage impressing means.

6. In combination, a high energy output electric discharge device having a cathode and an electrode which is subject to energy dissipation in the presence of electric discharge, a high voltage source, means for connecting said source to said device for producing an electric discharge, means including a conduit for continuously supplying cooling liquid to the energy dissipating electrode of said discharge device, and means directly responsive to changes in the velocity of the liquid in said conduit for controlling the connection of said voltage source to said device.

7. In combination, a high energy output electric discharge device having an anode and a cathode, a high voltage source, means for connecting said source to the anode and the cathode of said device, means including a supply source of cooling liquid and a conduit for continuously supplying cooling liquid to the anode of said device, means for producing a pressure difference due to the velocity of the liquid in said conduit, and means for utilizing the pressure difference so produced for controlling the said voltage connecting means.

8. In a vacuum tube system employing vacuum tubes of such power as to necessitate electrode cooling means other than cooling due to radiation, an electrode to be cooled, a high voltage source connected to said electrode, a source of water supply, means including an insulating conduit for supplying water from said source into direct contact with said electrode, said conduit being of sufficient length and sufficiently small cross-sectional area to render the conductance of the water therein negligibly small, means for producing a pressure difference due to the velocity of the water in said conduit, and means for utilizing the pressure difference so produced for controlling the connection of said voltage source to said electrode.

In witness whereof, I hereunto subscribe my name this 10th day of May A. D. 1922.

ARTHUR A. OSWALD.