July 26, 1966 J. V. WHITE 3,263,121

HIGH CURRENT DISCHARGE TUBES

Filed Sept. 3, 1963 2 Sheets-Sheet 1

FIG. 1

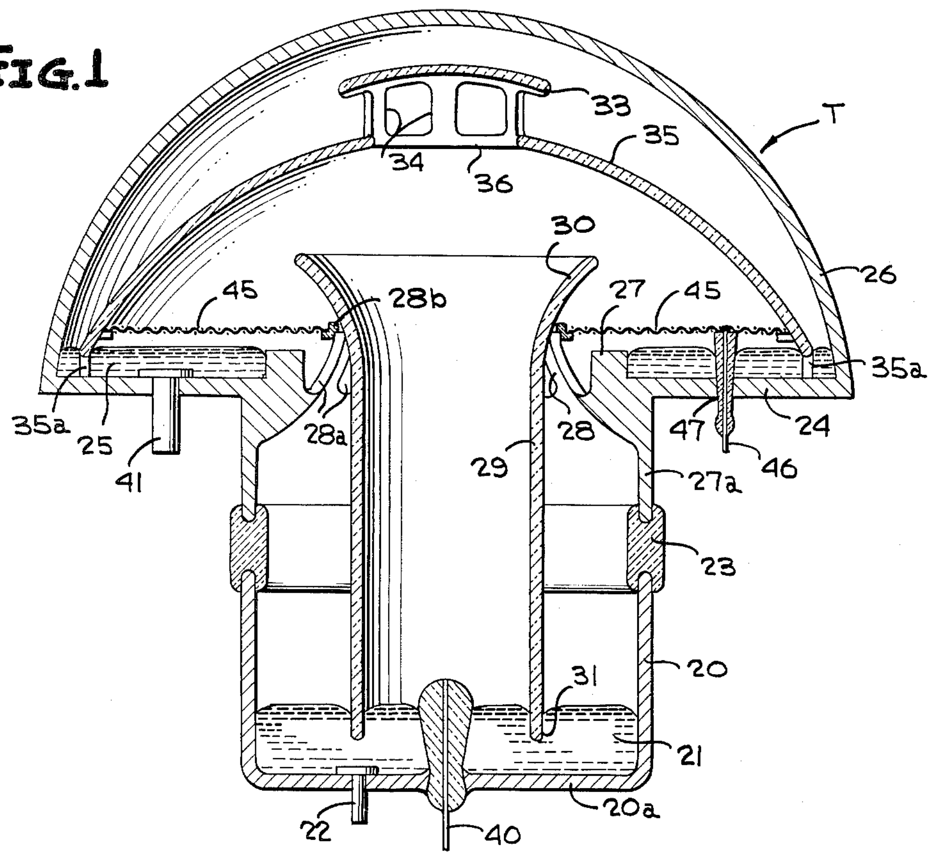
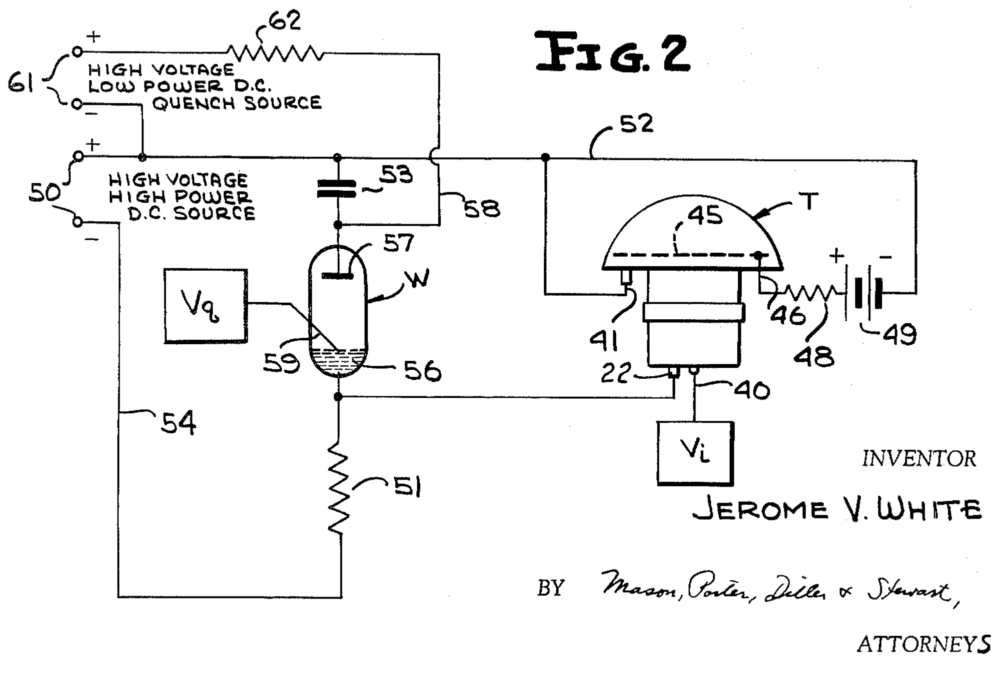


FIG. 2



INVENTOR

JEROME V. WHITE

BY Mason, Porter, Diller & Stewart,

ATTORNEYS

July 26, 1966 J. V. WHITE 3,263,121

HIGH CURRENT DISCHARGE TUBES

Filed Sept. 3, 1963 2 Sheets-Sheet 2

FIG. 3

FIG. 3a

FIG. 3b

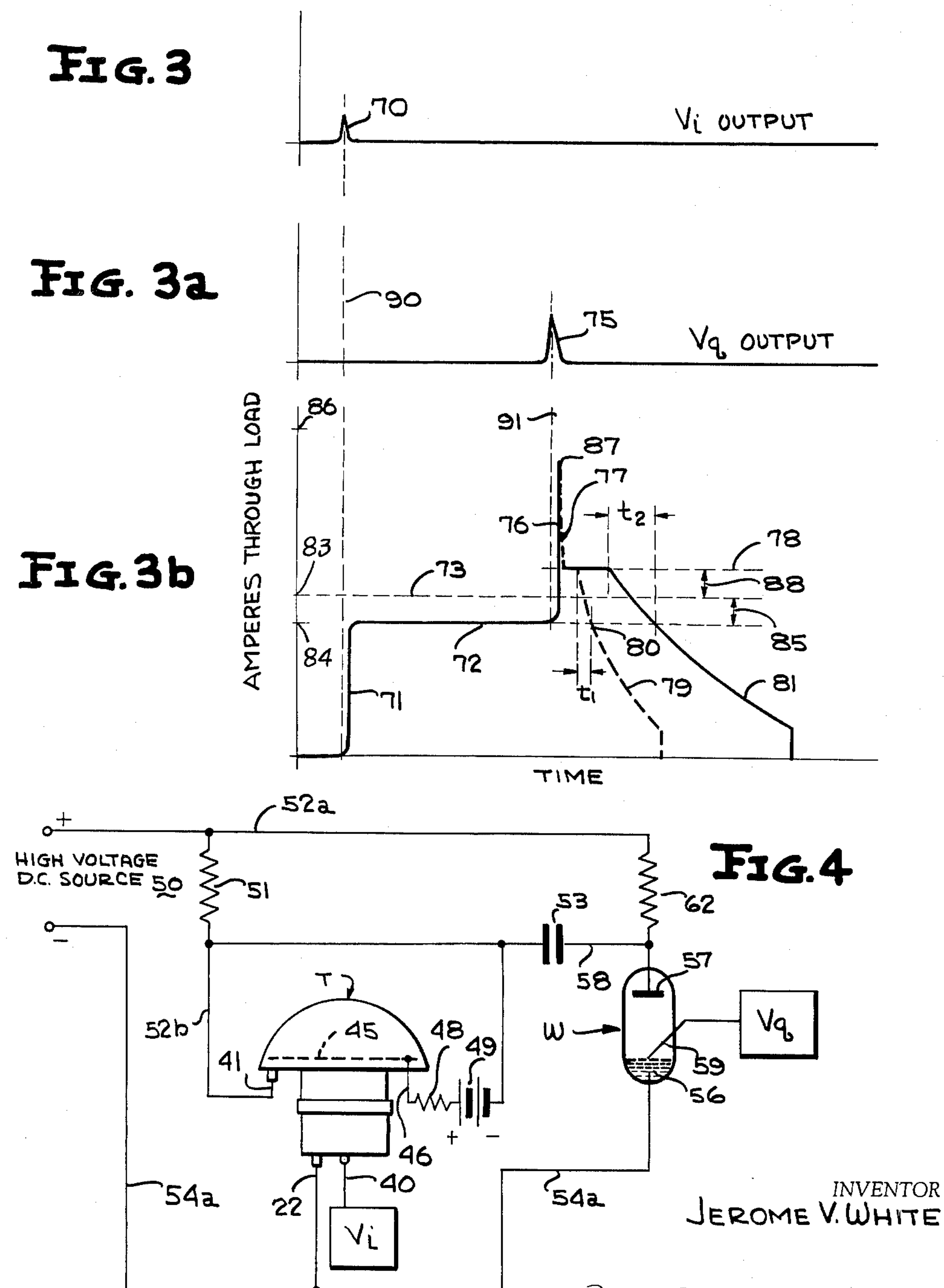


FIG. 4

INVENTOR
JEROME V. WHITE

BY Mason, Porter, Diller & Stewart,

ATTORNEYS

United States Patent Office

3,263,121

Patented July 26, 1966

3,263,121

HIGH CURRENT DISCHARGE TUBES

Jerome V. White, Hinsdale, Ill., assignor to Continental Can Company, Inc., New York, N.Y., a corporation of New York

Filed Sept. 3, 1963, Ser. No. 306,216
17 Claims. (Cl. 315—208)

This invention relates to high current discharge tubes and their employment in controlling current flow through a load.

It is known to employ tubes having cathode and anode electrodes, with the cathode provided by a mercury pool, and having an igniting device for initiating the ionization of mercury vapor whereby the tubes become conductive and self-maintaining. It has been a practice to use such tubes as switching means for a direct current source connected to a load: and to stop the conduction effect in the tube by reversing the flow therethrough. Carbon or metal anodes have been employed; and therewith a momentary reversal of current flow can reduce the ion content to a point at which a continuous reverse flow of current does not occur at low voltages, but with failure of the tube for circuit interruption at high current values due to ion bombardment effects. Further, the physical impact effect at the surface of such anodes places a current-carrying limit upon the tube, due to the difficulty of removing the heat generated at the anode surface.

Such difficulties of carbon and metal anodes are not present with tubes having both cathodes and anodes in the form of mercury pools. However, the anode mercury pool can become a cathode when the polarity is reversed, because there are ions present to initiate a high rate of continuous reverse flow: and further, even if the tube has not been conducting, the peak inverse rating is no larger than the forward hold-off rating due to the tendency of the anode to emit electrons when reversely subjected to a large field strength. In practice, these prevent economical employment of so-called "double pool" mercury tubes as switching devices.

According to the present invention, the difficulties can be resolved, and tubes operated at high forward current densities and high peak inverse ratings, by employing a further electrode adjacent to the anode pool and biased positive relative to the anode. This bias need only be sufficient, with the further or screen electrode close to the anode pool, to absorb the emitted electrons before they can attain the energy needed to cause ionization.

Illustrative practices of the invention are shown on the accompanying drawings, in which:

FIGURE 1 is an upright diametrical section through a tube according to this invention;

FIGURE 2 is a circuit diagram showing connections to the tube of FIGURE 1;

FIGURE 3 is a graph showing the current flow to an igniter for the tube, with a firing pulse;

FIGURE 3*a* is a like graph, showing current flow to the quenching tube of FIGURE 2;

FIGURE 3*b* is a graph showing the current flow through the tube of FIGURE 1, as controlled by the pulses of FIGURES 3*a* and 3*b*;

FIGURE 4 is a second circuit diagram.

The discharge tube T comprises a sealed enclosure comprising a cup-like lower portion having a cylindrical

wall 20 and a floor 20*a*, which holds a pool 21 of mercury constituting the cathode above the floor. A metal conductor sealed into the floor 20*a* provides the cathode connection to external circuit means. Above the upper end of the wall 20 is an outwardly projecting, substantially horizontal portion 24 which provides a floor beneath a second and annular mercury pool 25 constituting the anode. The periphery of the portion 24 is connected to a top dome 26 which completes the sealed enclosure. An annular dam 27 is integral with the enclosure, and defines the level of mercury in the anode pool 25: and inward projections 28 therefrom maintain the cylindrical shield 29 concentric with the wall 20 and spaced inward therefrom. Illustratively the dam 27 is extended downward as a cylindrical wall 27*a* aligned with the peripheral wall 20. The upper end of the shield 29 has an outward flare 30 extending to points above the dam 27, and rests on the projections 28 so that the lower end 31 of the shield 29 is supported above the floor 20*a* so that the cathode mercury can flow from between the shield 29 and wall 20 into the central space above the cathode connection 22. The projections 28 have apertures 28*a* between them, so that anode mercury which overflows the dam 27 can pass downward between the shield 29 and the wall 20, the projections 28 being spaced so that the apertures 28*a* provide the major portion of the annular region involved.

The enclosure can have the wall 20 and floor 20*a* formed from a metal cup for heat transfer and cooling. The dome 26, portion 24, dam 27, projections 28 and wall 27*a* can also be formed of metal for like reasons. These cathode and anode parts of the enclosure can be joined by an insulating sleeve 23, illustratively of glass with glass-metal seals of known type for sealing the interior of the enclosure, or of ceramic with like seals to the metal. External cooling of the metal parts assures condensation upon the dome 26; and on the inside of walls 27*a*, 20, so that vapor in the space between the shield 29 and these walls is condensed, and current flow in this region is prevented.

A condensation shield 35 of non-conducting material not wetted by the mercury, such as glass, has a dome shape with an axial orifice 36, and is immersed at its periphery in the anode pool 25. The shield 35 permits the mercury vapor to pass through the opening 36 for condensation upon the externally cooled dome 26; and acts to guide this condensate to the anode pool 25. The edge of the shield 35 is serrated, with spaced legs 35*a* which rest on the portion 24 and with gaps between the legs through which the mercury can flow radially inward toward the dam 27. The opening 36 is illustrated as covered by a roof piece 33 larger than the opening and supported above it by legs 34. This roof piece prevents droplets at the top of the dome 26 from falling downward through the opening 36.

An igniting electrode 40 is sealed into the floor 20*a* at the cathode space inside the shield 29. An anode connection 41 is sealed into the annular portion 24.

An annular screen electrode 45 is supported horizontally and above the surface of the anode pool 25; and is illustrated with its outer edge supported by the non-conductive shield 35 at the inner surface of the latter, and with its inner edge supported by the insulating ring 28*b* on the projections 28: therewith the screen electrode 45 is kept from electrical contact with the anode pool and its associated metal parts. The screen electrode 45 consists of fine wires spaced several diameters apart, and has an electrical connection to the exterior by a wire 46 which is sealed in a glass tube 47 which itself is sealed into the projecting portion 24 and extends through the anode pool 25 to the screen 45. The meniscus effect of the mercury in contact with the dam 27 is indicated by the curvature of the upper surface of the anode pool 25: and the screen 45 is positioned at a distance above the surface of the pool 25 which is less than the distance that an electron must travel, under operating conditions of potentials of the anode and cathode pools upon reversal of current, to attain the energy necessary to cause ionization by collision. This may be of the order of 0.015 inch. Illustratively, the screen grid can be made of wire of 0.001 inch diameter, with the wires spaced 0.010 inch center to center in the weave. Wires as small as 0.0002 inch and as large as 0.005 inch diameter can be employed under normal operating conditions, with the spacing about 10 times the diameter.

The interior of the sealed tube enclosure is at a high vacuum, in the absence of mercury vapor.

The circuit diagram in FIGURE 2 comprises a high voltage direct current source 50, the flow from which is to be switched relative to a load 51. Conductor 52 leads from the positive terminal of the source 50 to the anode connection 41 of the tube T, and to a capacitor 53. The conductor 54 leads from the negative terminal of the source 50 through the load 51 to the cathode connection 22 of tube T and to the cathode 56 of a supervising tube W, illustratively of the so-called "Ignitron" type, having an anode 57 connected to conductor 58 and thus to the other terminal of the condenser 53. A direct current source 49, illustrated as a battery, is connected between conductor 52 and its anode connection 41, and the screen connection 46 so that the screen 45 is at a higher positive potential than the anode: this biasing voltage is illustratively selected as less than but close to the first ionization potential of mercury which is 10.30 volts. Current flow can be limited by a resistor 48. The igniter 40 of the tube T is shown as connected to a source V*i* which can deliver a momentary firing pulse thereto. The igniter 59 of the tube W is connected to a like source V*q* for momentary delivery of a firing pulse to tube W. A direct current quenching source 61 has its negative terminal connected to conductor 52, and its positive terminal is connected through a resistor 62 to conductor 58. The source 61 has a voltage between terminals, while the tubes T and W are not conducting, which is of at least the same magnitude as that between the terminals of source 50, but can be of low power capability: it is then effective to charge condenser 53. The current limiting resistor 62 is of such impedance that the tube W cannot be kept ionized by current flowing from the source 61.

In the graph of FIGURE 3*b*, the abscissae denote time, and the ordinates the load current. The graph is illustrative, and no relative scales are shown.

As indicated in FIGURES 3, 3*a* and 3*b*, when a momentary pulse 70 is delivered from V*i* to the igniter 40, a local breakdown or arcing between the igniter and the cathode pool 21 produces a cathode spot with thermal emission of a stream of mercury vapor. The particles of this stream are immediately ionized by the potential across the tube, between cathode and anode. Electrons are liberated which carry almost all the current which has passed through the load 51, by their flow to the anode. Current flow through the tube T rises rapidly, as shown by line 71, FIGURE 3*b*. Positive ions are drawn toward the cathode where they create a "cathode spot" which maintains the generation of mercury vapor and the flow of electrons from the cathode to the anode. Further, a large gradient of the electric field exists at the surface of the pool, noting that most of the voltage drop across such a discharge tube occurs within a short distance of the cathode: and this gradient under a normal operating condition of the tube can be large enough to establish a field emission effect by which electrons are drawn forcibly out of the mercury pool. The motion of ions and electrons in the electric field differs greatly because the positive ion has a mass approximately 400,000 times as great as the negative electron here present. Hence, a field that is adequate to produce very low electron transit times will produce only a slow drift of positive ions. When the voltage is removed from a discharge tube, the electrons disappear essentially instantaneously, but the positive ions continue their slow drift until they strike some surface. The de-ionization time of a large tube, under these condtions can be as much as several milliseconds. When the voltage is reversed in polarity, instead of merely being removed, the electrons again disappear almost instantly; but the positive ions are accelerated by the entire applied potential (not merely by the tube drop as is the case when the voltage is removed), and are rapidly pulled to the electrode which has been the anode. Such heavy ions strike this electrode with great violence, and can cause a cathode "spot" to form on what was the normal operation anode, and a reversed discharge can occur.

When the current is brought to the tube, with the pool 21 being the cathode, and the pool 25 the anode, the initial ionization by the pulse 70 from V*i* is quickly followed by generation of the "cathode spot" on the cathode pool 21. A heavy current thus flows from the source 50 and through the load 51 as shown by the line 72 on the graph of FIGURE 3*b*, noting that this flow is unidirectional and determined by the size and other structural constants of the tube T and the load circuit. Thus the current which would flow if the full voltage of source 50 was impressed on the load may be represented by the dash line 73 in FIGURE 3*b*: wherewith the ordinate distance 85 represents an amount of current due to the voltage drop across the tube T not appearing across the load. The mercury vapor evolved continuously at the cathode spot rises within the shield 29 and passes through the opening 36; is condensed on the inner surface of the cooled dome 26; and flows to the anode pool 25.

The power thus transmitted to load 51 is the product of the amperage (represented by the line 72) and the effective voltage, which is that of the source less the drops in tube T and the conductors.

When the selected amount of power has been passed, which can be a time function as in FIGURE 3*b*, the pulse emitter V*q* is energized to quench the system and stop the flow. The tube W has had a voltage between its cathode 56 and its anode 57 which is the sum of the voltage of source 50 and the voltage across the capacitor 53, this capacitor having been charged through the limiting resistor 62 from the source 61: but the tube W is not then conducting. When a pulse 75 comes from V*q*, the tube W becomes conductive, and a pulse of current flows from the storage in the condenser 53, through the load 51, raising its voltage drop toward the sum of the two potentials, and the flow through the load 51 momentarily rises. The energy stored in the capacitor 53, upon ignition of the tube W, momentarily supplies the load current through the load 51, with the additional current to reverse the potential across the tube T and cause the current in tube T to reverse direction. The time of current reversal in the tube T is represented in FIGURE 3*b* by the point 87 between lines 76 and 77, and the line 77 indicates the rapid decrease in current through the load 51 to a value indicated by the line 78, noting that this current value can be represented by the vertical or ordinate line 88, and corresponds to the now-reversed potential drop across the tube for the current impressed on the load 51. Below the line 78, the continuance 79 of the line 77 represents the current decay, with the shape of the line portion 79 dictated by the capacitance of the condenser 53 and the resistance of the load 51; followed by a final quick drop to zero current value as the tube W is extinguished. The time required for the current decrease from line **78** to line **72** is critical, and is indicated by the time abscissa t_1 for the specific shape of the exponential decay line **77, 79** for the specific respective value of the capacitor **53**. That is, the minimum value selected for the capacitor **53** must permit the tube T to become de-ionized before the current supplied by capacitor **53** has fallen to this point. If the time interval for the de-ionization of the tube T is the value t_1, then the line **77, 79** represents the behavior for the minimum energy storage condition for the condenser **53**. When the condenser **53** is larger in capacity, the system is operative but less economical in energy. Such a condition for a larger condenser **53** is shown by the exponential decay line **81**, which crosses the lines **78** and **72** at a time interval t_2 which is greater than the time interval t_1: that is, the time interval t_2 is longer than needed for the de-ionization of the tube T.

The calculated current intensity due to the voltage of source **50** acting across the load resistance **51** is shown by line **73**, whose intercept **83** with the ordinate reference axis is above the intercept **84** of the actual load current line **72** by a value **85** representing the effect of the voltage drop across the tube T. The reference point **86** correspondingly indicates the calculated current intensity due to the action of the sum of the voltages of the sources **50** and **61** acting across the load **51**: which point **86** must of course be higher than the point **87** representing the reversal of current flow in the tube T. The line **78** above the calculated current intensity line **73** by a value **88** also representing the effect of the voltage drop across the tube T, but now in reverse direction: in general, the values **85** and **88** are the same. The dotted lines **90, 91** represent the coordination in time of the pulse **70** with the beginning **71** of flow through the tube T, and of the pulse **75** with the beginning of action by the quenching tube W. However, when the potential across the the tube T reverses, the current flow therethrough also reverses. For this reverse flow in the tube T, the pool **21** becomes relatively positive and the pool **25** relatively negative. The space within the shield **29** and the dome **26** contains many positively charged mercury ions which, by impact upon the pool **25** may create a new cathode spot therein, for continuing the reverse flow. The screen **45**, being at a positive potential, collects the electrons leaving the pool **25** before they have gained enough energy to create new positive ions by collision. Thus the tube is quickly cleared of ions and the undesired cathode spot of the pool **25** disappears. The effect of the screen **45** is that of rapid de-ionization of the tube attainable by applying a reversed potential across the tube while preventing the reverse discharge which such a procedure of reversal of current flow through the tube would normally cause in a tube having two mercury pools. For example, this can reduce the de-ionization time from several milli-seconds to only a few tens of microseconds. This greatly eases the requirements of capacitor **53**. Neither the peak inverse rating of the tube nor the high forward current capacity of the tube is affected by the presence of the screen **45**.

An alternative circuit for employment of the tube is shown in FIGURE 4. The high voltage direct current source **50** has its positive terminal connected by conductor **52a** to the load **51** and thence by conductor **52b** to the anode connection **41** of the tube T. The battery **49** is connected as before between the anode connection **41** and the screen connection **46** to hold the screen positive relative to the anode pool **25**. The conductor **52b** is also connected to the capacitor **53**. The conductor **52a** extends to a limiting resistor **62** and thence by conductor **58** to the other terminal of the capacitor **53** and to the anode **57** of the quenching tube W which has a cathode **56** and an igniting electrode **59**, the latter being connected to the source *Vq* of the quenching pulses. The return conductor **54a** to the negative terminal of the source **50** is connected to the cathode terminal **22** of the

tube T and the cathode **56** of the quenching tube W. The limiting resistor **62** must have an impedance value large enough so that the tube W cannot be kept ionized by current flowing through it; noting that the charging time for the capacitor **53** is limited to the "ON" time of the tube T. The operation is essentially as before. When *Vi* emits a starting pulse, the tube T conducts and a heavy current flows through the load **51**: the condenser **53** charges at a rate determined by the resistor **62**. When a quenching pulse is emitted by *Vq*, the tube W conducts, the flow through the tube **45** momentarily reverses, but continued reverse flow is inhibited by the screen **45** permitting rapid de-ionization. When the charge of capacitor **53** has been exhausted by flow through the tube W, the latter becomes non-conductive again.

As the mercury level rises in the anode pool **25**, the excess can pass over the dam **27** and through apertures **28** and drip downward in the space between the shield **29** and the wall **20** of the well, and thus return to the cathode pool **21** for further service, essentially without disturbing the forward and reverse potential and current characteristics of the tube.

It will be understood that the illustrative practice is not restrictive; and that the invention may be practiced in many ways within the scope of the appended claims.

What is claimed is:

1. A mercury electrical circuit controlling tube system comprising partially insulating walls providing a cathode pool and an anode pool at a level above the cathode pool, shield means for controlling the movement of mercury vapor and liquid between the cathode pool and the anode pool, a screen located close to and spaced from the anode pool and in the path of ions from the cathode pool, and electrical potential means having a positive terminal coupled to said screen and a negative terminal coupled to said anode pool for maintaining said screen positive with respect to said anode pool.

2. A current discharge tube comprising a sealed enclosure having walls for cathode and anode mercury pools, said pools being spaced and insulated from one another by the enclosure structure, an igniter for activating the cathode pool, a grid screen adjacent to and spaced from the surface of the anode pool, said screen being insulated from said pools and electrical potential means having a positive terminal coupled to said screen and a negative terminal coupled to said anode pool for maintaining said screen positive with respect to said anode pool.

3. A discharge tube as in claim **2**, in which the enclosure comprises a metal cup providing the walls of the cathode pool, and an upper metal dome structure having an inturned annular lower wall for supporting the anode pool, and an insulating sealing member joining said cup and said dome structure.

4. A discharge tube as in claim **3**, in which the said lower wall includes a dam rising therefrom and restricting the anode pool to a horizontally annular shape of a depth defined by the height of the dam.

5. A discharge tube as in claim **4**, in which the said lower wall is annular and has spaced projections at its inner periphery, and includes a shield located inside the cup and extending upward from beneath the surface of the cathode pool, said shield being in engagement with and supported by the said spaced projections, whereby mercury overflowing said dam will pass between said projections and downward between the shield and the cup wall.

6. A discharge tube as in claim **2**, including an upper condensation dome forming part of the enclosure, a condensation shield within and spaced from the dome and extending over the cathode pool, said condensation shield having an opening therein above the cathode pool, and a cover member spaced from and extending over said opening.

7. A discharge tube as in claim **6**, in which said condensation shield is of non-conductive material and includes parts for supporting the grid screen.

8. A discharge tube as in claim 4, in which the said lower wall is annular and has projections extending therefrom, and including an insulating member carried by said projections for supporting the grid screen.

9. A current discharge tube comprising a lower metal cup having an upstanding outer wall, a metal upper structure including a dome having an inwardly extending annular portion at its lower edge, an insulating and sealing connection between said cup wall and the inner periphery of said annular portion, a first shield within and spaced from the said cup wall and extending upwardly and having a flared portion extending outwardly above said inner periphery, spaced projections on said inner periphery for supporting said first shield, a second shield of dome shape located within the dome and spaced therefrom, a dam on said annular portion adjacent the inner periphery for establishing the depth of a mercury anode pool on said annular portion, said second shield being of insulating material and having an opening above the space within said first shield, a grid screen of annular shape supported by said second shield and insulatedly supported from said spaced projections, said cup providing walls for a cathode mercury pool, an igniter electrode for said cathode pool insulatedly supported by said cup, and a conductor from said screen to the exterior insulatedly supported by said upper structure.

10. A mercury electrical switching tube comprising insulating walls providing a well for a cathode pool, a cathode connection to said pool, a horizontal wall located at a level above the cathode pool and including a dam for confining an anode pool on said horizontal wall, a dome wall connecting the outer periphery of the horizontal wall and extending over the anode pool and the well, a shield located within and spaced from the well wall and from the bottom of the well, and extending upward to above the level of the anode pool, an anode connection to the anode pool, a horizontal screen close to and spaced from the upper surface of the anode pool, and electrical potential means having a positive terminal coupled to said screen and a negative terminal coupled to said anode pool for maintaining said screen positive with respect to said anode pool.

11. A switching tube as in claim 10, including a condensation member within and spaced from the said dome and having its periphery immersed in the anode pool, and having an opening therethrough above the level of the anode pool.

12. A switching tube as in claim 10, including inward projections from the well wall for supporting said shield, said projections having openings through which excess mercury escaping over the dam can pass downward to the cathode pool in the space between the shield and the well wall.

13. A discharge tube system including an enclosure providing walls for spaced and relatively insulated cathode and anode mercury pools and for the flow of mercury particles and electrons therebetween, a grid screen insulatedly supported adjacent to and spaced from the surface of the anode pool and in the path of said flow, electrical potential means having a positive terminal coupled to said screen and a negative terminal coupled to said anode pool for maintaining said screen positive with respect to said anode pool, and means for reversibly applying potential differences between said cathode and anode pools.

14. A discharge tube system including an enclosure providing walls for anode and cathode mercury pools, means for directing the stream of mercury vapor and electrodes from the cathode pool during current flow through the system, said enclosure including walls for condensing the vapor and directing the condensate to the anode pool, a grid screen and means to support the same in spaced relation and close to the surface of the anode pool and in the path of said stream, insulated connections

from said pools and screen, electrical potential means having a positive terminal coupled to said screen and a negative terminal coupled to said anode pool for maintaining said screen positive with respect to said anode pool, an igniter communicating with said cathode pool, a source of starting pulses connected to said igniter, a quenching tube having an anode, a cathode and an igniter, a source of quenching pulses connected to the igniter of the quenching tube, a capacitor, a resistor connected to the capacitor for limiting the current flow to said quenching tube, a load, means for supplying direct current, and circuit means for connecting said supplying means to said load in series with the anode and cathode pools with the said stream therebetween, and also connecting said capacitor through said resistor with the anode and cathode of the quenching tube whereby to limit the energy flow through the quenching tube after ignition thereof.

15. A discharge tube comprising a sealed enclosure having walls for cathode and anode mercury pools, said pools being spaced and insulated from one another by the enclosed structure, and means for decreasing the deionization time of said tube during current reversals by suppressing electron generation to thereby prevent collisions yielding positive ions, said means including a screen adjacent to and spaced from the surface of said anode pool, and an electrical potential means having a positive terminal coupled to said screen and a negative terminal coupled to said anode pool for maintaining said screen positive with respect to said anode pool.

16. Apparatus for controlling the application of power through a load comprising a first discharge tube and a parallel coupled second discharge tube in series with said load, said first tube serving as a quenching tube and having an anode, a cathode and an igniter, said second tube having a cathode pool and an anode pool spaced from said cathode pool, means adjacent said anode pool for decreasing the de-ionization time of said tube during current reversals by capturing electrons to thereby prevent positive ion generation, a source of power coupled across said tubes and load, capacitive means coupled between said anode of said first tube and said source of power having a value which permits de-ionization of said second tube before discharge of said capacitive means, auxiliary source of power coupled across said capacitive means, means for initiating conduction through said load and said second tube, and means coupled to said igniter for terminating conduction through said load and second tube by firing said first tube, said means adjacent said anode pool for decreasing the de-ionization time of said tube including a screen adjacent to and spaced from the surface of said anode pool, and electrical potential means having a positive terminal coupled to said screen and a negative terminal coupled to said anode pool for maintaining said screen positive with respect to said anode pool.

17. Apparatus for controlling the application of power through a load comprising a first discharge tube and a parallel coupled second discharge tube, a load in series with said second tube, said first tube serving as a quenching tube and having an anode, a cathode and an igniter, said second tube having a cathode pool and an anode pool spaced from said cathode pool, means adjacent said anode pool for decreasing the de-ionization time of said tube during current reversals by capturing electrons to thereby prevent positive ion generation, a source of power coupled across said tubes and load, capacitive means coupled between said anode and said anode pool and chargeable through said load and having a value which permits de-ionization of said second tube before discharge of said capacitive means, means for initiating conduction through said load and said second tube and thereby charge said capacitive means, and means coupled to said igniter for firing said first tube and discharging said capacitive means and thereby terminate conduction through said load and said second tube, said means adjacent said anode pool for decreasing the de-ionization

time of said tube includes a screen adjacent to and spaced from the surface of said anode pool, and electrical potential means having a positive terminal coupled to said screen and a negative terminal coupled to said anode pool for maintaining said screen positive with respect to said anode pool.

References Cited by the Examiner

UNITED STATES PATENTS

1,281,518	10/1918	Chubb	313—167 X
2,287,541	6/1942	Vang	313—165
2,490,562	12/1949	Van Dorsten	315—207 X
2,549,654	4/1951	Wittenberg	315—207 X
3,089,053	5/1963	Vang	313—165

FOREIGN PATENTS

657,829	9/1951	Great Britain.

JOHN W. HUCKERT, *Primary Examiner.*

D. O. KRAFT, *Assistant Examiner.*