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[54] **GAS FILLED THYRATRON TYPE SWITCHING DISCHARGE TUBES**

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[52] **U.S. Cl.** **315/350;** 313/195; 313/197; 313/307; 315/109; 315/261; 315/337; 315/341

[51] **Int. Cl.**[2] **H01J 17/10;** H01J 17/54

[58] **Field of Search** 315/108, 109, 260, 261, 315/264, 265, 341, 342, 349–353, 330, 334–337; 313/193, 195–198, 302, 306, 307

[56] **References Cited**

UNITED STATES PATENTS

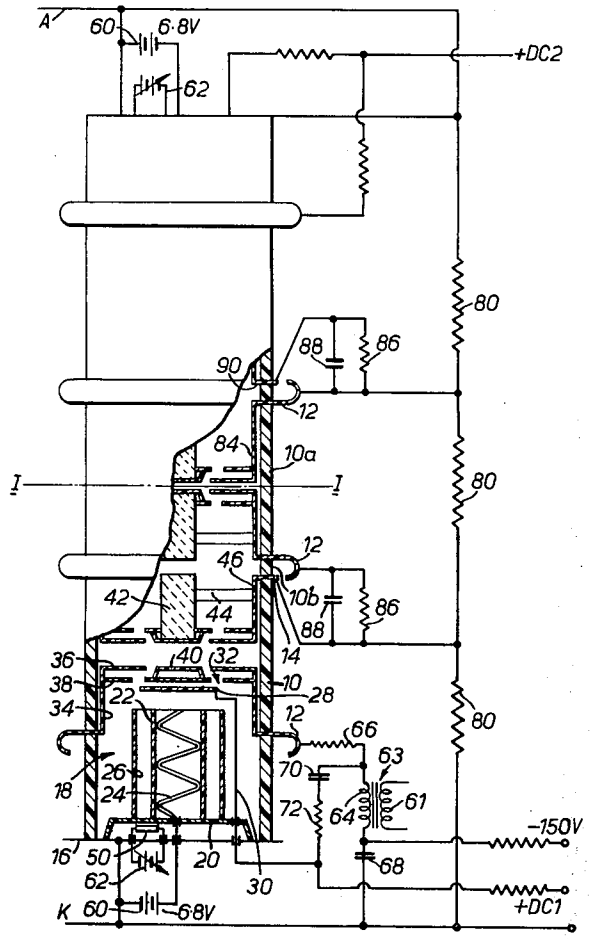
1,897,482	2/1933	Kenty	313/198 X
2,159,767	5/1939	Liebich	315/341 X
2,797,348	6/1957	Watrous, Jr.	313/195 X
2,930,922	3/1960	Coolidge, Jr. et al.	313/221 X
3,223,884	12/1965	Ward	313/192 X
3,349,283	10/1967	Krefft	313/197 X

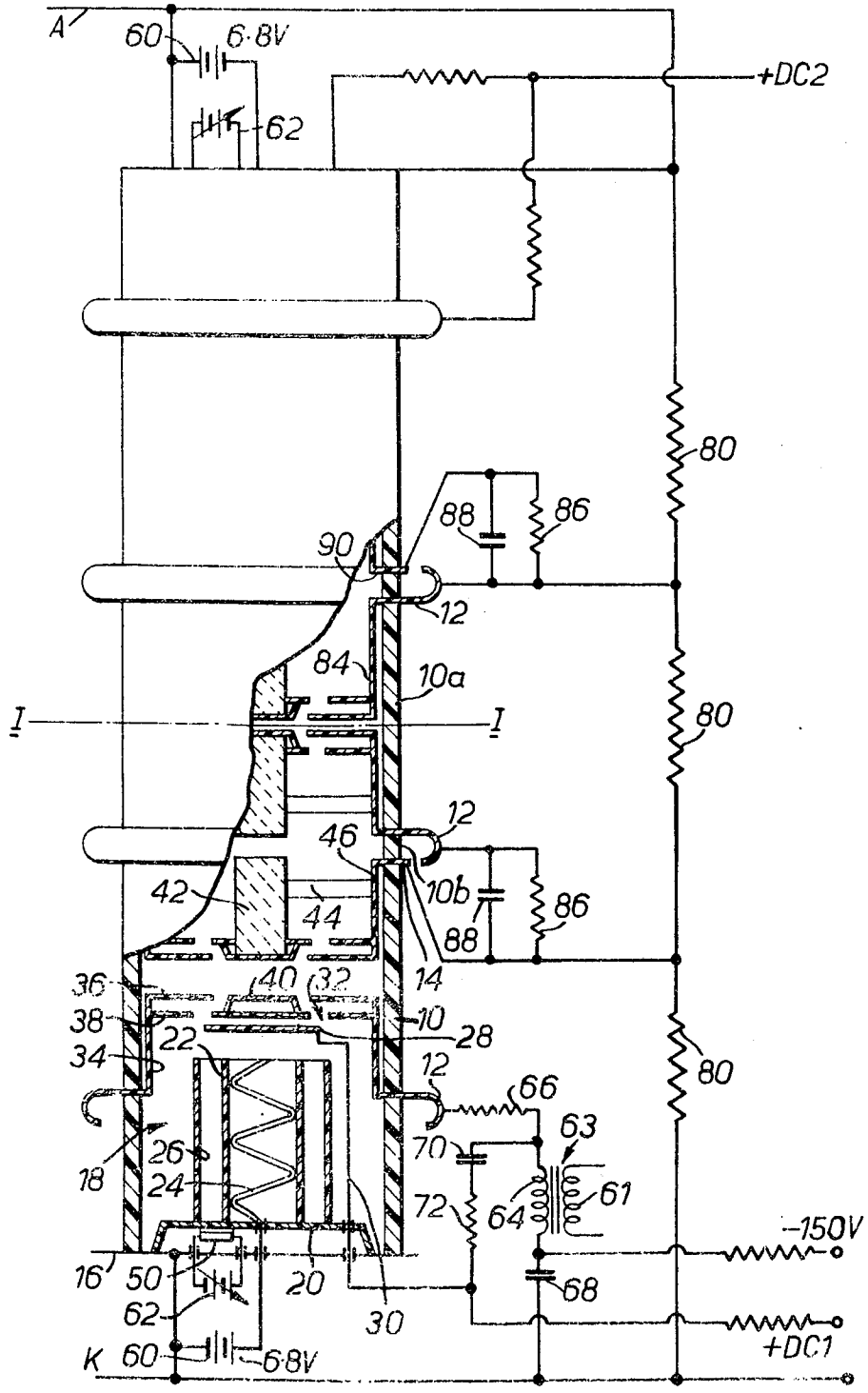
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[57] **ABSTRACT**

The invention relates to a gas filled thyratron type switching discharge tube. Known hydrogen thyratrons conduct in only one direction and if forced to conduct in the opposite direction through being connected in an oscillatory circuit there is a likelihood of damage occurring to the anode. To overcome the disadvantage, the anode structure incorporates means for generating a plasma including a thermionic electrode and at least one adjacent discharge electrode, the plasma generated during operation serving as a source of charged particles so that current reversal may be achieved with a minimum of bombardment of the anode structure by high energy ions.

5 Claims, 1 Drawing Figure




A
60
6·8V
62
+DC2
80
88
86
90
12
84
10a
I
I
80
12
46
42
44
10b
88
86
36
40
32
14
38
10
22
28
34
12
66
80
63
26
70
18
24
72
64
61
-150V
16
50
20
68
62
30
+DC1
K
60
6·8V

GAS FILLED THYRATRON TYPE SWITCHING DISCHARGE TUBES

This invention relates to a thyratron type switching discharge tube, that is to say a thermionic cathode gas-filled discharge tube.

Hydrogen thyratrons as at present known normally conduct in only one direction and if such a tube is forced to conduct in the opposite direction there is a likelihood of electrode damage occurring due to sputtering. This adversely limits the types of circuit for which known hydrogen thyratrons are suitable. Thus, for example, a single conventional hydrogen thyratron cannot be used safely as the switch in a circuit of an oscillatory nature in which it is required to provide a fast acting triggerable switch which will hold off positive voltages until triggered but which, when triggered, will have to pass current in both directions.

In order to mitigate the problem encountered with known thyratrons, the present invention provides a thyratron type discharge tube comprising a cathode structure, a control grid and an anode structure arranged in an envelope filled with a gas at a suitable pressure, the anode structure incorporating means for generating a plasma including a thermionic electrode and at least one adjacent discharge electrode, the plasma generated, during operation, serving as a source of charged particles whereby immediately upon reversal of the bias of the anode-cathode path after triggering of the tube, a current flow may be achieved with a minimum of bombardment of the anode structure by high energy ions.

Thus, in a discharge tube of the invention, at least the anode is constituted by a plasma which is produced by a discharge and which is capable both of emitting charged particles and of neutralizing incoming charged particles. By thus reducing collision between high energy charged particles and the anode electrode, damage to this electrode by sputtering is at the same time considerably reduced.

In a preferred embodiment of the present invention, the cathode structure of the discharge tube also incorporates means for generating a plasma including a second thermionic electrode and at least one adjacent discharge electrode. This feature avoids sputtering of the cathode electrode though this problem is by no means as great as the problem normally encountered with the anode electrode. What is more important, this feature enables the cathode and the anode structures to be effectively identical with one another, thereby considerably simplifying manufacturing techniques.

Conveniently, there may be arranged between the control grid and the anode structure one or more intermediate electrodes which, in operation, are maintained at a potential intermediate the potentials of the anode and cathode structures such that the voltage between no two adjacent electrodes of the tube is sufficient to cause breakdown prior to triggering of the tube.

Advantageously, the cathode and anode structures each with its associated discharge electrode are mounted on respective end plates which together with a cylindrical insulator constitutes the envelope of the tube.

The invention will be described further, by way of example, with reference to the accompanying drawing in which the FIGURE is a partially sectioned elevation of a thyratron and also shows schematically the circuitry controlling the thyratron.

In the ensuing description, the terms "anode" and "cathode" will be used to describe electrodes which at least before the thyratron has fired are connected to points at positive and negative potential respectively but it is pointed out that these two elements are structurally indistinguishable from one another so that should the voltage across the thyratron be reversed the functions of these electrodes would be reversed and what was previously the anode would then act as cathode and vice versa.

The tube is structurally symmetrical about a central plane I—I perpendicular to the electron flow in the thyratron. The thyratron includes an envelope **10** formed of several cylindrical, for example, sections **10***a* and **10***b* and filled with hydrogen, which term is intended to include the isotopes deuterium and tritium. Adjacent sections are separated from one another by annular flanges **12** and **14** which are connected to electrodes disposed within the envelope and which constitute means of establishing an electrical contact to these electrodes. The end section of the envelope **10** is closed by a cover plate **16** which carries an anode or cathode structure **18** as the case may be.

Each of the anode and cathode structures **18** is mounted on a platform **20** which is supported by the end plate **16** of the envelope. The platform **20** carries a thermionic electrode **22** which surrounds and is heated by a heating element **24.** The thermionic electrode **22** is itself surrounded by a heat shield **26** which is at the same potential as the electrode **22.** Arranged axially in line with the electrode **22** is a discharge electrode **28** which is isolated from the cathode and mechanically supported on the heat shield **26** by struts not shown in the drawing. Electrical contact is established with the discharge electrode **28** through a separate wire **30** passing through the end plate **16.**

A control grid **32** is located adjacent the discharge electrode **28** and is made up of an annular flange **12** which, as previously described, extends externally of the housing, a cylindrical section **34** and a pair of radial plates **36** and **38** integral with the cylindrical portion **34** and its end remote from the annular flange **12.** Each of the plates **36, 38** is formed with a circular aperture and a cylindrical capsule **40** occupies this aperture and is secured to the plate **38** by three circumferentially spaced strips which establish electrical contact between the capsule **40** and the remaining portions of the control grid. The overall structure of the control grid **32** thus defines two axially spaced plates each formed with an annular aperture with the diameter of one larger than the diameter of the other. Such a construction of the electrodes in the thyratron has the effect of reducing the tendency for voltage breakdown.

The intermediate electrodes **84, 90** in the thyratron resemble the control grid though each is fitted with a cental cylindrical portion **42** which is suspended from three support rods **44** extending radially between the cylindrical portions **42** and cylindrical sections **46** of the electrodes. The main purpose of the cylindrical portions **42** is to improve the cooling of the capsule **40** of the intermediate electrodes.

Each of the platforms **20** carries a hydrogen reservoir **50** which is itself known in the art and which is adapted to give off hydrogen when a voltage is applied across it. Separate leads for the hydrogen reservoir **50** extend

through the end plate **16** to the exterior of the thyratron envelope.

Referring now to the circuitry connected to the thyratron in the accompanying drawing, the anode A and the cathode K are connectible in series with whatever load it is desired to control and for example may be connected in series with a resonant circuit. A 6.8 volt voltage source **60** is connected between the cathode and the heating element to provide the necessary current and a variable voltage source **62** is connected across the reservoirs at both ends of the thyratron to enable the gas pressure in the tube to be maintained at the desired level. A source of positive potential relative to the cathode, labelled +DC1 in the drawing, is connected through a resistor to the discharge electrode **28,** this voltage being sufficient to maintain a constant discharge between the discharge electrode **28** and the cathode **22** so as to generate a plasma in the intermediate space. A voltage of −150 volts, also D.C., is applied across the control grid **32** by way of the secondary **64** of a transformer **63** and a resistor **66.** The −150 volts acts as a hold-off voltage and prevents the thyratron firing. THe end of the secondary winding **64** of the transformer to which the −150 volts is fed is connected to the cathode terminal by way of a decoupling capacitor **68** and its other end is connected to the discharge electrode **28** by way of a series combination of a capacitor **70** and a resistor **72.** The primary of the transformer is connectible to a pulse generator for delivering the triggering pulses which, when applied, have the effect of rendering the control electrode **32** positive with respect to the cathode to fire the thyratron.

A voltage divider comprising three resistors **80** of high value, for example of 20MΩ, is connected between the anode and the cathode and the tappings of this voltage divider are connected respectively to the intermediate electrodes of the thyratron. Thus, the tapping **82** is connected directly to the flange **12** of electrode **84** and through a parallel combination of a resistor **86** and a capacitor **88** to the adjacent electrode **90.** Any number of sections each containing an electrode similar to the one labelled **84** and one similar to the one labelled **90** may be included and each will have an associated voltage dropper resistor in the voltage divider connected between the anode and the cathode. The effect of the intermediate electrodes is to ensure that the voltage applied between no two adjacent electrodes is sufficient to result in voltage breakdown prior to triggering of the tube.

At the anode end of the thyratron, a voltage source is provided for the reservoir and the heater and again a positive D.C. voltage (this time with respect to the anode) is applied for the discharge electrode by a source +DC2. By contrast with the arrangement at the cathode end it is preferable to connect this same D.C. supply +DC2 through a second resistor to the electrode at the anode end of the tube corresponding to the control grid **32.**

The described thyratron and associated triggering circuitry operate as follows:

The anode-cathode path of the thyratron is connected in series with the circuit to be controlled, which in this case may, if required, be an oscillatory circuit. The application of the D.C. voltages at the anode and cathode ends of the tube generate discharges within the anode and cathode structures so that even before firing there will be localized plasmas within the tube. However, the total gaseous content of the tube is not ionized owing to the reverse bias of the control grid **32** by the −150 volt voltage source.

When a triggering pulse is applied to the primary of transformer **63,** a pulse appears on the secondary winding **64** which raises the potential of the control grid **32** and also of the discharge electrode **28** to which it is applied by way of the capacitor **70** and resistor **72.** The positive bias on the control grid **32** now attracts electrons from the plasma and in transit, these electrons collide with the hydrogen to ionize the gas and generate more charged particles. The generated plasma enters the space between the plates **36** and **38** of the control grid and electrons from it are then attracted to the adjacent intermediate electrode and effect still further ionization.

As the voltage maintained at the intermediate electrode is derived from a high impedance divider, the current flow to the intermediate electrode results in the potential dropping towards that of the grid **32.** A voltage is thus developed across the capacitor **88** and until the stored charge decays through resistor **86,** an accelerating potential is present between the two adjacent intermediate electrodes connected to the same tapping of the voltage divider and thus the plasma is extended further towards the anode. This process repeats itself until the electrons arrive at the anode structure. Upon reaching the anode structure, the electrons are attracted to the plasma generated by discharge and with a minimum of collision of high energy particles with the structure a current is made to flow in the external anode-cathode circuit of the thyratron.

If the circuit to which the thyratron is connected is oscillatory, the voltage at some subsequent time will be reversed so that a negative potential is applied to the anode and a positive potential is applied to the cathode. As there is a plasma already present in the tube, ions and electrons will now migrate in the opposite direction to their previous directions of flow, electrons now travelling to what was previously the cathode and ions to what was previously the anode. The electrons necessary for the reverse current flow are derived at first from the plasma generated by discharge and subsequently the heated electrode acts as a thermionic cathode, the roles of the structures at the ends of the tube now being reversed.

If a heated electrode alone was used as an anode this electrode would be severely damaged by impinging high energy particles. Alternatively, if a cold electrode was used, then electrons for the reverse current flow could only be obtained by bombardment with high energy ions again resulting in permanent damage. The problem is however not present in a tube constructed in accordance with the invention in which a heated anode electrode supplied sufficient electrons for reverse current flow whilst the provision of a plasma at that electrode cushions the effect of incoming high energy particles.

We claim;

1. A thyratron type switching discharge tube comprising a cathode structure, a control grid and an anode structure arranged in an envelope filled with a gas at a suitable pressure, the anode structure incorporating means for constantly generating a plasma confined to said anode structure and including a thermionic electrode and at least one adjacent discharge electrode, means for applying a hold off voltage to the control

grid, and means for enabling triggering pulses to be superimposed on said hold off voltage, the plasma generated, during operation, serving as a source of charged particles whereby immediately upon reversal of the bias of the anode-cathode path after triggering of the tube, a current flow may be achieved with a minimum of bombardment of the anode structure by high energy ions.

2. A thyratron type tube as defined in claim **1** wherein said means for constantly generating a plasma includes means for applying a D.C. potential across said thermionic electrode and said discharge electrode.

3. A discharge tube as claimed in claim **1,** in which the cathode structure of the discharge tube also incorporates means for generating a plasma confined to said cathode structure and including a thermionic electrode and at least one adjacent discharge electrode.

4. A thyratron type switching discharge tube which may be subjected to reversal of bias of its anode-cathode path after triggering of the tube comprising, in combination:

an elongate envelope having a thermionic anode structure within one end and a thermionic cathode structure within the opposite end;

a discharge electrode adjacent said anode structure and located between said anode structure and said cathode structure;

bias means for maintaining a constant plasma generation confined between said discharge electrode and said anode structure prior to triggering of the tube in order to minimize bombardment of said anode structure by high energy ions in the event of said reversal of bias of the anode-cathode path after triggering of the tube;

a control grid adjacent said cathode structure and located between said anode structure and said cathode structure;

means for applying a hold off voltage to said control grid normally to prevent firing of the tube; and

triggering means connected to said control grid for altering said hold off voltage to cause said tube to be switched to initiate current conduction through its anode-cathode path.

5. A thyratron type switching discharge tube as defined in claim **4** including a second discharge electrode adjacent said cathode structure and second bias means for maintaining a constant plasma generation confined between said second discharge electrode and said cathode structure during operation of the tube so that even before firing there will be localized plasmas within the tube confined adjacent said anode and cathode structures respectively.

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