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[54] **HIGH VOLTAGE INSULATORS FOR LONG, LINEAR SWITCHES**

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[73] Assignee: **The United States of America as represented by the Secretary of the Air Force**, Washington, D.C.

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[51] **Int. Cl.**[5] **H01J 17/48**

[52] **U.S. Cl.** **313/58.9**; 313/597

[58] **Field of Search** 313/589, 595, 597, 643, 313/637, 602, 634

[56] **References Cited**

U.S. PATENT DOCUMENTS

2,573,373	10/1951	Wales, Jr.	313/589 X
3,267,204	8/1966	Peters	174/137
3,582,586	6/1971	Jones	200/144
3,673,305	6/1972	Mashikian et al.	174/12 BH
3,880,194	4/1975	McNeal	138/128
4,069,357	1/1978	Miller et al.	427/123
4,177,322	12/1979	Homan et al.	428/447
4,223,071	9/1980	Boyer et al.	428/411
4,401,920	8/1983	Taylor et al.	313/643 X

FOREIGN PATENT DOCUMENTS

47701	1/1977	U.S.S.R.	313/589

OTHER PUBLICATIONS

IEEE Transactions on Electron Devices, vol. ED-26, No. 10, Oct. 1979, article by T. Burkes et al., "A Review of High-Power Switch Technology".

Section 8-11 of Pulse Generators produced by MIT entitled "The Hydrogen Thyratron" by K. J. Germeshausen.

Preamble on Hydrogen Thyratrons, 1972 by English Electric Valve Co., Ltd.

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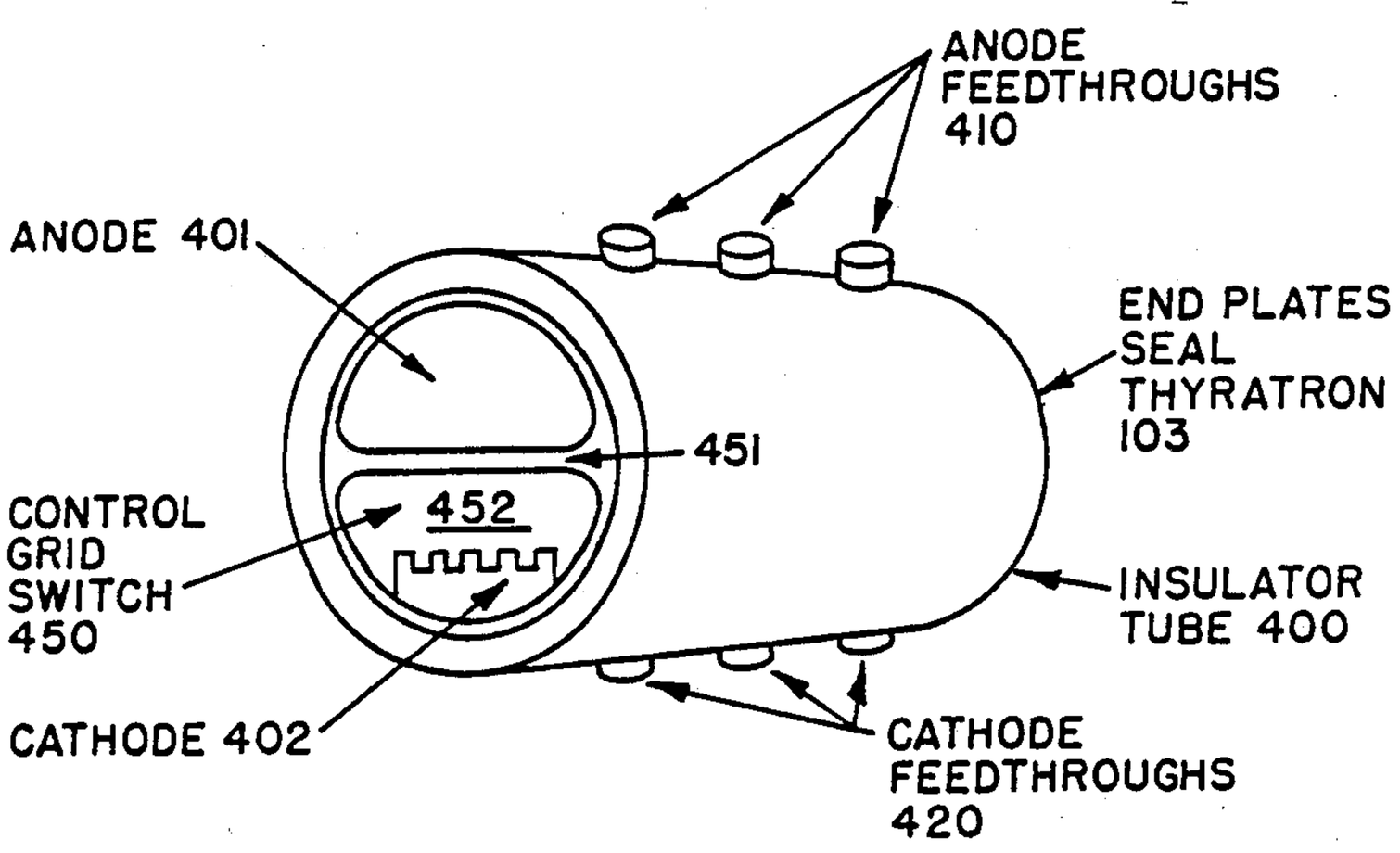
[57] **ABSTRACT**

A high voltage linear switch assembly is disclosed that uses a hollow quartz tube as the insulator, and houses the anode, cathode and switch within the insulator tube. The anode and cathode are fixed within the tube on opposite sides so that they do not make physical contact with each other. A chamber filled with either hydrogen or helium and a metal electrode screen act as the switch as follows. By separating the anode from the cathode the gas filled chamber normally acts as an open circuit. When a charge is conducted by the metal electrode screen, the gas in the chamber is ionized and provides a medium to provide electrical contact between the anode and the cathode.

1 Claim, 2 Drawing Sheets



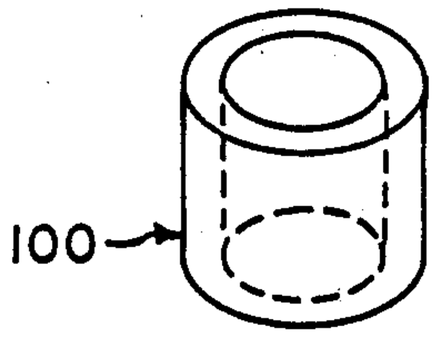


FIG. 1
PRIOR ART

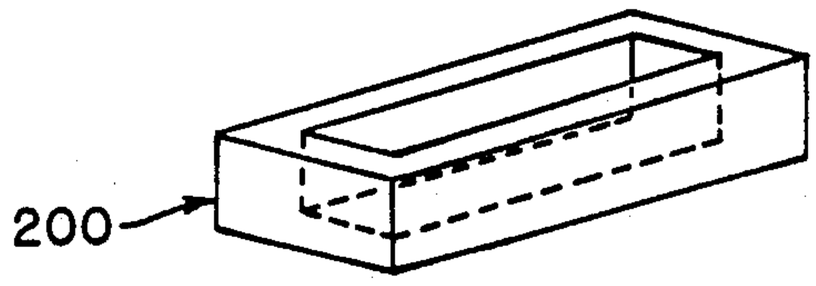


FIG. 2
PRIOR ART

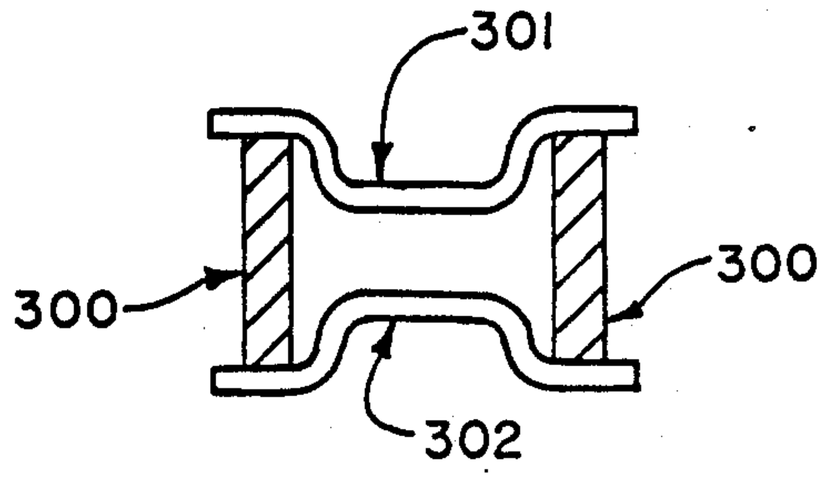


FIG. 3
PRIOR ART

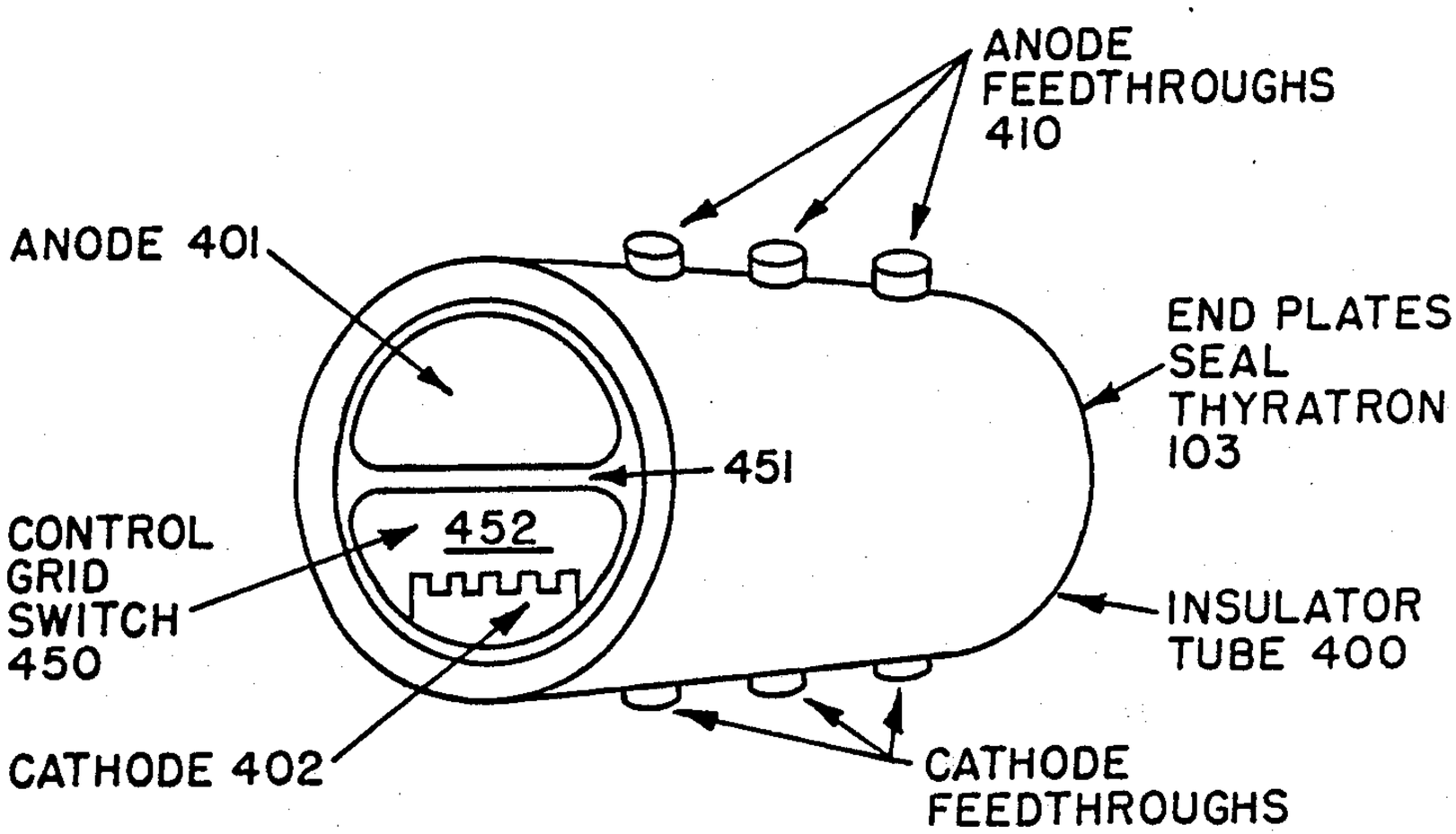


FIG. 4

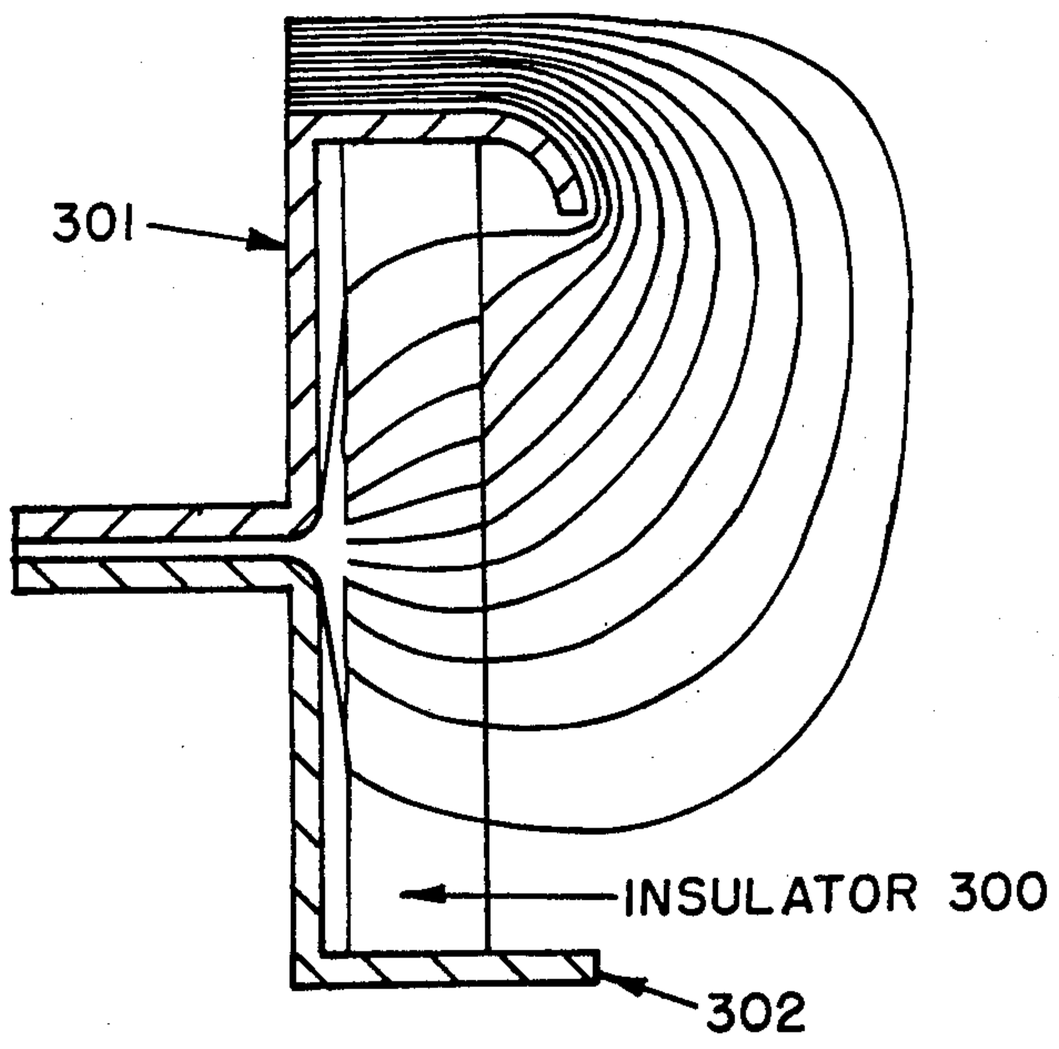


FIG. 5

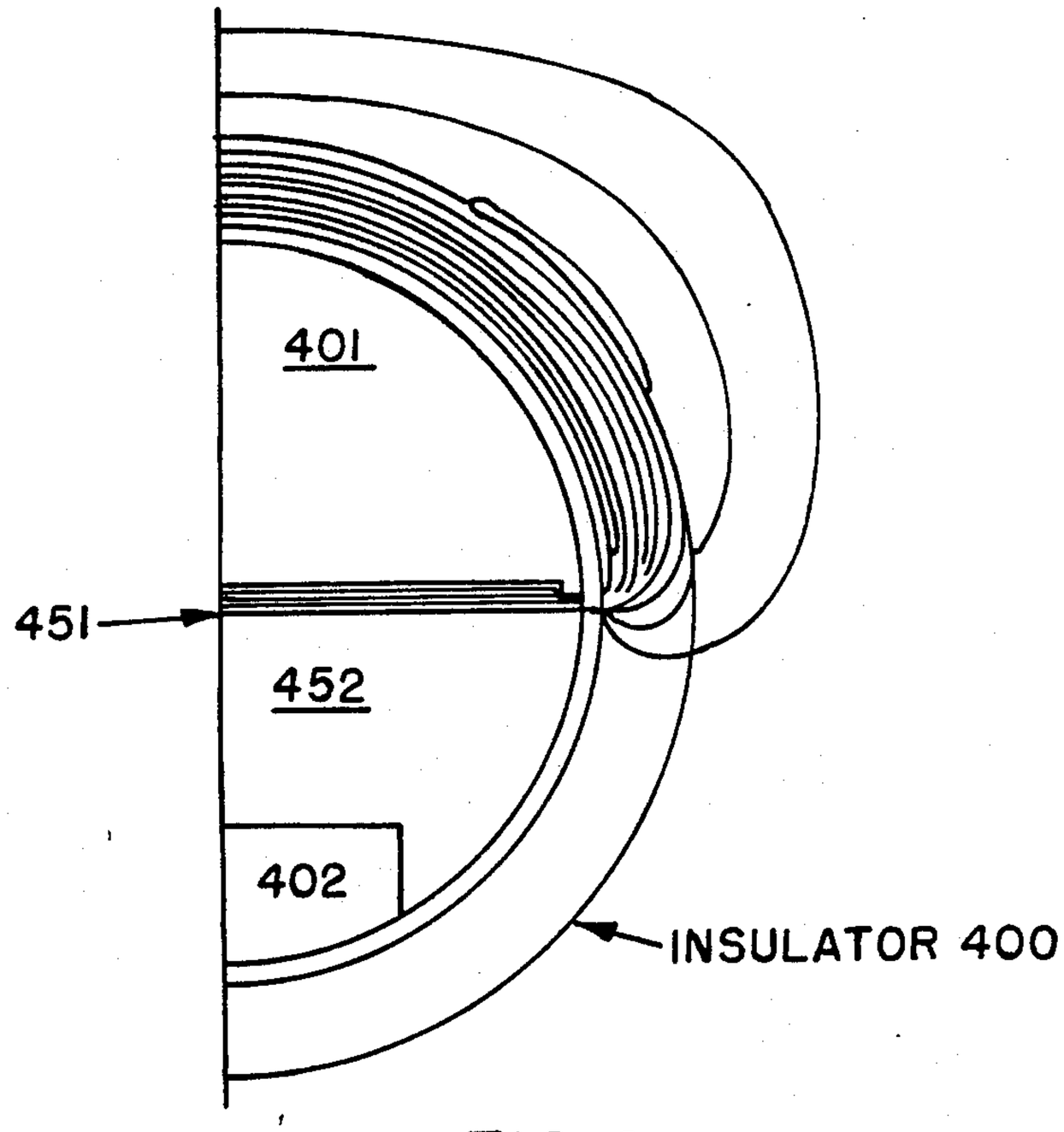


FIG. 6

HIGH VOLTAGE INSULATORS FOR LONG, LINEAR SWITCHES

STATEMENT OF GOVERNMENT INTEREST

BACKGROUND OF THE INVENTION

The present invention relates generally to electrical insulators, and more specifically to an insulation configuration for use with high voltage switches which provides high voltage holdoff characteristics.

Modern lasers, electron beam projectors and accelerators possess switching requirements that include the need for insulators with holdoff capabilities exceeding voltages of 100 kV and currents exceeding of 100 kA. In the past, people have used large (up to eight inches) diameter ceramic cylinders along with hollow rectangular insulators made of plastic. In such prior art systems, current scaling was achieved by simply increasing the switch length, but this solution imposes severe constraints on the manufacture of insulators to provide long (up to several meters) switches which maintain their mechanical integrity while providing high voltage holdoff characteristics.

The task of providing high voltage insulators for long linear switches is alleviated, to some degree, by the following U.S. Patents, the disclosure of which are incorporated by reference:

U.S. Pat. No. 3,267,204 issued to D. Peters;
U.S. Pat. No. 3,880,194 issued to W. McNeal;
U.S. Pat. No. 3,673,305 issued to Mashikian et al;
U.S. Pat. No. 4,177,322 issued to Homan, et al;
U.S. Pat. No. 3,582,586 issued to P. Jones;
U.S. Pat. No. 4,223,071 issued to Boyer et al; and
U.S. Pat. No. 4,069,357 issued to Miller et al.

U.S. Pat. Nos. 3,267,204; 3,880,194; 3,673,305; and 4,177,322 each disclose an insulator used in high voltage electrical applications.

U.S Pat. No. 3,582,586 discloses an arc-interrupting composition for the walls of electrical interrupting devices to improve the characteristics of such devices for interrupting high power circuits. The composition comprises melamine, and a thermoplastic organic binder. U.S. Pat. No. 4,223,071 discloses a high voltage insulating composition which includes phosphorus-containing compounds. U.S. Pat. No. 4,069,357 discloses a method for diffusing a coating of manganese powder and titanium powder into a ceramic to improve voltage holdoff withstanding capability.

The above-cited patents are exemplary in the art, and further demonstrate the attention being paid to the need to provide an insulation system for high voltage switches which have high voltage holdoff characteristics. The present invention is intended to satisfy that need.

SUMMARY OF THE INVENTION

The present invention is an electrical insulation system and a high voltage switching assembly for use in lasers, electron beam projectors, and particle accelerators.

In one embodiment of the invention, the insulator is made of quartz, and is configured in a cylindrical shape which houses the anode and cathode electrodes as well as the switch. Quartz was selected as an insulator substance because of its high voltage holdoff characteristics.

It is an object of the present invention to provide a high voltage insulator for long, linear switches by surrounding the electrodes with an insulator which has high voltage holdoff characteristics.

It is another object of the present invention to provide a high voltage insulation system which allows both current scaling and voltage scaling to high voltages and currents (exceeding 100 kA and 100 kV) by allowing increases in switch length.

These objects together with other objects, features and advantages of the invention will become more readily apparent from the following detailed description when taken in conjunction with the accompanying drawings wherein like elements are given like reference numerals throughout.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1–3** are illustrations of prior art insulation systems;

FIG. **4** is an illustration of the preferred embodiment of the present invention;

FIG. **5** is a potential contour diagram of the prior art insulator system of FIG. **3**; and

FIG. **6** is a potential contour diagram of the insulation system and switching assembly of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention is a high voltage linear switch assembly which uses a hollow quartz tube as the insulator.

The reader's attention is now directed towards FIGS. **1**, **2**, and **3** which illustrate prior art conventional insulator systems. FIG. **1** depicts a ceramic cylindrical insulator **100** which is commonly used as the insulators **300** of FIG. **3** which separate the anode **301** from the cathode **302**. Similarly, the hollow rectangular insulator **200** of FIG. **2** is commonly made out of plastic for use as the insulators **300** of systems such as shown in FIG. **3**.

FIG. **4** is an illustration of the preferred embodiment of the present invention. In FIG. **4**, an insulator tube **400** made of quartz completely encompasses the anode **401** and cathode **402** which are fixed along opposite sides of the quartz tube's interior. The anode **401** is shown in FIG. **4** as having a cross-sectional shape of a half-moon, but this shape isn't essential. A number of anode and cathode feedthroughs **410** and **420** provide electrical contacts to the anode and cathode through apertures in the quartz tube. Finally, a control grid **450** switching means is housed within the tube to provide controlled switching between the anode **401** and cathode **420**.

Quartz was selected for use in the preferred embodiment since it has exceptionally high voltage holdoff characteristics. Since quartz is not generally available in long rectangular geometries, plastics are almost universally used in application to long insulators. However, quartz is available in hollow form in lengths of up to several meters. The availability of long lengths allows current and voltage scaling to be achieved by simply increasing the length of the insulator tube as well as the anode and cathode housed therein. The selection of the control grid switch allows a commensurate selection of length increases in the switch, as well as the electrodes and the insulator for current scaling while avoiding difficulties of maintaining mechanical integrity, because

the control grid switch provides switching without the use of awkward moving parts (which become more awkward with increases in length). The function of the control grid switch is described briefly below.

While several alternatives to the control grid switch are known in the art, the control grid switch was selected for use due to its absence of moving parts. As depicted in FIG. **4**, the control grid switch **450** comprises a metal electrode screen **452** which separates the anode **401** from the cathode **402**, and a chamber **451** which separates the cathode **402** from the anode **401**, and works as a switch with the metal electrode screen. In FIG. **4**, the numeral **452** is placed on the item it identifies, the metal electrode screen. The gas chamber **451** is between the metal electrode screen **452** and the anode **401**. Both the metal electrode screen **452** and the chamber **451** extend along the length of the insulator tube **400** between the lengths of the anode **401** and cathode **402**. Like all thyratron linear switches that are currently in use, the metal screen **452** extends the length of the tube to provide the electrical connection for the control guide switch **450** at one end of the tube. Since the anode **401** and cathode **402** don't extend the length of the tube, their external electrical connections are provided by their respective feed throughs **410** and **420**, as mentioned above. The chamber **451** is filled with a gas, usually hydrogen or helium, at low pressures. As described so far, the anode is effectively isolated from the cathode and the switch provides an open circuit between them. To close the circuit, an electrical pulse is sent down the metal electrode screen **452** to ionize the gas in the chamber **451**. When ionized, the gas provides a medium for electrical contact between the anode **401** and the cathode **402**.

A key parameter in judging high voltage holdoff capability is obtained by generating voltage potential contours around the high voltage section by computer. FIGS. **5** and **6** compare potential contour diagrams for the conventional insulator for FIG. **5** and the tube insulator system of the present invention in FIG. **6**. Surface flashover of charge carriers limit high voltage holdoff in prior art insulation systems, and these carriers move normal to the potential contours. Thus, the conventional insulator of FIG. **3** can experience flashover from anode to control grid, while it is virtually impossible for this to happen with the tube insulator of the present invention because charge carriers are driven into the insulator and have no opportunity to flash to an electrode. Therefore, the tube geometry of this invention will offer much higher voltage holdoff than the conventional insulator approach.

In summary, the tube insulator of the present invention provides improved voltage holdoff with the option of scaling the length of the switch to many meters for increased current-carrying capability. While the insulator tube may be composed of conventional insulation materials such as ceramics or plastics, its voltage holdoff capabilities are enhanced by the use of hollow quartz tubes as the insulator tube.

While the invention has been described in its presently preferred embodiment it is understood that the words which have been used are words of description rather than words of limitation and that changes within the purview of the appended claims may be made without departing from the scope and spirit of the invention in its broader aspects.

What is claimed is:

1. A high voltage linear switch assembly comprising:

an insulator tube with a first and a second side which are opposite each other and which has a plurality of apertures along its first and second sides, said insulator tube having a hollow interior, and said insulator tube being constructed from a hollow quartz tube to provide high voltage holdoff insulation;

an anode housed within the hollow interior of said insulator tube adjacent to the plurality of apertures along its first side;

a cathode housed within the hollow interior of said insulator tube adjacent to the plurality of apertures along its second side, said cathode not being in physical contact with said anode;

a switch housed in said insulator tube between said anode and said cathode, said switch normally providing an open circuit between said anode and said cathode, said switch being capable of providing electrical contact between said anode and said cathode; and

a plurality of electrical feeds which extend into said apertures along said first and second sides of said insulator tube to contact said anode and said cathode, said electrical feeds thereby providing electrical contacts for said anode and said cathode.

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