Nov. 28, 1950 F. M. PENNING ET AL 2,532,188

ION DISCHARGE TUBE FOR HIGH-VOLTAGES

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Fig. 1

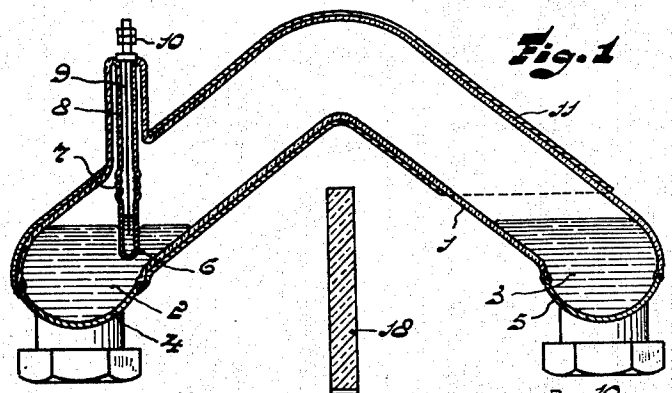


Fig. 3

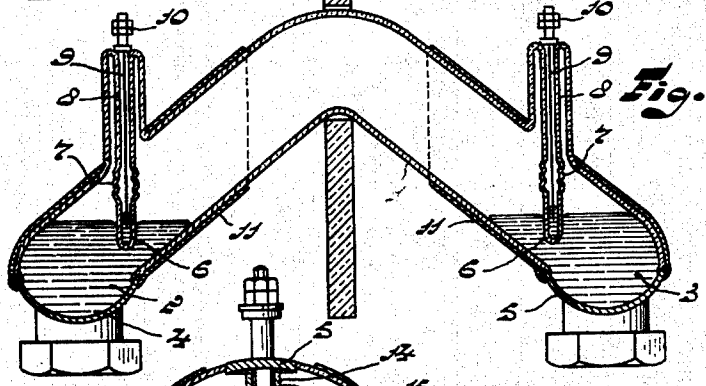
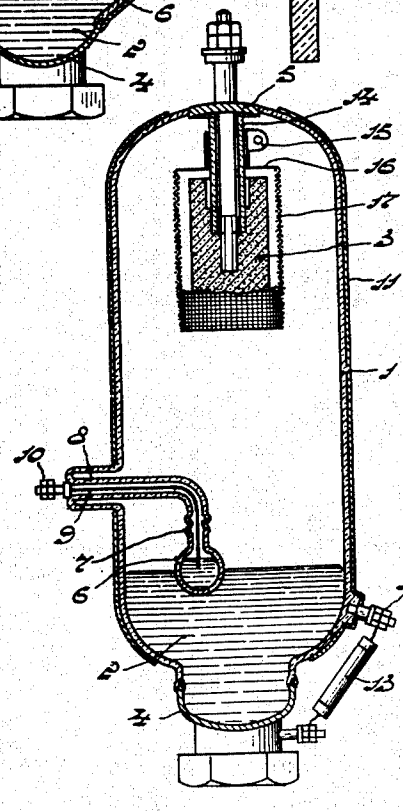


Fig. 2



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ION DISCHARGE TUBE FOR HIGH VOLTAGES

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7 Claims. (Cl. 250—27.5)

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This invention relates to an ion discharge tube for high voltages, having a liquid cathode which is provided with an ignition electrode capable of igniting the tube at an arbitrary moment.

Tubes having a liquid cathode are particularly suitable to convey strong currents for a short time. However, in the case of high voltages the disadvantage often occurs that the tube ignites before the igniting voltage is applied to the ignition electrode. This drawback is of particular importance if the tube contains, besides the cathode liquid, also a gas filling having a low pressure (some hundredths of a mm.). Sometimes the gas filling is provided to obtain a rapid development of the discharge, for example, in tubes used in an oscillograph to study extremely rapid phenomena.

These spontaneous ignitions are mostly initiated by sparks at the mercury surface, if the tube does not contain an additional gas filling, and by a glow discharge on the cathode, if the tube contains gas having a pressure of 0.01 mm. or more. The mechanism of these spontaneous ignitions has not yet entirely been cleared up. Probably the strong electric field at the cathode plays an important role. Due to the spontaneous ignitions the moment of ignition is no longer under control, which entails difficulties not only with controllable rectifiers, but more particularly also with tubes used to constitute switches.

The invention meets these drawbacks by providing that in a device comprising an ion discharge tube having a liquid cathode and equipped with an ignition electrode which is capable of initiating the ignition of the tube, at least the portion of the envelope around the cathode space is covered with a conductive layer which is connected to the cathode. As a result of this conductive layer the field constituted by the anode at the cathode surface is normally very weak, so that no spontaneous ignitions can occur, at least the voltage at which they occur is greatly increased. In the case of tubes having a gas filling this voltage increase has an extremely high value. It is particularly advantageous to establish the connection between the conductive layer and the cathode at the tube itself. This connection may also be established through a high resistance.

Impurities in the tube may annihilate the effect of the conductive layer, i. e. the increase of the voltage at which the tube ignites spontaneously. In this case the ignition voltage may even become still lower than is the case of a clean tube without a conductive layer. Therefore, it is of particular advantage to provide the tube with a so-called capacitative ignition electrode which consists of a conductor cover with insulating material, preferably quartz, and to use for the two electrodes mercury masses consisting of extremely pure mercury. In this case neither the ignition electrode nor the other electrodes can contaminate the tube.

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In the case of tubes which are used to constitute rectifiers care should be taken that the conductive layer does not extend too close to the liquid anode, since otherwise the latter may act as an ignition electrode for the anode in the negative phase. Also in tubes having a solid anode difficulties may be experienced, if the conductive layer approaches the anode too closely, since at the beginning of the negative phase this may involve a stronger ion bombardment of the anode, which may readily involve backfire. In tubes having a liquid anode, which need not act as a rectifier, the conductive layer may with impunity extend to such a short distance from the anode inlet as is permissible in connection with the insulation conditions and the risk of arcing over.

In the case of tubes having a solid anode, for instance of graphite or carbonized iron, it is particularly advantageous to surround the anode with a conductive screen, preferably consisting of metal gauze by which solely the active front surface of the anode is left clear and which is so secured as to be insulated from the anode.

In tubes having two liquid electrodes, it is of particular advantage to cover the wall about the two electrodes with a conductive layer which is connected to the associated electrode. In this way it is achieved that the electric field at the surface of each of the electrodes is weak, so that spontaneous ignitions in the positive phase and backfires in the negative phase are avoided. It is readily possible to provide both of the electrodes with an ignition electrode, so that the tube permits the passage of current in both directions. To avoid sparking and puncture outside the tube, it is of advantage to provide a shielding plate of

insulating material between the two conductive layers. As an alternative the whole tube may also be immersed in oil.

In order that the invention may be clearly understood and readily carried into effect, it will now be explained more fully with reference to the accompanying drawing, in which Figure 1 is a vertical section of a tube according to the invention having two liquid electrodes, one of which is provided with a capacitative ignition electrode, Figure 2 is a vertical section of a tube having only one liquid electrode, and Figure 3 is a vertical section of a tube having two liquid electrodes, each of which is surrounded by a conductive layer on the glass wall.

In Figure 1 the reference numeral 1 denotes the glass wall of the tube, 2 and 3 denoting mercury masses of the cathode and the anode respectively, 4 and 5 are chrome-iron tabs sealed to the tube, which serve for the supply of current and are therefore provided with connecting nuts. The ignition electrode consists of a quartz tube 6 which is partly filled with mercury and immersed in the cathode. By means of transition rings 7 the quartz tube 6 is sealed to a glass tube 8 inside which extends the supply wire 9 which has the connecting terminal 10. The tube 8 is exhausted. At the outside the tube is surrounded with a conductive layer 11 which may consist of a graphite preparation, commercially known under the registered trade mark "aquadag." This layer contacts with the cathode inlet 4 and extends close to the mercury surface of the anode. By providing the conductive layer the anode voltage, at which the tube ignites spontaneously, was raised, in a definite case, from 20 kv. to more than 30 kv., the tube having no gas filling; if the tube contained argon having a pressure of about 0.01 mm., the anode voltage at which a spontaneous ignition occurs was raised from 7 kv. to more than 25 kv. by providing the conductive layer. With 0.02 mm. of argon these values amounted to 4 and 20 kv. respectively. The conductive layer does not extend too close to the anode inlet to permit the tube also to be given a low negative anode-voltage without involving backfire. If the tube has to act as a rectifier, it is advisable to make use of the construction shown in Figure 3.

In Figure 2 the parts corresponding with Figure 1 bear the same reference numerals as in Figure 1. In this case the conductive layer 11 is connected, through a connecting terminal 12 located in the glass, through the intermediary of a resistance 13 of 0.5 megohms to the cathode inlet. About the anode inlet is provided a ceramic tube 14 on which a clip is clamped which carries the anode screen. The anode screen consists of a flat part 16 and a cylindrical part 17 which consists of metal gauze. The conductive layer extends close to the anode inlet. The screen provided around the anode prevents the anode in the negative phase from being too heavily bombarded by ions impelled by the field between the conductive layer and the anode, so that the tube is excellently suitable for use as a rectifier.

In Figure 3 also, the parts corresponding with those of Figure 1 are denoted by the same reference numerals as in Figure 1. Each of the liquid electrodes 2 and 3 is provided with a capacitative ignition electrode 6, and the electrode and the associated space is surrounded by a conductive layer on the glass wall. To prevent sparking of the two graphite layers 11 an insulating screen or shield 18 is provided about the tube at the middle. The increase in anode voltage, at which a spontaneous ignition occurs, may still be somewhat stronger than in the tube shown in Figure 1.

What we claim is:

1. A device comprising a high voltage discharge tube comprising a liquid cathode, an envelope having a wall portion of insulating material surrounding said liquid cathode, an ignition electrode to initiate a discharge from said cathode, and a layer of conductive material outside said insulating wall portion surrounding said liquid cathode, said conductive layer being directly connected to said cathode.

2. A high voltage discharge tube comprising two electrodes one of which is liquid, an envelope enclosing said electrodes and having a wall portion of insulating material surrounding said liquid electrode, an ignition electrode to initiate a discharge from said liquid electrode, and an outer layer of conductive material on said insulating wall portion surrounding said liquid electrode and extending to the region of said other electrode, said conductive layer being directly connected to said liquid electrode.

3. A high voltage discharge tube comprising a liquid cathode, a solid anode spaced from said cathode, a control electrode surrounding said anode, an envelope enclosing said cathode, said anode, and said control electrode and having a wall portion of insulating material surrounding said cathode, and a layer of conductive material on said insulating wall portion surrounding said liquid cathode and extending toward said solid electrode, said conductive layer being directly connected to said cathode.

4. A high voltage ion discharge tube comprising a liquid anode, a liquid cathode, a capacitative ignition electrode to initiate a discharge from said cathode, an envelope enclosing said cathode and anode and having an insulating wall portion surrounding said liquid cathode, and an outer layer of conductive material on said wall portion and surrounding said cathode, said layer being directly connected to said cathode.

5. A device comprising a high voltage discharge tube comprising a liquid cathode, an anode, an envelope surrounding said cathode and anode and having a wall portion of insulating material surrounding said liquid cathode, an ignition electrode to initiate a discharge from said cathode, and an outer layer of conductive material on said insulating wall portion and surrounding said liquid cathode, and a resistance element connecting said conductive layer and said cathode.

6. A high voltage ion discharge tube comprising two liquid electrodes, two ignition electrodes each for initiating a discharge from one of said electrodes, an envelope enclosing said liquid electrodes and having wall portions of insulating material surrounding each of said liquid electrodes, and two separate outer layers of conductive material on each of said insulating wall portions and surrounding each said liquid cathodes, each of said wall portion being directly connected to the said liquid electrode which it surrounds.

7. A high voltage ion discharge tube comprising two liquid electrodes, two ignition electrodes each for initiating a discharge from one of said electrodes, an envelope enclosing said liquid electrodes and having wall portions of insulating material surrounding each of said liquid electrodes, and two separate outer layers of conductive material one on each of said insulating wall portions and surrounding each of said liquid cath-

odes, each of said wall portions being directly connected to the said liquid electrode which it surrounds, and a shield of insulating material encircling said tube envelope and separating said conductive layers.

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Certificate of Correction

Patent No. 2,532,188 November 28, 1950

FRANS MICHEL PENNING ET AL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 4, line 64, after the word "each", first occurrence, insert *of*; line 65, for "portion" read *portions*;

and that the said Letters Patent should be read as corrected above, so that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 30th day of January, A. D. 1951.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.