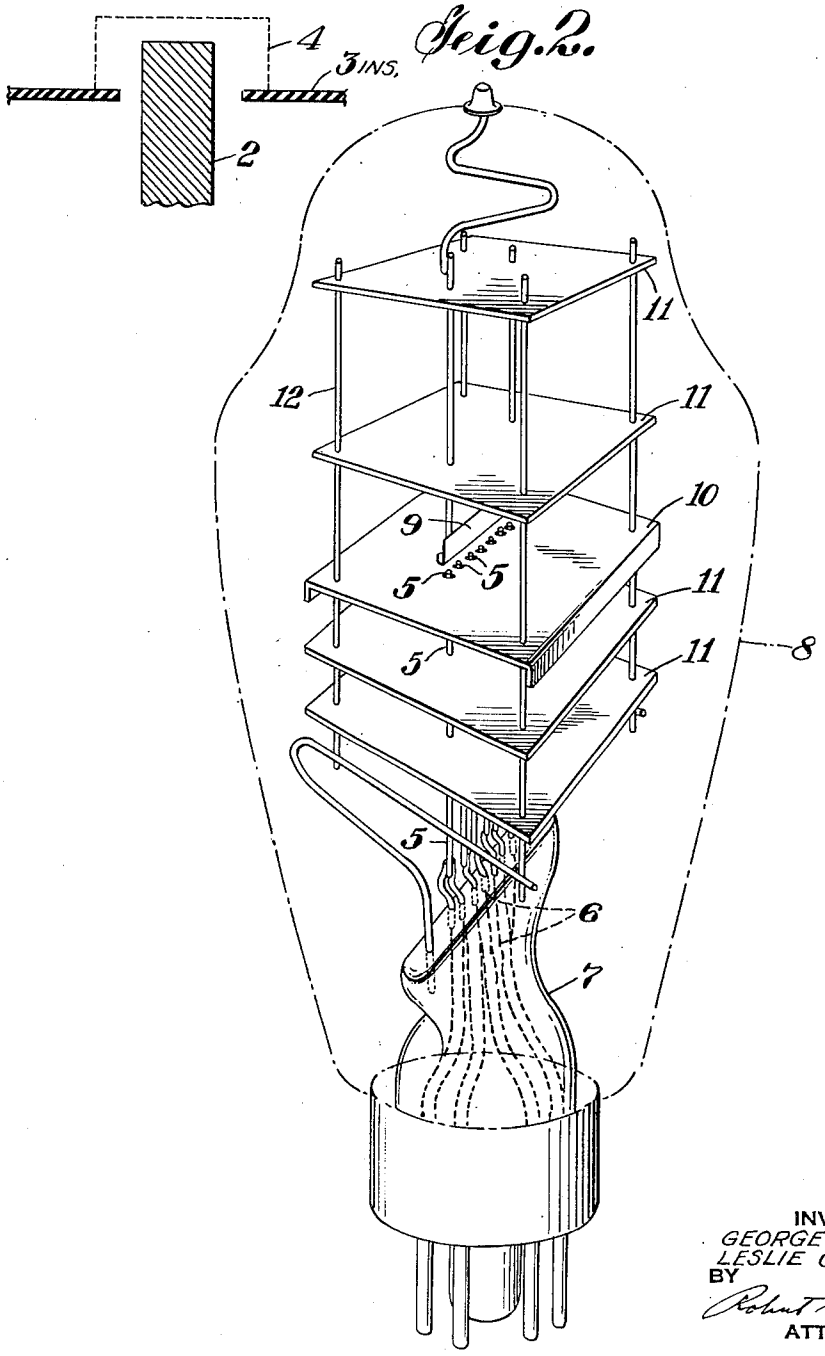
Jan. 27, 1953 G. H. HOUGH ET AL 2,627,045

ELECTRON DISCHARGE GLOW CONTROL ELECTRODE

Filed April 29, 1949

Fig. 1.

Fig. 2.



INVENTORS
GEORGE H. HOUGH
LESLIE C. BAKER
BY
Robert Harding Jr.
ATTORNEY

Patented Jan. 27, 1953

2,627,045

UNITED STATES PATENT OFFICE

2,627,045

ELECTRON DISCHARGE GLOW CONTROL ELECTRODE

George Hubert Hough and Leslie Charles Baker, London, England, assignors to International Standard Electric Corporation, New York, N. Y., a corporation of Delaware

Application April 29, 1949, Serial No. 90,316
In Great Britain May 3, 1948

6 Claims. (Cl. 313—188)

1

This present invention relates to cold cathode electric discharge devices.

By cold cathode discharge devices we mean a device having an envelope filled with an ionisable gas at reduced pressure and containing one or more discharge gaps designed as to their gap lengths and dimensions to function as glow discharge devices as opposed to arc or spark discharge gaps.

As is well known, in cold cathode discharge tubes so long as the whole of the available cathode surface is not covered with glow, the potential across the tube remains considerably below that required to initiate a discharge; the discharge in this region is referred to as "normal." When the whole of the available cathode surface is covered with glow, "abnormal" discharge commences with a corresponding rise of potential which increases more than proportionately to the increase in cathode current, until finally arcing occurs. For many applications it is required to limit the normal discharge from any given cathode to a prescribed area; this is particularly the case in what are known as sequence discharge tubes such as disclosed in the co-pending application of Alec H. Reeves, bearing Serial No. 15,582 and filed March 18, 1948. In such a device, a plurality of cathodes is provided with one or more corresponding anodes and it is arranged that the ionisation association with the cathode glow at any one gap primes the neighbouring discharge gap so that the striking potential of that gap is reduced. When voltage pulses are applied across the gaps in common, discharges may thus be set up in sequence from cathode to cathode. For satisfactory operation of such a tube as a counter for example, we prefer to work in the region of abnormal glow but well below the arcing region; for this reason the cathodes are made small in area and heretofore nickel rods have been coated with alumina or some similar discharge inhibiting substance except for a small area comprising the required cathode surface immediately facing the anode. A disadvantage of such a coating is that at the edges of the discharge area, insulating material tends to be removed during operation and furthermore sputtering of the conducting material onto the surface of the insulator results in a gradual increase in the effective cathode discharge area which results in unstable operation. In this connection it should be pointed out that for sequence discharge tubes we have found it preferable to use the same materials, usually pure metal, for both cathode and anode and have

2

found it necessary to take great care of the purity of the gas filling and cleanliness of any other materials introduced in the tube. It should also be pointed out that in such tubes although anode and cathode may be of the same material, completely different operating conditions result if these electrodes are interchanged in circuit, for if only the anode discharge surface is limited in area the cathode glow may wander all over the surface of a cathode during normal glow resulting in indeterminate ionisation coupling between gaps.

We have found that if a cathode electrode is surrounded by but separated from material—which may be either insulating such as mica or metallic—provided the separation between the electrode and the material is less than the extent of the cathode fall—approximately the distance between the cathode and the cathode glow in normal operation—the cathode glow will not pass between the electrode and the material to any appreciable extent until abnormal glow conditions have set in. Furthermore, even after this abnormal glow has occurred the restriction of the glow continues for some distance on the characteristic curve of the gap.

It is pointed out that the present invention is not to be confused with the procedure adapted in rectifier tubes for providing insulation against breakdown between conductors during the application of high peak inverse voltages. It has long been known that if two conductors in an ionisable gas be separated by a distance less than the mean free path of an electron in the gas, breakdown of the gap between them is prevented. For a typical gas mixture which we use in embodiments of the present invention the mean free path is but 0.008 mm. and it is considered impracticable to use such small clearances for present purposes. On the other hand as the length of the cathode fall in the same gas is 0.18 mm. it becomes practicable to use clearances of this order.

According to the present invention therefore, there is provided a cold cathode gas filled electric discharge device comprising a discharge gap between a pair of electrodes adapted to be used as a cathode and an anode respectively and a non-contacting collar of insulating or metallic material surrounding the cathode electrode at such distance from the surface thereof (being a distance greater than the mean free path of an electron in the gas) that cathode glow is restricted substantially to one side of said collar at least for discharge currents less than a given

value in the region of abnormal discharge conditions for said gap.

A collar is often most conveniently provided by a flat sheet of material and the invention provides a cold cathode gas filled electric discharge device comprising a pair of electrodes forming a discharge gap and a non-contacting sheet of insulating or metallic material surrounding one of said electrodes to form a collar spaced from the surface thereof by a distance greater than that of the mean free path of an electron in the gas but less than that of the cathode fall for normal cathode glow discharge from that electrode.

According to a further aspect of the invention there is provided a cold cathode gas filled electric discharge device comprising a plurality of discharge gaps formed between separate cathode surfaces and at least one anode electrode and a non-contacting sheet of insulating or metallic material juxtaposed said cathode surfaces at said distance therefrom as will permit abnormal glow discharge to occur before cathode glow extends beyond a limited area of each said surface.

According to yet another aspect of the invention there is provided a cold cathode gas filled electric discharge device comprising an anode or anodes, an apertured sheet of insulating or metallic material and a plurality of cathode rods projecting through said apertures to form discharge gaps with said anode or anodes, the clearance between said rods and the surrounding said sheet being greater than the mean free path of an electron in the gas but less than the extent of the normal cathode fall for each said discharge gaps.

The invention will be described with reference to the accompanying drawings, in which:

Fig. 1 shows a cross section through a typical discharge gap, and

Fig. 2 shows an electric discharge device of the sequence discharge type according to the present invention.

In many of the standard text books (see for example L. B. Loeb "The Fundamental Processes of Electrical Discharge Through Gases") the length of the cathode dark space for various gases is given, or it can be derived from the curve relating to the product of the gas pressure and the gap length to the minimum striking voltage for a particular gas. On such a curve the minimum value of the product of pressure and gap length corresponds to the length of the cathode dark space.

Referring now to Fig. 1, reference numeral **1** indicates a part of the anode, which may be in the form of a wire or plate and **2** represents a cathode which is assumed in this example to be cylindrical. **3** indicates a sheet of metal or insulating material surrounding the cathode to prevent the spread of glow according to the present invention, while the dotted line **4** indicates the extent of the cathode dark space. Thus, for a gap length between anode and cathode of 1 mm., using a gas mixture containing 92% Ne, 1% A and 7% H_2 at a pressure of 100 mm. of mercury, the cathode dark space extends approximately 0.183 mm. from the cylindrical cathode surface. We have found that provided the separation between the cathode surface and plate is less than this, say 0.125 mm. the cathode glow is inhibited from spreading below the plate even though the discharge current is taken well into the abnormal glow region. For higher values of abnormal glow the cathode dark space becomes smaller and eventually the glow will spread through the aperture but this is relatively unimportant because even then a stable glow is still obtained above the plate. Thus for a cathode rod of 1 mm. diameter with an anode-cathode gap of 1 mm. we have found that with the aperture spacing as given above a current of 7 Ma. can be drawn from the cathode before the glow spreads below the plate to an appreciable extent. It will be seen that the plate is effectively a field control member and owing to this fact, and provided the potential of the plate if of metal be less than required to maintain a discharge to the cathode, its effect upon the operation of the discharge between anode **1** and cathode **2** will be negligible except for its purpose of confining the glow to the region above the plate.

A practical construction of a sequence discharge device suitable for use as a counter is shown in Fig. 2. Cathode rods **5** are mounted by means of the lead-in wires **6** on a conventional glass press **7** forming part of the envelope **8** of the device. A single anode **9** and a field control plate **10** are mounted by means of mica separators **11** secured in normal manner via support rods **12** to the press **7**. It will be seen that only the tip of the cathode rods **5** protrude through the field control plate **10**.

By means of the present invention it has been possible to eliminate from the inside of the discharge tube all materials other than the pure metals of the electrodes, glass, mica and the necessary gas filling. In consequence the effect of ageing is reduced, operation is stable and cathode sputtering leads to little loss of tube life. A tube such as here described has been used to count 1 μ sec pulses of 1.3 Ma. current at a repetition rate of 10 kc./s. continuing for more than 2000 hours without any measurable change in characteristic.

While the principles of the invention have been described above in connection with specific examples and particular modifications thereof, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of the invention.

What is claimed is:

1. A cold cathode electric discharge device comprising a gas-filled envelope, an anode, cathode electrode means having a first portion defining a discharge gap with said anode and having a second portion adjacent said first portion, discharge field control means surrounding said cathode means and spaced in a first direction from the first portion of said cathode means a distance greater than the mean free path of an electron in the gas; said field control means spaced in a second direction from said second portion of said cathode means a distance less than the cathode dark space, whereby cathode glow is restricted substantially to the area between said field control means and the first portion of said cathode means when discharge currents of less than a given value in the region of abnormal discharge conditions are passed through said gap.

2. A cold cathode electric discharge device comprising a gas-filled envelope, an anode, a plurality of spaced cathode electrodes, each defining a separate discharge gap with said anode, discharge field control means surrounding each of said electrodes and spaced from those portions of said electrodes which define said gaps, said spacing being greater than the mean free

path of an electron in the gas, whereby cathode glow is restricted substantially to an area between said field control means and the portions of said electrodes defining said gaps when discharge currents of less than a given value in the region of abnormal discharge conditions for said gaps are passed therethrough.

3. A cold cathode electric discharge device as claimed in claim 2, wherein said discharge field control means comprises a multi-apertured plate, each of said cathode electrodes projecting through a different aperture in said plate, the clearance between each cathode electrode and the sides of the material surrounding its associated aperture being greater than the mean free path of an electron in the gas but less than the extent of the normal cathode fall for each said discharge gap.

4. A cold cathode electric discharge device as claimed in claim 2, further comprising insulating supporting means, wherein said cathode electrodes are disposed in parallel alignment and are maintained in position by said supporting means.

5. A cold cathode electric discharge device as claimed in claim 4, wherein said supporting means comprises a plurality of sheets of insulating material supported within said envelope, said cathode electrodes being rigidly held by said sheets.

6. A cold cathode electric discharge device comprising a gas-filled envelope, a plurality of mounting rods supported by said envelope therein, a plurality of insulating sheets mounted on said rods, each of said sheets mounted parallel in plane with the other and spaced from each other, an anode supported by at least one of said sheets, a plurality of cathode rods disposed

in parallel alignment, each of said cathode rods defining a separate discharge gap with said anode, a multi-apertured metallic field control plate supported on said mounting rods in a plane parallel to the plane of said insulating sheets, said plate disposed between a pair of said sheets and spaced therefrom, each of said cathode rods projecting through a different aperture in said plate, the clearance between each cathode electrode and the sides of the material surrounding its associated aperture being greater than the mean free path of an electron in the gas but less than the extent of the normal cathode fall for each of said discharge gaps, whereby cathode glow is restricted substantially to an area between said plate and the end of said cathode rods defining said discharge gaps when discharge currents of less than a given value in the region of abnormal discharge conditions for said gaps are passed therethrough.

GEORGE HUBERT HOUGH.
LESLIE CHARLES BAKER.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,877,716	Claude	Sept. 13, 1932
2,098,301	Mendenhall	Nov. 9, 1937
2,331,398	Ingram	Oct. 12, 1943
2,373,175	Depp	Apr. 10, 1945
2,443,407	Wales	June 15, 1948
2,456,854	Arnott et al.	Dec. 21, 1948
2,487,437	Goldstein et al.	Nov. 8, 1949