Oct. 19, 1937. P. FREEDMAN 2,096,236

ELECTRICAL DISCHARGE DEVICE

Original Filed April 5, 1935

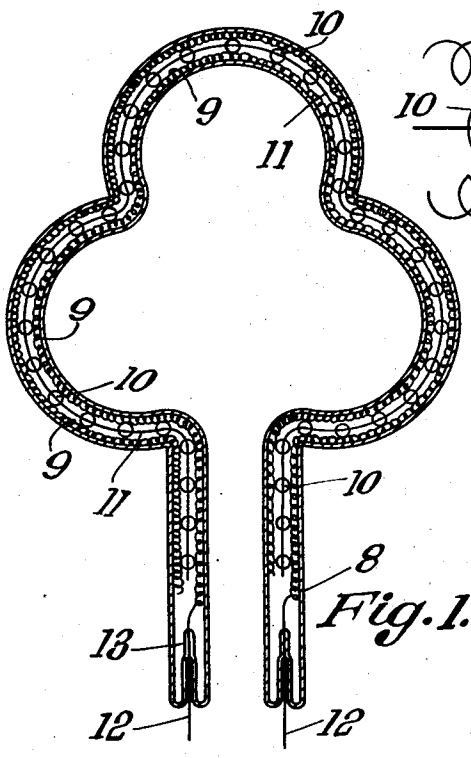


Fig. 1.

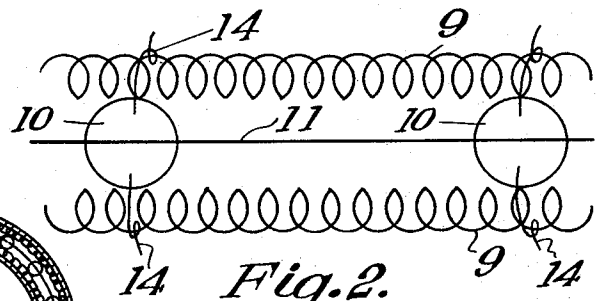


Fig. 2.

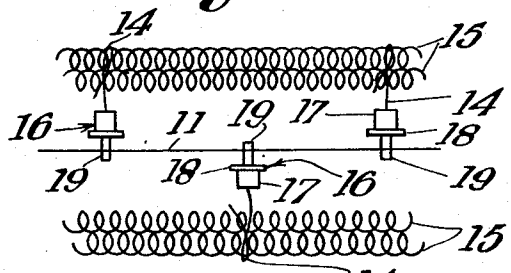


Fig. 3.

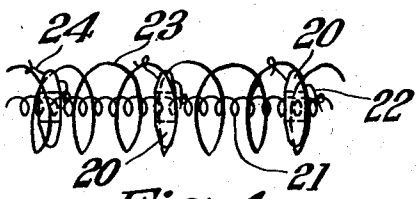


Fig. 4.

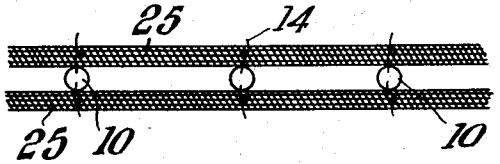


Fig. 5.

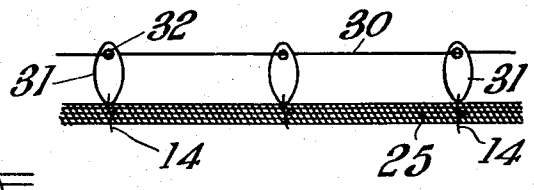


Fig. 7.

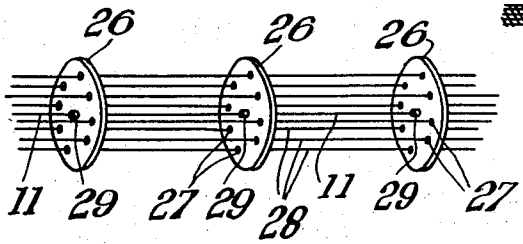


Fig. 6.

Inventor:
Paul Freedman
By Thurs. Ackerman
Atty

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ELECTRICAL DISCHARGE DEVICE

Paul Freedman, Highgate, London, England

Application April 5, 1935, Serial No. 14,940. Renewed August 24, 1937, In Great Britain April 6, 1934

14 Claims. (Cl. 176—122)

The present invention relates to improvements in and relating to electrical discharge tubes for production of luminous effects, more particularly of the kind wherein the luminous effect is obtained by an electrical discharge through a relatively long column of permanent gas or gases at low pressure and/or vapour of metals of metallic compounds. The invention is applicable for example to discharge tubes either straight or bent into shape of letters or other suitable designs, filled with neon, argon, helium or an admixture of these gases at a suitable pressure with or without admixture of mercury or other metallic vapour and employed for display purposes.

In such devices the luminous gaseous or vapour column is from six or seven inches up to many feet long and consequently high potentials have hitherto been employed for their operation which consisted in passing the current through the said column of gas or vapour, between electrodes situated at the opposite ends of the said column, and utilizing the luminous effect of the positive column glow between the electrodes. Thus, operation of such devices in the case of an A. C. supply necessitated the use of a step up transformer, and in the case of a D. C. supply in addition to a step up transformer, means for transforming D. C. to A. C., such as a rotary converter.

It has long been known that an electrical discharge can be initiated between two parallel, closely spaced electrodes in an atmosphere of readily ionizable gas or gases such as neon, helium or argon, at low pressure, upon application of normal household supply voltage. Under such conditions the luminous effect produced by the electrical discharge is due to the negative glow which appears in the case of an A. C. supply at both electrodes and in the case of a D. C. supply at the cathode only. Negative glow discharge lamps possessing a vitreous envelope similar in shape and size to that of ordinary household electric lamps, comprising two parallel, closely spaced and rigidly mounted electrodes in a suitable gaseous atmosphere, and provided with a current limiting resistance, have long been known. It has also been proposed to construct negative glow discharge lamps having a vitreous envelope of tubular shape, long in comparison to its diameter, and comprising two parallel, closely spaced electrodes, extending substantially over the entire tube length and located with respect to each other either by means of a rigid insulating support, or by having both electrodes in a state of tension, or by one electrode being in tension and the other in compression: the first and second methods of electrodes spacing enabled the construction of straight tubes while the last method enabled the construction of tubes bent into shape of a circle or part of a circle. Up till now no mode of construction has been proposed whereby it might be possible to construct negative glow discharge tubes bent into shape of letters or other suitable designs, such as are possible in the case of the discharge tubes utilizing the positive column glow.

According to the present invention means are provided and a method is disclosed whereby discharge tubes of any desired length and either straight or bent into any desired shape, may be constructed so as to be readily operable direct from household mains, whether A. C. or D. C.

This is achieved by providing the discharge tube constructed according to the invention with two or more flexible internal electrodes extending substantially over the entire tube length and spaced at desired distances from each other by means of associated spaced insulators, said insulators being preferably attached in a suitable manner to the said electrodes and preferably mounted upon a flexible metallic support.

The above flexible electrodes, which may be in the form of metallic spirals, strips of metallic gauze, multiplicity of wires, or the like, and which henceforth will be designated by the term "extended flexible electrodes", together with associated spaced insulators, may be readily slipped into position within the tubular glass envelope of the discharge tube, however complex the shape into which the said tubular envelope has been bent. As will be shown, the system comprising the flexible extended electrodes and the associated insulators may be easily drawn into position within a previously bent tubular envelope, by applying a pull, preferably to the flexible metallic support upon which the insulators are mounted or, in some cases, to one of the electrodes, without the electrodes being brought into electrical contact with each other or suffering any appreciable distortion as a result of this process.

Various modifications of the device constructed according to the invention may be employed. Thus, for example, the extended flexible electrode system may be in the form of two similar spirals spaced at substantially constant distance from each other over their entire length by means of spaced insulators attached to both electrodes and mounted upon a flexible metallic wire. Again, the extended flexible electrode system may be in the form of two concentric spirals, the inner spiral being suitably spaced from the outer spiral by

means of spaced insulators attached to both spirals. According to another modification of construction the extended flexible electrode system may consist of a multiplicity of flexible wires threaded through holes in spaced insulators, which insulators may be mounted on a flexible supporting wire. In another modification of construction extended flexible electrodes which are not concentric may be located with respect to each other by means of suitably spaced insulators attached thereto, the flexible wire acting as mounting for the said insulators being omitted. According to yet another modification of construction extended flexible electrodes which are not concentric may be spaced in a suitable manner by means of insulators attached to one flexible extended electrode only, the insulator mounting flexible wire being omitted. Numerous modifications of the invention are possible and will readily suggest themselves to those skilled in the art.

The insulators employed to locate the extended flexible electrodes with respect to each other are of refractory insulating material such as alumina, magnesia, zirconia, silica or hard glass such, for example, as the glass known by the trade name Pyrex. The flexible metallic support upon which the insulators are mounted consists of a single wire or of several wires which may be intertwined and must combine high flexibility with mechanical strength; molybdenum wire is preferably used. The mode of attachment of the insulators to the extended flexible electrodes must be such that there is no impediment to the spread of the negative glow over the entire surface of an electrode when it functions as the cathode.

In order that the invention may be better understood, it will now be described with reference to the accompanying drawing in which:—

Figs. 1 to 7 show various methods of carrying the invention into effect.

Fig. 1 shows a type of discharge tube constructed according to the invention adapted to be operated on A. C. and particularly suitable for a negative glow discharge in neon. The device shown in the figure has a clear or translucent glass envelope 8 in which are enclosed extended flexible electrodes 9 having the form of single wire spirals. The electrodes 9 are separated by and attached to insulators 10 mounted upon a flexible wire 11. Current is conveyed to and from the electrodes by means of leads 12 passing through seals 13.

Fig. 2 shows the details of electrode and associated insulator assembly employed in the device shown in Fig. 1. In Fig. 2 the spiral wire electrodes 9 are attached to hard glass bead insulators 10 by means of wire hooks 14 fused into the hard glass beads. The beads 10 are fused to the supporting flexible wire 11. Both the hooks 14 and the wire 11 are preferably of molybdenum.

Fig. 3 shows the details of extended flexible electrode and associated insulator assembly adapted to be employed in a type of discharge tube designed to operate on A. C. and particularly suitable for a negative glow discharge in a mixture of argon and mercury vapour. In the figure each extended flexible electrode 15 consists of several wire spirals laced together, the spirals being of smaller diameter and thinner wire than the spirals 9 shown in Figs. 1 and 2. The electrodes 15 are attached to the hard glass insulators 16 by means of wire hooks 14. The insulators 16 have a well or skirt 17 such as is commonly employed in high tension insulators, a flange 18 and a stem 19, which stem is fused to the supporting flexible wire 11. Both the hooks 14 and the wire 11 are preferably of molybdenum.

Figure 4 shows the details of extended flexible electrodes and associated insulator assembly in which the electrodes are concentric spirals. In the figure, 20 are washers of hard glass, employed as insulators. The inner spiral electrode 21 passes through the hard glass washers 20, the holes in these washers being appreciably greater in diameter than the spiral electrode 21. The washers 20 are attached to the spiral electrode 21 and to the supporting flexible wire 11 which passes through the spiral electrode 21, by means of wire hooks 22 which are fused to the washers 20 and welded to the wire 11. The external spiral electrode 23 is attached to the washers 20 by means of wire hooks 24. The hooks 22 and 24 and the wire 11 are preferably of molybdenum.

Figure 5 shows the details of extended flexible electrodes and associated insulator assembly adapted to be employed in a type of discharge tube designed to operate on A. C. and characterized by the fact that no flexible metallic wire or wires acting as mounting for the said insulator are employed. In the figure, 25 are extended flexible electrodes of metallic gauze, 10 are hard glass beads acting as insulators and 14 are wire hooks attaching the electrodes 25 to the insulators 14.

Figure 6 shows the details of extended flexible electrode and associated insulator assembly adapted to be employed in a type of discharge tube designed to operate either on A. C. or D. C. In the figure 26 are disc shaped insulators of alumina, magnesia or zirconia, having a number of holes 27 near their periphery. Wires 28, acting as electrodes are threaded through the holes 27, the diameter of the wire being appreciably smaller than the diameter of the holes. Each insulator disc 26 has a small central hole in which is fixed a thin metal bush 29. The flexible wire 11, acting as insulator mounting passes through the central hole in the insulator disc 26 and is pinched in the metal bushes 29.

The arrangement shown in Figure 6 is not suitable for discharge tubes in which the tubular envelope has sharp bends. In the case of a tubular envelope having sharp bends it is preferable to employ three flexible wires similar to 11, the object of the three wires being to prevent tilting of the discs 26 and consequent distortion and electrical contact of the electrodes 28 when the assembly is drawn into the tubular envelope of the discharge tube.

Figure 7 shows the details of electrode and associated insulator assembly employed in a type of discharge tube adapted to be operated on D. C. In the figure, 25 is the negative electrode of metallic gauze, 30 is a wire acting as the positive electrode, and 31 an insulator of alumina, magnesia, zirconia, silica or hard glass. The wire electrode 30 passes through holes 32 in the insulators 31, the diameter of the holes 32 being appreciably greater than the diameter of the wire electrode 30. The insulators 31 are attached to the gauze electrode 25 by means of wire hooks 14.

It will be observed that in all types of construction shown in the appended figures and described above, the mode of assembly and attachment of the insulators is such as to offer no impediment to the spread of the negative glow over the entire surface of an electrode when it functions as the cathode. Apart from employing spaced insulators for the purpose of suitably locating extended flexible electrodes with respect

to each other it is also often advantageous to employ the same or additional insulators to space the said extended flexible electrodes from the glass envelope of the device.

It will also be observed that the extended flexible electrode and associated insulator assembly may be easily drawn into position within a previously bent tubular envelope in the case of structures shown in Figures 1, 2, 3, 4, and 6 by applying a pull to the flexible metallic support upon which the insulators are mounted, and in the case of structures shown in Figures 5 and 7 by applying a pull to an electrode attached to the insulators. In each case, the electrodes would not be brought into electrical contact with each other or suffer any appreciable distortion as a result of this process.

Effective results can be obtained with iron electrodes but electrodes of other metals, for example nickel, may also be employed. To decrease the voltage drop at the electrodes the electrodes may be superficially coated with substances calculated to increase their electron emissivity; for example the electrodes may be coated with oxides of alkaline earth metals, calcium, barium and strontium used severally or admixed in suitable proportions. Decreased electrode drop of potential may also be obtained by making the electrodes of nickel or iron incorporating a percentage of strontium and barium, oxides. Alkaline metals, sodium, potassium, lithium, rubidium and caesium may also be introduced into the discharge tube to facilitate the discharge.

Besides mercury and the alkaline metals mentioned above various metallic compounds such as thallium chloride may be used in addition to the gaseous filling to obtain desired luminous effects. While the most suitable permanent gases are neon, helium and argon, other gases such as nitrogen may also be employed.

Insulators may be employed to protect the seals from the effects of the electrical discharge.

What I claim and desire to secure by Letters Patent is:

1. A discharge tube comprising a tubular transparent envelope and a flexible electrode structure extending through said envelope from end to end thereof said electrode structure comprising two flexible electrodes and a plurality of spaced insulating members supporting said electrodes in electrically insulated relation, and an inactive wire connecting the insulators and holding them in spaced relation.

2. A discharge tube comprising a tubular transparent envelope, a flexible support extending through said envelope from end to end thereof, a plurality of insulators secured in spaced relation upon said support, a pair of flexible electrodes each extending through said envelope from end to end thereof, and means supporting each of said electrodes upon said insulators, and an inactive wire connecting the insulators and holding them in spaced relation.

3. A discharge tube comprising a tubular transparent envelope and a flexible electrode structure extending through said envelope from end to end thereof, said electrode structure comprising two flexible electrodes, and a plurality of spaced insulating members supporting said electrodes in electrically insulated relation, each of said electrodes consisting of a spirally wound wire, and an inactive wire extending through said insulators and holding the same in spaced relation.

4. A discharge tube comprising a tubular transparent envelope, a flexible support extending through said envelope from end to end thereof, a plurality of insulators secured in spaced relation upon said support, a pair of flexible electrodes each extending through said envelope from end to end thereof, and means supporting each of said electrodes upon said insulators, each of said electrodes consisting of a spirally wound wire, and an inactive wire extending through said insulators and holding the same in spaced relation.

5. A discharge tube comprising a tubular, transparent and bendable envelope, an electrode structure flexible in all directions extending through said envelope from end to end thereof, said electrode structure comprising two flexible electrodes each comprising wires whose aggregate length substantially exceeds the length of the electrode and having a free conducting surface continuous and uninterrupted throughout its length and a plurality of spaced insulating members supporting said electrodes in electrically insulated relation.

6. A discharge tube comprising a tubular, transparent envelope so bent that it does not lie wholly in one plane, an electrode structure flexible in all directions extending through said envelope from end to end thereof, said electrode structure comprising two flexible electrodes each comprising wires whose aggregate length substantially exceeds the length of the electrode and having a free conducting surface continuous and uninterrupted throughout its length and a plurality of spaced insulating members not in direct engagement with said electrodes supporting said electrodes in electrically insulated relation.

7. A discharge tube comprising a tubular, transparent and bendable envelope, two flexible electrodes each extending through said envelope from end to end thereof and having a free conducting surface continuous and uninterrupted throughout its length, and means for mechanically connecting together said electrodes so as to maintain them in spaced relation, said means being arranged to allow of relative longitudinal movement between said electrodes.

8. A discharge tube comprising a tubular, transparent envelope so bent that it does not lie wholly in one plane, two flexible electrodes each extending through said envelope from end to end thereof and having a free conducting surface continuous and uninterrupted throughout its length, and means for mechanically connecting together said electrodes so as to maintain them in spaced relation, said means being arranged to allow of relative longitudinal movement between said electrodes.

9. A discharge tube comprising a tubular, transparent envelope so bent that it does not lie wholly in one plane, two flexible electrodes each extending through said envelope from end to end thereof and having a free conducting surface continuous and uninterrupted throughout its length, each comprising a helically wound wire, and means for mechanically connecting together said electrodes so as to maintain them in spaced relation, said means being arranged to allow of relative longitudinal movement between said electrodes.

10. A discharge tube comprising a tubular, transparent envelope so bent that it does not lie wholly in one plane, an electrode structure flexible in all directions extending through said envelope from end to end thereof, said electrode structure comprising two flexible electrodes each ex-

tending through said envelope from end to end thereof, a plurality of spaced insulators not in engagement with said electrodes, and conducting means for mechanically connecting said electrodes to said insulators so as to allow of relative longitudinal movement between said electrodes.

11. A discharge tube comprising a tubular, transparent envelope so bent that it does not lie wholly in one plane, two flexible electrodes each extending through said envelope from end to end thereof and having a free conducting surface continuous and uninterrupted throughout its length, each comprising a helically wound wire, the helices formed by said wires being concentric, and means for mechanically connecting together said electrodes so as to maintain them in spaced relation, said means being arranged to allow of relative longitudinal movement between said electrodes.

12. A negative glow discharge tube comprising a transparent hermetically sealed tube containing inert and readily ionizable gas, and an electrode structure in said tube arranged for bending in all directions and including a pair of electrodes each comprising wires whose aggregate length substantially exceeds the length of the electrode and each having a free conducting surface continuous and uninterrupted throughout its length and means for supporting said electrodes in insulated relation for relative longitudinal movement.

13. A negative glow discharge tube comprising a transparent hermetically sealed tube containing inert and readily ionizable gas, and an electrode structure in said tube arranged for bending in all directions and including a pair of helical electrodes each having a free conducting surface continuous and uninterrupted throughout its length and means for insulating said electrodes from each other.

14. A negative glow discharge tube comprising a transparent hermetically sealed tube containing inert and readily ionizable gas, and an electrode structure in said tube arranged for bending in all directions and including a pair of helical electrodes and means for insulating said electrodes from each other, said electrodes having the axes of their helices in spaced parallel relation.

PAUL FREEDMAN.