

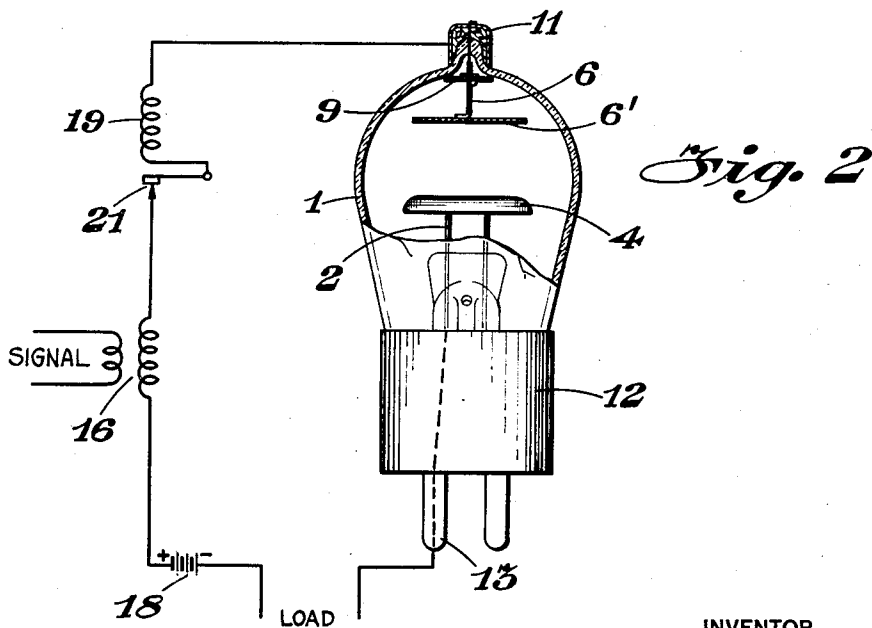
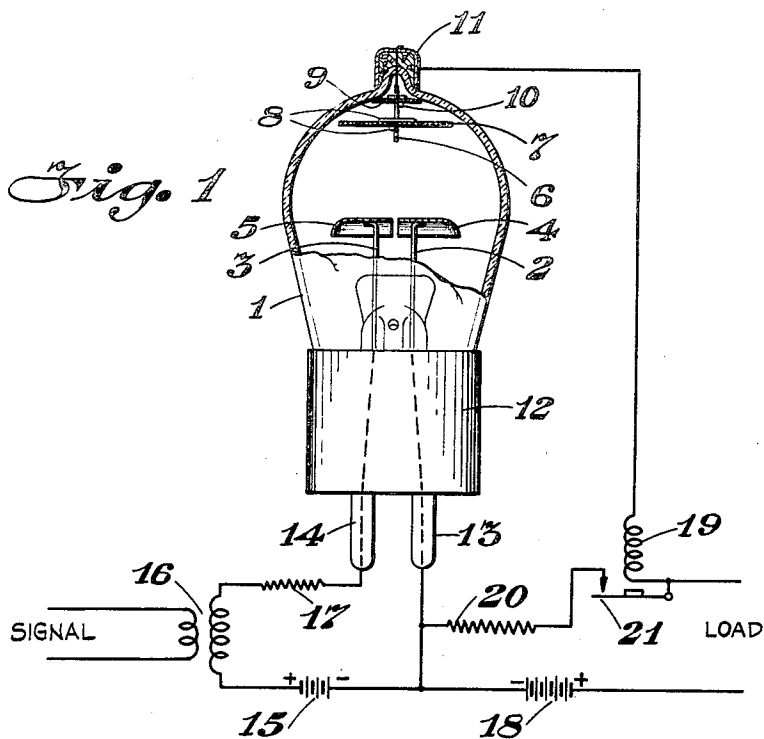
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GASEOUS ELECTRIC DISCHARGE DEVICE AND METHOD OF MAKING THE SAME

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GASEOUS ELECTRIC DISCHARGE DEVICE
AND METHOD OF MAKING THE SAME

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The present invention relates to gaseous electric discharge devices generally, and more particularly to cathode glow discharge devices and to the method of making the same.

3 A particular object of the invention is to provide a gaseous electric discharge device which will have a low breakdown potential. Another object of the invention is to provide a device having an extremely low discharge maintaining potential. Another object of the invention is to provide a device which will act as a relay permitting large energy flow in response to a signal of relatively low energy. Another object of my invention is to provide a device having two anodes in which the breakdown potential from one anode is much higher than that from the other anode. Still another object of the invention is to provide a device having a constant breakdown potential. A further object of the invention is to provide a novel method of producing a gaseous discharge device having the foregoing characteristics. Still other objects and advantages of the invention will appear from the following detailed specification, or from an inspection of the accompanying drawing.

25 ing. The invention consists in the new and novel gaseous electric discharge device, and in the novel method of making the same, as hereinafter set forth and claimed.

30 To satisfactorily serve as relay tubes gaseous electric discharge devices of the cathode glow type must meet three requirements. They must have a fairly high breakdown potential; they must be able to pass considerable current once the discharge is initiated therein, and the breakdown potential must remain constant throughout the life of the device. These three requirements have not been met by any of the devices of the prior art. I have now discovered a novel structure having all of the desired characteristics. According to my invention the anode is placed at some distance from the cathode, the exact spacing depending upon the breakdown voltage desired. In order to reduce the maintaining voltage the cathode is coated with any suitable alkaline or alkaline earth metal, although I prefer to produce a coating of barium thereon according to the novel method disclosed hereinafter. While this combination of elements meets the first two of the requirements outlined hereinbefore I have found that the particles sputtered from the cathode onto the envelope of the device during operation tend to form a film thereon which may make contact with either the cathode or the anode. This film, which may be invisible, forms

an extension of the electrode surface to which it is connected, and modifies the electrode spacing, with a resulting gradual decrease in the breakdown potential as the device operates. This decrease is especially marked where the electrode separation is larger than the distance between the electrodes and the walls of the enclosing envelope. I have now discovered that this decrease in breakdown potential, which is wholly undesirable, can be eliminated by shielding that portion of the envelope which is adjacent to the inleads from sputtered particles. As a result of this novel construction the breakdown potential is maintained at the desired value throughout a long useful life. Thus my novel tube fully meets all the requirements of a successful relay tube, as set forth hereinbefore.

The novel method of coating the electrodes which I have discovered produces a surface having unique properties. This surface is believed to consist of particles of alkaline metal homogeneously intermixed with atoms of oxygen, the latter atoms serving to tenaciously bind the particles of the alkaline metal to the electrodes. This surface has quite different characteristics from one which is prepared by any of the methods of the prior art, applicant having found that not only is the work function of his new surface lower than is otherwise attainable by use of the same alkaline metal, but also that this novel surface has an exceptionally long useful life, of at least several thousand hours. This novel surface is, of course, extremely useful not only in relay devices, but also in the gaseous discharge art generally, as in lamps, rectifiers, voltage regulators, and the like.

For the purpose of illustrating my invention I have shown several embodiments thereof in the accompanying drawing, in which

Fig. 1 is an elevation, in part section, of a preferred form of relay tube, together with a schematic diagram of an operating circuit therefor, and

Fig. 2 is an elevation, in part section, of a modification of the device of Fig. 1, together with a schematic diagram of a modified operating circuit therefor.

In this drawing, with particular reference to Fig. 1, there is shown a relay tube having a sealed envelope 1 of glass or other suitable material. Two inleads 2 and 3 are sealed into one end of said envelope through a conventional pinch seal. Said inleads carry similar semi-circular electrodes 4 and 5, respectively, the straight edges of said electrodes being parallel and spaced

about a millimeter apart. The symmetry of these electrodes is a matter of convenience only, however. An inlead 6 is sealed through the opposite end of said envelope 1 and extends therein to a point which is of the order of a few centimeters from the electrode 4, said inlead serving as an anode. A disc 7 of insulating material, such as mica, glass or the like, and which is of the order of an inch in diameter, has a hole therein through which the inlead 6 passes. Said disc is maintained at some distance from the end of said inlead by the cross wires 8 which are welded to said inlead 6 on either side of said disc, said wires being positioned at right angles to each other. A second mica disc 9 of small diameter is positioned about said inlead 6 at a point in contact with the envelope 1, being held thereagainst by the cross wire 10 which is welded to said inlead. Said disc 9 serves as a convenient guide to the spacing of the inlead 6 when said inlead is being sealed into the envelope 1, the practice being to pull the inlead outwardly after the seal is made until said disc is pressed against said envelope. A suitable gaseous filling is provided within the envelope 1. A terminal 11 is attached to the inlead 6, while a conventional base 12 is attached to the other end of said envelope, the pin contacts 13 and 14 thereof being connected to the inleads 2 and 3, respectively.

In the manufacture of the foregoing device the electrodes 4 and 5 are preferably made of nickel, iron or the like. The electrode 4, which is destined to act as a cathode, is then coated on the face with an alkali or alkaline earth metal or an easily reducible compound thereof in order to reduce the work function thereof. According to the preferred novel method this electrode is sprayed or otherwise coated with a mixture of barium and strontium carbonates, although the nitrate or any other compound which is easily reduced to the oxide of these or any of the other alkaline metals may be used if desired, it being understood that in some cases a single alkaline compound is sufficient. For low breakdown potential and long life a barium compound is preferred, but the additional use of a strontium compound has been found to produce a more uniform corona. The alkaline compound is mixed with a suitable binder, such as nitrocellulose, and any suitable vehicle, such as cellulose acetate. While the electrode 5, which is destined to serve solely as an anode, is not benefited by such a coating, it is not essential that it should be shielded from stray spray during this process, and in practice it is at least partially covered with the same coating. For an alternating current discharge both of these electrodes would be uniformly coated, of course. The back of the electrodes 4 and 5 is then preferably sprayed with a mixture of powdered aluminum with the same binder and vehicle, as disclosed in my co-pending application, Serial No. 506,849, filed January 6, 1931, in order to confine the glow to the face of said electrode. The electrodes 4 and 5 are then sealed into the envelope 1 and said envelope exhausted while being heated to a temperature of the order of 450° C. to drive occluded gas therefrom. The electrodes are then heated, preferably by means of a high frequency magnetic field, to a temperature of the order of 1300° C. to decompose the barium and strontium carbonates to the oxide, the gas being exhausted as evolved. During this heating the cellulose binder is likewise reduced to carbon. This heating is continued until all gas evolution ceases. The desired gaseous at-

mosphere is then admitted and the envelope 1 sealed off in a conventional manner. The inleads 2 and 3 are then connected to a source of steep wave front, high frequency, highly damped, oscillations, such as produced by the discharge of an inductance through a condenser during the period of primary circuit interruption. The steep wave front of these oscillations is highly important, since it is responsible for producing a discharge of sufficient energy to break up a portion of the barium oxide, leaving barium which is cemented to the electrode surface by an oxygen and barium oxide bond. This bombardment of the electrode 4 (and of the electrode 5, if coated) is carried on until there is a uniform corona on the surface of said electrode. Any oxygen evolved during this bombardment which is not adsorbed by the electrode, where it becomes homogeneously intermixed with the barium and serves as a bond therefor, is cleaned up by the aluminum coating on the back of said electrode 4, which has been rendered especially active as a getter by the previously described heating in vacuo. The active coating produced in this way has an extremely low work function, appreciably lower than that of a coating formed by distilling barium onto barium oxide, and has a useful life many times that of such a coating, and hence is known to be different from the coatings produced by this process of the prior art. After being allowed to age by connecting the inleads 2 and 3 to a potential source of 110 volts, 60 cycles, with a resistance of several thousand ohms connected in series therewith, the device is ready for use. Where the gaseous filling consists of neon with ½% argon at a pressure of 50 mm. of mercury, for example, a potential of the order of 50 volts A. C. or 68 volts D. C. will break down the gap between the electrodes 4 and 5, the electrode 4 being cathode, and the ensuing discharge will be maintained therebetween by a potential of the order of 50-55 volts D. C. With the foregoing gas mixture and pressure, and with a gap of 15 mm. between the anode 6 and the cathode 4 the normal breakdown potential therebetween will be approximately 150 volts D. C., but 65 volts is sufficient to maintain a discharge therebetween. This breakdown potential will be reduced to considerably less than 135 volts, however, whenever a discharge occurs between the electrodes 4 and 5.

The foregoing characteristics may be availed of by connecting the device as shown in Fig. 1, for example. As there shown the pin contact 13 is connected to the negative side of a 45 volt battery 15, while the positive terminal of said battery is connected through the secondary of a transformer 16 and a resistance 17 to the pin contact 14. The primary of said transformer 16 is connected in any desired circuit to whose condition the relay device is intended to be responsive. The pin contact 13 is likewise connected to the negative terminal of a 135 volt battery 18 whose positive terminal is connected to any desired load circuit, while the terminal 10 is connected to the same load through a magnet coil 19. A resistance 20 and contacts 21, which are normally open but which are arranged to be closed by the magnet 19, are connected between the pin contact 13 and the load side of the magnet coil 19.

Whenever there is any increase in the potential applied across the primary of the transformer 16 the potential which is added by said transformer to the 45 volts of the battery 15 is like-

wise at least momentarily increased. If the total potential at any instant exceeds the breakdown potential between the electrodes 4 and 5 a discharge of the order of a few microamperes (depending upon the circuit constants) occurs from the anode 5 to the cathode 4, this discharge persisting until the total potential drops below the discharge maintaining potential of 50-55 volts D. C. As soon as this discharge starts, the ionization within the envelope 1 reduces the breakdown potential between the anode 6 and the cathode 4, permitting the battery 18 to produce a discharge therebetween. Due to the very low cathode drop the voltage available in excess of the arc maintaining potential is extremely large, with the result that a large discharge current, of the order of 100 milliamperes, is easily produced, the actual current being dependent upon the constants of the load circuit, of course. This discharge would continue indefinitely, due to the fact that the voltage of the battery 18 is greater than that necessary to maintain the discharge. Hence some means of extinguishing this discharge is necessary. This is accomplished by the magnet coil 19, resistance 20 and contacts 21. As soon as current flows through the magnet 19 the contacts 21 are closed connecting the resistance 20 in shunt to the discharge. This resistance allows enough additional current to flow from the battery 18 to drop the voltage between the anode 6 and the cathode 4 to less than the 65 volts required to maintain the discharge therebetween. The discharge is thereupon extinguished, whereupon the contacts 21 again open. If the discharge between the electrodes 4 and 5 still persists the discharge from the anode 6 is immediately reinitiated; otherwise there is no further discharge until an incoming signal again initiates a discharge between the electrodes 4 and 5.

A modified structure employing only two electrodes, and useful where a lower degree of sensitivity is required, is shown in Fig. 2. In this structure the envelope 1 has a single cathode 4 at one end thereof. This cathode is preferably coated in the same manner as the cathode of Fig. 1. At the opposite end of the envelope the inlead 6 carries a disc anode 6' of nickel, iron or the like, said anode having substantially the same diameter as the mica disc 7 of Fig. 1. The secondary of the transformer 16 is connected in series with the load, a battery 18 of say 135 volts, a magnet coil 19 and a pair of contacts 21 between the terminal 11 and the pin contact 13. The contacts 21 are normally closed, but are adapted to be opened by the magnet 19.

With this circuit whenever the sum of the voltage of the battery 18 and that supplied by the transformer 16 equals the breakdown potential of the device a discharge occurs from the anode 6'. This current flowing through the magnet 19 opens the contacts 21, extinguishing the discharge. The contacts thereupon again close. If the total voltage is still in excess of the breakdown potential this discharge is immediately reinitiated; otherwise there is no further discharge until another signal is received.

With the construction illustrated in either figure the inlead 6 enters the envelope 1 at a point which is in the center of a considerable area which is shielded from particles sputtered from the cathode, either by the disc 7 of Fig. 1 or the anode 6' of Fig. 2. Thus there is no possibility of this inlead making contact with the sputtered metallic film which is inherent in this

type of device. Furthermore the inlead 2 likewise enters the envelope 1 at a point which is shielded by the cathode itself from sputtered particles, due to the confinement of the discharge to the electrode surface which is away from the inlead seal, although it is to be understood that a mica disc or the equivalent may be used for this purpose, if desired. Thus this electrode is also maintained electrically insulated from the sputtered film. As a result of this novel insulation of the inleads from the sputtered film this film does not alter the effective electrode separation, as heretofore. Consequently the breakdown potential of the device remains constant throughout the life of the device. The importance of this feature in relay work cannot be overestimated, as it marks the difference between a satisfactory device and one which is wholly useless for relay use.

It is to be understood, of course, that various changes, substitutions or omissions, within the scope of the appended claims, may be made in the structures used for illustration without departing from the spirit of my invention.

I claim as my invention:—

1. A gaseous electric discharge device comprising a sealed envelope, a gaseous atmosphere therein, a cathode and an anode within said envelope, the distance between said cathode and said anode being greater than the distance between either thereof and the nearest portion of said envelope, inleads sealed through said envelope and supporting said cathode and anode, an insulating shield about the inlead to said anode near the seal to protect an appreciable area of the envelope from particles sputtered from said cathode, a coating of an alkaline metal on a portion of said cathode, and a coating of aluminum on the portion of said cathode which faces toward the seal of the supporting inlead, whereby an appreciable area of said envelope adjacent to said seal is likewise maintained free of particles sputtered from said cathode.

2. A gaseous electric discharge device comprising a sealed envelope, a gaseous atmosphere therein, a cathode and an anode within said envelope, the distance between said anode and said cathode being greater than the distance between either thereof and the nearest portion of said envelope, inleads sealed through said envelope and supporting said cathode and anode, a coating of an alkaline metal on the surface of said cathode, means to shield an appreciable area of the inner surface of said envelope about each of said inleads from particles sputtered from said cathode, an auxiliary anode close to said cathode, and an inlead sealed through said envelope and supporting said auxiliary anode.

3. The method of producing a gaseous electric discharge device which comprises coating at least one of the electrodes thereof with a reducible oxygen compound of an alkaline metal, sealing said electrodes into an envelope, heating said electrodes in vacuo to a temperature sufficient to decompose said compound to the oxide, providing a gaseous atmosphere about said electrodes, producing a steep wave front discharge between said electrodes of sufficient energy to reduce said oxide to the metal, and cleaning up any evolved gas which is not adsorbed by said electrodes.

4. The method of producing a gaseous electric discharge device which comprises coating a portion of at least one of the electrodes thereof with a reducible oxygen compound of an alkaline metal, coating another portion of said electrode

with powdered aluminum, sealing said electrodes into an envelope, heating said electrodes in vacuo to decompose said compound to the oxide and to render said aluminum effective as an absorption agent for oxygen, providing a gaseous atmosphere about said electrodes, and producing a steep wave front discharge between said electrodes of sufficient energy to reduce said oxide to the metal.

10 5. The method of producing a surface of low work function on an electrode having an alkaline oxide thereon which comprises bombarding said electrode with a gaseous discharge of steep wave front whereby particles of the alkaline metal

15 are produced in the presence of freshly evolved oxygen and form a mixture with said oxygen on the surface of said electrode.

6. An electrode having a coating of a homogeneous mixture of an alkaline metal and oxygen thereon, said oxygen forming a tenacious bond between said alkaline metal and said electrode.

7. An electrode having a coating comprising a homogeneous mixture of an alkaline earth metal and oxygen thereon, said oxygen serving to bond said metal to said electrode. 80

8. An electrode having a coating comprising a homogeneous mixture of barium, strontium and oxygen thereon, said oxygen serving to bond said barium and strontium to said electrode. 85

9. A nickel electrode having a coating comprising a homogeneous mixture of an alkaline earth metal and oxygen thereon, said oxygen serving to bond said metal to said electrode. 90

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