March 7, 1933. D. McF. MOORE 1,900,577

GASEOUS CONDUCTION LAMP

Filed July 12, 1928

Fig. 1.

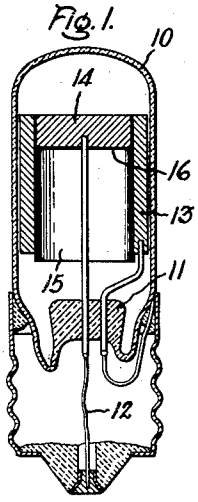


Fig. 2.

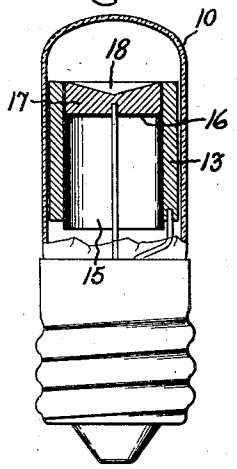


Fig. 3.

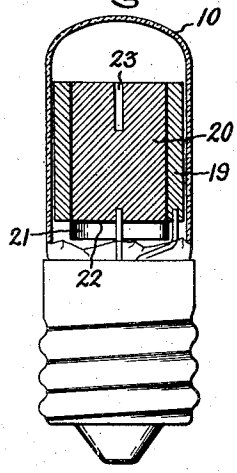


Fig. 4.

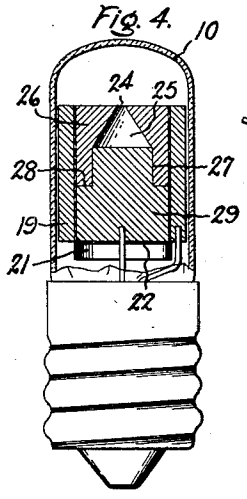


Fig. 5.

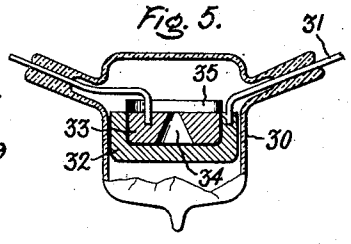


Fig. 6.

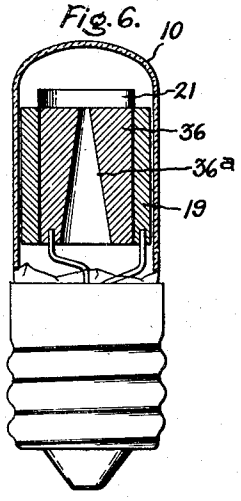


Fig. 7.

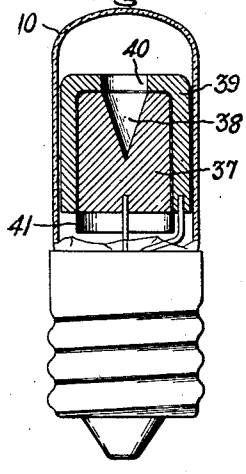
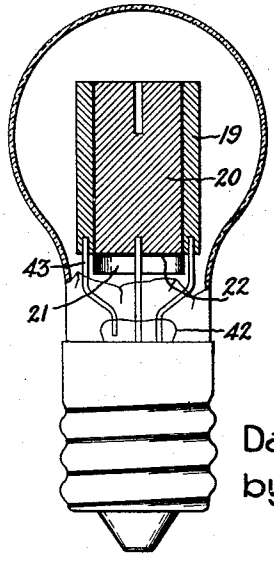


Fig. 8.



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by Charles W. Mullen
His Attorney.

Patented Mar. 7, 1933

1,900,577

UNITED STATES PATENT OFFICE

DANIEL McFARLAN MOORE, OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK

GASEOUS CONDUCTION LAMP

Application filed July 12, 1928. Serial No. 292,223.

My invention relates to gaseous conduction lamps, and more particularly to gaseous conduction lamps with a discharge, such as a negative glow discharge which is responsive without appreciable time lag to rapid voltage variations of the order of radio frequency. Such lamps are particularly useful as light sources for facsimile apparatus, by which facsimiles of pictures, documents, and similar objects may be obtained by wire or by radio; for the light source of the receiver or reproducer in television apparatus; for signalling; and for many other purposes in which a light source accurately responsive to high frequency voltage variations is of utility.

One object of my invention is to provide a lamp which emits light variable in amount substantially in accordance with variations in the amount of voltage impressed on it, even though such voltage variations are of a frequency as high as radio frequency, but which is so simple and rugged in construction as to be well adapted for commercial use. Another object is to construct such a lamp so that it will produce over a comparatively large area or surface a substantially uniform glow which will vary in intensity substantially in accordance with variations in the impressed voltage. A further object is to provide a lamp for producing a very brilliant spot of light which varies in brilliancy with variations in the impressed voltage. Still another object of my invention is to so improve such lamps that they will be commercially useful, and may be manufactured economically on a commercial scale.

To these ends and in accordance with my invention, I make the lamps with a sealed bulb containing a rarefied gas of good conductivity, such as neon, and provide a tubular or annular anode, and a cylindrical cathode mounted concentric with or in the bore of the anode, but spaced from it, and also insulated from it by a very thin insulating spacer or partition of some good insulating material, such as mica, which permits the cathode to be fitted into the anode so firmly as to be held in place. To maintain the electrodes at a low temperature during the operation of the lamp the anode is preferably of considerable mass with enough surface to provide sufficient radiation to maintain the electrodes at the desired temperature. Such a lamp with a comparatively massive anode into which the cathode is firmly fitted may be made mechanically rugged by fitting the annular anode into the lamp bulb with such clearance that objectionable movement of the electrodes transversely of the bulb is prevented.

Some types of television apparatus for producing at the receiver a moving picture of an object at the transmitter utilize a glow lamp having a flat cathode of considerable area over which there is a uniformly diffused cathode glow. In a lamp with a tubular anode having fitted into its bore a cathode with a substantially flat front or active surface flush with the end of the anode, I obtain by my invention a glow very uniformly distributed over the active surface of the cathode. To confine all the discharge or cathode glow to the active surface of the cathode I prefer to line the tubular anode throughout its bore with an insulating lining, such as mica, by which the cathode and the anode are spaced apart to leave a very narrow gap between them. In some cases the rear or inactive and non-luminous surface of the cathode may to advantage be covered with an insulating coating or layer. Although such a lamp will usually have all the flat active surface of the cathode covered very uniformly with the luminous cathode glow, I find that in some cases the distribution of the glow may to advantage be controlled by special shaping of the active surface of the cathode. For example I may provide in the front or exposed surface of the cathode a recess or cavity, in general of conical form like a funnel, so that the walls of the cavity are inclined somewhat to the longitudinal axis of the cathode. The density and brightness of the cathode glow at the bottom of the cavity depends upon the shape of the bottom and the angle between the walls of cavity. If the cavity is rather shallow and the angle of the walls at the tip or bottom is obtuse the glow will tend to be only slightly denser

at the bottom than on the walls, hence a tendency of the cathode glow to be somewhat more dense near the edges than at the middle of a large cathode may be corrected by using a cavity of such shape and such inclination of its walls that the glow over the entire surface of the cathode is substantially uniform.

In those forms of my invention which provide a concentrated light source well adapted for use as the variable light source in certain types of television and facsimile apparatus the cathode may to advantage be made hollow, or with a cavity in which the gas is more or less confined and held near the active surface of the cathode. Preferably the cavity in the cathode is of such cross section and depth that under normal operating conditions practically the entire discharge is concentrated in the cavity which forms a crater for the cathode glow discharge. This cavity or crater may be a deep funnel of rather small bore, with its depth greater than its maximum diameter so that its walls form an acute angle with each other, or it may be a cylindrical hole with parallel walls. If desired the bore of the hole may be expanded below its outlet or muzzle so that the crater has the general shape of a bottle or of an inverted cone, with the outlet or muzzle where the light escapes of less cross section than the remainder of the cavity. A very intense glow discharge may be produced in such an inverted cone cavity and as the light escapes only thru an outlet or muzzle of small diameter a very concentrated light source is obtained. The crater for the discharge may also be made as a tapered hole thru the cathode, which is so mounted that light from the glow discharge in the tapered hole is emitted only thru the small end of the hole. This tubular cathode with the tapered hole thru it may be used with either an annular anode, or a cup shaped anode in which the cathode is set with the large end of the hole toward the bottom of the cup, and insulated from the anode by a thin sheet of mica perforated in registry with the large end of the hole in the cathode to expose the anode to the interior of the tubular cathode. As a matter of convenience the cathode with the bottle shaped crater in the end may be made in two parts by fitting to the end of a solid rod a block perforated with a tapered hole, the large end of the hole fitting over that end of the rod which forms the bottom of the crater.

The anode and the cathode of a lamp embodying my invention may conveniently be connected at the rear to a stem such as is used in an incandescent lamp or radio tube, or may be entirely supported on the stem, if desired. A base on one end of the lamp provides for connecting the lamp in circuit, and leaves the end of the bulb over the active surface of the cathode entirely unobstructed. Such a based lamp is a very simple and rugged device well adapted for commercial use. My invention also comprises novel features and details of construction more fully described hereinafter and pointed out with particularity in the appended claims.

My invention will best be understood in connection with the accompanying drawing, in which merely for purposes of illustration I have shown in longitudinal section to illustrate the relation of the electrodes and their construction some of the various forms of lamps in which my invention may be embodies, and in which Figure 1 shows a glow lamp with a flat cathode having the luminous cathode glow uniformly distributed over its active surface; Figure 2 shows a modification in which the cathode has a recess or shallow cavity for modifying the distribution of the cathode glow; Figure 3 shows a lamp with a hollow cathode for producing a concentrated brilliant spot of light; Figure 4 shows a modified form with a two part hollow cathode in which the glow occurs in a cavity larger than the outlet or opening through which the light is emitted; Figure 5 shows a lamp having a cup shaped anode in which is set a perforated cathode; Figure 6 shows a lamp with an annular anode and a tubular cathode perforated by a tapered hole or crater; Figure 7 shows a lamp in which a cathode with a deep funnel shaped crater is covered by an anode having in it a window to permit the light from the crater to escape; and Figure 8 shows a lamp based at one end and in which the electrodes are entirely supported on the stem.

Lamps embodying my invention may be made in much the same way as incandescent lamps or radio tubes. The particular form of lamp shown in Figure 1 comprises a bulb 10, preferably of the cylindrical form often referred to as a tubular bulb, into which there is sealed at one end a stem 11 of the usual construction with two leads 12 which supply current to the electrodes and in some cases also support them. The bulb contains a rarefied gas of good conductivity such as neon, at a pressure such as 30 mm. of mercury, which will cause a good cathode glow at the normal operating potential of a few hundred volts. The neon may be purified before it is introduced into the tube, although for many purposes commercial neon, which contains about 20% of helium, may be used, and I find it advantageous to add a small amount of argon, such as one half of one per cent to the neon. For some purposes an atmosphere which contains a much higher percentage of argon, or which may be practically pure argon, may be used, but for most purposes the atmosphere which is predominantly neon is preferable. The cylindrical anode 13 is annular or tubular in form, and may fit with

rather slight clearance, such as one thirty second of an inch, into the cylindrical bulb 10, so as to limit movement of the electrodes transversely of the bulb, although considerable space may be left between the electrodes and the walls of the bulb if the electrodes are supported on the stem by leads 12 heavy enough to carry the electrodes, or by support wires embedded in the stem, such as are commonly used in radio tubes. The anode 13 is thick-walled and rather massive so as to remain cool during operation, and has a length considerably greater than the thickness of its walls. It consists preferably of aluminum or magnesium, although it may be made of iron, copper or nickel if treated to clean it and free it from gas. The cathode 14 is a thick disc concentric with the anode and its front or active surface on which the glow appears is preferably a flat polished surface substantially flush with the outer end of the anode. The cathode is to advantage fitted snugly into the bore of the anode, but is electrically separated from and also held in place within the anode 13 by a very thin insulating barrier or partition 15, which may to advantage consist of mica. I have found it advantageous to make this insulating barrier or partition about 1/100 of an inch thick when the lamp is intended to be operated on direct current at about 300 volts. I prefer, as shown in Figure 1, to extend the insulating partition 15 between the cathode and the anode, along the inner surface of the tubular anode so far that the bore of the anode is lined with insulation. It is also advantageous, in some cases, to cover the rear surface of the cathode with an insulating layer or coating 16, such as a sheet of mica, or a coating of varnish or similar insulating material. The insulation on the anode compels the cathode glow to appear upon the front or active surface of the cathode, and practically no leakage occurs from the anode to the cathode at other points.

As a concrete illustration of this particular embodiment of my invention a lamp may be constructed as shown in Figure 1 with a bulb about two inches in diameter and between three and four inches long, a tubular anode of aluminum about two inches outside diameter, about 1¾ inches inside diameter, and a length of about 2 inches, a circular cathode in the form of a disc of polished nickel, of aluminum or similar metal, of a thickness up to about one half inch, which fits into the bore of the anode, a mica insulating barrier about one one-hundredth of an inch thick between cathode and anode, and a rarefied atmosphere of neon, or similar good conductive gas, at a pressure of about 30 mm. of mercury. Both the cathode and anode should be cleaned before being put in the lamp. Under the conditions of gas pressure described 1/100 of an inch is well within the dimensions of the Crookes dark space, that is, the distance between the electrodes being less than the mean free path of the gas molecules, no appreciable ionization by collision and no glow can occur between the electrodes.

Such a lamp when operated on direct current or unindirectional current at a voltage of about 300 to 400 volts takes about twelve one-hundredths of an ampere, has a reasonable length of life, and produces a cathode glow which is substantially uniform all over the flat active surface of the cathode. For convenience the lamp is shown in Figure 1 with a large or mogul base, but it may be made with the smaller standard base such as commonly used in incandescent lamps of the sizes generally used.

As the conditions under which a luminous discharge substantially confined to the cathode glow are described in my prior Patents 1,316,967, patented September 23, 1919, and 1,816,690, patented July 28, 1931, and are well understood by those skilled in the art, the gaseous pressure will be referred to in the claims briefly as a cathode glow pressure.

For some purposes the cathode is to advantage made of magnesium, but there is at times a tendency for the cathode glow to be more dense at the edge than at the center of a magnesium cathode. To control the distribution of the glow on the cathode surface I change its contour somewhat from a plane, and in that particular type of lamp where an annular anode, surrounds a circular cathode, I may, as illustrated in Figure 2 depress the middle of the active surface of the cathode. For example, I may make in the active surface of the cathode 17 a shallow recess or depression 18, which is in general conical or funnel-shaped, the apex or bottom being either pointed or slightly rounded. If the sides of the cavity 18 are straight the angle between the sides of the cavity may be an obtuse angle as shown in Figure 2, to obtain a substantially uniform illumination over all of the active surface of the cathode. By varying the depth of the cavity, the angle between its sides, and the shape of its sides, the distribution of the glow over the cathode surface and the intensity of the glow at the bottom of the cavity may be varied. As shown in Fig. 7, the depth of the funnel-shaped recess 18 may be greater than its diameter.

Lamps constructed as above described have been successfully used in television receivers of the type in which the observer sees the active or illuminated surface of the cathode thru a rotating disc provided with holes arranged in a spiral line on a disc which rotates in synchronism with an identical disc at the transmitter, the brilliancy of the illuminated surface varying in response to electrical impulses transmitted by wire or radio from the transmitter,

For many purposes, and particularly for certain types of television receivers, and for receivers for apparatus for making photographic facsimiles in response to electrical impulses sent over a wire or by radio, it is desirable to use a very concentrated and brilliant light source which varies in brightness with variations in voltage. A lamp constructed in accordance with my invention to produce such a light source is illustrated in Figure 3, in which the bulb and stem are practically the same as in Figure 1, and in which the electrodes are concentric. The anode 19 is tubular, and like the anode 13 is preferably of sufficient mass to remain reasonably cool during operation. The cathode 20 is cylindrical, fits snugly into the bore of the anode, and is insulated from it by an insulating partition 21, preferably of mica, and preferably about one one-hundredth of an inch thick. The insulating partition preferably encircles the cathode, and its front end is flush with the front or active surfaces of the cathode and anode, while at the rear this insulating sleeve or cylinder of mica projects far enough, for example a quarter of an inch, to form an insulating sleeve or barrier to prevent the discharge occurring at undesired places, and to assist in preventing discharges between the leads 12. In some cases it may be desirable to cover the rear end of the cathode with a washer or sheet 22 of mica or similar insulating material.

To concentrate the cathode glow into a bright spot or concentrated source of light, I provide a hollow cathode by making for example in the end of the cathode 20 a cavity or crater 23 with an outlet or muzzle of the size and shape of the spot of light desired for a light source. Under normal operating conditions of the lamp practically all the glow discharge occurs in the crater, since by adjusting the gas pressure and the voltage applied to the lamp practically all the luminous cathode glow can be confined to the crater. As the radius of the crater does not exceed the depth of the cathode glow which occurs on the active cathode surface with a properly chosen pressure and voltage, the cathode glow or corona on the sides of the crater seems to fill the crater completely and an observer looking into the crater sees a solid and very bright spot of light.

One lamp constructed as shown in Figure 3, and with which I have obtained good results, has a bulb about one and one quarter inches in diameter and about three inches long, an annular anode 19 about one inch long with an outside diameter of about one inch, and a bore of about one quarter of an inch, an insulating barrier or lining 21 of mica about one one-hundredth of an inch thick, a solid cathode 20 filling the bore of the anode and having in its front end a crater or cylindrical hole 23 about one quarter of an inch deep and made with a drill having a diameter of about five hundredths of an inch, the rarefied atmosphere of neon or similar conductive gas, such as argon, being at a pressure of about 30 mm. When operated on direct current at a voltage in the neighborhood of 300 volts this lamp consumes about four one-hundredths of an ampere, and has a very bright cathode glow which is confined entirely to and fills the crater 23, thereby producing a bright spot of intense light about five hundredths of an inch in diameter. The diameter of the crater 23 may be varied within certain limits, but its radius should not exceed the depth of the cathode glow or corona which is produced on the cathode under normal operating voltage. The depth of the glow or corona depends very largely on the character of the gas and its pressure, and in a lamp constructed as in the example above given the diameter of the crater should not exceed about one eighth of an inch, nor should it be less than about two one-hundredths of an inch to obtain a spot of light which is solid and uniform and of commercially useful brightness. A comparison of the brightness of the spot of light in the crater 23 with the brightness of the negative or cathode glow on a flat cathode shows that at the same gas pressure and voltage the spot of light in the crater is from 150 to 200 times brighter than an equal area of the negative glow on a flat cathode. Such a comparison may be obtained by temporarily changing the connections to make the cathode 20 act as the anode, and the annular anode 19 act as the cathode, whereupon the front end of the annular anode becomes covered with the negative glow. When the anode is made thick-walled as described, the exposed surface of the anode is sufficiently large to prevent the formation of an anode glow thereon.

I may also shape the hollow cathode to provide a crater such that the glow discharge occurs in a space or cavity from which the light escapes through a restricted outlet or muzzle smaller than the cross section of the main part or body of the crater. One example of such a crater is shown in Figure 4, illustrating a lamp which is constructed, except for the cathode, like that shown in Figure 3. The hollow cathode of the lamp shown in Figure 4 has a crater with a restricted outlet or muzzle 24 of about the diameter of the crater 23 in Figure 3, but with a larger main or body portion 25 in which the cathode glow occurs, and in which the gas is held or confined substantially in contact with the active surface of the cathode. In the particular example shown the crater, which has the general form of a bottle, or of an inverted cone with flaring or diverging walls, is conveniently formed in a two part cathode by making through a block or cap 26 a tapering

hole which at the large end becomes a cylindrical socket 27 fitted over the shoulder 28 on the end of a rod 29, the cap and rod when assembled forming a hollow cathode which has in its exposed end the crater 25 of the general shape of an inverted cone or funnel, with a restricted outlet 24, and a bottom formed by the end of the shoulder 28 on the rod 29.

The lamp of Figure 4 with the inverted cone crater 25 can be operated to take more current and to produce a spot of light of greater brightness with a longer life than a similar lamp with the cylindrical crater 23. With the crater 25 there is less blackening than with a cylindrical crater under like conditions, apparently because the material sputtered from the active surface of the cathode, which in this case is the inner walls of the crater 25, is caught in the crater before it passes through the outlet 24. More current can be passed thru a cathode with the inverted cone crater 25 before the glow spreads out of the crater and over the front of the cathode than can be passed thru a similar cathode with a cylindrical crater, and consequently greater brightness of the discharge in the crater can be obtained. For instance, if a lamp constructed as described and shown in Figure 3 which consumes four one-hundredths of an ampere with a cylindrical crater 23 be provided with the cathode of Figure 4 with an inverted cone crater 25 having an outlet 24 of the same diameter as the crater 23, the current consumption can be increased to five one-hundredths of an ampere with a considerable increase in brightness.

Some advantages of the inverted cone crater may also be obtained in a hollow cathode having a tapering hole thru it. One embodiment of this modified form of crater is illustrated in Figure 5, showing a lamp with a bulb 30 having the leads 31 brought in through arms on the sides of the bulb. In this particular lamp the anode 32, preferably of aluminum or magnesium, is cup shaped. A disc cathode 33 fits into the cup anode and is perforated at the center by a tapered hole 34 which forms a crater of the inverted cone type, the small end of the hole constituting the outlet or muzzle of the crater. The electrodes are insulated from each other by a lining 35 of mica or similar material about one one-hundredth of an inch thick, which is perforated at the center in registry with the large end of the hole 34, preferably by a hole of about the same diameter as the large end of the hole 34, so that the sloping walls of the crater are exposed to the anode. As shown, the anode is connected to one lead 31 and the cathode to the other lead, so that current flows between the center of the anode and the walls of the crater to produce a cathode glow in the atmosphere in the crater. The outlet or small end of the hole 34 is about the diameter of the cylindrical crater 23 in Fig. 3, but the other end may be as much larger as desired. The cathode glow in the crater is intense, and light of great brightness is emitted thru the small end of the hole 34.

Figure 6 shows a modification of the tapering crater obtained in a cathode perforated with a tapering hole. In the particular lamp shown in Figure 6 the construction is in general similar to that shown in Figure 3, but the cathode 36 mounted in the bore of the anode is tubular and of about the same length as the anode, and is perforated with a tapering hole 36^a open at both ends. The glow discharge is confined to this tapering hole.

By means of the cathode perforated with a tapered hole a spot of light of great brightness and of very small diameter can be obtained, as the small end of the tapered hole can be made very small without interfering with the flow of current into the cathode thru the large end if the hole.

In Figure 7 is shown a modified form of lamp in which the cathode 37 is a cylindrical block of metal which has in its front end a crater 38 in the form of a deep funnel of comparatively small bore. This funnel, for example, may be about one tenth of an inch in diameter at the large end, taper to a point at bottom, and have a depth considerably in excess of the diameter at the large end. It may also be made in the form of a deep hole or cavity about two one-hundredths of an inch in diameter, flared out at the upper end into a funnel or cone about one tenth of an inch in diameter at the large end, so that it becomes substantially the funnel cavity of Figure 7 with a cylindrical hole like 23 at the bottom. With such a cavity a small current will produce a glow in the cylindrical bottom of the funnel, and as the current increases the glow rises higher in the funnel. This cathode may be used with any form of anode, and may be substituted for the cathode 20 in the lamp of Figure 3, but usually I prefer to place it concentric with and inside of a cup-shaped anode 39 which fits over the cathode and has in its bottom an outlet or window 40 in registry with the crater 38. The anode and cathode are insulated from each other by a lining 41 of thin mica which covers the sides and front end of the cathode, except where perforated in registry with the crater 38 and the window 40 to permit free flow of current at that point.

In my copending application Serial No. 440,178 filed March 31, 1930 claims are made on the construction shown in Fig. 7.

Figure 8 shows a lamp constructed in accordance with my invention with the anode 19 and cathode 20 mounted on the stem 42 by the leads 12 and a support 43 to form a self

contained mount which can be sealed into the bulb on a sealing in machine such as used in the manufacture of incandescent lamps and radio tubes, whereby the manufacture of the lamp is facilitated and cheapened. In this form of my invention bulbs such as are commonly used for radio tubes and incandescent lamps may be used, since the mount need not be steadied or supported by the bulb.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. A gaseous conduction lamp comprising a sealed vessel containing a gas at cathode glow pressure, a hollow cathode the interior walls of which are inclined to the longitudinal axis thereof and having an opening through which the active surface of the cathode is exposed, an anode encircling said cathode but out of registry with said opening, and a layer of insulation between said cathode and said anode of about 1/100ths of an inch in thickness, said electrodes and insulation being fitted to support one another as a compact structure.

2. A gaseous conduction lamp comprising a sealed vessel containing an elongated tubular anode lined with a thin insulating lining, a cathode fitted firmly into said lined anode to expose one end and having in said exposed end a cavity with a metal bottom and metal walls inclined to the longitudinal axis of said cathode and a gas at cathode glow pressure.

3. A gaseous conduction lamp comprising a sealed vessel containing a thick walled elongated tubular anode lined with a thin insulating lining, a cathode fitted firmly into said lined anode to expose one end and having in said exposed end a cavity having the shape of a cone truncated near the apex by the surface of said exposed end to form in said surface a restricted opening of a diameter which is only a fraction of the altitude and base of said conical cavity, and a gas at cathode glow pressure in said vessel.

4. A gaseous conduction lamp comprising a sealed vessel containing a thick-walled elongated tubular anode lined with a thin insulating lining, a two part cathode fitted firmly into said lined anode and comprising a metal block perforated by a tapered hole and a metal bottom fitted into the large end of the hole in said block, the end of said block which is pierced by the small end of the hole being exposed and substantially flush with the end of said anode, and a gas at cathode glow pressure in said vessel.

5. A gaseous conduction lamp comprising a sealed vessel containing a thick-walled elongated tubular anode lined with a thin insulating lining, a hollow cathode fitted firmly into said anode to expose one end and comprising a rod having on one end a shoulder, and a block perforated by a tapered hole which fits at the large end over said shoulder, and a gas at cathode glow pressure in said vessel.

6. A gaseous conduction lamp comprising a sealed vessel containing a thick-walled elongated tubular anode lined with a thin insulating lining, and a cathode perforated by a tapered hole and fitted firmly into said lined anode to expose the end pierced by the small end of said tapered hole, and a gas at cathode glow pressure in said vessel.

7. A gaseous conduction lamp comprising a sealed vessel containing a hollow cathode with a cavity and an opening to said cavity of a diameter less than the diameter of said cavity, an anode mounted out of registry with said opening and spaced with relation to said cathode to cause only the walls of said cavity to be the active surface of said cathode, and a gas at the cathode glow pressure in said vessel.

8. A gaseous conduction lamp comprising a sealed vessel containing a cathode with a cavity and an opening to said cavity of a diameter less than the diameter of said cavity, an anode mounted out of registry with said opening and spaced with relation to said cathode to cause the glow discharge to be restricted to said opening and said cavity, and a gas at cathode glow pressure in said vessel.

9. A gaseous conduction lamp comprising a sealed vessel, electrodes therein including a cathode mounted in said vessel with one end exposed and having in the exposed end a conical depression with metal walls and bottom and of a depth greater than its diameter, but materially less than the length of said cathode, and a tubular anode with a length greater than the thickness of its walls and mounted concentric with said cathode with one end adjoining the exposed end of said cathode, a layer of solid insulation of about 1/100ths of an inch in thickness separating and gripping said electrodes to form a unitary structure, and a gas at cathode glow pressure in said vessel.

10. A gaseous conduction lamp comprising a sealed vessel containing a rarefied atmosphere of good conductivity at a pressure of about 30 millimeters of mercury, electrodes therein including an elongated cathode secured at one end to the wall of the vessel and having in its free end a funnel-shaped recess extending longitudinally of said electrode with a depth greater than its diameter, and an annular thick-walled anode mounted concentric with said cathode and a layer of interposed insulation of about 1/100ths of an inch in thickness constituting with said electrodes a unitary structure.

11. A gaseous conduction lamp comprising a sealed vessel containing a rarefied atmosphere of good conductivity, a cylindrical cathode of solid, conducting material having a recess which forms a deep cup with inclined

interior walls, the volume of which is materially less than the volume of said cathode, a thick-walled elongated annular anode lined with a layer of insulation of about 1/100ths of an inch in thickness and firmly fitted on said cathode.

12. A gaseous conduction lamp comprising a sealed substantially cylindrical bulb, an interior stem joined to said bulb at one end of said bulb, electrodes mounted upon said stem comprising a tubular anode of substantially the diameter of said bulb, and approximately of the order of length of said bulb, a thin insulating lining therefor, a cathode fitting closely within said lining and a gaseous filling of such pressure that an electric glow discharge may be produced therein by passage of current between said electrodes.

13. A gaseous conduction lamp comprising a sealed envelope, electrodes therein including a cathode therein provided with a tapered cavity, and an anode spaced about 1/100ths of an inch from said cathode, a layer of mica fitted into the space between said electrodes and a rare gas at a pressure of about 30 millimeters of mercury in said envelope.

14. A gaseous conduction lamp comprising a sealed vessel containing a gas at cathode glow pressure, a thick-walled cup-shaped anode, a thin insulating lining mounted on the inner walls of said cup and having an opening which exposes the center of the bottom of the anode, a disc cathode fitted into said cup anode with its front surface substantially flush with the edge of said cup anode, said cathode being perforated by a tapered hole which pierces at its small end the front of said cathode and at its large end is exposed to the bottom of the cup anode through the opening in said lining.

15. A gaseous conduction device comprising a sealed vessel, a cathode mounted in said vessel with one end exposed and provided in the exposed end with a conical cavity having metal walls and of a depth greater than its diameter, and an anode embracing said cathode while being insulated therefrom, with one end adjoining, but out of registry with the depression in said cathode, and a gas at cathode glow pressure in said vessel.

In witness whereof, I have hereunto set my hand this 9th day of July 1928.

DANIEL McFARLAN MOORE.