March 14, 1939. O. C. BLEICHER 2,150,356

GLOW DISCHARGE LAMP

Filed July 21, 1936

FIG. 1

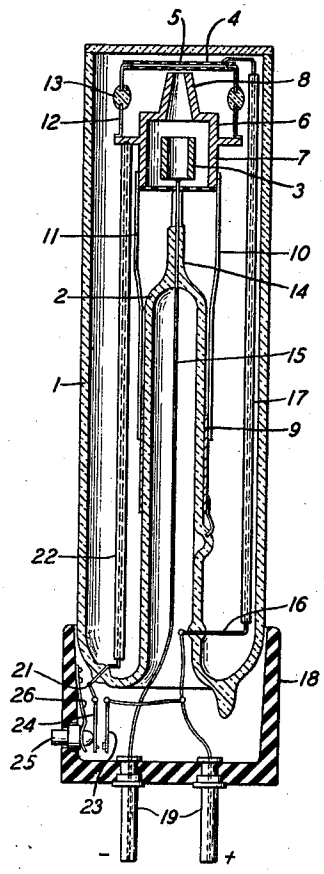
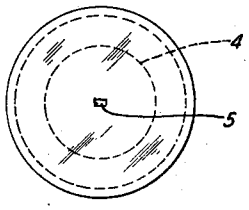


FIG. 2



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GLOW DISCHARGE LAMP

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7 Claims. (Cl. 176—122)

This invention relates to glow discharge devices and more particularly to positive column lamps.

United States Patent 1,912,146, issued May 30, 1933, to J. B. Johnson discloses a positive column glow lamp comprising an enclosing vessel charged with a mixture of a monatomic and a diatomic gas and including a cylindrical cathode, a glass support which surrounds the cathode, engages its outer surface and extends beyond it, the extension being provided with a capillary opening, and an apertured anode. The cathode, capillary opening and aperture in the anode are axially aligned, and the discharge, which occurs between the inner surface of the cathode and the walls of the anode aperture, passes through and is concentrated in the capillary opening to provide an intense spot of light which may be usefully employed in signaling systems, for example, in sound recording, picture transmission and television systems.

An object of this invention is to provide a lamp of the type described above having improved operating characteristics.

Another object is to provide a glow discharge lamp in which the breakdown and extinction voltages are substantially alike.

A feature of the invention relates to the use of a metallic member having a tapered capillary opening through which the discharge passes.

Another feature relates to the use of the metallic member, as an auxiliary anode to effect breakdown of the discharge path.

In accordance with one embodiment of the invention, the discharge device comprises a transparent vessel which encloses a cylindrical cathode, extending axially of the vessel, and an apertured anode, a metallic member intermediate the cathode and anode, and contains a gaseous atmosphere, such as a monatomic gas. The metallic member comprises a cylindrical portion surrounding the cathode, and a portion which tapers in a direction toward the anode and is provided with a tapered capillary opening. The cylindrical cathode, capillary opening and anode aperture are axially aligned, and the positive column discharge between the electrodes passes through and is concentric in the capillary opening to produce a spot of light of great brilliancy, the intensity of which readily and faithfully follows variations in the potential applied between the electrodes.

Under normal operating conditions, the metallic member is insulated from the electrodes, but for starting purposes, i. e., to effect initial ionization of the gas charge, this member may be temporarily connected to the anode to provide, in effect, an auxiliary anode adapted to cooperate with the cathode to constitute a path over which an initial discharge readily takes place. Once this auxiliary discharge is started, the main discharge path is readily bridged by the normal operating voltage impressed between the main electrodes.

A description of the invention follows and is illustrated in the attached drawing, in which

Fig. 1 is a sectional view taken axially of a lamp embodying the invention; and

Fig. 2 is a plane view of the lamp shown in Fig. 1.

One disadvantage of glow lamps of the type to be hereinafter described, which have been disclosed in the prior art, is that they operate to produce oscillations in the discharge path, when the electrodes are supplied with varying potentials. The oscillations are of a frequency which is independent of the rate of variation of the applied potential, and appear to be caused by an after-ionization or after-glow, resulting from the fact that the walls of the capillary opening becomes negatively charged and acts as a third electrode to cause ionization after each cycle of change in the applied potentials. While the amplitude of the oscillations could be decreased by varying the pressure of the gas charge and could be completely eliminated by this expedient when varying direct current potentials were supplied to its electrodes, it was found impossible to eliminate them when the lamp was supplied with potential variations having different frequencies.

Again, when alternating current potentials were applied to the electrodes of a lamp of the earlier type and the frequency of the potential was increased, a loop appeared in its voltage-current characteristic curve.

Electro-optical systems, such as for example, picture, television and sound recording and reproducing systems involve the use of signal potentials which include variations extending over a wide frequency band. In certain cases this band may extend from substantially zero frequency to an upper limiting frequency of several thousand cycles or even a million or more cycles for high quality television operation, and it has been proposed to apply such signal potentials to a glow discharge lamp to control the production of a record or an image of a remote field. It has also been proposed to apply a potential varying at a carrier frequency rate to lamps of this type for the purpose of producing

carrier modulated light which is used to illuminate or scan a picture, a photographic record or an image field. For distortionless operation it is essential that the intensity of the light supplied by the lamp faithfully follow the amplitude variations of the applied signals or carrier variations.

The amount of distortion resulting from the operation of lamps of the type disclosed in the prior art including that in the above-mentioned patent to Johnson is well within permissible limits under certain given operating conditions and hence they may be satisfactorily used for many purposes. However, the present invention provides a construction which possesses many advantages over those earlier disclosures, chief of which is, that it can be supplied with energizing potentials of varying frequencies without causing the production of oscillations or a loop in its voltage-current characteristic curve, due to frequency changes.

Referring to the drawing, there is shown a lamp comprising a bulb 1, having a reentrant stem 2 and enclosing a cylindrical cathode 3, a disc-shaped anode 4, provided with an aperture 5, and a member 6 having a cylindrical portion 7, concentric with the cathode, and a cone-shaped extension 8, having a capillary opening 8'.

The bulb contains a charge consisting of monatomic gas or a mixture of monatomic gases. If desirable, the charge may include, in addition to the monatomic gas or gases, a small quantity of diatomic gas, the amount being of the order given in and for the purpose disclosed in United States Patent 1,871,266, issued August 9, 1932, to F. Gray.

Encircling the stem 2 is a band 9 provided with rods 10 and 11 for supporting the member 6 and the anode 4. These elements are mounted with the opening in the cathode, capillary opening in the extension 8 and the aperture 5 in the anode axially aligned, and the anode is supported from the member 6 by short rods 12 each including an insulating bead 13, whereby the member 6 is insulated from the anode 4.

The reentrant stem terminates in a press 14 through which a leading-in wire 15 passes to the cathode 3. A leading-in wire 16 passes through the wall of the stem 2 and extends to the anode 4. This leading-in wire is surrounded by an insulating sleeve 17, to prevent discharges between it and the cathode.

The lamp is provided with a base 18, having a pair of contacts 19, respectively connected to the leading wires 15 and 16, and a switch. The electrodes of the lamp are adapted to be connected to an energizing source via the contacts 19, and the switch is provided to permit a conductor 21, extending to the member 6, to be connected to the lead-in wire 16, whereby the anode potential may be simultaneously applied to this member and the anode. The lead-in wire 21 is also surrounded by an insulating sleeve 22, to prevent the occurrence of discharges between it and the cathode 3. Under conditions to be hereinafter described, member 6 may be used as an auxiliary anode which cooperates with the cathode to constitute a relatively short path over which a discharge may be initiated for starting the lamp.

The switch comprises a pair of contacts 23 and 24, respectively connected to the lead-in wire 16 and the conductor 21, and contact 24 is adapted to be moved into engagement with contact 23 by a push-button 25, which extends through the side wall of the base and is held in the position shown by a spring 26, whereby the switch contacts are normally disengaged, the conductor wire 21 is disconnected from the supply source and, as a result, the member 6 is not supplied with energizing potential.

When it is desired to initiate a discharge within the lamp, push-button 25 is actuated to connect the conductor 21 to the lead-in wire 16 and thereby cause normal operating potential to be applied between the cathode 3 and member 6. A discharge having been initiated between this member and the cathode it will be readily transferred to the anode 4. When this occurs, the push-button is released, the member 6 is disconnected from the energizing source and, normal operating potential being applied between the cathode 3 and anode 4, the positive column discharge occurs between these electrodes. This discharge passes through the capillary opening in the metallic member 6 and is concentrated to produce a small spot of light of extremely high brilliance as viewed through the aperture 5. This light spot can be directly used to scan a picture, sound track, recording surface or film or may be used with an optical system for illuminating or scanning an object or field of view.

The cylindrical portion of the member 6 has a diameter many times that of the larger end of the capillary opening, and its length should preferably be approximately one and a half times the length of the conical section including the capillary. The member, therefore, constitutes an element having a large superficial area compared with that of the capillary opening, and since it is made of metal, the charge imparted to the walls of the capillary by the passage of the luminous discharge will continuously leak along the surface of the member and thereby cause the latter to become substantially uniformly charged at a potential which does not materially differ from that of the cathode. Consequently, under normal operating conditions, this member will not act as an auxiliary electrode to produce after-ionization or afterglow and hence will not cause oscillations to be set up in the discharge path.

For satisfactory use in electro-optical systems, the electrical requirements of a discharge lamp are that the exposure versus current relation should preferably be linear, the light of the discharge glow should be concentrated so as to obtain maximum brightness, the variation of light intensity between maximum and minimum brightness should be great enough to give sufficient contrast, the breakdown voltage and extinction voltage should be low and the difference between these two voltages should be as small as possible, the frequency characteristic should be good, the lamp should have a long useful life, and it should be reproducible. While these desirable characteristics are partially contradictory, a satisfactory compromise between the conflicting requirements was attained by providing a lamp including an assembly comprising a disc-shaped anode having a rectangular aperture, a glow discharge concentrating member having a cone-shaped portion, provided with a tapered capillary opening, integral with a cylindrical portion which completely surrounds a tubular cathode. In a typical design of lamp, which has been successfully operated, the anode, concentrating member, and cathode, were of nickel, and the aperture in the anode, the capillary opening and the cathode were axially aligned, and the enclosing bulb contained a charge of pure helium or pure neon. One surface of the anode was separated from the apex of the cone-shaped portion of the concentrating member by a thin

insulating disc, provided with an aperture which was slightly larger than that in the anode and somewhat smaller than the diameter of that in the apex of the cone-shaped element.

The cathode was a thin walled tube and had an internal diameter of approximately eight millimeters. The internal diameter of the cylindrical portion of the concentrating member was substantially twice that of the cathode, and it terminated in a plane more remote from the base of the cone-shaped portion than that occupied by the corresponding terminal of the tubular cathode. Thus the cylindrical portion of the concentrating member is spaced apart from and is concentric with the cathode, and its length is such as to preclude the possibility of a discharge occurring between the cathode and the anode over a path extending along the outer surface of the concentrating member and around its base. In other words, it insures that the discharge between the electrodes will pass through the capillary opening, which tapers from a diameter of five millimeters at the base of the cone, i. e., adjacent the near end of the cathode, to a diameter of 1.5 millimeters at its apex, or adjacent the anode.

The use of the metallic member having a capillary opening, in place of a concentrating element of insulating material provided with a capillary opening, resulted in the provision of a positive column lamp which can be supplied with energizing potentials extending over a wide frequency range without causing free oscillations to be produced in the discharge path, i. e., the presence of the metal capillary member results in stabilizing the frequency characteristic of the lamp. Again its use resulted in a better compromise as to brightness, current range, operating voltage and extinction and breakdown voltages. An important advantage of the use of a tapered capillary resides in the fact that the voltage required to initiate a discharge within the lamp is far below that required to effect this result in lamps, identical as to design and operating conditions, but which are provided with a straight-walled capillary of the same diameter, i. e., the breakdown voltage of the lamp is materially reduced.

While the brightness of the illumination, supplied by lamps of the type described herein, for a given value of current in the discharge path between the electrodes, can be varied by changing the pressure of the rare gas, this change affects the extinction current, as well as the breakdown, operating and extinction voltages. It was found by experiment that the best compromise with a lamp of given design is obtained by using a charge of helium at approximately seven millimeters of mercury in a lamp for recording purposes, and a charge of neon at approximately nine millimeters of mercury in a lamp which is used to illuminate a record or picture.

The operating characteristics of positive column glow discharge lamps of the type described above was investigated by applying to its electrodes a direct current potential of sufficient value to maintain a discharge within the lamp and by varying the current in steps between one mil and sixty mils. The intensity of the light supplied by the lamp was found to vary substantially linearly from a minimum value to a value approximately 170 times that of the minimum value. These comparative values were obtained by measuring the direct current output of a potassium-hydride photoelectric cell, the response curve of which is similar to that of process film when it is illuminated from a tungsten lamp, activated by the light radiated from the glow discharge produced in helium. The results serve to illustrate the fact that for current variations of the order commonly used in picture and sound recording systems, the light intensity may be controlled to provide wide variations in contrast.

Again, lamps of the type described above were supplied with energy from a direct current source and their voltage-current characteristics were measured. Certain of the lamps contained a gas charge of pure helium, while the gas charge in others was pure neon. In general they were so designed that a glow discharge was initiated by applying a direct current potential of approximately 350 volts across the cathode and anode. When the push button switch was operated to connect the concentrating member to the anode, a discharge was initiated by the application of a potential of about 200 volts. As the voltage was increased the current flow in the discharge column increased substantially linearly and the glow discharge, in the helium lamps being tested, was interrupted when the applied voltage was reduced to approximately 225 volts and, in the neon lamps under test, the glow discharge was interrupted when the applied voltage was reduced to about 230 volts. In other words, the breakdown voltage was reduced from 350 volts to approximately 200 volts, and the extinction voltage of the respective lamps was 225 and 230 volts. When a current of constant amplitude but which varied in frequency from approximately zero frequency to a frequency of several thousand cycles was supplied to the lamp, the intensity of the light supplied by the glowing column was found to be independent of frequency, and an oscillograph study of the operation of the lamp failed to indicate the presence of oscillations in the discharge path.

Life tests were made with a series of lamps supplied with current of 20 mils and light current and voltage-current measurements were made at stated intervals. These tests were made under identical operating conditions and indicate that the variation of light with increase in life is small, and at the end of 1500 hours, the lamps were still operating satisfactorily.

An additional advantage of the type of construction described above resides in the fact that the electrodes and concentrating member, being of metal, may be accurately machined. Precision in the manufacture of these parts assures the production of lamps having substantially identical operating characteristics, optical properties and useful life. Consequently, lamps of the type herein disclosed, and having these desirable characteristics, are readily reproducible.

While certain specific details and dimensions have been set forth above, it is to be understood that the important features of the present invention are the use of a metallic member for concentrating the positive column glow discharge and that a tapering passage terminating in a capillary opening be used to effect the concentration. As to the details and dimensions of the parts, as well as the gas pressure to be used, this will depend largely upon the operating conditions in any given case and the result to be accomplished.

What is claimed is:

1. A positive column glow discharge lamp comprising cold electrodes, and, intermediate said electrodes, a metallic member having a tapered passage terminating in a capillary opening.

2. A positive column glow discharge lamp com-

prising a cold cathode, a cold anode, and, intermediate said cathode and anode, a metallic member comprising a section surrounding but spaced from the cathode and having a conical extension provided with a tapered opening between said section and said anode.

3. A positive column glow discharge lamp comprising a vessel containing gas and enclosing electrodes in the form of a cold anode and a cold cathode, and a hollow metallic member in part surrounding said cathode, the interior wall of said part being cylindrical and symmetrically spaced from the exterior surface of said cathode with respect to the axis of said cylindrical wall, said member being effectively extended into the space between said cathode and anode and having its interior wall in this portion shaped to form a conical channel coaxial with said cylindrical wall with its larger end toward said cathode and its smaller end terminating in a capillary opening.

4. A positive column glow discharge lamp comprising a vessel containing gas and enclosing electrodes in the form of a cold anode and a cold cathode, a hollow metallic member in part surrounding said cathode, the interior wall of said part being cylindrical and symmetrically spaced from the exterior surface of said cathode with respect to the axis of said cylindrical wall, said member being effectively extended into the space between said cathode and anode and having its interior wall in this portion shaped to form a conical channel coaxial with said cylindrical wall with its larger end toward said cathode and its smaller end terminating in a capillary opening, and means for starting a glow discharge between said cold electrodes when the latter are at operating potentials the difference of which is below the striking voltage comprising means for temporarily bringing said member to a potential not substantially greater than that of said anode.

5. A positive column glow discharge lamp comprising a vessel containing gas and enclosing electrodes in the form of a cold cylindrical cathode and a cold plate-like anode, the latter having a small opening therein in line with the axis of said cathode, and a hollow metallic member in part surrounding said cathode, the interior wall of said part being cylindrical and spaced a unifom distance from the cylindrical exterior surface of said cathode, said hollow metallic member being effectively extended into the space between said cathode and anode and having its interior wall in this portion shaped to form a conical channel concentric with said cathode and aperture with its small end near and aligned with said aperture in said anode and terminating in an opening of a diameter at least as great as the maximum dimension of said aperture.

6. A positive column glow discharge lamp comprising a vessel containing gas and enclosing electrodes in the form of a cold cathode and a cold anode and a metallic element forming a conical shaped channel between said electrodes with its larger end toward said cathode, said cathode having an opening symmetrically positioned with respect to said channel, the walls of said cathode surrounding said opening and nearest said channel being circular in shape in a plane perpendicular to the axis of said channel, the diameter of said opening in said plane being not greatly different than the diameter of the large end of the channel.

7. The combination as set forth in claim 6 in which said cathode is in the form of a hollow cylinder open at both ends and having its axis coincide with that of said channel.

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