July 29, 1958 J. W. WEST ET AL 2,845,568

GASEOUS DISCHARGE DEVICE

Filed Sept. 13, 1956

FIG. 1

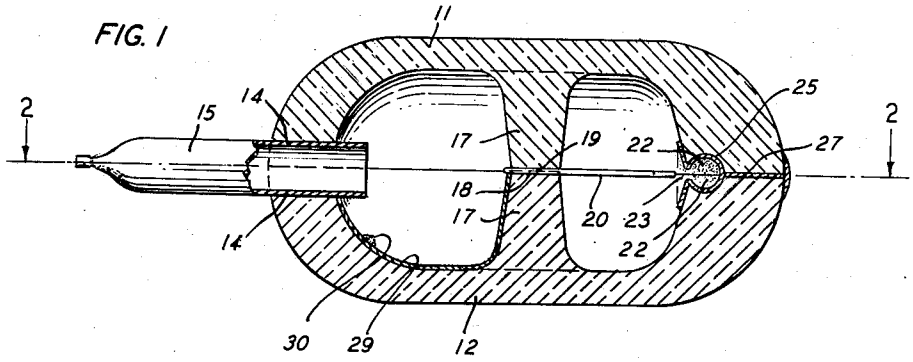
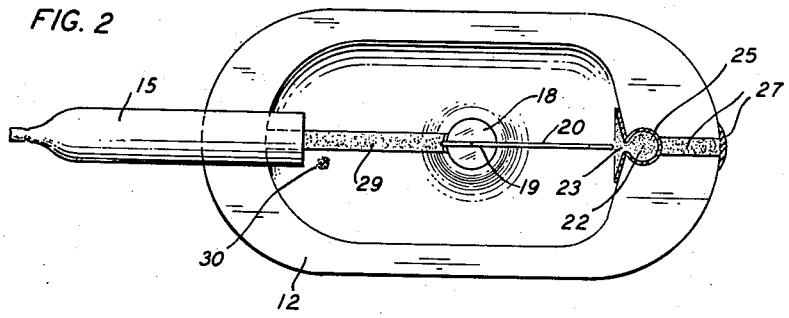


FIG. 2



4 FIG. 3

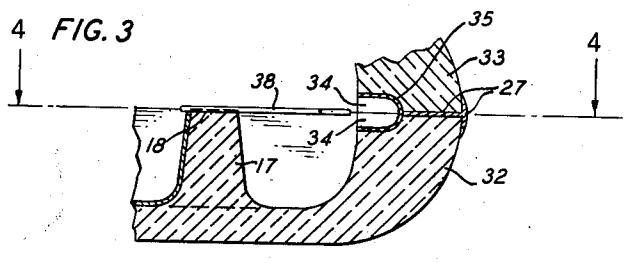
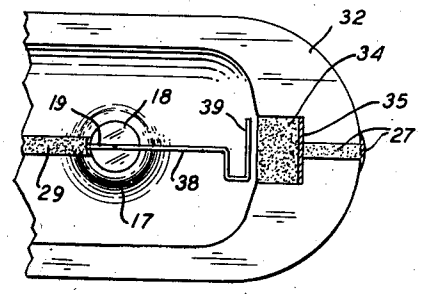


FIG. 4



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GASEOUS DISCHARGE DEVICE

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Application September 13, 1956, Serial No. 609,672

14 Claims. (Cl. 313—216)

This invention relates to gaseous discharge devices and more particularly to such devices of the talking-path type.

Gas tubes have switching properties which render them particularly useful as switching devices. Particularly of value for this purpose is their breakdown characteristic whereby a gas tube may be switched from a nonconducting state at a given applied voltage to a conducting state at that same applied voltage by application thereto of a control or breakdown potential or voltage pulse. Further, by proper choice of cathode dimensions, anode positioning, and gas pressure the gas tube may present a negative resistance to the talking path currents over a suitable range of operating currents in the abnormal glow discharge region of the current-voltage characteristic. Such negative resistance talking path gas tubes are described in Patent 2,804,565, issued August 27, 1957 of M. A. Townsend, and in application Serial No. 583,671, filed May 9, 1956, of A. D. White, the cathodes of the latter application being known as cavity cathodes.

When gas tubes of this type are utilized in large 10,000-line telephone central offices and in particular in the switching networks for such central offices, a very large number of such tubes may be required, the number being in the order of tens and hundreds of thousands. Accordingly, it is exceedingly important both that the size of these tubes be reduced to a minimum, for space considerations, and also that the cost of these tubes be exceedingly low.

However, the desirable ends stated above cannot be obtained at a sacrifice in accuracy of the critical dimensions involved in the attainment of the negative resistance characteristic. Accordingly, miniaturizing of the tubes cannot be at the expense of the necessary tolerances, nor can economies in initial cost of fabrication be obtained by relaxation of the desired transmission characteristics of the tubes.

It is an object of this invention to provide improved talking-path gas tubes.

It is another object of this invention to reduce the size and decrease the cost of such gas tubes.

It is a further object of this invention to facilitate the attainment of the necessary critical dimensions in talking-path gas tubes in an efficient and economical manner.

These and other objects of this invention are attained in specific illustrative embodiments wherein the tube comprises a ceramic envelope formed of two half sections, which are advantageously identical. At one end of each section there is formed in the mating surface thereof a groove, depression, or hemispherical cavity accurately conforming to the demanding dimensions of the desired cathode. This cathode form is then metallized, as by painting, plating, or in other ways known in the art, to define the cathode itself. Accordingly, in accordance with one aspect of this invention, the cathode is defined within the ceramic wall of the envelope at the mating surfaces of the two half sections of the envelope and communicating with the interior of the envelope.

The desired accurate dimensions can readily be formed directly into the ceramic at the time of its fabrication.

To reduce both the cost and the size of the gas tube no independent electrode support members are utilized other than portions of the ceramic envelope itself. As just described, the cathode is formed directly within the ceramic wall at the mating surfaces of the two envelope sections. The wire anode is positioned directly adjacent the cathode, as taught by the above-identified applications, to attain the desired negative resistance characteristic. In accordance with another aspect of this invention, the anode wire is supported in a groove in the upper surface of an integral embossment or pillar extending inwardly from the base of at least one of the two ceramic envelope sections. In this manner no independent electrode support is required for the anode, and its distance from the cathode and position within the tube can be very accurately maintained.

Further in accordance with an aspect of this invention, the need for distinct lead-in wires or lead-in wire connections within the tube is obviated by having the lead-in conductors defined by metallic coatings on the surfaces of the ceramic envelope portions. Advantageously the cathode conductor extends along each of the mating surfaces of the envelope sections from the cathode itself formed in the envelope to the exterior surface of the envelope. Similarly, the anode conductor is a metallized layer or conductor extending down the side of the integral pillar by which the anode wire is supported and to an exhaust tubulation sealed in the envelope at the end of the tube opposite to the cathode.

It is a feature of this invention that the cathode of a gaseous discharge device be defined, dimensionally, by mating grooves, depressions, or hemispherical cavities in the mating surfaces of two ceramic envelope sections of the tube, a metallic layer then being placed in these grooves, depressions, or cavities. Further in accordance with this feature of the invention the metallic layer is advantageously painted or otherwise deposited directly onto the ceramic surfaces. Thus, in accordance with our invention, the cathode is formed not just on but actually within the ceramic wall of the envelope of the tube.

It is a further feature of this invention that the anode of a gaseous discharge device be a wire supported in a groove in the upper surface of an integral pillar extending inwardly from the base of a ceramic envelope section.

It is a further feature of this invention that the cathode and anode thus defined and supported be utilized in a minute ceramic talking-path discharge tube and wherein no separate and distinct conductors, supports, or connections need be incorporated into the tube, the lead-in paths for the cathode and anode comprising metallized conductors deposited or painted onto the surfaces of the ceramic wall sections.

A complete understanding of this invention and of these and other features thereof may be gained from consideration of the following detailed description and the accompanying drawing, in which:

Fig. 1 is a side view, partially in section, of one illustrative embodiment of this invention;

Fig. 2 is a plan view of the embodiment of Fig. 1 taken along the line 2—2 thereof;

Fig. 3 is a partial side sectional view of another illustrative embodiment of this invention utilizing a different cathode configuration; and

Fig. 4 is a plan view of the embodiment of Fig. 3 taken along the line 4—4 thereof.

Turning now to the drawing, the specific illustrative embodiment of our invention therein depicted comprises a ceramic envelope, as of aluminum oxide, formed in two

identical sections 11 and 12. Each section is hollow and includes three specific portions. The first of these is a groove 14 at one end in which an exhaust tubulation 15 is sealed, the tubulation 15 also serving as the anode lead-in connection, as discussed further below.The second of these is a pillar or embossment 17 integrally formed with the remainder of the section 11 or 12, positioned centrally in the base of the hollow section, and extending inwardly therefrom. At the upper surface 18 of this embossment is a groove 19 in which is sealed the anode wire or rod 20. The anode rod 20 is thus firmly secured between the two embossments and sealed thereto. The third of the specific portions of the hollow envelope sections 11 and 12 is a hemispherical depression or cavity 22 in the upper or mating surfaces of the sections 11 and 12 at the opposite end of the sections from the exhaust tubulation 15.

The hemispherical cavities 22 are formed so as to define a communicating orifice between the interior of the cavity and the interior of the hollow envelope. Further, and in accordance with an aspect of this invention, the inner surfaces of the cavities 22, the orifice 23, and the immediately adjacent portions of the inner surfaces of the sections 11 and 12 are metallized so that the cavities 22 define a cavity cathode as further described in application Serial No. 583,671, filed May 9, 1956, of A. D. White. The metal coating or layer 25, which is shown of exaggerated thickness in the drawing for purposes of clarity, may be applied in any of a number of ways known in the art. Thus, for example, zirconium hydride may be applied, as by a painting or spraying technique, to the ceramic surfaces and fired, or molybdenum or columbium may be coated onto the cathode by similar techniques.

Lead connections may similarly be made from the two electrodes of the device by metallizing techniques. Thus, the cathode lead connection may comprise a metallic strip 27 applied to the mating surfaces of the sections 11 and 12 between the cavity cathode and the exterior of the tube envelope, the strips 27 extending also partially along the outer surface of the envelope for connection thereto by a suitable external spring contactor or socket. The anode lead connection may also comprise a metallized strip 29 extending down the side of at least one of the embossments 17 and along the base of the hollow envelope section to the exhaust tubulation 15.

A spot 30 of radium, as in the form of radium bromide, may be applied to the inner wall of the tube envelope to provide the initial ionization desired in such devices, as is well known, or other ionizing techniques known in the art may advantageously be employed.

In accordance with our invention not only may the various dimensions be very small, which is exceedingly advantageous when large numbers of such devices are employed in large switching networks, but they may be very accurate, as is required to attain the desired transmission characteristics of the device. Accordingly, the dimensions of the cavity cathode, as determined by the cavities 22, and of the orifice 23, and the distance of the nearest end of the anode rod 20 from the cathode are accurately determined, in relation to the gas pressure, so that the device exhibits a stable negative resistance characteristic for the transmission of speech currents over a wide range of currents in the abnormal glow discharge region of operation of the device, as further disclosed in the above-mentioned White application.

An appreciation of the dimensions involved can be gained from one specific illustrative embodiment wherein the over-all maximum width of the device is 0.250 inch and the over-all maximum length of the device, excluding the protruding exhaust tubulation, is 0.500 inch. In this embodiment the diameter of the cathode cavity, which is to say, the diameter of the cavities 22, in the ceramic envelope is 0.040 inch and the diameter of the circular orifice 23 is 0.010 inch. The metallic coating 25 may be of the order of 0.005 inch thick, when initially applied. However, as is taught in the above-mentioned White application, some redistribution of the metal of the coating between different portions of the cavity cathode will occur during initial operation or aging of the cathode. The anode wire 20 is of 0.005 inch diameter and the slot 19 is of substantially that width tightly to accommodate the anode wire. To insure accurate positioning and holding of the wire 20, if two embossments 17 are employed, the depth of the wire may be slightly less than 0.0025 inch and the upper surfaces 18 of the embossments slightly ground away so that the wire extends slightly above the upper surface and between the two embossments. While the anode wire may be accurately held if only one of the sections 11 and 12 has an embossment 17, savings may be realized by utilizing identical sections 11 and 12 each having an embossment 17 thereon.

In the specific illustrative embodiment described above the sections 11 and 12 were 0.030 inch thick over their base portions, but enlarged at each end; at the end wherein the cavity cathode is formed within the envelope of the tube itself, the thickness of the envelope is 0.080 inch. An exhaust tubulation 15 of 0.050 inch Kovar tubing is employed.

It is therefore apparent that in devices in accordance with our invention the ceramic envelope itself defines all the electrode support structure, the ceramic envelope further accurately defining the critical dimensions of the cathode and its shape. Further, distinct lead-in conductors, which would require separate connections and handling, have been obviated. Such devices are readily fabricated solely by the forming of the identical ceramic envelope sections 11 and 12, the metallizing of the metallic coatings 25, 27, and 29 to define the cathode and the lead-in conductors, and the sealing operation wherein the anode rod 20 is sealed in the grooves 19, the tubulation 15 is sealed in the grooves 14, and the two sections 11 and 12 of the envelope are sealed together. Thus, by reason of the simplicity of the structure of devices in accordance with our invention, their fabrication has been reduced to a minimum number of steps, the number of parts required has been reduced, and their cost has similarly been considerably reduced.

Devices in accordance with our invention may be filled with a gas or gaseous mixtures known in the art and at pressures to attain the desired negative resistance transmission characteristic of the cavity cathode. Thus, in the exemplary embodiment described above, the device is filled with neon at a pressure of 90 millimeters of mercury. In this embodiment the anode wire 20 was located 0.007 inch from the cavity cathode orifice 23.

While the employment of the exhaust tubulation 15 is advantageous as it enables accurate control over the gas filling, if desired the exhaust tubulation could be omitted. In such an embodiment the metallic layer 29, which defines the anode lead-in conductor, would extend itself between the mating surfaces of the sections 11 and 12 to the exterior surfaces thereof. Further, with such an embodiment the gaseous filling could be introduced by sealing the two sections 11 and 12 together in an atmosphere of the gaseous filling at the desired pressure.

Figs. 3 and 4 depict another specific illustrative embodiment of this invention wherein the cathode is not of the cavity cathode type, as disclosed in the above-mentioned White application, but is rather a U-shaped channel or hollow cathode, as disclosed in Patent 2,804,565, issued August 27, 1957, of M. A. Townsend. As disclosed in the Townsend patent, such a cathode configuration, when properly correlated to gas pressure and anode position, will also give a stable negative resistance characteristic for the transmission of speech currents over a range of currents when the tube is operated in the abnormal discharge portion of its current-voltage characteristic; the range of currents over which the negative resistance is attainable is somewhat smaller than for the cavity cathodes of the White application.

In this illustrative embodiment each of the ceramic

envelope sections **32** and **33** has a shallow flat groove **34** at its mating surface at the end of the envelope opposite the exhaust tubulation **15**. Onto the walls of this groove is placed a metallic layer **35** defining the U-shaped cathode; electrical connection thereto is again made by the conducting layer **27**. Similarly, the anode wire **38** is again mounted in the groove **19** in the surface **18** of an embossment **17** extending inwardly from the base of at least one of the ceramic envelope sections; in the embodiment recited an embossment **17** extends in from only the bottom envelope section **32**. Electrical connection to the anode wire can be made as described for the prior embodiment.

The anode wire **38** is advantageously bent so as to have a long linear portion **39** opposite to the mouth or cathode gap portion of the U-shaped cathode. However, the critical positioning of the anode wire **38** with respect to the cathode **35** can again be readily determined by its position in the groove **19**.

While in the illustrative embodiment described above with reference to Figs. 3 and 4 the U-shaped cathode comprises a conducting layer painted or otherwise deposited onto the surface of the grooves **34**, in other embodiments the cathode may be a preformed member fitted into the grooves under a slight spring bias and sealed thereto.

It is to be understood that the above-described arrangements are merely illustrative of the application of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. A gaseous discharge device comprising a ceramic envelope formed in two parts, each of said parts having a depression in its mating surface at one end and said depressions being contiguous to each other, means defining a metallic cathode member in said depressions and conforming to the configuration thereof, an integral pillar extending inwardly into said envelope from the base of one of said envelope parts, said pillar having a groove at the upper surface thereof, an anode wire positioned in said groove and extending toward and immediately adjacent said cathode member, and a gaseous atmosphere in said envelope.

2. A gaseous discharge device in accordance with claim 1 wherein said metallic cathode member defining means includes a layer of a conducting member deposited directly onto the surface of said depressions.

3. A gaseous discharge device in accordance with claim 1 wherein said metallic cathode member defining means includes a distinct metallic member.

4. A gaseous discharge device in accordance with claim 1 further comprising a conducting layer deposited on the mating surfaces of said envelope parts and extending from said cathode member to the exterior surface of said envelope, said conducting layer defining the cathode lead-in conductor.

5. A gaseous discharge device comprising a ceramic envelope formed of two parts, each of said parts having a depression at the mating surface of said parts at one end of said envelope, said depressions being contiguous, a metallic layer on the inner surfaces of said depressions and defining the cathode for said device, an integral embossment extending inwardly from the base of at least one of said parts, said embossment having a groove at its upper surface, an anode wire positioned in said groove and extending toward and immediately adjacent said cathode, and a gaseous atmosphere in said envelope.

6. A talking-path gas tube comprising a ceramic envelope formed of two parts, each of said parts having a hemispherical cavity in the mating surface at one end of said envelope, a metallic layer positioned directly on the inner surfaces of said cavities and extending over the inner surfaces of said parts immediately adjacent said cavities and thereby defining a cavity cathode, an integral

pillar extending inwardly from at least one of said parts, said pillar having a groove at its upper surface, an anode wire positioned in said groove and extending toward and immediately adjacent said cavity cathode, and a gaseous atmosphere in said envelope.

7. A talking-path gas tube in accordance with claim 6 further comprising a metallic coating extending on said mating surfaces of said parts from said cavities to the outer surfaces of said parts, said metallic coating defining a lead-in conductor to said cavity cathode.

8. A talking-path gas tube in accordance with claim 7 further comprising an exhaust tubulation positioned between said parts at the opposite end of said envelope from said cavity cathode and a metallic coating extending along said pillar and the inner surface of said one part between said anode wire and said tubing and defining a lead-in conductor to said anode wire.

9. A talking-path gas tube comprising a ceramic envelope formed of two parts, each of said parts having a hemispherical cavity at one end at the mating surface of said part, a metallic layer secured to the inner surfaces of said cavities and extending over the inner surfaces of said parts immediately adjacent said cavities and thereby defining a cavity cathode having an orifice communicating between said cavities within the wall of said ceramic envelope and the interior of said envelope, means within said envelope positioning an anode immediately adjacent said cathode cavity orifice, and a gaseous atmosphere in said envelope.

10. A talking-path gas tube comprising a ceramic envelope formed of two parts of equal size, each of said parts having a depression at the mating surface of said part at one end of said envelope, a metallic layer on the inner surfaces of said depressions within the wall of said ceramic envelope and defining the cathode of said device, said depressions communicating through the inner wall of said envelope with the interior of said envelope, means within said envelope positioning an anode immediately adjacent said cathode, and a gaseous atmosphere in said envelope.

11. A talking-path gas tube comprising a ceramic envelope formed of two parts of equal size, means defining the cathode of the tube within the wall of said envelope, said means including mating depressions in the mating surfaces of said envelope parts and a metallic layer on the inner surfaces of said depressions and conforming to the configurations thereof, said depressions within the wall of said envelope communicating with the interior of said envelope, an anode, means within said envelope positioning said anode in immediately proximity to said cathode, and a gaseous atmosphere in said envelope.

12. A talking-path gas tube in accordance with claim 11 wherein said anode comprises a wire and said positioning means includes an integral pillar extending inwardly from the base of at least one of said envelope parts, said pillar having a groove at its upper surface in which said anode wire is secured.

13. A talking-path gas tube comprising a ceramic envelope formed of two parts, means defining a cavity cathode for said tube within the wall of said envelope, said means including mating hemispherical depressions in the mating surfaces of said envelope parts and a metallic layer deposited on the inner surfaces of said depressions and extending over the inner surfaces of said parts immediately adjacent said depressions, said depressions communicating through an orifice formed in the inner wall surface of said envelope with the interior of said envelope, an anode within said envelope, means within said envelope positioning said anode immediately adjacent said cavity cathode orifice, and a gaseous atmosphere in said envelope.

14. A talking-path gas tube in accordance with claim 13 wherein said positioning means comprises an integral portion of at least one of said ceramic envelope parts.

No references cited.