

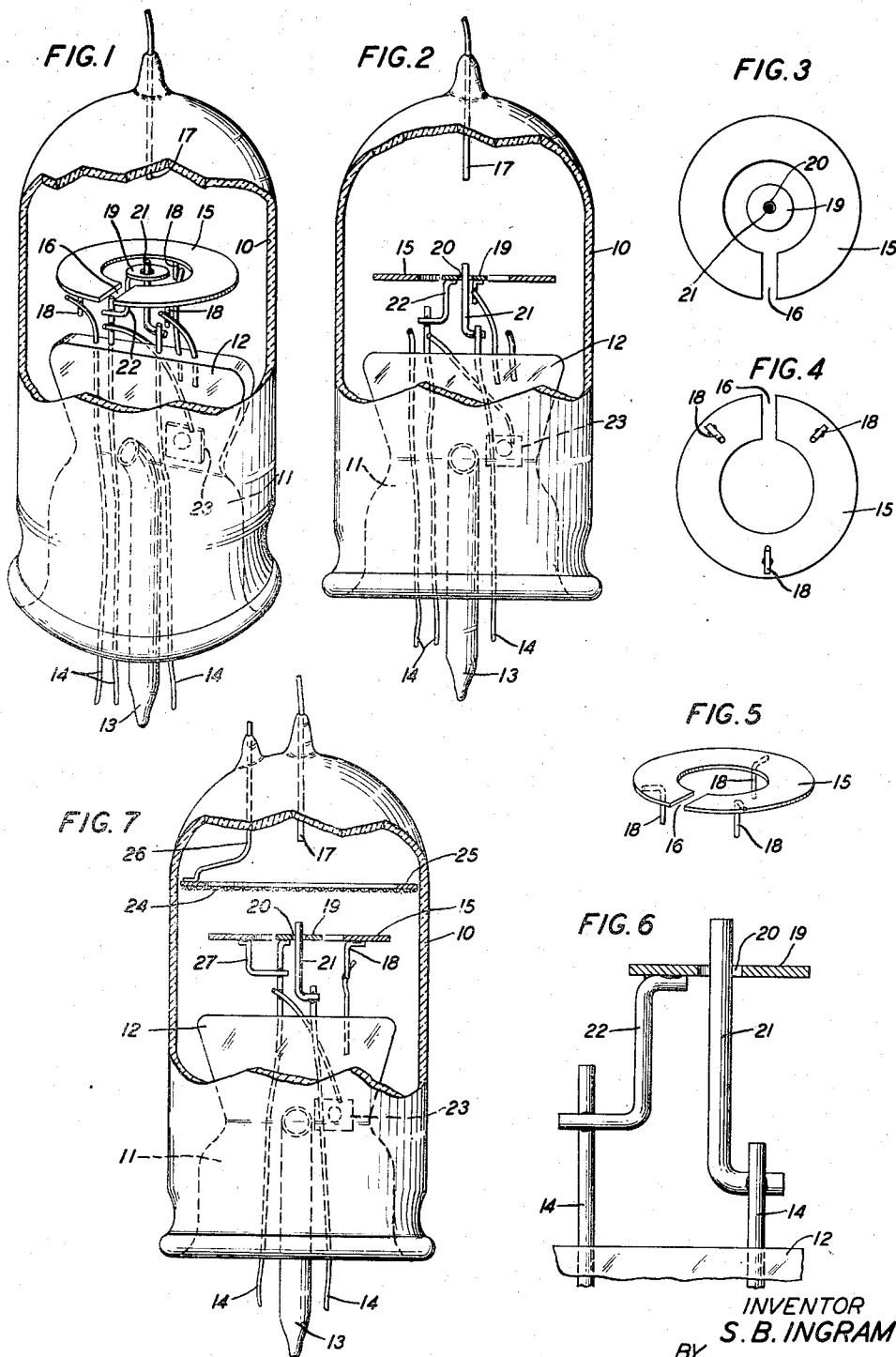
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ELECTRONIC DISCHARGE DEVICE

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ELECTRONIC DISCHARGE DEVICE

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This invention relates to electronic discharge devices and more particularly to gaseous trigger or switching devices of the cathode glow type.

For many switching purposes it is highly desirable to control the electrical and transfer characteristics of such devices within narrow limits. This requirement is not easily attainable in the usual type of trigger device which includes a large area cathode and a small anode spaced a considerable distance from the cathode and where conduction therebetween is accomplished through a gaseous medium of suitable pressure and ionizing characteristic. Even the introduction of an auxiliary starting electrode close to the cathode surface to initiate conduction fails to assure stable and reproducible operation of the transfer discharge due, in a large measure, to the variability in the location of the initiating discharge on the surface of the cathode. Furthermore, in multicontrol electrode devices the critical screen grid voltage deviates and is rendered unreliable by irregularities in the initiating discharge so that efficiency of operation is impaired.

An object of this invention is to increase the efficiency and characteristics of glow discharge devices.

Another object is to reduce the initiating discharge range to a minimum so that stable and reproducible operation is attained.

A further object of the invention is to facilitate the transfer of the main discharge current with uniformity and within a limited range of transfer current.

These objects are realized in accordance with this invention by separating the cathode surface into minor and major proportions in concentric relation along the axis of the main discharge path. In effect, the electrodes constitute an initiating discharge path involving a pair of closely related concentric electrodes and a main discharge path involving a pair of widely spaced concentric electrodes in which the initiating discharge is uniformly confined to a limited current range at low voltages and the main discharge is readily controlled in accordance with the operating characteristics desired for definite switching requirements.

In a specific embodiment of the invention, the initiating discharge takes place in a gas-filled vessel containing a central auxiliary anode surrounded by a small annular cathode disc. A larger diameter annular disc or main cathode is spaced radially from the initiating cathode with a large gap therebetween and a small area anode

is spaced linearly from the auxiliary anode so that the gap between the main cathode and the main anode is large, whereby a fairly high breakdown potential is required to transfer the discharge from the initiating path to the main path.

A feature of the invention relates to the allocation of the initiating discharge to a uniform zone of influence so that the short gap breaks down within narrow limits of applied voltage of low value. The close spacing and uniformity of cathode surface presented to the starter anode insures the establishment and maintenance of a glow discharge at a relatively low potential.

Another feature of the invention is concerned with the transfer characteristic of the glow discharge whereby the initiating discharge is controlled within prescribed limits to fire or break down the main discharge path to permit a large energy flow for the operation of switching mechanism and to prevent false transfer of the discharge by leakage or cumulative charges within the device, whereby the characteristics of the device are maintained constant throughout the operating life of the device.

A further feature of the invention involves the separation of the initiating and main discharge paths by an insulating gap which permits definite control of the transfer current, whereby the main discharge path is energized consistently under operating potentials of narrow limits. This arrangement facilitates positive firing of the device within a definite operating range to insure regularity of actuation and freedom from faults due to indiscriminate charges within the device.

These and other features and advantages of the invention will be set forth in the following detailed description and will be more clearly understood when considered with the accompanying drawing.

Fig. 1 is a perspective view of one form of device made in accordance with this invention with a portion of the vessel broken away to show the detail assembly of the electrodes.

Fig. 2 illustrates the device of Fig. 1 in cross section to show the interspacial relation of the various electrodes incorporated in the device of this invention.

Fig. 3 is a plan view illustrating the construction and relation of the electrodes supported in the stem of the device as shown in Fig. 2.

Fig. 4 shows the reverse side of the large ring electrode and the disposition of the supporting extensions.

Fig. 5 is a perspective view of Fig. 4 showing the supports projecting from the rear surface.

Fig. 6 illustrates, on an enlarged scale, the relative positions of the initiating discharge path electrodes of the device of this invention; and

Fig. 7 shows a modification of the device in a cross-sectional view in which a screen grid is mounted between the main discharge electrodes to increase the control of the transfer current for multiswitching operation.

Referring to the drawing and particularly to Fig. 1, the electronic glow discharge device of this invention comprises a cylindrical enclosing vessel 10, of vitreous material, hermetically sealed to the flare of an inwardly projecting stem 11 having a flat press 12 extending from the inner end, and a coaxial exhaust tubulation 13 extending from the other end, the tubulation being in communication with the interior of the vessel, and the stem being provided with a plurality of leading-in conductors 14 for applying suitable potentials to various electrodes supported on the stem. The main discharge electrodes in the vessel are constituted by a large area annular flat metallic disc or ring 15 having a radial slot 16 and coated on the upper surface with an electron emitting material, such as barium and strontium oxides to function as the emitter or glow cathode in cooperation with a small area metallic electrode 17, in the form of a wire, sealed through the top of the vessel and spaced a considerable distance from the cathode and coaxial therewith to produce a large gap which forms the main discharge path when suitable potentials are applied thereto to break down the high resistance of the discharge gap to transfer currents of high value. In order to prevent the glow discharge from spreading to the rear surface of the main cathode 15 an insulating or electron inhibiting coating may be applied thereto, such as aluminum oxide.

The cathode 15 is provided with a plurality of angle-shaped wires 18, as shown in Figs. 4 and 5, distributed in spaced relation on the rear surface and welded thereto, the wires forming downward extensions which are suitably attached to bent continuations of the leading-in conductors 14 extending from the press. This arrangement forms a rigid mounting for the large area cathode surface to insure the stable position of the cathode ring in relation to other cooperating electrodes mounted on the stem. The slot 16 in the cathode surface is provided to prevent excessive heating of the large area cathode ring during the final processing of the device in which high frequency heating is utilized for activating the electron emissive coating on the main cathode and small control cathode surfaces.

The cathode, in accordance with this invention, is formed of two parts, the large area surface 15 being the major part or main cathode while a small disc 19, coaxially mounted within the boundary of the main cathode disc 15 and in the same plane therewith, forms the minor section or part and functions as the control cathode of the device, the small disc 19 being provided with an electron emitting coating on the upper surface and an insulating coating on the rear surface the same as the disc 15. The control cathode 19 is provided with a central circular aperture 20 and a control anode or auxiliary electrode 21, in the form of a circular rod extending through the aperture 20, is supported therein by being attached to one of the leading-in wires 14. The small disc 19 may be supported

coaxially with respect to the auxiliary element 21 by an angle wire 22 which is secured to one of the leading-in wires 14.

After the electrodes are suitably mounted in the vessel the enclosed space is highly evacuated to remove air and deleterious gases and an inert gaseous filling is injected therein to form the ionizing medium for the conduction of the discharge in the device. This filling may be a mixture of gases, such as neon and argon, in the proportions of 95 per cent neon and 5 per cent argon at a pressure of .1 to 50 millimeters of mercury depending on the characteristics desired in the operation of the device. A getter mounting 23 is also provided in the device to fix residual gases in the final processing of the enclosing vessel. This construction shows the preferred cooperation of the various electrodes in the device to achieve the functional characteristics of readily producing an initiating discharge path between the auxiliary control anode 21 and the control cathode section 19 so that the main discharge path between the anode 17 and the cathode 15 will break down for definite values of transfer current of limited range when suitable potentials are applied to the anode 17, the discharge readily being transferred across the gap between the control cathode 19 and the main cathode 15.

The construction of this invention centers in the segregation of the cathode into minor and major proportions wherein the initiating discharge is readily established over the limited area of the control cathode 19. This is more clearly shown in Fig. 6 in which the interrelation between the control anode 21 and the control cathode 19 can be realized to effect the initiating discharge at a relatively low potential to produce an initiating glow discharge over the top surface of the control cathode 19 as presented to the tip of the control anode 21 projecting through the small diameter aperture in the disc. This initiating glow discharge is concentrated on the surface of the control cathode due to the large gap separating the control cathode from the main cathode 15 but the initiating glow discharge is readily transferred to the main cathode section 15 when suitable potentials are applied to the main anode 17 to effect the production of large current flow in the device.

This functional operation is produced by the correlation of the areas of the respective electrodes and the spaced relation therebetween so that the separate discharge paths are isolated under given operating conditions so that the characteristics of the device are stable and reproducible regardless of the length of time the device is in operation. These functional characteristics are dependent upon the correlation of the areas and the diameters of the gaps between the segregated electrodes in which the control cathode surface must be kept small and closely spaced in relation to the control anode in order to concentrate the initiating glow discharge within narrow limits of ignition voltage; that is, the control cathode surface must not be so large that the initiating glow discharge will wander over different portions of the surface. Likewise the space relation between the control cathode and the main cathode and the control cathode and the main anode must be large to prevent the spreading of the initiating glow discharge by erratic charges within the device which accidentally destabilize the transfer characteristics of the device.

A typical example of the electrode dimensions and spacing will convey the importance of these considerations although, of course, the following dimensions are not critical or intended to be limited, since it is obvious that other measurements and spacing may be employed to accomplish the results of this invention, except that the control cathode surface should be held to a minimum in order to prevent wandering of the striking glow in the initiating path. For example, the main cathode 15 is formed of a flat metallic ring, such as nickel, having an outside diameter of $\frac{3}{4}$ inch and an inside diameter of $\frac{3}{8}$ inch with the slot $16\frac{1}{2}$ inches wide. The control cathode 19 is a nickel disc $\frac{1}{8}$ inch in diameter with a central hole .040 inch and the control anode 21 is a nickel wire or rod 30 mils in diameter and centrally positioned in the aperture 20 so that the space relation between the control anode and the control cathode is 5 mils, the control anode projecting beyond the control cathode a distance slightly less than the radius of the control cathode. The concentric mounting of the control cathode within the boundary of the main cathode 15 provides a large gap having the dimension of .09 inch so that the initiating discharge of low potential gradient cannot reach the main cathode over the large gap and is therefore concentrated over the small area of the control cathode 19. The space relation between the tip of the main anode 17 and the control cathode 19 is $\frac{3}{8}$ inch so that a relatively high voltage may be applied to the main anode in the absence of ionization between the other electrodes. When transfer current of a small and definite amount flows between the control anode 21 and the control cathode 19, current will also be initiated in the path between the control cathode 19 and the main anode 17. This current will be limited only by the load impedance which will generally be connected in series with the main anode of the device, and will therefore be much larger than the current which initially flows between the control anode 21 and the control cathode 19. This larger current will overload the small area of the control cathode 19 causing the voltage drop of the discharge to rise so that the glow discharge spreads to the main cathode 15 and overcomes the gap between the control cathode 19 and the main cathode 15. This causes current to flow directly between the main anode 17 and the main cathode 19.

A modification of the device of Fig. 1 is shown in Fig. 7 in which a screen grid 24 is interposed between the main anode 17 and the main cathode 15 and this control electrode is supported by a reinforcing ring 25 and a leading-in conductor 26 through the top of the vessel, to facilitate the use of the device in an interlocking circuit in which three control voltages are necessary before the device breaks down for the particular switching operation. It will be noted in this figure that the main cathode is interconnected with the control cathode within the device by a strap connector 27, whereas in Fig. 1 the main cathode is connected to a separate conductor whereby the two sections of the cathode may be connected externally of the device.

While the invention has been disclosed in several embodiments it is, of course, understood that many other variations may be made in the assembly and interrelation of the electrodes to realize the functional precepts of the invention, and such modifications are intended to be comprised

within the scope of this invention as defined in the appended claims.

What is claimed is:

1. An electronic discharge device comprising an enclosing vessel containing a gaseous atmosphere, a plurality of electrodes therein including a cathode formed of two sections, one section being of small area and the other section of larger area and surrounding the small area section, an anode cooperating with said cathode sections and forming with said larger area section a main discharge path, and an auxiliary anode mounted closely adjacent said small area section of said cathode and constituting therewith an initiating discharge path, the spacing of the electrodes in the initiating discharge path being relatively small to facilitate the starting of a glow discharge on said small area cathode section at low ionizing potentials.

2. An electronic discharge device comprising an enclosing vessel containing a gaseous atmosphere, a plurality of electrodes therein including a pair of cathode sections in concentric relation in substantially the same plane, an auxiliary anode cooperating with the smaller section, and a main anode cooperating with the larger section, the inner section and auxiliary anode serving to initiate and sustain a starting glow discharge path therebetween, and the outer section and said main anode serving to support a main discharge path in said vessel.

3. An electronic discharge device comprising an enclosing vessel containing a gaseous atmosphere, a plurality of electrodes therein including a pair of cathode sections in concentric relation in substantially the same plane, an auxiliary anode cooperating with the smaller section, and a main anode cooperating with the larger section, the inner section and auxiliary anode adapted to initiate and sustain a starting glow discharge path therebetween, and the outer section and said main anode adapted to support a main discharge path in said vessel, the gap between said cathode sections being of such large magnitude to inhibit transfer of the glow discharge to said main path until the potential applied to said main anode causes a current flow of such magnitude as to overload said starting path and overcome the resistance of said gap.

4. A gaseous discharge device comprising an enclosing vessel, a plurality of electrodes supported from one end of said vessel including a small metallic cathode surface, means spaced relatively close to said surface and forming therewith an initiating discharge path, a large diameter ring cathode surface surrounding said small cathode surface and spaced therefrom by a relatively wide gap, and an anode associated with said surfaces and forming a main discharge path with said ring cathode surface.

5. A gaseous discharge device comprising an enclosing vessel, a plurality of electrodes supported from one end of said vessel including a bipart cathode surface mounted substantially in a single plane, one part having a small central aperture and the other part separated therefrom by a relatively large gap, an auxiliary electrode extending through said small central aperture, and a main electrode mounted in cooperating relation with said cathode surface and auxiliary electrode.

6. A gaseous discharge device comprising an enclosing vessel, a plurality of electrodes supported from one end of said vessel including a small diameter disc cathode section having a

central aperture, a ring-shaped plane cathode section surrounding said disc section and mounted substantially in the same plane therewith, an auxiliary electrode extending through said central aperture, and an anode cooperating with said ring-shaped cathode section.

7. A gaseous discharge device comprising an enclosing vessel, a plurality of electrodes supported from one end of said vessel including a small apertured metallic cathode surface, a wire electrode extending through the aperture and spaced relatively close to said surface, a large diameter ring cathode surface surrounding said small cathode surface and spaced therefrom by a relatively wide gap, a main anode disposed opposite said electrodes and supported from the other end of said vessel, and a control electrode between said electrodes and said main anode.

8. A gaseous discharge device comprising an enclosing vessel, a plurality of electrodes supported from one end of said vessel including a small apertured metallic cathode surface, a wire electrode extending through the aperture and spaced relatively close to said surface, a large diameter ring cathode surface surrounding said small cathode surface and spaced therefrom by a relatively wide gap, said ring cathode surface being split, and a main anode disposed opposite said electrodes and supported from the other end of said vessel.

9. A gaseous discharge device comprising an enclosing vessel having a stem, a plurality of electrodes supported from said stem at one end of said vessel including a small diameter disc cathode section having a central aperture, a ring-shaped plane cathode section surrounding said disc section, said cathode sections being coated with electron emissive material on the surfaces extending away from said stem and coated with electron inhibiting material on the reverse surfaces, an auxiliary electrode extending through said central aperture, and an anode cooperating

with said ring-shaped cathode section and supported from the opposite end of said vessel.

10. A gaseous discharge device comprising an enclosing vessel, a plurality of electrodes supported from one end of said vessel including a small diameter disc cathode section having a central aperture, a ring-shaped plane cathode section surrounding said disc section and mounted substantially in the same plane therewith, a rod-shaped anode projecting through and spaced relatively close to said small cathode section, and a main anode wire disposed opposite said electrodes and supported from the other end of said vessel.

11. A gaseous discharge device comprising an enclosing vessel, a plurality of electrodes supported from one end of said vessel including a small diameter disc cathode section having a central aperture, a ring-shaped plane cathode section surrounding said disc section and mounted substantially in the same plane therewith, a rod-shaped anode projecting through and spaced relatively close to said small cathode section, and a main anode wire cooperating with said ring-shaped cathode section, the end of said rod-shaped anode extending beyond said small cathode section being of a length less than the radius of said small cathode disc.

12. A gaseous discharge device comprising an enclosing vessel, a plurality of electrodes supported from one end of said vessel including a small apertured metallic cathode surface, a wire electrode extending through the aperture and spaced relatively close to said surface, a large diameter ring cathode surface surrounding said small cathode surface and spaced therefrom by an insulating gap comparable in width to the diameter of said small cathode surface, and a main anode disposed opposite said electrodes and supported from the other end of said vessel.

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