

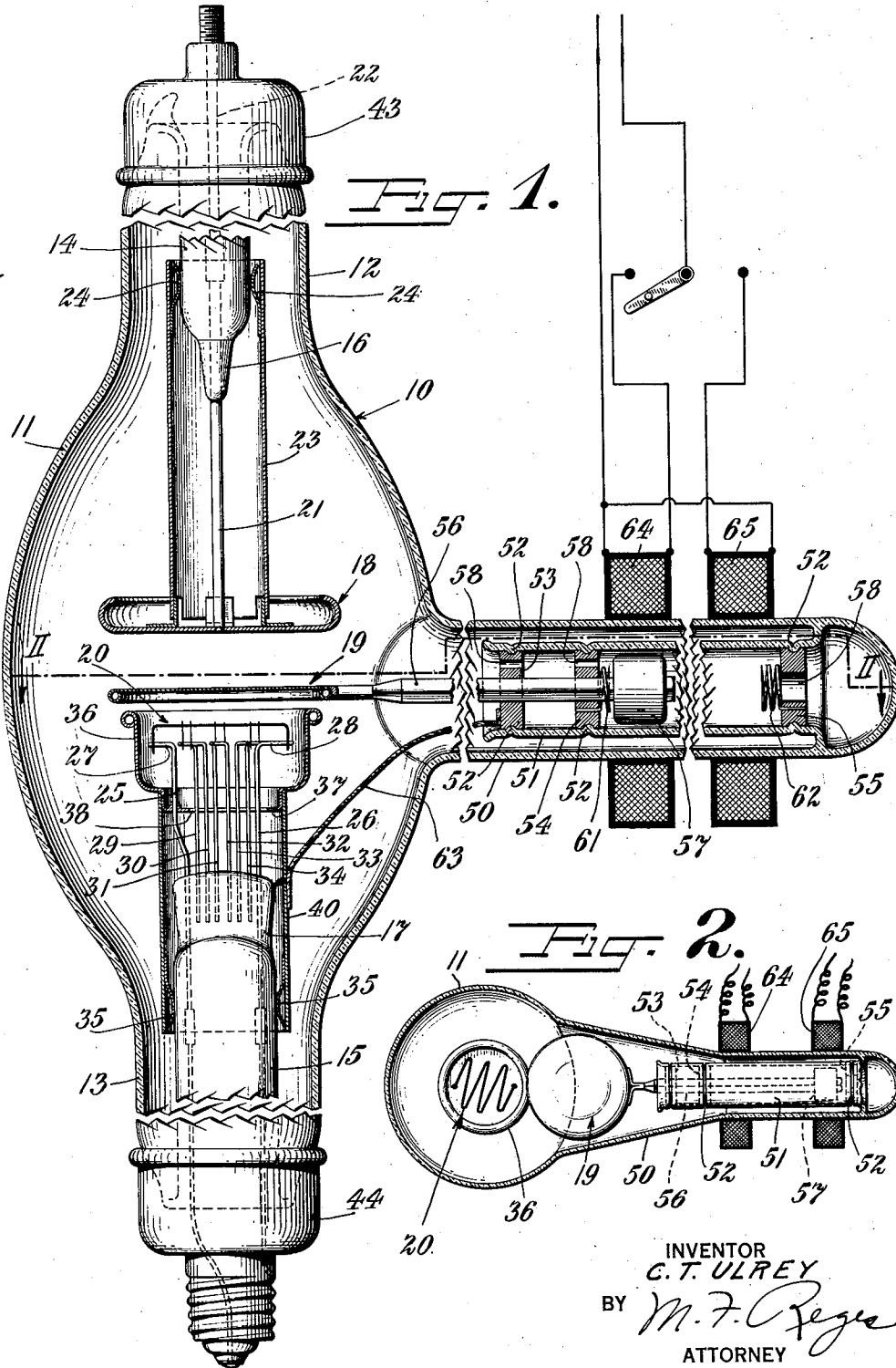
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ELECTRONIC SWITCH

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ELECTRONIC SWITCH

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5 Claims. (Cl. 250—36)

This invention relates to electrical switches and more particularly to switches of this character adapted to "make" and "break" an electrical circuit.

5 In one of its aspects the invention is directed to an electronic switch or trigger device adapted to operate without detrimental arcing in an electrical circuit with a voltage, applied across the terminals of the device, of the order of about
10 40,000 or more volts and the current passing through said device may be 1,000 more or less milliamperes.

In its more specific aspect the invention is an improvement over the device illustrated and described in the copending application of Montford Morrison, Serial No. 596,948 filed March 5, 1932, and assigned to the same assignee as the present invention.

The aforementioned copending application describes a circuit which may be employed to produce good X-ray photographs of the "instantaneous" exposure type. The circuit, as illustrated in Fig. 6 of the drawing of said copending application, consists essentially of a condenser, an X-ray tube and a novel trigger tube all in series with the trigger tube having its grid or control electrode and its cathode connected to an outside source of potential whereby the absolute prevention and "instantaneous" flow of electrons from the cathode to the anode may be effected at predetermined and appointed times.

The novel trigger tube disclosed in said copending application in its briefest aspect consists of a thermionic cathode, an anode and a grid or control electrode interposed between the anode and cathode. The grid consists of a perforated or foraminous cup-shaped element. In the operation of the circuit heretofore set forth, it is necessary that a means be employed for charging the grid negatively in order to prevent electrons from flowing from the cathode to the anode and at a predetermined time for charging the grid positively so that the electrons will flow from the cathode to the anode.

45 When the grid is positively charged the grid becomes heated due to electron bombardment. Thus, there is a dissipation of electrical energy at the grid. In order to overcome these as well as other difficulties inherent in trigger tubes when
50 employed in said circuit, I have provided the present invention.

Briefly stated my invention comprises a three-electrode tube which is adapted to prevent and allow the passage of current therethrough. The
55 tube consists primarily of a gas-tight dielectric

envelope having an anode and a cathode appropriately spaced from each other and a control electrode of novel operation and design appropriately spaced between the cathode and the anode. With a tube of this general construction and embodying my invention it is practical to prevent the flow of current for an indefinite period of time and at an appointed time to allow the flow of current therethrough, which current may be of any desired magnitude at any desired voltage and, as herein illustrated, as high as 1,000 or more milliamperes at 40,000 or more volts.

One object of my invention is to provide means that are substantially fool-proof and adapted to prevent the passage of current therethrough over a period of time and to allow the passage of current therethrough at an appointed time.

Another object of my invention is to provide a new method for preventing and allowing the passage of electrical energy from a source of electrical supply to a load.

Another object of my invention is to provide a new method of preventing and allowing the passage of electrical energy of high voltage and high current values in the X-ray field from a source of electrical supply to a load.

Other objects and advantages of my invention will be readily apparent from the following specification and appended drawing wherein:

Figure 1 represents a shortened longitudinal cross-sectional view, with some of the parts in elevation, of a device embodying my invention; and

Figure 2 represents a cross-sectional view taken along line II—II of Fig. 1 in the direction of the arrows.

As shown in Figure 1, one embodiment of my invention is the illustrated trigger tube comprising an evacuated enclosing gas-tight dielectric elongated envelope 10, composed of glass or the like, in the form of a bulbous midportion 11 with a pair of diametrically opposed elongated tubular arms 12 and 13. Extending within said tubular arms 12 and 13, are reentrant dielectric tubes 14 and 15, respectively, having presses 16 and 17 at their respective ends, located in the proximity of the respective limits of the bulbous portion 11.

Located within the envelope 10 and with the effective portions thereof in the approximate center of the bulbous portion of the envelope are spaced parallelly arranged electrodes 18, 19 and 20. The pressure of the residual gas within the tube is preferably as low as possible and may be of the order of about 10^{-5} to 10^{-4} mm. of mercury.

The electrode 18 is the plate or anode in the form of a plane smooth surface disk, having the circumferential outer portion thereof curled upwardly and inwardly towards the anode end of the envelope, and away from the electrodes 19 and 20 to provide a surface of large radii of curvature so as to minimize cold electron emission between the electrodes.

This anode or plate 18 may be of the desired thickness and composed of a refractory metal, as for example molybdenum, and is supported by an electrical conductor 21 of molybdenum or the like having one end secured thereto and its outer end secured to the conductor 22. The effective anode area is preferably greater and about fifty percent greater than the overall area of the cathode 20, hereinafter more specifically described. Between the anode or plate 18 and the conductor 22, a portion of the supporting conductor 21 forms an air-tight seal and supporting means with the vitreous press 16. Secured to a face of the anode or plate 18, within the periphery of the curled edge thereof by means of welded right angle supports or other mechanical means, is a metallic tubular section 23 composed of molybdenum or the like.

This tubular section 23 extends away from the effective face of the anode 18, surrounds that portion of the anode support and conductor 21 within the envelope, the seal and press 16, and a substantial portion of the reentrant tube 14 beyond the press. On the inner surface of that portion of the tube 23 surrounding the reentrant tube are secured spring fingers 24 whose outer surfaces bear against the outer surface of the reentrant tube 14. This metallic tubular section 23, due to its peculiar assembly and design, serves as a heat distributor and a shock-absorbing and distributing means to aid in the prevention of anode over-heating, seal impairment due to heat and stray electron bombardment thereof and seal fracture.

Moreover, this particular construction aids in the prevention of general tube fracture caused by mechanical shocks to which tubes of this character might normally be subjected in the course of practical commercial manufacture, manipulation or operation. It also serves to assist in supporting the anode 18.

At the cathode side of the tube and forming an air-tight seal with the press 17 are cathode lead-in and rigid supporting wires 25 and 26 having portions thereof extending exteriorly of the envelope and portions thereof extending within said envelope. Substantial lengths of the upper free ends 27 and 28 of the support wires 25 and 26 are bent outwardly and away from each other and are at about right angles to the longitudinal axis of the tube. Between said supporting wires and sealed in the press 17 are, and as illustrated six, rigid supporting wires 29, 30, 31, 32, 33 and 34 composed of molybdenum or the like, and insulated from each other at the press 17. The upper portions of these wires are bent away from the longitudinal axis of the tube, with upper portions of the wires 29, 30 and 31 bent in a direction generally opposite to the direction of bend of the wires 32, 33 and 34.

The free ends of these wires are all approximately in the same general plane, which is substantially normal to the longitudinal axis of the envelope. Securely mounted by welding or other convenient means to the bent portions at or near the free ends hereof, in a generally zig-zag fashion, as shown, with each of its segments being in

the same general approximate plane, is the filamentary cathode 20.

The cathode 20 may comprise a tungsten filament of appropriate length and diameter and has its respective ends secured to the bent portions 27 and 28 of the support wires 25 and 26. Because of its composition, length and diameter, the cathode 20 will provide a thermionic emission therefrom, of sufficient magnitude to supply the desired comparatively large current of the order of about 1000 milliamperes, when a potential of about seventeen volts is applied between its terminals from the secondary winding of a low voltage transformer (not shown) connected to lead-in wires 25 and 26. Moreover, this comparatively large thermionic electron emission is effectively secured at the temperature to which the filament is raised without any substantial vaporization thereof at its maximum attained temperature due to said voltage being applied between its terminals.

Spaced from and closely surrounding the thermionic cathode 20 is an open-ended cup 36 of molybdenum or the like, having an inwardly directed flange with a downwardly extending cylindrical portion integral with said flange and having a curled upper end whose edge is away from the face of the anode 18 and in close proximity of the outer surface of the cup proper.

The cup 36 has a base 37 provided with an elongated slot 38 adapted to receive the rigid support wire 26 and the support wires 29, 30, 31, 32, 33 and 34. The other rigid support wire 25 passes through and is in contact with the base. The support wire 25 may be welded to said base, although this is not necessary because it is sufficiently in contact therewith, as shown.

The inner wall of the cup 36 is in close proximity of the ends of the bent support portions. Its upper curled edge is above the plane of the cathode and the flange portion extends inwardly and below the edges of the bent portions of the support and together with its base serves as a reflecting surface for the electrons emitted at the cathode 20. Telescoping the downwardly extending cylindrical portion integral with said flange is a metallic tubular section 40 having one end thereof frictionally secured to said cylindrical portion. This tubular section 40, composed of molybdenum or the like, supports the cup, surrounds all of the cathode supporting wires, the press and a substantial portion of the reentrant tube beyond the press.

On that portion of the inner wall of the tubular section 40, surrounding the reentrant tube 15, are secured a plurality of spring fingers 35 adapted to frictionally engage and bear against the reentrant tube 15.

The cup 36, together with the cylindrical section 40, serves as a heat distributor and a shock-absorbing and distributing means to aid in prevention of seal impairment due to heat and stray electron bombardment thereof which may ultimately result in seal breakdown. Moreover, this particular construction aids in the prevention of tube fracture caused by mechanical shocks to which a tube of this character might normally be subjected in the course of practical commercial manufacture, manipulation or operation.

It also serves to prevent the electrons emitted at the cathode from migrating over towards the walls of the envelope and acts to constrain the electrons in a limited field so that they may approach the anode in a preferred path upon excursion, that is to say, the cup 36 focuses the

electrons emanating from the cathode so that substantially all of them are directed to strike the anode 18.

At the respective ends of the vitreous bulb 10 are secured terminal caps 43 and 44 in electrical contact with the respective lead-in wires 22 and 25, 26. The vitreous envelope 10 is of appropriate length so that these caps 43 and 44 are remotely disposed from each other to prevent spark-over therebetween when a predetermined potential, as for example, a potential of forty thousand volts or more is applied therebetween.

The anode and cathode are preferably so spaced from each other that any danger of filament distortion or other deleterious effects, such as cold emission or arcing, may be prevented during the operation of the tube at the high voltages to which it may be normally subjected.

At about its mid-length the envelope has a portion thereof in the form of an elongated closed vitreous arm 50 of appropriate length and diameter. Ring-sealed therein adjacent the closed end of said arm is a reentrant vitreous tube 51 having a plurality of spaced ribs 52. Mounted within said reentrant tube are spaced electrically conductive guides 53, 54 and 55 maintained in fixed position by virtue of the ribs 52 fitting into circumferential grooves on the exterior walls of said guides. Adjacent guides 53 and 54 have openings at the approximate centers thereof and are of approximately the same dimensions as the corresponding dimension of an electrically conductive shaft 56 to which, at one end, is secured an armature 57 in the form of a soft iron core and at its other end is electrically secured the control electrode 19. All of the guides have openings 58 so that the arm 50 may be completely evacuated.

Located in the space between the guides 54 and 55 and respectively secured thereto are a plurality of shock-absorbing springs 61 and 62 adapted to take up shocks and relieve the tube from the forces of impact during the operation of the switch in the manner which will be hereinafter described.

The control electrode 19 is essentially in the form of a circular plate having no openings therein and having a diameter that is at least as great as that of the anode and preferably about ten percent greater than that of the cathode cup 36. The edges of the control electrode 19 are curled away from the anode so that there will be no cold emission between the anode 18 and the control electrode 19. The control electrode 19 is spaced about one-eighth of an inch from the cathode for the sake of clearance and is maintained at substantially the same potential as the cathode and the cathode cup by virtue of an electrical conductor 63 secured to the extension 40 of the cathode cup and to the guide 53.

The distance between the guide plates 54 and 55 is preferably greater than the diameter of the control electrode 19, and the distance between the guide 53 and that edge of the cathode cup immediately adjacent thereto is preferably greater than the diameter of the control electrode 19.

Located exteriorly of said tube and surrounding the arm 50 are spaced windings 64 and 65 adapted to magnetize the core 57 whereby the control electrode 19 may be actuated away from or towards the cathode for the operation of the switch.

The cathode 20 may be heated to the desired temperature and a predetermined working potential applied between the anode and cathode.

With these conditions existing when the control electrode 19 at the same potential as the cathode is in the position shown in Figure 1, and completely blocking the mouth of the cup 36, it prevents all of the electrons emanating at the cathode from traveling to the anode 18. In this manner a zero plate current may be maintained. This condition may be maintained until such time that the operator desires a current at the working voltage to flow through the tube. At that time one of the windings, as for example the winding 65, is energized which causes the shaft 56 and control electrode 19 to move in a direction away from the cathode cup so that the control electrode 19 is in the position shown in Figure 2.

In this manner the control electrode 19 may be actuated so that there is a large, substantially unobstructed space between the anode and the cathode and the electrons emanating at the cathode are allowed to travel undisturbed from the cathode to the anode.

If it is desired to again block the flow of electrons from the cathode 20 to the anode 18, so that the plate current may again be zero, the winding 65 is de-energized and the winding 64 is energized to cause actuation of the control electrode 19 towards the cathode cup 36. The control or blocking electrode 19 travels and assumes the position shown in Figure 1 so that all of the electrons emanating at the cathode 20 are prevented from traveling to and reaching the anode 18. When high voltages are to be applied between the terminals 43 and 44, I prefer to insulate the coils 64 and 65 from the low voltage supply line. The coils may be energized by means of an insulating transformer and a remote control may be employed.

The magnetic windings 64 and 65 may be entirely eliminated and actuation of the control electrode 19 may be accomplished by merely rotating the tube about its longitudinal axis. The force, due to gravity, will cause the control electrode 19 to assume the desired position depending on the position of the tube.

Instead of having the control electrode 19 spaced from the cup 36 and if desired the elimination of the conductor 63 it is within the purview of my invention to have a plurality of electrically conductive tracks or guides secured to and supported by the cathode cup 36 and extending over to the guide 53. These tracks or guides may be so arranged that the control electrode 19 is in contact therewith and supported thereby so that when the control electrode is in blocking position, it will have its bottom face in contact with the upper edge of the focusing cup 36.

One other means that I may employ as a blocking medium is a control electrode 19 supported by the cup 36 and being in the form of a trip shutter arrangement such as those commonly employed in the camera art. With this type of construction, like the others, it is possible to completely block the path of electrons between the anode and cathode and to maintain a zero plate current when the working voltage is applied between the anode and cathode, and the cathode temperature is at the maximum required. When it is desired to allow the electrons to pass through the tube, the trip shutter, which may be completely opened in 0.002 of a second, are caused to be actuated so that there is a large unobstructed space between the anode and cathode

which allows the undisturbed excursion of electrons from the cathode to the anode.

This invention is susceptible to a number of modifications and it is to be limited only by the prior art.

What is claimed is:

1. A switch comprising an envelope, an anode, a cathode, focusing means surrounding said cathode, and a control electrode therein, said anode and cathode being spaced from each other, said control electrode being adapted to maintain a zero plate current while in a blocking position and to allow the flow of current between the anode and cathode when in another position, said control electrode being electrically connected by means wholly within said envelope to said cathode, said control electrode while in blocking position being closely adjacent said focusing means and obstructing the electron path between said cathode and said anode to maintain a zero plate current and means for actuating said control electrode from said blocking position to operating position for allowing the establishment of a substantially unobstructed electron path between the anode and the cathode, said control electrode when actuated being movable in a direction at an angle to the effective electron path between the anode and the cathode, the space between said anode and cathode being substantially unobstructed when the control electrode is in said second mentioned position.
2. A switch comprising an envelope, an anode, a thermionic cathode, focusing means surrounding said cathode, and a control electrode therein, said anode and said cathode being spaced from each other, said cathode upon incandescence being adapted to emanate electrons, said control electrode being adapted to maintain a zero plate current while in a blocking position and to allow the flow of electrons between said anode and said cathode when in another position, said control electrode when in blocking position being closely adjacent said focusing means and being electrically connected to the cathode for main-

taining the same at a potential sufficient to prevent the electrons emanating at said cathode from reaching the anode and when in said other position allowing the establishment of an effective electron path to obtain the desired plate current, the space between said anode and cathode being substantially unobstructed when said control electrode is in said second mentioned position.

3. A switch comprising an envelope, an anode and a cathode and a control electrode therein, said control electrode being slidable and when in one position blocking the flow of current from the cathode to the anode and while in another position allowing the establishment of a desired plate current, means electrically connecting said control electrode to said cathode for maintaining the control electrode at approximately the same potential as said cathode during tube operation, said means being located entirely within said envelope.

4. A switch comprising an envelope, an anode, a cathode and a control electrode therein, said envelope having an arm, a plurality of guides in said arm, a shaft carrying said control electrode, said shaft being slidably mounted in said guides, means electrically connected to one of said guides and said cathode for maintaining the potential of the control electrode at approximately the same potential as said cathode, said means being located entirely within said envelope.

5. A switch comprising an envelope, an anode, a cathode and a control electrode therein, said envelope having an arm, a reentrant stem in said arm, a plurality of guides in said stem, a shaft slidably mounted in said guides, and secured to said control electrode carried thereby, means surrounding the cathode for limiting the direction of electrons emanating therefrom, and means electrically connecting said control electrode and cathode, said means being located entirely within said envelope.

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