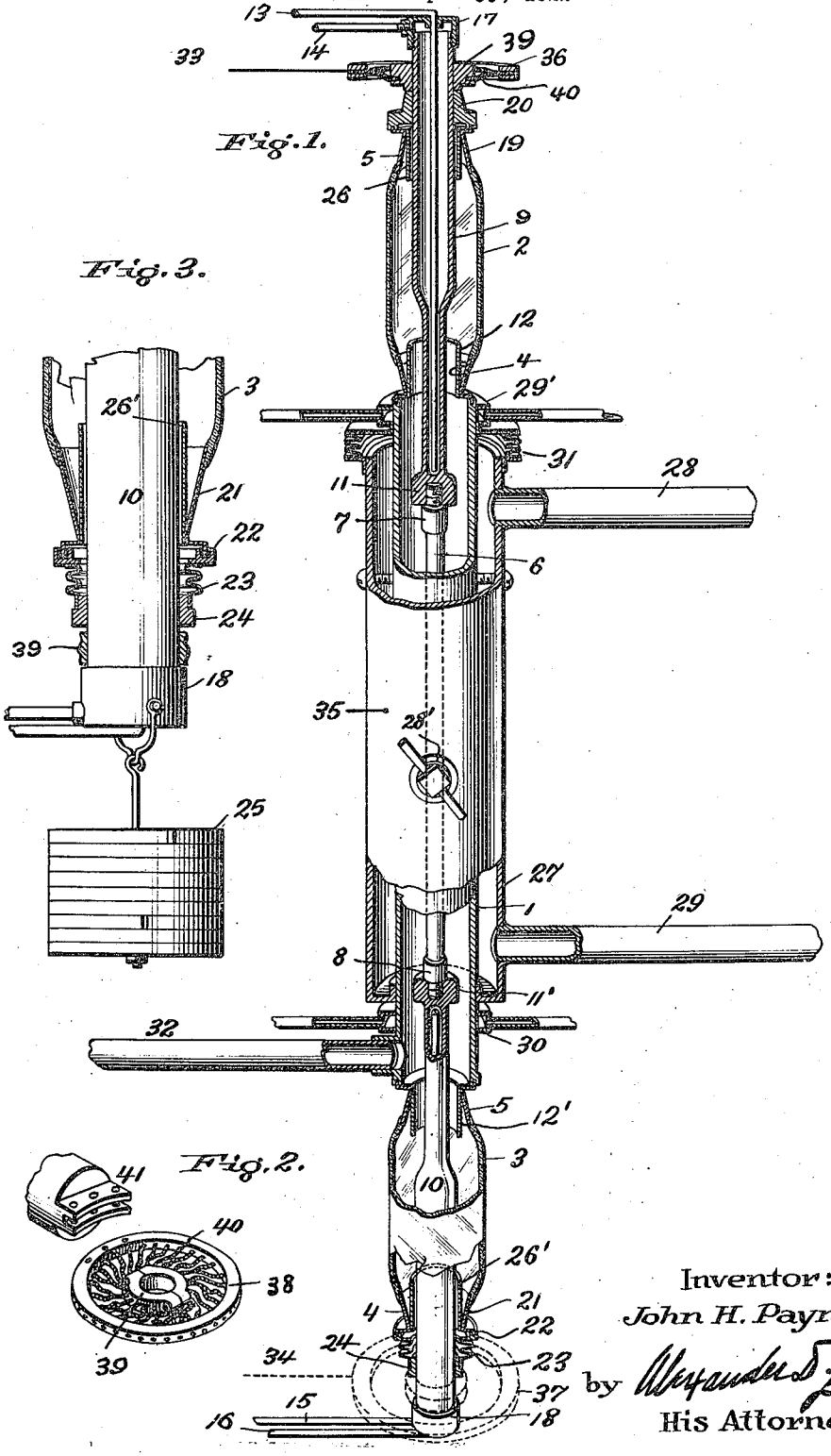
Oct. 12, 1926. 1,603,209

J. H. PAYNE, JR

ELECTRICAL DISCHARGE DEVICE

Filed Sept. 30, 1922



Inventor:
John H. Payne Jr.,
by Alexander S. Lunt,
His Attorney.

Patented Oct. 12, 1926. 1,603,209

UNITED STATES PATENT OFFICE.

JOHN H. PAYNE, JR., OF BALLSTON SPA, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

ELECTRICAL DISCHARGE DEVICE.

Application filed September 30, 1922. Serial No. 591,495.

The present invention relates to the construction of electrical discharge devices of large power, and it is the object of my invention to provide a device of such high current-carrying capacity, and of such ruggedness and reliability that it may be employed for transmitting and controlling electric currents for industrial purposes.

Although the benefits of my invention are not restricted to any particular form or type of electrical discharge apparatus, my invention may be advantageously embodied in a high powered discharge device adapted to be controlled by the magnetostrictive effect; that is, the current-controlling effect of the magnetic field of the heating current traversing the cathode.

As considerable heat is liberated at the anode, or plate, of an electron discharge device, this electrode in some instances has been constituted the container so as to permit of efficient cooling. The cathode was sealed in a glass stem which in turn was sealed to the lip or rim of the container. Although this construction increased the power capacity of this class of devices, it was found that other serious limitations were encountered as the transmitted energy was increased. One limitation was imposed by the current-carrying capacity of the conductors which were sealed into glass. Another serious limitation was conditioned by the relative displacement of heavy metal parts when expanding and contracting over the wide range of temperatures to which electrical discharge devices are subjected, for example, rupture of seals is likely to be caused by the expansion at high temperatures of a heavy cathode when held in a fixed relation to the container and other parts which operate at a lower temperature. The difficulty of disassembling a device in which glass is sealed directly to the electrodes rendered repair of such a device impracticable, or at least very expensive.

In accordance with one of the features of my present invention, I have provided an electrical discharge device in which are provided easily demountable seals for large, rigid conductors in gas-tight and electrically insulating relation to a metal container. In accordance with another feature of my invention, I provide a construction permitting displacement during expansion of the parts of an electrical discharge apparatus while maintaining the apparatus gas-tight. The above and other structural features of my invention, for example, novel cooling arrangements, will be set forth with greater particularity in the accompanying claims.

The accompanying drawing shows in Fig. 1 a longitudinal sectional view of an apparatus embodying my invention; Fig. 2 is a detail view of a terminal, and Fig. 3 shows somewhat enlarged and partly in section the lower end of the apparatus.

The apparatus shown in Fig. 1 comprises an enclosing tube 1, consisting of copper, or other suitable metal, joined at opposite ends to glass tubes 2, 3 by conical rings or thimbles 4, 5 consisting of a copper coated alloy of nickel and iron having a coefficient of thermal expansion approximately that of the adjoining glass. A flux of borax or the like preferably is provided on these thimbles when making the seal by fusion of glass. These thimbles 4, 5 are joined to the tube 1 by inserting the rim of the thimbles in a groove in the tube 1, a solder being applied to make a tight seal, shown in Fig 3, (as hereinafter described and in connection with the junction of parts at the lower end of the device).

A rod-like cathode 6 extends axially through the tubular anode 1. The cathode consists of a suitable refractory metal, for example, tungsten. It is joined by swaging, or other convenient way, at opposite ends to threaded caps 7, 8 of machinable refractory metal, as for example, molybdenum which in turn are screwed, or otherwise inserted, into heavy tubular conductors 9, 10, preferably consisting of copper. The enlargements 11, 11′ upon the ends of the cathode conductors 9, 10 act as shields to prevent electrons striking the glass or seals at the extremities of the tube. The narrowness of the space between the shields 11, 11′ and the tube 1, prevents the entry of an electron discharge. Additional shields 12, 12′ preferably are provided between the leads 9, 10 and the thimbles 4, 5 to completely protect the seals from over-heating.

The tubular cathode conductors 9, 10 are artificially cooled by water, or other suitable fluid, supplied respectively by tubes 13, 14 to the conductor 9 and by tubes 15, 16 to the conductor 10. These tubes project through the terminal caps 17, 18. The respective inlet tube of each set extends into

close proximity to the connection of the terminal conductors with the cathode. The ends of the glass tubes 2, 3 are sealed to make a gas-tight closure.

At the upper end of the tube the thimble 19 which is joined to the glass tube 2 by fusion of the glass is also joined by solder (as shown in Fig. 3) directly to a conical metal closure 20, which in turn is soldered to the cathode lead 9. At the lower end of the tube the thimble 21 is joined by solder to a ring 22 in turn attached to an extensible collar 23 consisting of sylphon metal or other suitable material. The diaphragm is joined to a ring 24 fixedly attached to the tube 10. The solder in 22 should have a lower melting point than the adjoining parts to permit softening the solder by heat when demounting the apparatus. The extensible crimped metal collar which constitutes part of the enclosing container permits relative displacement of the cathode 6 and the anode 1 without injuring the apparatus. A weight or spring 25 may be attached to the lower end of the cathode conductor 10 to exert traction upon the cathode. When the device is suitably supported, the weight may be hung from the terminal cap 18 thus holding the diaphragm extended to prevent displacement of the parts during operation. Shields 26, 26′ preferably also may be provided between the thimbles 19, 21 and the cathode leads 9, 10 respectively although these shields are not essential.

Externally the anode 1 is surrounded by a jacket 27, conveniently consisting of brass, and provided with inlet and outlet tubes 28, 29 for circulating a cooling fluid in contact with the anode 1. A removable closure 28′ may be provided to permit inspection of the anode 1 especially during the preliminary bake-out, when removing gas. Fluid-cooled collars 29′, 30 are interposed between the seals 4, 5 and the anode section and adjacent the current receiving portion of the cathode 6 to permit heating the anode by operating the tube to drive out gas without overheating the seals. An expansible diaphragm 31 is provided as part of the jacket 27 to permit relative linear displacement of the anode 1 and the jacket 27 when subjected to different temperatures. Evacuation of the gas space within the enclosure 1 occurs through a tube 32 leading to a suitable pump.

An electron discharge may be controlled by a magnetic field generated by a current traversing one of the electrodes. For example, in the apparatus above described, the magnetic field of the current traversing the cathode may be used to control the electron current traversing the device, commonly known as the space current. When the cathode current exceeds a critical value the space current decreases and at higher cathode currents falls to zero by the choking action of the electromagnetic field, which is known as the electrostrictive effect, the relation between the cathode current I, the diameter D, of an enclosing anode. The diameter d of the cathode to the voltage V impressed between cathode and the anode at which the reduction of space current occurs (cut off voltage) may be expressed as follows:

$$V = .0188\, I^2 (\log \frac{D}{d})^2$$

In the above described device, extremely high powers of the order of magnitude of 1000 kilowatts may be controlled by the electrostrictive effect, no auxiliary electrodes being necessary. For example, a powerful high frequency current may be produced from a direct current, by impressing a high frequency current of half the desired frequency upon the cathode by the conductors 33, 34 and connecting the cathode 6 and the anode 1 to a suitable source of direct current by the conductors 33, 35. The connection of conductor 35 to the anode has merely been indicated as terminal clamps suitable for this purpose are well known.

As shown in Fig. 2 the terminals 36, 37 preferably consist of a copper ring 38 connected to a split clamp 39 by flexible radial wires 40. The ring 38 engages with a channel in an arc-shaped fixed terminal 41. Firm contact may be secured by drawing the engaging parts together by bolts for which the holes have been indicated. This construction permits making a firm electrical contact while still permitting longitudinal movement of the cathode and provides a low resistance for high frequency currents as the skin effect is reduced by radial arrangement of the conductors 40.

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

1. An electrical discharge device comprising an envelope, an electrode sealed therein at regions spaced apart and yielding means constituting part of said envelope permitting changes of length of said envelope.

2. An electrical discharge device comprising a cylindrical envelope, and a substantially rigid conductor sealed into opposite ends thereof, said envelope consisting in part of yielding material permitting longitudinal expansion and contraction of said conductor.

3. An electrical discharge device comprising a tubular electrode, a linear electrode axially located within said tubular electrode, a yieldable collar interposed between said electrodes and insulating means for completing the enclosure of the space between said electrodes.

4. An electrical discharge device compris-

ing a cylindrical electrode, an electrode for producing an electrical discharge therein, means for insulating said electrodes from each other and a yieldable gas-tight closure located between said electrodes whereby longitudinal displacements of said electrodes are permitted while a gas-tight condition is maintained.

5. An electrical discharge device comprising a linear electrode capable of supporting an electrical discharge, a cylindrical electrode surrounding said linear electrode, a cylindrical section of insulating material sealed to said cylindrical electrode and a yielding link interposed between said insulating section and said linear electrode and sealed thereto.

6. An electrical discharge device comprising an enclosure, means for supporting therein an electrical discharge, a second enclosure about said first enclosure and connected thereto the wall of said second enclosure in part at least including an extensible portion to permit longitudinal displacement of said enclosures when at different temperatures.

7. An electrical discharge device comprising an evacuated vessel consisting in part of metal, glass tubes sealed to opposite ends of said vessel, an electrode extending through said vessel and projecting from the outer ends of the glass tubes, and means connecting the glass tubes and said electrode, said means including a crimped extensible collar.

8. An electrical discharge device comprised in part at least of a glass member, a metal sleeve fusion-sealed into said glass member at one end, and a metal member having a groove engaging with the opposite end of said sleeve and a seal of metal of lower melting point than said engaging member making a gas-tight seal at the joint between said members.

9. An electrical discharge device comprising an enclosure consisting of a main section of metal joined to terminal zones of glass, metal members sealed to said glass zones, and conductors soldered to said metal members.

10. An electrical discharge device comprising cooperating electrodes one of which consitutes part of an enclosure for the other electrode, means for insulating said electrodes from each other and separate means for sealing said enclosure by fusion of metal.

11. An electrical discharge device comprising an enclosing envelope, a conductor therein operable at an elevated temperature and means external to said device for maintaining said conductor taut when heated.

12. An electrical discharge device comprising a tubular anode, a rod-like cathode extending axially through said anode, rigid current conveying conductors connected to opposite ends of said cathode, closures at opposite ends of said anode joined to said respective cathode conductors, each of said closures including an insulating section and at least one of said closures including an extensible section to permit relative changes of length of said electrodes to occur without injury, an enclosing jacket mounted upon said anode and joined thereto, said jacket also including an extensible section and means for circulating a cooling fluid through the space between said anode and said jacket.

13. An electrical discharge device comprising a tubular anode, a rod-like cathode extending therethrough, rigid current-conveying conductors connected to opposite ends of said cathode, cylindrical insulating closures respectively sealed to opposite ends of said anode, metal members including an easily fusible seal connecting said closures to said respective cathode conductors, one of said members comprising an extensible section and external means for exerting traction upon said cathode.

14. An electrical discharge device comprising a cylindrical anode, a rod-like cathode located therein, electric terminals for said cathode, closures including an insulating section sealed between the ends of said anode and said terminals, one of said closures being provided with an extensible section and means external to said device for exerting traction upon said cathode, to maintain said cathode taut when expanded at operating temperatures.

15. In combination, an electrical device comprising a metallic casing, an electrode supported in the casing, a seal mounted on the casing, said seal including a vitreous sleeve, means connecting said electrode and seal, said means including a flexible member.

16. In combination, an electrical device comprising a casing, an electrode rigidly mounted within the casing, a seal, including a vitreous portion, associated with said casing and electrode, means connecting the electrode and seal, said means including a crimped extensible collar.

17. In combination, an electrical device comprising a metallic casing, an electrode rigidly mounted within the casing, a seal mounted on said casing, said seal including a vitreous sleeve, means connecting said electrode and seal, said means including a crimped extensible collar.

In witness whereof, I have hereunto set my hand this 29th day of September, 1922.

JOHN H. PAYNE, JR.