

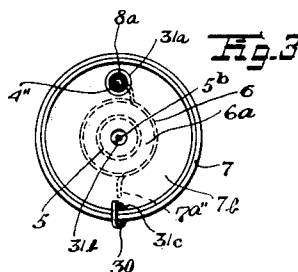
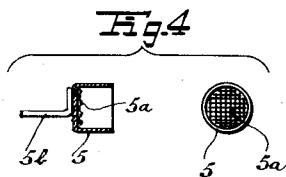
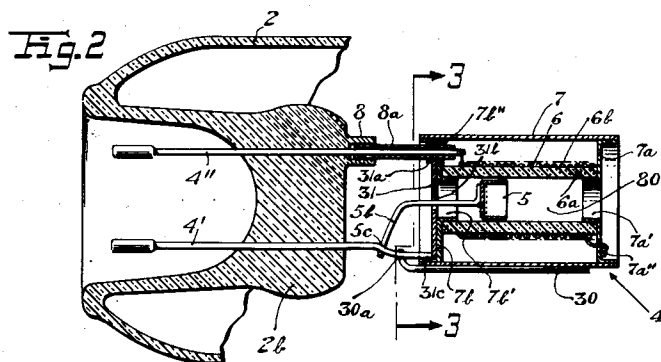
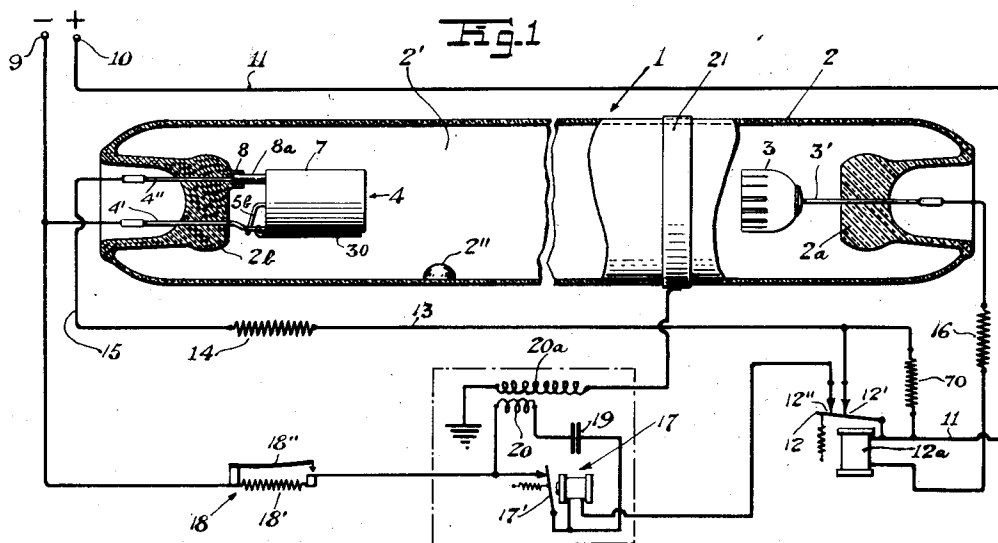
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ELECTRIC DISCHARGE DEVICE

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ELECTRIC DISCHARGE DEVICE

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This invention relates to electric discharge devices, and more particularly to such devices wherein an arc discharge takes place in a gaseous atmosphere—i. e., of gas, metal vapor, or a combination of one or more gases and/or vapors.

In initiating the operation of such devices it is common practice to heat the cathode or cathodes proper by appropriate heating elements adjacent thereto and energized by some external source of current, this heating serving both to bring the cathode to substantially normal emissivity before the arc strikes through the device, and also to facilitate the striking of the arc. After the arc has struck, however, the impact of the arc upon the cathode is sometimes largely or even wholly relied upon to maintain the cathode at normal emissive temperature, the externally supplied heating current above mentioned being materially reduced or wholly cut off.

It is always important, however—particularly with coated cathodes—to maintain the cathode at a temperature sufficiently high and even throughout, otherwise the arc will destructively concentrate on a small spot of the cathode surface, overheating and disrupting the surface material at this spot, shifting to and disrupting another small spot, and so on to the rapid ruination of the cathode. When the arc impact is wholly or largely relied upon to maintain the cathode at normal emissive temperature (the above mentioned practice of materially reducing or cutting off the externally supplied heating current being followed), it is frequently extremely difficult to maintain the cathode at the requisitely high and even temperature.

It is an object of this invention to provide an improved cathode structure adapted for proper cathode temperature maintenance wholly or principally by the arc impact.

It is another object to provide improved cathode pre-heating means which will not interfere with proper heating of the cathode by arc impact during the normal operation of the discharge device.

It is another object to provide improved mutual arrangements of cathode and heater to result in satisfactory operation of the discharge device both during pre-heating and normal arc discharge periods.

General objects are the provision of an improved discharge device system, and of a generally improved cathode structure therefor.

Other and allied objects will more fully appear from the following description and the appended

claims.

In the detailed description of my invention, hereinafter set forth, reference is had to the accompanying drawing, of which:

Figure 1 is a view, partly elevational and partly sectional, of a typical discharge device in which my invention has been incorporated, together with a diagrammatic view of a typical operating circuit therefor;

Figure 2 is an enlarged sectional view of a portion of Figure 1, including the cathode structure in detail;

Figure 3 is a cross-sectional view taken along the line 3—3 of Figure 2;

Figure 4 is a further enlarged sectional and end view of the cathode proper.

Reference is first invited to Figure 1, wherein I have illustrated a discharge device incorporating my invention, together with typical operating circuits therefor. The device may for example be a luminous discharge device, and may comprise the elongated glass envelope 2 having the seals 2a and 2b at its respectively opposite extremities. The space 2' within the envelope 2 is evacuated of air and may be filled with a noble gas, such as neon, krypton or argon; alternatively or additionally to the gas filling there may be provided within the space 2' a source of metal vapor, such as the globule 2'' of mercury, adapted to vaporize upon heating of the device. Passing through the seal 2a may be the tungsten or other lead wire 3' to which is supported and connected the carbon or other anode 3. Passing through the seal 2b may be two tungsten or other lead wires 4' and 4'', to which is supported and connected the cathode structure 4. The cathode structure, and the manner of its support and connection to the lead wires 4' and 4'' are illustrated in Figure 2 and hereinafter set forth in detail; it may at this point be mentioned, however, that the cathode proper (5, Figure 2) is connected to the lead 4', and that a heating element (6, Figure 2) is connected between the leads 4' and 4''.

The operating circuits have been shown, by way of simple illustration only, as adapted for connection to a D. C. line by means of terminals 9 and 10. The heater circuit,—i. e., for the heating element 6—may be traced from the positive terminal 10, through conductor 11, circuit-breaker switch 12', conductor 13, resistance 14, and conductor 15 to the lead wire 4'', through the heating element 6, and from the lead wire 4' to the negative terminal 9. The circuit for the discharge current may be traced from positive terminal 10 through conductor 11, circuit-breaker coil 12a, ballasting resistance 16 and lead wire 3' to the an-

ode 3, and from the cathode through the lead wire 4' and to the negative terminal 9. The circuit-breaker coil 12a, being serially disposed in the discharge current circuit, is energized upon the occurrence and throughout the continuance of the arc discharge, and when and while energized opens and maintains open the circuit-breaker switch 12'; thus the heater circuit, closed at switch 12' until striking of the arc discharge through the device, becomes open upon that striking, reducing the current through and voltage across the heating element each to zero. If desired, however, a resistance 70 may be shunted across the switch 12' so that the reduction of the voltage and current will be partial only, rather than to zero.

For causing the arc discharge to strike through the tube there is provided from the conductor 11 to the terminal 9 a starting circuit serially comprising a circuit breaking switch 12'' operated simultaneously with the switch 12' (having for example the same pole 12), a vibrator 17 and a thermostatic switch 18—the latter comprising a resistance 18' and an arm 18'' responsive to heat generated in the resistance and arranged upon response to short circuit the resistance. When the terminals 9—10 are first connected to the line and the heater circuit thus energized, the starting circuit is energized; the resistance 18', which limits the current to less than required for vibrator operation, accordingly begins to heat. After an interval—which by adjustment of the arm 18'' may be made substantially coincident with the interval required for the heater element 6 to bring the cathode to normal emissivity—the arm 18'' shorts out the resistance 18' and the vibrator 17 starts to operate. The appearance between anode and cathode of the inductive kick attendant upon the operation of the vibrator may be sufficient to cause the arc to strike; but I have shown, as a positive and well-known means for causing the arc to strike upon vibrator operation, a serially arranged condenser 19 and high frequency coil 20 shunting the contacts of the vibrator 17 and a second high frequency coil 20a coupled to the coil 20, and connected between a starting ring 21 (closely surrounding the device intermediate anode and cathode) and ground (ground if desired being made electrically coincident with the negative terminal 9). It will be noted that the open condition of circuit-breaker switches 12' and 12'' throughout the continuance of the arc discharge will then maintain open not only the heater circuit but also the starting circuit, so that the vibrator will not continue to operate after it has performed its function.

The structure as thus far described does not itself comprise the instant invention, but is shown and referred to as typical of a simple system in which my invention, which concerns principally the cathode structure 4, may be advantageously employed.

In order that the cathode proper may be sufficiently and evenly heated by the arc impact, it is important that heat losses from the cathode be kept at a relatively small value. Were the cathode capable of complete isolation from other components this specification could be fairly easily adhered to. But in a device in which the cathode is to be pre-heated as hereinabove mentioned, the necessary adjacency of the heating element makes much more difficult the minimization of these heat losses. The heater during continuance of the discharge is subjected to little or no

heating excepting by the cathode, and consequently runs at least somewhat cooler than the cathode; accordingly significant losses may occur to it. The degree of these losses is of course determined not only by the initial cathode-to-heater transfer tendencies, but also by the tendencies for heat transfer from the heater to elements or media other than the cathode.

In most conventional constructions the heater is placed within the cathode, a relatively high coefficient of thermal coupling resulting from this relative disposition; of the effective mutually exposed heater and cathode areas that of the heater is materially the smaller. Much of the heat transfer from the heater is of course intercepted by the cathode; but considerable loss transfer inevitably occurs—for example through lead-in wires, etc., no matter how thoroughly the cathode may surround the heater. By virtue of the cathode interception of much of the transfer from the heater, the necessary power consumption of the heater during starting for pre-heating the cathode is moderate. Other conventional constructions depart somewhat from those just mentioned, in that the heater is placed on one side of or behind the cathode. Not quite as much of the heat transfer from the heater is now intercepted by the cathode; and of course the necessary power consumption of the heater for pre-heating the cathode is somewhat increased. Of the effective mutually exposed areas of heater and cathode, however, that of the heater remains the smaller; and the coefficient of thermal coupling, as resulting from the relative dispositions of heater and cathode, remains fairly high.

I have found that with these conventional constructions difficulty is experienced in so apportioning and arranging the elements that the cathode will be properly heated by the arc impact, and that at the same time the heater will be of a sturdy construction and of satisfactory life. According to this invention I reverse the usual arrangements in several respects; I form the cathode within the heater; of the effective mutually exposed areas of heater and cathode I make that of the heater materially larger; the coefficient of thermal coupling, as resulting from the relative disposition of heater and cathode, I make relatively low; and in other ways I depart from the conventional constructions to produce an improved cathode structure 4, as will now be described in detail with reference to Figures 2, 3 and 4—

The cathode 5 may be formed as a small cup, for example of nickel, the bottom of the cup being welded on its outside to the nickel or other supporting wire 5b which is in turn welded to the lead-in wire 4' so as to maintain the open top of the cup facing the arc stream. On the interior bottom of the cup may if desired be welded the grating or mesh 5a (see Figure 4), the inside bottom of the cup, including the mesh, being coated with a suitable oxide or oxides according to well-known cathode coating practice. The cathode so described and illustrated will be recognized as one which is not only of small extent, but also of small mass; it may be considered as of shell formation, in distinction to cylindrical and other solid cathodes.

Supported about the cathode cup, co-axial therewith and spaced at least slightly therefrom, is an alumina or other ceramic tube 6a, of length exceeding by several times the axial length of the cup; preferably this will overhang the cup to a greater extent in the direction of the anode

than in the opposite direction. On the outside of this tube 6a is wound the helical heating element 6, which may be relatively fine resistance wire closely spaced. Desirably there is coated and dried over the heating element a solution of alumina powder in amyl acetate or the like, to form an insulating layer 6b in which the heating element is imbedded; this obviates the danger of mechanical shorting of turns and otherwise renders the heating element more sturdy. The extremities of the heating element 6 are electrically connected with the lead-in wires 4' and 4'' as hereinafter more particularly described.

In a circuit of the character described and shown in Figure 1 it is desirable to operate the heater during the starting period at relatively high voltage and low current, rather than vice versa—otherwise the power losses in the resistance 14 become excessive. Were the heating element 6 and its extremities exposed to the gaseous atmosphere within the tube, the permissible heater voltage would be limited to a relatively low value, because of danger of arc-backs. For this reason, as well as for others hereinafter developed, I surround the outside of the tube 6a and the heating element 6 with a metallic shield. This is formed of a nickel or other cylinder 7, of appreciably larger diameter than the tube 6 and preferably of slightly greater length, maintained coaxial therewith by two similar circular nickel or other end members 7a and 7b at the ends of the cylinder toward and away from the anode, respectively. These members may be outwardly flanged at their peripheries to fit within the end portions of the cylinder 7, and may be provided with central hole (7a' and 7b' for the two members, respectively) inwardly flanged to fit within the end portions of the tube 6.

The entire enclosure 7—7a—7b being electrically connected with the lead-in wire 4', one end of the heating element 6 may be welded to the end member 7a as at 7a''. The other end of the heater is welded within the enclosure to the other lead-in wire 4'', which must be introduced into the enclosure without significant exposure to the gaseous atmosphere within the device. To adhere to this last specification I may form a glass or other ceramic flange 8, spaced about the lead-in wire 4'' and extending somewhat interiorly of the device from the seal 2b, and bring the lead-in wire 4'' from within this flange into the enclosure through a suitable hole 7b'' in the end member 7b, entirely encased in a glass or other ceramic tube 8a which fairly snugly fits the interior of the flange 8 and which at least substantially fits the hole 7b''.

For a convenient and practical procedure for forming the cathode structure I may proceed as follows, first having the heating element wound upon the tube 6a and imbedded in the layer 6b, having a longitudinally extending stiffening wire 30 welded to the outside of the cylinder 7 co-axial therewith, and having the cathode prepared and welded to its supporting wire 5b: I may first slip the ceramic tube 8a over the lead-in wire 4''. I may next slip over the tube 8a a nickel or other disc 31, which is pierced and flanged near its periphery (i. e., at 31a) quite close to fit over the tube 8a, which is provided with the central aperture 31b, and which is of external diameter just adapted to fit within the flanged end member 7b; the disc 31 may be brought into abutment against the end of the lead-in wire 4' and thereto welded as at 31c. I may next place the end member 7b against the disc 31, welding it thereto and if de-

sired to the end portion of the lead-in wire 4'. Next I may pass the cathode supporting wire 5b through the end-member and disc holes 7b' and 31b, and weld it to the lead-in wire 4' as at 5c. Next I may assemble the end-member 7a on the tube 6a, weld an extremity of the heating element thereto at 7a'', slip the tube 6a in place on the end-member 7b, and weld the other extremity of the heating element to the extremity of the lead-in wire 4''. Finally I may slip over the end-members the cylinder 7, welding the same to their flanges, and bending the wire 30 into contact with the lead-in wire 4' and welding it thereto as at 30a.

Beside performing the useful function of shielding the heating element 6 to prevent arc-backs, the enclosure formed by cylinder 7 and end members 7a and 7b greatly increases the efficiency of the heating element 6 in its cathode pre-heating function. It quite effectively shields the heating element 6 from the gaseous atmosphere, preventing convection cooling, and even serves to some extent to reduce radiation losses by reflection to the heating element. With the cylinder 7 the cathode structure 4 becomes a furnace having exterior insulation provided by the enclosure 7—7a—7b, and the heater which may be considered to comprise the heating element 6 and refractory tube 6a and layer 6b, and to form the interior furnace wall defining the interior chamber 80. One end of this chamber must be open (i. e., at 7a') for admission of the arc stream during normal operation; but the chamber is relatively long and narrow, and this construction, together with the preferred location of the cathode relatively further from the open end, largely overcomes the disadvantages of the presence of the opening during the pre-heating period. The net result of this construction is that the heating element power requirements for pre-heating, while of course larger than those for a heater artfully disposed within an associated cathode, remain reasonable. The far greater permissible physical size of the heater, than in a structure wherein attempts are made to keep the heater small with respect to a necessarily small cathode, facilitates the apportionment of the heating element and its power consumption to result in rapid pre-heating, without risking short life or necessitating a mechanically weak heater or heating element construction.

During normal operation, when the heating current is cut off or reduced and the requirement is for conservation of cathode heat, the operation of the improved cathode structure is likewise highly satisfactory. The effective area of the cathode exposed to the heater, principally the peripheral area of the walls of the cup 5, is not maintained large as in the conventional effort to secure a high thermal coupling coefficient, but is instead made very small—materially smaller than the effective area of the heater (i. e., of the interior of tube 6a) exposed to the cathode. Radiation losses are thus minimized; in addition, of course, convection cooling of the cathode is substantially eliminated by the structure. The net heat losses are therefore greatly minimized, and the arc impact is thus able to maintain the cathode at a high temperature throughout, with avoidance of spot arcing.

It will be understood that while I have illustrated a particular embodiment of my invention, and have described the invention with reference to that embodiment, I do not intend to be limited

by the details thereof, but rather undertake to express the scope of my invention in the appended claims. Thus for example, I do not intend to limit the cathode of my invention to one of shell formation, or any of the other elements to the precise forms shown and described, excepting in claims specifically reciting such limitations.

I claim:

1. In an electric discharge device: a cathode, and a tubular heater surrounding said cathode, said cathode extending through only a minor intermediate portion of the length of said heater.

2. In an electric discharge device: a cathode, and a tubular heater spacedly surrounding said cathode, said cathode extending through only a minor intermediate portion of the length of said heater.

3. In an electric discharge device: a relatively small cathode in the form of a cup, and a tubular heater spacedly surrounding said cup, coaxial therewith, and of length several times the axial length of said cup.

4. In an electric discharge device: a cathode, and a furnace and a heating element included in the wall of said furnace, said furnace having a relatively long and narrow interior chamber containing said cathode, and said cathode extending through only a minor portion of the length of said chamber.

5. In an electric discharge device: a cathode, and a furnace and a heating element included in the wall of said furnace, said furnace having a relatively long and narrow interior chamber with one open and one at least substantially closed end, and said cathode being disposed within said chamber relatively near said closed end thereof.

6. In an electric discharge device having anodic discharge-supporting means: a cathode; and an apertured furnace surrounding said cathode, interposed between said cathode and said anodic means, and including a heating element, said cathode having an exterior area substantially less than the interior area of said furnace.

7. In an electric discharge device having anodic discharge supporting means: a cathode; and an apertured furnace surrounding said cathode interposed between said cathode and said anodic means, and including a heating element, the exterior area of said cathode being a minor fraction of the interior area of said furnace.

8. In an electric discharge device: a cathode substantially of shell formation, and a furnace surrounding said cathode and including a heating element, said furnace having an interior area of several times the exterior area of said cathode.

9. In an electric discharge device having anodic discharge-supporting means: a cathode; and an apertured furnace spacedly surrounding said cathode, interposed between said cathode and said anodic means, and including a heating element, said cathode having a mass substantially less than that of said furnace.

10. In an electric discharge device having anodic discharge-supporting means: a cathode; a heating element therefor, and a furnace including said element and removed from said anodic means, said cathode being spacedly and wholly contained within said furnace and having a mass substantially less than that of said furnace.

11. In an electric discharge device having

anodic discharge-supporting means: a cathode, a heating element therefor, and a furnace including said element and removed from said anodic means, said cathode being spacedly and wholly contained within said furnace and having a mass which is a minor fraction of the mass of said furnace.

12. In a gaseous discharge system including means for supplying a pre-heating current and for reducing said current during an initial period of operation: a cathode, and a tubular heater surrounding said cathode and connected with said supplying means, said cathode extending through only a minor intermediate portion of the length of said heater.

13. In a gaseous discharge system having anodic discharge-supporting means, and including means for supplying a pre-heating current and for reducing said current during an initial period of operation: a cathode, and an apertured furnace surrounding said cathode, interposed between said cathode and said anodic means, and including a heating element connected with said supplying means, the exterior area of said cathode being substantially less than the interior area of said furnace.

14. In a gaseous discharge system having anodic discharge-supporting means, and including means for supplying a pre-heating current and for reducing said current during an initial period of operation: a cathode; and an apertured furnace surrounding said cathode, interposed between said cathode and said anodic means, and including a heating element connected with said supplying means, the exterior area of said cathode being a minor fraction of the interior area of said furnace.

15. In a gaseous discharge system having anodic discharge-supporting means, and including means for supplying a pre-heating current and for reducing said current during an initial period of operation: a cathode; and an apertured furnace spacedly surrounding said cathode, interposed between said cathode and said anodic means, and including a heating element connected with said supplying means, said cathode having a mass substantially less than that of said furnace.

16. In a gaseous discharge system having anodic discharge-supporting means, and including means for supplying a pre-heating current and for reducing said current during an initial period of operation: a cathode, a heating element therefor connected with said supplying means, and a furnace including said element and removed from said anodic means, said cathode being spacedly and wholly contained within said furnace and having a mass substantially less than that of said furnace.

17. In a gaseous discharge system having anodic discharge-supporting means, the combination with means for supplying a pre-heating current and for reducing said current during an initial period of operation: of a heater removed from said anodic means, and connected with said supplying means, and a cathode wholly contained within said heater, said cathode and heater being mutually disposed to have a low coefficient of thermal coupling.

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