Feb. 9, 1937. W. F. WESTENDORP 2,070,501

POOL TYPE DISCHARGE DEVICE

Filed June 13, 1935

Fig. 1.

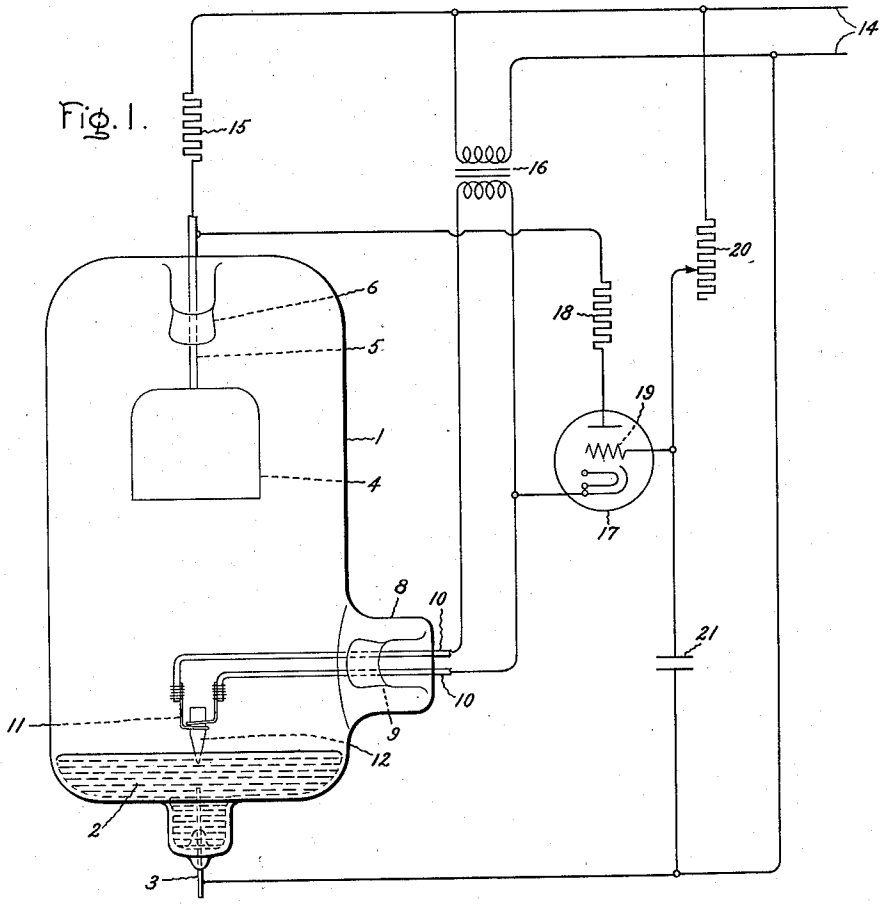


Fig. 2.

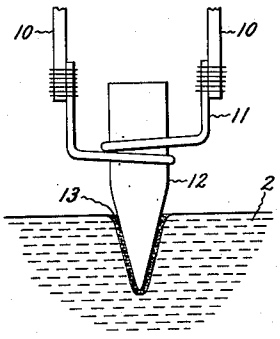
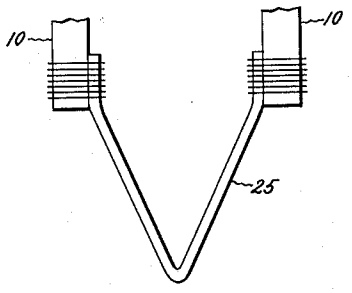


Fig. 3.



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POOL-TYPE DISCHARGE DEVICE

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5 Claims. (Cl. 250—27.5)

My invention relates to controlled pool type arc discharge devices, and more particularly to an improved starting electrode for such devices.

For uses involving the control of high intensity current, arc devices having a cathode comprising a pool or other large body of vaporizable material have outstanding advantages in view of their relatively great current-carrying capacity. Many applications of such devices, such as spot welding, require precise and delicate control of the instant of initiation of a discharge. Such control has previously been found difficult to obtain without the use of a holding arc and a separate grid electrode.

In accordance with my present invention, I have found that a continuously heated starting electrode projecting below the surface of the pool may be made to yield extremely accurate discharge regulation. Furthermore, the starting action of an electrode of this type requires only a low voltage and a very slight amount of power.

The novel features which I consider to be characteristic of my invention will be pointed out with particularity in the appended claims. My invention itself, however, may best be understood by reference to the following specification taken in connection with the accompanyinw drawing, in which Fig. 1 is a plan view of a discharge tube and work circuit embodying my invention, while Figs. 2 and 3 are detailed plan views of electrode structures suitable for the practice of my invention.

Referring more particularly to Fig. 1, I have shown a sealed transparent envelope 1 adapted to receive and retain in its base a pool 2 of mercury, or a similar material, which is capable of serving as an electron-emitting cathode. As substitutes for mercury I may alternatively employ such substances as gallium or tin which are capable of vaporization at relatively low temperatures. The pool 2 is connected to an external source of potential by means of a lead-in wire 3 which passes through a suitable glass to metal seal at the lowest point of the tube.

In the upper portion of the tube an anode 4 of graphite or molybdenum is supported by means of a rod of conducting material 5 which is passed through a conventional press 6 to the exterior of the tube. The anode is shown as comprising an inverted cup or bowl, but may take various other shapes without altering the effectivenes of its operation.

The envelope 1 is also provided with a lateral tubulation 8 having a re-entrant stem and press 9. A pair of rigid conducting rods 10 of low resistance material are passed through the press 9 and extend horizontally to a position above the center of the mercury pool. Their depending ends are interconnected by a filamentary resistance heater 11. This latter element is shown as comprising a single loop of wire which encloses and supports a starting electrode in the form of a stick or rod 12. I have found it practical to construct the starting electrode of various heat-resisting conducting materials such as tungsten, molybdenum, or tungsten carbide. A good thermal contact should exist between the electrode rod and the heating filament which when energized from a suitable supply source comprises means for maintaining the electrode at an elevated temperature independently of the passage of current between the electrode and the pool 2.

I have found that when the heater 11 is continuously energized by a current sufficient to maintain the electrode 12 above about 500° C. which is above the vaporization temperature of the mercury, a turbulent layer 13 will be established between the electrode and the mercury surface. As is illustrated in Fig. 2, the boiling of the mercury adjacent the heated electrode tip results in the creation of something equivalent to a series of casual or transitory point contacts between the tip and the pool. Consequently, if the starting electrode 12 is made positive with respect to the pool by an amount at least as great as 2 volts, the resulting current will generate enough heat to break the casual surface contact and ionize the vapor layer. As two volts is not enough to maintain an arc in mercury vapor, the current, which is momentarily sustained by the self-inductance of the leads, will drop rapidly until contact is made again at some point in the layer. Thereupon the current will once more build up and the cycle repeat itself. This process will take place very rapidly at a rate of 1000 times per second, or even more.

If the anode 4 is positive and the starting electrode 12 is also made positive with respect to the mercury pool, the ionizing action just described will cause the tube to break down and a main discharge to take place. Due to the fact that the electrode contact surface is continuously maintained at a sufficiently high temperature to keep the contiguous mercury in constant turbulence, this result will occur almost instantaneously upon energization of the starting electrode. The starting action is so rapid that no delay is observable with an instrument capable of detecting a lag as small as 50 micro-seconds.

For a more complete understanding of the man-

ner of operation of my invention, I have illustrated a typical work circuit in connection with which it may conveniently be utilized. In this the cathode and anode are connected to a pair of alternating current mains 14. In the anode circuit I have shown a direct current load 15 which is conventionally illustrated as a resistance, but may alternatively comprise an electrically operated mechanism, such as a spot welding set.

The heating element 11 is also connected with the source of power 14 through the intermediation of a step-down transformer 16. Starting current is furnished to the electrode 12 through a unidirectional discharge device 17 of such nature that current is permitted to flow only when the anode is positive with respect to the cathode pool. The plate electrode of the rectifier 17 is connected directly to the anode 4 in series with a resistance 18 which serves to restrain within desired limits the amount of starting current permitted to flow through the starting electrode to the mercury contact surface.

If the load circuit is such that it is desired to permit a discharge to occur only when the anode voltage has reached a certain critical value on the potential curve, the grid 19 may be utilized to control the functioning of rectifier 17. For this purpose the grid is shown as connected to a phase shifting device which comprises a resistance 20 and a capacitive impedance 21 serially connected across the mains 14. The grid 19 is connected intermediate these last two elements so that its biasing potential will depend upon the relation between them. Some measure of regulation of this potential is possible through adjustment of the resistance 20, which is shown as being of variable character.

As soon as the variation of alternating current potential causes the anode 4 to become positive with respect to the mercury pool there is a tendency for current to flow through conductor 20 and rectifier 17 to starting electrode 12. If such a flow should take place, a main discharge would be initiated immediately. The inhibiting effect of the grid 19, however, causes the flow of starting current to be delayed until a definitely predetermined value of positive anode potential has been reached. At such a time the reactance elements 20 and 21 permit a sufficient change in the bias imposed on the grid 19 to allow starting current to flow. The main arc thus initiated will then persist until the anode once more becomes negative with respect to the cathode. In this way an exactly measured amount of power is transmitted to the load 15 during positive half cycles. This can be varied only by altering the phase shifting quality of the impedance elements 20 and 21.

In Fig. 3 I have illustrated a modified electrode structure which may be employed in the practice of my invention. This comprises a filament 25 suitably supported in electrical contact with a pair of heavy conductors which correspond to the elements 10 of Fig. 1. In the use of this embodiment the filament 25, which may be composed of tungsten, molybdenum, or other heat-resisting material, is permitted to project below the surface of the mercury pool. Its operation is then entirely similar to that of the electrode member 12 above described.

While I have shown a particular embodiment of my invention, it will of course be understood that I do not wish to be limited thereto since many modifications in the structure may be made, and I contemplate by the appended claims to cover all such modifications as fall within the true spirit and scope of my invention.

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

1. In combination, an arc discharge device including an anode, a pool-type cathode, and an electrode positioned in permanent contact with said pool, the starting of said device being dependent on the passage of current between the contacting surfaces of said electrode and said pool, means for impressing a starting potential between said electrode and said pool, and separate means for maintaining said electrode at an elevated temperature independently of the passage of current between said electrode and said pool.

2. In combination, an arc discharge device including an anode and a pool-type cathode, means for impressing an alternating discharge potential between said anode and cathode, an electrode positioned in permanent contact with said pool, the starting of said device being dependent on ionization produced by the passage of current between the contacting surfaces of said electrode and said pool, means for producing a starting current between said electrode and said pool in predetermined time relation to said discharge potential, and means for continually heating said starting electrode independently of the passage of current between the electrode and the pool.

3. In an arc discharge device including an anode, a vaporizable cathode body, a rod of heat-resisting conducting material in permanent contact with said cathode body, the starting of said device being dependent on the passage of current between the contacting surfaces of said rod and said pool, means for impressing a starting potential between said rod and said pool, and means for maintaining said rod at an elevated temperature independently of the passage of current between said rod and said pool.

4. In combination, an arc discharge device including an anode and a mercury-pool cathode, a pointed rod of conducting heat-resisting material projecting into permanent contact with the mercury pool, a loop of resistance wire encircling said rod for supporting and heating the same, a potential source for continually supplying heating current to said resistance wire, and means for impressing a starting potential between said rod and said pool independently of said first-named potential source.

5. In combination, an arc discharge device including an anode, a pool-type cathode and a heat-resisting conducting filament in permanent contact with said pool, the starting of said device being dependent on the passage of current between the contacting surfaces of said filament and said pool, means for impressing a starting potential between said electrode and said pool, and means for circulating heating current through said filament independently of the passage of current between the filament and the pool.

WILLEM F. WESTENDORP.