Dec. 18, 1951 I. W. COX 2,579,366

CONTROL CIRCUIT FOR MULTIPLE HIGH RESISTANCE IGNITION ELECTRODE

Original Filed Nov. 12, 1948

Fig. 1

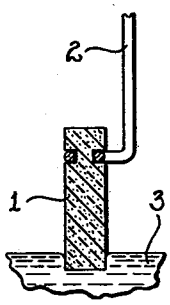


Fig. 2

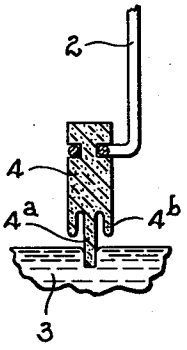


Fig. 3

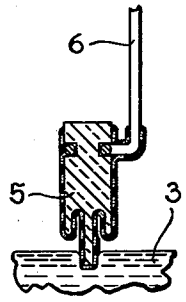


Fig. 4

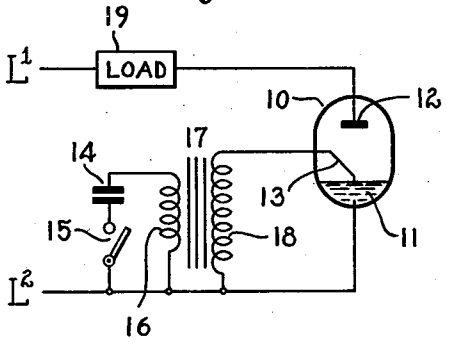


Fig. 5

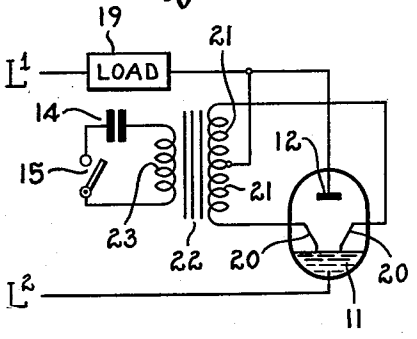
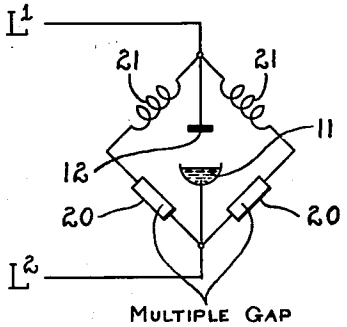


Fig. 6



MULTIPLE GAP ARC STARTING IONIZER.

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CONTROL CIRCUIT FOR MULTIPLE HIGH RESISTANCE IGNITION ELECTRODE

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Original application November 12, 1948, Serial No. 59,480. Divided and this application April 13, 1950, Serial No. 155,652

3 Claims. (Cl. 315—341)

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This invention relates to control circuits for liquid cathode type tubes having multiple high resistance ignition electrodes.

The present application is a divisional application of my copending application Serial No. 59,480, filed November 12, 1948, for Multiple Gap Arc Starting Ionizers, now Patent No. 2,533,095, issued December 5, 1950.

Discontinuous starting means in which a gap is introduced into the ignition circuit adjacent to the cathode have been in use for a long time. One of the earliest types of discontinuous starting means included an external band on the outside of the glass envelope of the tube opposite and adjacent to the top surface of the mercury pool cathode on the inside. In order to reduce the high potential stresses on the glass, the band was later placed on the inside of the glass as a thinly insulated probe projecting into the mercury pool. To ionize the mercury vapor in the tube for starting a discharge current between the main electrodes, a high voltage was suddenly applied between the mercury cathode and the starting band, creating a sudden high gradient therebetween and producing a minute and random visible spark which, under the influence of the anode-cathode potential, grew into an arc spot which started the main discharge of the tube.

External band type ionizers are shown in the Hewitt Patent No. 682,690, granted September 17, 1901. The internal band immersed type starters were used soon thereafter. The advantage of the internal type starter band is the fact already stated that the dielectric resistance between the mercury pool and the starting band could be reduced. The external type band was, of necessity, separated from the mercury pool by a distance equal to the thickness of the glass, which thickness was, for mechanical reasons, relatively great. Thus with the internal type starter band the voltage necessary to produce arc starting ionization was substantially reduced.

Several modifications of internal discontinuous starters have been tried, but they have not come into general use, as they were short-lived and fragile and subject to puncture of the adjacent glass wall due to: deterioration of the dielectric; gradual wetting of the dielectric surface between the ionizer and the cathode; reaction of the ingredients of the ionizer sheath with the mercury, and to the impurities which accumulate on and in the mercury due to chemical processes which are accelerated by electric stresses operating on the material of the walls of the tube and on the insulating sheath of the ionizer.

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An improved form of internal discontinuous starter was disclosed in U. S. Patent No. 1,410,702, granted March 28, 1922, to F. W. Meyer, and assigned to the same assignee as the present invention. In Patent No. 1,410,702 is described a carborundum rod placed inside of the tube in proximity to but out of contact with the mercury. The rod was provided with a sharp point adjacent the mercury surface to provide a gap having an extremely intense field of ionization, which produced an arc spot on the mercury. The ionizing starter herein disclosed is an extension of the Meyer type to n gaps. It employs a discontinuous ionizing means which, at ordinary line voltage, is essentially a non-conductor, being made up of a series of gaps between conducting particles which may be carborundum crystals or the like embedded in a normally non-conducting ceramic. Discontinuous material of this general character has been known for a long time.

The Gage U. S. Patent 1,105,070, dated July 28, 1914, page 1, lines 77 to 84, discloses such a material. However, the material of the Gage patent was intended for use only as a resistor, such as those employed for high temperature furnaces and the like, and was not intended for use as an ionizer for mercury vapor tubes. In the Gage device currents of many amperes are conducted throughout the cross section of the material, while in accordance with my invention the operation depends entirely upon the formation of an ion sheath at the surface, as will be pointed out more in detail hereinafter. The present invention relates to an arc starting ionizer which is of such composition and form that it may be used as an internal starter for tubes of the cathode pool type without being subjected to the deterioration above referred to and common to previously known starters of the band type. The operation of the device herein disclosed is furthermore not dependent on its temperature or on the current density inside of the ionizer.

An object of the present invention is to provide a novel type of discontinuous arc starting ionizer for cathode pool type electron tubes.

Another object is to provide an arc starting ionizer which is mechanically but not conductively in contact with the cathode pool.

Another object is to provide an arc starting ionizer which will operate reliably for an unusually long period of time.

Another object is to provide such a device which is not short-circuited by liquid vapors which have a tendency to condense on and amalgamate with internal ignition devices.

Another object is to provide a device of the type described which is self-cleaning, or self-restoring.

Another object is to provide an ignition circuit, for liquid pool cathode type tubes, of improved reliability.

Another object is to provide an ignition circuit, for liquid pool cathode type tubes, which insures against impression of excessive voltages from the ignition circuit upon the main circuit controlled by the tube.

Other objects and advantages of the invention will hereinafter appear.

The accompanying drawings are illustrative of several embodiments of the invention. In the drawings, Figs. 1, 2 and 3 illustrate several forms of multiple gap arc starting ionizers embodying the invention, while Figs. 4, 5 and 6 illustrate several different circuit connections employing arc starting ionizers of the character herein disclosed.

The arc starting ionizer may be formed of a composition consisting of the following materials in the proportions given, by weight:

Mix 1

17% ball clay,
17% Pyrex glass, and
66% carborundum crystals

Tungsten carbide, or any other suitable refractory conducting material which is stable under ion bombardment may be substituted for the carborundum. For example, I may alternatively employ a composition consisting of the following materials in the proportions specified, by weight:

Mix 2

51.7% barium oxide,
12% strontium oxide, and
33..6% titanium dioxide

The ingredients just mentioned are moistened with a five per cent starch solution, and then mixed with one hundred parts, by weight, of fine silicon carbide.

The materials in the form of fine powders which will pass through a 100 mesh screen are mixed, plasticized and shaped into the desired form such as a rod by any of the methods well known for various ceramics. Thereafter the molded material is fired to provide for rigidity. It is desirable to perform the final heat treatment of the material in a vacuum. Photomicrographs show the completed material of "Mix 1" to consist of discrete particles of carborundum crystals which are separated from each other by a ceramic matrix which is an insulator so that the carborundum particles form a plurality of conductors and capacitors in cross linked series circuits, the conductors being separated from each other by the matrix which acts as a dielectric. As will be understood by those skilled in the art, the material should have high stability under the conditions of use and should also have high dielectric constant.

The device shown in Fig. 1 is a substantially cylindrical rod 1, prepared as aforestated and provided near its upper end with an annular groove in which a lead wire 2 is secured in any suitable way. In use the rod 1 is partially immersed in the mercury cathode 3 of an electron tube to be controlled. If a voltage is impressed between the arc starting ionizer and the cathode, an ion sheath shunts the plurality of gaps between conducting (carborundum, for instance)

particles of the rod, starting an arc at the meniscus between the rod and the mercury, thus initiating an arc between the cathode 3 and the anode of a tube (not shown), if a suitable potential is impressed upon the main discharge path therebetween.

Fig. 2 illustrates a modified form of arc starting ionizer 4 in which the cross section of the lower end 4^a which is immersed in the mercury cathode is reduced, thus increasing the potential gradient and the resulting ionization at the interface. The starting element 4 is further provided with a skirt 4^b presenting a reentrant surface which provides an equipotential region between the immersed tip and skirt, thus preventing amalgamation in this region from forming a continuous film of high conductivity, which might otherwise produce a short circuit around the aforementoned interface to the head of the element 4 and thus render the latter inoperative.

Another form of the arc starting ionizer is shown in Fig. 3. A core 5 of porcelain, clay, glass, or other ceramic material and of a shape similar to the electrode shown in Fig. 2 is banded with a refractory wire 6 and is then dipped into a slip made of the preferred materials (of either "Mix 1" or "Mix 2", for example). The banded ceramic is immersed in this slip to a depth so as to cover the band. Thereafter the lower end of the core over a length of about one-fourth of an inch, is sprinkled with a layer of 100 mesh carborundum crystals. Then the rod is rotated slowly and a stream of 100 mesh carborundum crystals is poured over it. The article is then slowly dried, baked in air at 1400 degrees F., and thereafter baked at 1400 degrees C. in a vacuum furnace for a period of about thirty minutes. The finished rod, of either composition, will then have a resistance of about 10 megohms per centimeter for voltages of the order of 250 volts in air.

With the tip immersed in mercury in an evacuated tube in which the mercury vapor is in equilibrium with the liquid mercury at about 70 degrees F., the rod has a resistance of about 2 megohms per centimeter for voltages from 250 to 440, but for a steep voltage wave of about 2000 volts crest or of high frequency the gaps in the arc starting ionizer break down and shunt the rod with an ion sheath of low apparent resistance. This ion sheath has negative resistance characteristics. Hence the current tends to concentrate at the points of greatest ionization and reliably starts an arc at the surface of the mercury possibly due to a pinch effect at this point of high current concentration at the uppermost edge of the film of mercury.

Fig. 4 shows diagrammatically a method of connecting the arc starting ionizer in circuit with a tube 10. The tube has a cathode 11, an anode 12, and a starter 13. The ignition arc energy is supplied by a capacitor 14 or other suitable source. The capacitor 14 is connected in series with control switch 15 and a primary winding 16 of a step-up transformer 17, whose secondary winding 18 is connected between the starter 13 and the cathode 11. The capacitor circuit may be completed by closure of the switch 15. The tube 10 has its main electrodes connected in series with a load 19, across the terminals L^1, L^2, of a current supply. When the capacitor 14 is charged and the switch 15 then closed, a current flows through the primary winding 16. This induces a high voltage in the secondary winding 18 which causes ignition energy to pass between

the starter 13 and the cathode 11 to ionize the mercury vapor of the tube and thereby initiate current flow therethrough in a well known manner.

The sudden flow of current in the secondary winding 18 causes high voltage surges which may be impressed upon the supply conductors L^1, L^2. These surges may be isolated from the supply line L^1, L^2 by providing, as illustrated in Fig. 5, two arc starting ionizers 20, 20 of the same resistance characteristics and connecting them to the outer leads of the center-tapped secondary windings 21 of an ignition transformer 22, while the center tap of said windings is connected to the anode 12. If now the primary winding 23 of transformer 22 is energized by the discharge current of the capacitor 14, it induces a high voltage between the center tap and either end tap of the secondary windings 21. Hence the transformer secondary windings 21 and the arc starting ionizers 20, 20 form a bridge circuit, as shown diagrammatically in Fig. 6, whereby the potential between the main electrodes of the tube with respect to the secondary voltage is zero. Therefore, no high voltage surges are transmitted to the main lines L^1 and L^2. A film of mercury which may have condensed on the starters 20, 20 reduces their resistance. Hence a leakage current may flow between the lines L^1, L^2 through the two parallel branches of the bridge circuit. This current heats the film and evaporates the mercury, thus re-establishing the initial high resistance of the starters, and assuring reliable ignition of the tube when the condenser 14 is discharged to initiate conduction of current between the main electrodes.

It will be obvious that instead of the condenser 14 any other suitable source of ignition current may be employed. It is also possible to employ more than two starters.

I claim:

1. The combination with a discharge tube having a reconstructible cathode pool, a cooperating anode and a plurality of ignition electrodes, each having one of its ends in contact with said pool, of a source of ignition voltage interposed between the two other ends of said ignition electrodes, and a connection between said anode and the neutral point of said source.

2. The combination with a discharge tube having a reconstructible cathode pool and a cooperating anode and adapted to be rendered conductive in response to a steep potential gradient at the surface of its cathode, of a pair of ignition electrodes, each electrode comprising discrete granular conducting particles embedded in a ceramic matrix and having one of its ends in contact with said pool, a source of ignition voltage interposed between the two other ends of said ignition electrodes; and a connection between said anode and the neutral point of said source.

3. The combination with a discharge tube having a reconstructible cathode pool, a cooperating anode and a plurality of high resistance ignition electrodes, each having one of its ends in contact with said pool, of a transformer having a primary winding to be energized and a secondary winding, said secondary winding having end terminals connected to the other ends respectively of said ignition electrodes and a center tap terminal connected to the anode of said tube.

IRVIN W. COX.

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The following references are of record in the file of this patent:

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