May 2, 1944. P. L. SPENCER 2,347,715

ARC STARTING DEVICE

Filed July 27, 1940

FIG. 1.

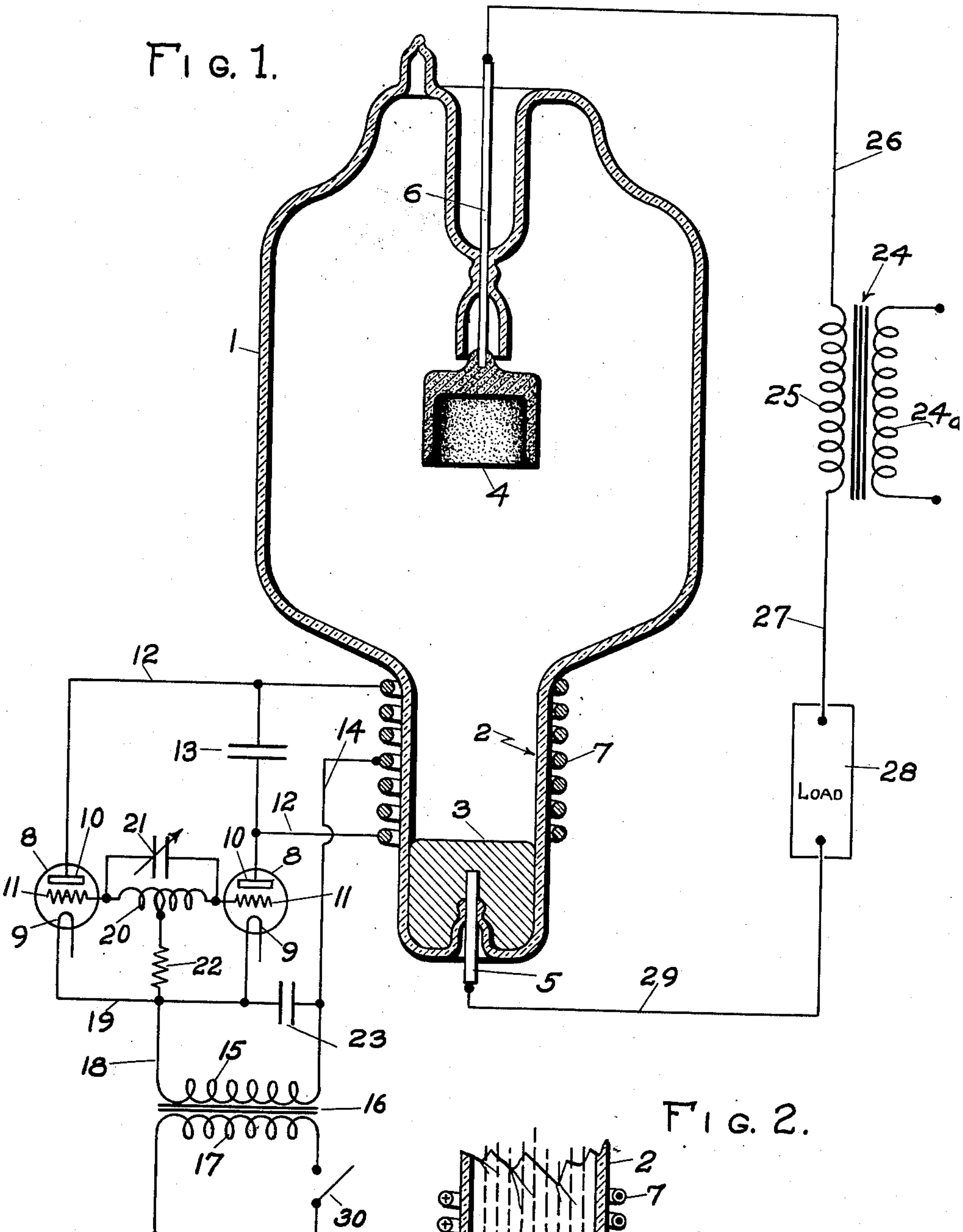
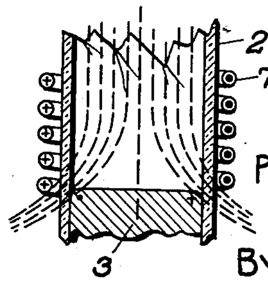


FIG. 2.



INVENTOR.
PERCY L. SPENCER,
BY Elmer J. Gorn
ATTY.

Patented May 2, 1944

2,347,715

UNITED STATES PATENT OFFICE

2,347,715

ARC STARTING DEVICE

Percy L. Spencer, West Newton, Mass., assignor to Raytheon Manufacturing Company, Newton, Mass., a corporation of Delaware

Application July 27, 1940, Serial No. 347,915

6 Claims. (Cl. 315—248)

This invention relates to an electrical space discharge tube arrangement containing an arc type cathode in which means are provided for initiating an arc spot on the cathode.

An object of this invention is to provide means for initiating an arc spot which is reliable, efficient, and easy to control.

Another object is to provide an arc igniting means which is electrically insulated from the tube circuit.

A further object is to provide for the initiation of an arc spot from the cathode by means of an induced auxiliary electrodeless discharge.

A still further object is to utilize high frequency currents to produce such an electrodeless discharge.

The foregoing and other objects of this invention will be best understood from the following description of an exemplification thereof, reference being had to the accompanying drawing, wherein:

Fig. 1 is a diagram illustrating my invention as applied to a pool type tube shown in vertical cross section; and

Fig. 2 is a fragmentary cross section of a portion of the tube of Fig. 1, showing the magnetic lines of force.

The tube as illustrated in the drawing consists of a glass envelope 1 having a lower tubular neck 2 containing an arc cathode 3, preferably of the conducting liquid type such as a mercury pool. The envelope 1 also contains an anode 4 adapted to cooperate with the cathode 3. In order to provide external electrical connections to the electrodes, a cathode lead 5 and an anode lead 6 are sealed through the wall of the envelope. In order to initiate arc spots on the surface of the cathode 3, a coil 7, the lower end of which is spaced slightly above the surface of the pool 3 surrounds the tubular neck 2.

The coil 7 is fed with high frequency currents from an oscillating circuit comprising a pair of tubes 8—8. Each of these tubes is provided with a cathode 9, an anode 10, and a control grid 11. The tubes 8 are of the continuously controllable type such as high vacuum tubes. Two leads 12 connect the opposite ends of the coil 7 to the two anodes 10 of the two tubes 8—8 respectively. A condenser 13 is connected directly across the coil 7. A conductor 14 extends from a center tap on the coil 7 to one end of a secondary winding 15 of a transformer 16, having a primary winding 17. A conductor 18 extends from the opposite end of the secondary winding 15 to a conductor 19 which is connected to both of the cathodes 9—9. The control grids 11 are inter-connected by a coil 20 across which is connected a variable tuning condenser 21. A grid leak resistor 22 connects the central point of the coil 20 to the conductor 19. A condenser 23 is connected between the conductors 19 and 14 to by-pass high frequency currents around the secondary winding 15. A switch 30 is provided for connecting the primary winding 17 to a suitable source of alternating current.

The arc tube may serve any suitable purpose. It is illustrated in the drawing as rectifying current supplied to it from a power transformer 24 having a primary winding 24a, energized from a suitable source of alternating current, and a secondary winding 25. One side of the secondary winging 25 is connected through a conductor 26 to the anode lead 6. The other side of said secondary winding is connected through a conductor 27, a load 28, and a conductor 29 to the cathode lead 5.

When the system as described above is energized and the switch 30 is closed, the oscillator tubes 8—8 generate high frequency currents which are fed into the coil 7. The frequency of these high frequency currents may be of any convenient value to produce a relatively intense electrodeless discharge in the mercury vapor within the tubular neck 2 liberated from the cathode power 3. This frequency is determined primarily by the inductance of the coil 7 and the capacity of the condenser 13. For maximum operation the coil 20 and condenser 21 are tuned to the frequency of the coil 7 and condenser 13.

When high frequency currents are fed into the coil 7 as described above, a corresponding electrodeless discharge will be produced within the tubular neck 2. The vapor for this discharge may be generated from the pool 3 by heating currents induced by the coil 7 although other means for producing the necessary vapor as by externally applying heat may be used if desired. However, electrodeless discharges may be produced in mercury vapor at relatively low pressures and in many instances pressure of the mercury vapor at about room temperature is sufficient to enable the electrodeless discharge to be initiated and maintained therein. In some cases, inert gas filling such as argon within the envelope 1 may be used at some suitable pressure such as of the order of several millimeters of mercury. The presence of the inert gas facilitates starting inasmuch as the electrodeless discharge may be initiated therein. Such inert gas filling may be utilized generally where the tube is to withstand relatively low voltages inasmuch as ordinarily the presence of the inert gas decreases the ability of the tube to withstand relatively high back voltage.

The electrodeless discharge, which is preferably intense, produces intense ionization of the mercury vapor with the consequent generation of large numbers of positive ions and electrons. During that half cycle of the high frequency current in which the upper end of the coil 7 is positive and the lower end negative, the positive ions of the electrodeless discharge will be driven toward the cathode 3. If at the same time the potential impressed on the arc tube by the secondary winding 25 is such as to make the anode 4 positive and the cathode 3 negative, the impelling of the positive ions toward the cathode 3 will be assisted. The magnetic field which is set up by the coil 7 also tends to direct and concentrate the stream of positive ions onto the cathode 3. In this connection, there is a tendency for the magnetic field to be concentrated at the edges of the mercury pool 3 and consequently to produce more intense ionization at this region as well as to direct the positive ions to the edges of said pool. This action may be more clearly understood by referring to Fig. 2, which shows the coil 7 carrying current represented as flowing into the plane of the drawing in the right side of the coil, and out of the plane of the drawing in the left side of the coil. An oppositely flowing current will be induced in the pool 3. While the upper portion of the coil 7 will produce a substantial, uniformly distributed longitudinal magnetic field, the opposing current in the pool 3 will tend to concentrate the lines of this field to the edges of said pool as illustrated in Fig. 2.

Under the above conditions of operation when a sufficiently intense electrodeless discharge is produced immediately adjacent the surface of the pool 3, incipient arc spots are produced on said pool, many of them adjacent the edge of the pool 3 although these incipient arc spots may occur haphazardly on the surface of the pool, usually where agitation or sharp curvatures exist. If, under these conditions, the anode 4 is positive, with respect to the cathode 3, one of these incipient arc spots will be picked up and converted into a direct arc spot, whereupon the discharge starts between the anode 4 and the cathode 3, and current flows into the load 8. Since the voltage impressed on the arc tube by the secondary winding 25 is alternating, the discharge for the arc spot will be extinguished at the end of each positive half cycle. Therefore, in order that the arc tube conduct on each positive half cycle, the coil 7 must re-establish the arc spot during each such positive half cycle. As long as the switch 30 is maintained closed and the coil 7 supplied with high frequency currents the arc tube will conduct as described above. When the switch 30 is opened, the discharge will be extinguished at the end of the positive half cycle and the arc tube will thereafter be non-conducting.

I have found that in devices of the above type, initiation of the arc spot may be facilitated by adding a small amount of barium to the mercury pool. The barium may, for example, be one-half of one per cent of the cathode pool.

In the specification and claims herein, it is to be understood that a "pool type cathode" is intended to cover that type of cathode in which an arc spot is initiated for carrying the discharge current, whether or not the cathode material is normally in solid or liquid form.

Of course, it is to be understood that this invention is not limited to the particular details as described above inasmuch as many equivalents will suggest themselves to those skilled in the art. For example, other sources of high frequency currents could be utilized for energizing the coil 7. Likewise, instead of a simple switch 30, more accurate circuit closing means could be utilized so as to predetermine the point on each positive half cycle at which the discharge is to be initiated. Instead of being merely a rectifier, the arc tube could be utilized in other types of circuits in which the initiation of an arc spot on the cathode may be useful. Various other modifications and applications of this invention will suggest themselves to those skilled in this art. It is accordingly desired that the appended claims be given a broad interpretation commensurate with the scope of the invention within the art.

What is claimed is:

1. An arc discharge device comprising a pool type cathode, an anode, an ionizable atmosphere adjacent said cathode and means for producing an electrodeless ionizing discharge in said atmosphere adjacent said cathode of sufficient intensity to initiate an arc spot on said cathode.

2. An arc discharge device comprising a mercury pool type cathode, an anode, and an ionizable atmosphere adjacent said cathode, and means for producing an electrodeless ionizing discharge in said atmosphere adjacent said cathode of sufficient intensity to initiate an arc spot on said cathode.

3. An arc discharge device comprising a pool type cathode, an anode, and an ionizable atmosphere adjacent said cathode, and means for inducing circulating ionizing currents in said atmosphere with the axis of said current flow substantially at right angles to the surface of said cathode.

4. An arc discharge device comprising a pool type cathode, an anode and a coil surrounding space adjacent said cathode and adapted to be supplied with periodically varying current for producing an ionizing discharge in said atmosphere adjacent said cathode of sufficient intensity to initiate an arc spot on said cathode.

5. An arc discharge device comprising a pool type cathode, an anode and a coil surrounding space adjacent said cathode and adapted to be supplied with periodically varying current for producing an ionizing discharge in said atmosphere adjacent said cathode of sufficient intensity to initiate an arc spot on said cathode, the axis of said coil being substantially perpendicular to the surface of said cathode.

6. An arc discharge device comprising a pool type cathode, an anode and a coil surrounding space adjacent said cathode and adapted to be supplied with periodically varying current for producing an ionizing discharge in said atmosphere adjacent said cathode of sufficient intensity to initiate an arc spot on said cathode, the axis of said coil being substantially perpendicular to the surface of said cathode and substantially parallel to the path of current flow between said cathode and anode.

PERCY L. SPENCER.