April 16, 1946. K. J. GERMESHAUSEN 2,398,422

IGNITER FOR MERCURY-POOL TUBES

Original Filed Nov. 23, 1938

FIG. 1.

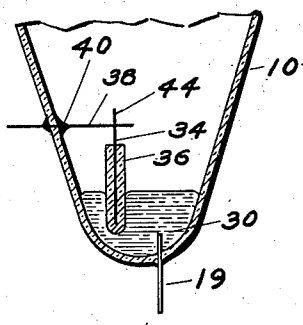



FIG. 2.

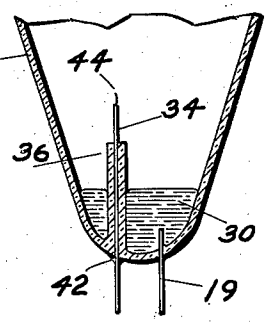



FIG. 3.

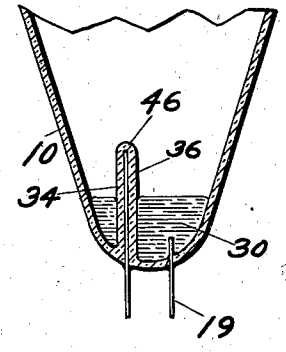



FIG. 4.

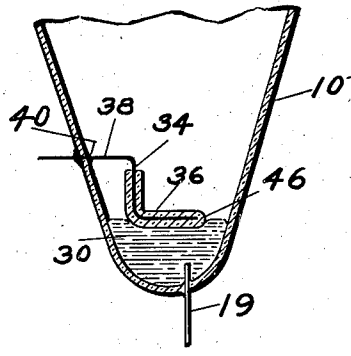



FIG. 5.

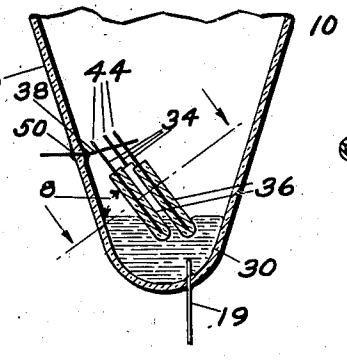



FIG. 6.

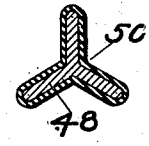



FIG. 7.

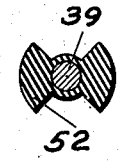



FIG. 8.

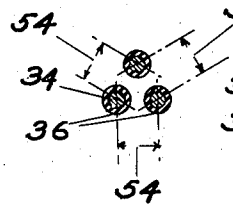



FIG. 9

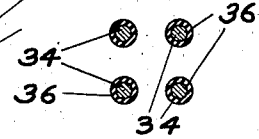
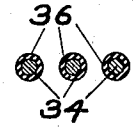



FIG. 10.




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Patented Apr. 16, 1946 2,398,422

# UNITED STATES PATENT OFFICE

2,398,422

## IGNITER FOR MERCURY-POOL TUBES

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Original application November 23, 1938, Serial No. 241,888. Divided and this application September 30, 1942, Serial No. 460,197

7 Claims. (Cl. 250—27.5)

This is a division of applicant's copending application, Serial No. 241,888, filed November 23, 1938, now Patent No. 2,325,603.

The present invention relates to mercury-pool tubes, and more particularly to igniters therefor.

Gaseous rectifiers and relay tubes with a mercury-pool cathode possess many advantages over tubes employing a hot cathode. Chief among these are ability to withstand heavy overloads without damage to the cathode, immediate starting without delay for the heating of the cathode, and sturdiness and simplicity of construction.

The main problem in connection with pool-type tubes has been to find a satisfactory method of starting the cathode spot on the mercury pool. Many schemes have been tried. One of these involves interrupting a circuit between the cathode and an auxiliary starting electrode. In combination with this, a holding arc is often employed to maintain the cathode spot, once it has been started, even though the main anode current falls to zero. Mechanical difficulties, however, attend the moving of an electrode in a vacuum-tight enclosed vessel, and the device does not operate rapidly enough when it is desired to start the arc once each cycle for 60-cycle operation.

A second method, developed by Peter Cooper-Hewitt, is with the aid of an external starting band, placed at the mercury meniscus external to the tube. When a high voltage, of the order of 10,000 volts, is impressed on the starting band, the cathode spot is initiated. Although the external starting band has long been used to start Cooper-Hewitt lamps, it has never proven successful with rectifiers or control tubes that must be started millions of times.

One objection to the band igniter has been the high starting voltage required, the best tubes requiring from 5,000 to 10,000 volts for ignition.

According to a more recent proposal, a partially conducting electrode is immersed in the mercury cathode. When a current of sufficient magnitude is passed between the starting electrode and the mercury pool, the arc is initiated. Ignitrons, as tubes employing this system are called, require rather large amounts of current and power to start the cathode spot. A typical igniter requires about 15 amperes at 75 volts for successful operation. As it is necessary, furthermore, that the current through the igniter be in one direction only, a rectifier tube is required to be connected in series with the igniter; and since the currents are large, the rectifier must be both large and somewhat expensive. The applications of ignitrons have consequently been sharply limited, so that they are now used mainly in large resistance welders to control the duration of the weld.

Each of the above methods, therefore, has certain inherent disadvantages which it is an object of the present invention to overcome.

A further object contemplates the provision of a device of the above described character that shall overcome the necessity for employing high starting voltages, such as are employed in the band starter type of tube, and shall at the same time overcome the necessity for using large currents, as are employed in the ignitron type of tube. According to the present invention, therefore, it is possible to employ low starting voltages accompanied by low currents, thus obtaining the advantages of both the band starter and the ignitron types of tubes, without their disadvantages. According to a feature of this invention, this result is attained by completely insulating an internal igniter electrode from the mercury in which it is immersed by means of an exceedingly thin insulating layer, a layer that is thin enough to permit the application of low voltages for starting, but yet thick enough to enable continued operation at low currents.

Other and further objects will be explained hereinafter, and will be particularly pointed out in the appended claims.

The invention will now be explained more fully in connection with the accompanying drawing, in which

Fig. 1 is a fragmentary view illustrating a starting electrode as separated from a mercury-pool cathode by an exceedingly thin insulating layer;

Fig. 2 is a similar view of a modification;

Fig. 3 is a similar view of a further modification in which the wire electrode is completely insulated from the inside of the tube;

Fig. 4 illustrates a modification of the insulated arrangement of Fig. 3;

Fig. 5 is a similar view illustrating a slanting disposition of starting electrodes;

Fig. 6 is a cross-section of a modified starting electrode;

Fig. 7 is a modification of the same;

Fig. 8 is a cross-section of the modification shown in Fig. 11; and

Figs. 9 and 10 are similar sections of modifications.

Dimensions that have been found to work, in

practice, were as follows: for an anode current of 1 ampere, the maximum cross-sectional area of the igniter was not more than about .09 square inch, and the maximum cross-sectional dimension not more than .3 inch. With increase in anode current, the dimensions of the starter may be increased. In general, the maximum cross-sectional dimensions must be determined by experiment, and may depend on the current rating of the tube. The starter for a particular tube may be small enough to enable the arc and cathode spot to keep the tube free from mercury that might otherwise stick to it.

The starting voltage required may be reduced by bearing in mind that it depends upon the voltage gradient produced at the mercury surface by the voltage applied to the starting electrode and the polarity of the voltage. The voltage gradient for a given voltage applied to the starter will depend on the thickness of the insulation between the starting electrode and the mercury, the dielectric constant of the insulation, and the shape of the mercury surface at the starting electrode. The starting voltage is much lower when the starting band is positive with respect to the mercury cathode.

According to previous practice, where the insulating layer between the starting band and the mercury **30** formed part of the wall of the tube, it was impractical to employ very thin insulating layers because of considerations of mechanical strength. According to a feature of the present invention, on the other hand, the insulating layer may be bonded to and supported by a conducting or semi-conducting member. The insulating layer may take many forms, such as a thin layer of mica cemented to a metallic support, or an enamel layer, such as is commonly employed on metallic surfaces.

It is possible to mount the igniter in the tube in various ways, some of which are illustrated in the drawing. A satisfactory method of preparing an igniter is to take a wire **34** of tungsten, slip over it a close-fitting thin glass tube **36**, and then melt the glass down onto the wire, as is done in the making of glass-to-metal seals. The glass used must have a similar coefficient of expansion to that of the tungsten; such glasses are commercially available. Other metals, such as the new sealing alloys, may be used with appropriate glasses. By the above technique, it is possible to produce a thin uniform layer of glass **36** on the tungsten **34**, having high electrical and mechanical strength. In practice, layers four to ten thousandths of an inch thick may be used. For clearness, the thickness is shown considerably exaggerated in the drawing.

A wire **34** of .040 inch diameter, coated with a glass layer **36** of five thousandths of an inch thickness, will start a cathode spot when voltages of about 3000 volts are applied. As the breakdown voltage of the glass layer **36** may be two to three times that value, ample safety factor is provided. The current required to start the cathode spot is negligible, being of the order of a small fraction of a milliampere.

The wire **34**, with the glass tube **36** thereon, may be supported in the mercury pool **30** by a wire support **38**, sealed in the wall of the tube **10** at **40**, as illustrated in Fig. 1, or the glass tube **36** may be integrally joined to the wall of the tube **10**, as illustrated at **42** in Fig. 2. In both cases, the glass tube **36** is disposed in the mercury pool **30** so as to insulate the wire **34** therefrom. In both cases, the free conducting portion **44** of the wire **34** of the igniter assembly is shown exposed inside the tube **10**. The wire may, however, be completely insulated from the inside of the tube **10**, as illustrated at **46** in Fig. 3. According to the arrangement shown in Figs. 1 and 2, when the cathode spot starts, an arc is drawn between the cathode and the exposed portion **44** of the starting wire **34**, which arc aids in the transfer to the anode **5**, particularly when the tube is operating at low plate voltages. The arrangement of Fig. 3, however, also has advantages. For high-voltage rectifiers, for example, it would be desirable to insulate the igniter as illustrated at **46**. This would protect the metal of the igniter from ionic bombardment and consequent sputtering. In the case of Fig. 4, the wire **34** may be supported as in Fig. 1, and may assume the horizontal position illustrated. A very effective form of starter, indeed, is a coated wire **34** lying horizontally on the surface of the mercury, as illustrated in Fig. 4.

The starting voltage is greatly dependent on the shape of the mercury around the starting electrode **34**. Slanting the starting electrode with respect to the mercury surface, as illustrated in Fig. 5, will reduce the starting voltage by as much as one-half.

A very effective form of igniter consists of a group of wires **34**, as shown in Fig. 8, each wire **34** having its own individual insulating layer **36**. The mercury assumes a shape about such groups of wires so that the starting voltage is greatly reduced. The wires may be actually touching, or there may be a small space between them, represented by the distance **54**, but the space should not be large enough so that the mercury can freely surround each wire and form a normal meniscus about each. A distance **54** of 0.080 inch has been found to be satisfactory for wires **34** of the dimensions given herein.

Three starting electrodes **34** are shown in Figs. 5, 8 and 11 all supported by the same supporting wire **38**. A single such starting electrode may, however, be employed, and a plurality of starting electrodes may, on the other hand, be employed in the other figures.

In Figs. 7 and 10, the three electrodes are shown disposed at the vertices of a triangle. They may, however, be linearly disposed, as illustrated in Fig. 10. In Fig. 9, four such electrodes are illustrated. Other numbers of electrodes, and other dispositions, may also be employed.

An igniter assembly slanted with respect to the mercury surface, as illustrated in Fig. 5, is very effective. One or more wires **34** may be employed. The smaller the angle $\alpha$ of slant, the lower the starting voltage will be, but it is desirable that the angle $\alpha$ be at least 30 degrees, so that different levels of mercury may be readily accommodated.

A typical igniter, as shown in Fig. 5, would consist of a wire **34** of .040 inch diameter, coated with a glass layer **36** of five thousandths of an inch thickness, the angle $\alpha$ being 45 degrees. Such an igniter will start a cathode spot when peak voltages of from 800 to 1200 volts are applied to it. Placed in a tube **10** designed to carry two amperes average current, such an igniter has been operated many thousands of hours, starting the arc 60 times per second, without any visible deterioration of the glass on the wires, and without the mercury tending to stick to the glass around the wire, even though the mercury had coated most of the rest of the tube with a sticky dirty layer.

It is not essential that the starting electrodes of Figs. 1 to 5 be in the form of a round wire or a group of round wires. The Y shape shown at 48 in Fig. 6, with correspondingly shaped insulating coating 50, has certain advantages, and even if round, the wire may be provided with an irregular shaped coating, illustrated at 52 in Fig. 7 as wing shaped. Irregular cross-section of the starting electrode, or irregular insulation around the wire, serves to lower the starting voltage required. The irregular igniter may be square, rectangular, or otherwise in cross-section. It has been found easier, however, to coat round wires with uniform insulating layers having high electric breakdown strength.

From the foregoing it appears that igniters may have many forms, the main considerations being that the shape cause an irregular mercury surface around the igniter that will promote easy formation of the cathode spot and that the igniter assembly be easy to make and strong mechanically and electrically.

An igniter consisting of a coated wire or sphere floating on the surface of the mercury is very effective. During operation, the level of the mercury, however, is constantly changing, so that it is desirable to mount the igniter flexibly so that it may follow the surface of the mercury.

Further modifications will occur to persons skilled in the art, and all such are considered to fall within the scope and spirit of the invention.

What is claimed is:

1. A tube having a mercury-pool cathode, a voltage type starting electrode adjacent said cathode, and an enamel layer secured to and completely covering all parts of said electrode immediately adjacent said cathode completely to insulate said electrode from said cathode, said layer also being in contact with said cathode.

2. A tube having a mercury-pool cathode, a voltage type starting electrode adjacent said cathode, said electrode comprising a conducting member having an insulating coating and being of a cross-sectional shape having one or more depressions therein, said insulating coating completely covering all parts of said conducting member immediately adjacent said cathode completely to insulate said conducting member from said cathode, said insulating coating also being in contact with said cathode.

3. A tube having a mercury-pool cathode, a voltage type starting electrode adjacent said cathode, said electrode comprising a conducting member having an insulating coating, said conducting member being of a cross-sectional shape having one or more depressions therein, said insulating coating completely covering all parts of said conducting member immediately adjacent said cathode completely to insulate said conducting member from said cathode, said insulating coating also being in contact with said cathode.

4. A tube having a mercury-pool cathode, a voltage type starting electrode adjacent said cathode, said electrode comprising a conducting member having an insulating coating, said insulating coating being of a cross-sectional shape having one or more depressions therein, said insulating coating completely covering all parts of said conducting member immediately adjacent said cathode completely to insulate said conducting member from said cathode, said insulating coating also being in contact with said cathode.

5. A tube having a mercury-pool cathode, a voltage type starting electrode adjacent said cathode, said electrode comprising a conducting member having an insulating coating and being of a cross-sectional shape having a plurality of depressions therein, said insulating coating completely covering all parts of said conducting member immediately adjacent said cathode completely to insulate said conducting member from said cathode, said insulating coating also being in contact with said cathode.

6. A tube having a mercury-pool cathode, a voltage type starting electrode adjacent said cathode, said electrode comprising a conducting member having an insulating coating, said conducting member being of a cross-sectional shape having a plurality of depressions therein, said insulating coating completely covering all parts of said conducting member immediately adjacent said cathode completely to insulate said conducting member from said cathode, said insulating coating also being in contact with said cathode.

7. A tube having a mercury-pool cathode, a voltage type starting electrode adjacent said cathode, said electrode comprising a conducting member having an insulating coating, said insulating coating being of a cross-sectional shape having a plurality of depressions therein, said insulating coating completely covering all parts of said conducting member immediately adjacent said cathode completely to insulate said conducting member from said cathode, said insulating coating also being in contact with said cathode.

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