Nov. 17, 1942. D. D. KNOWLES 2,302,373

IGNITOR FIRING TUBE

Filed Jan. 21, 1941

Fig. 1.

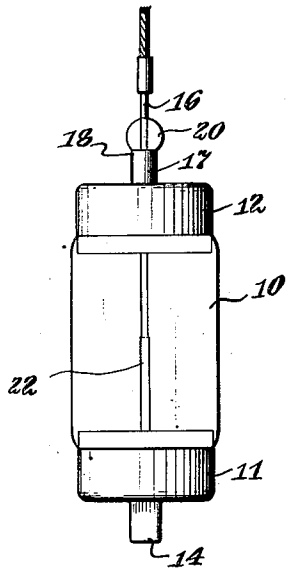


Fig. 2.

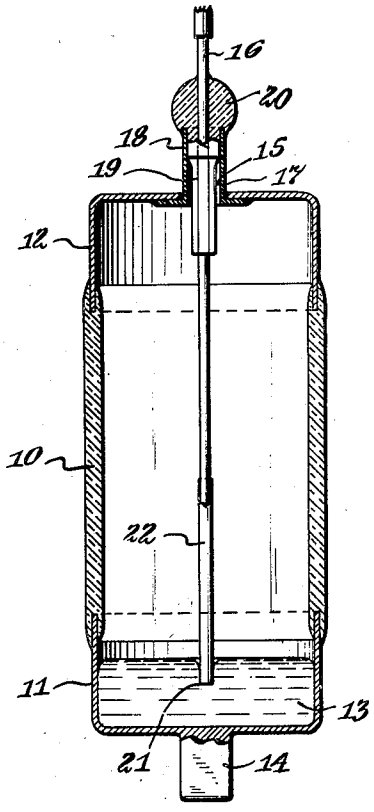
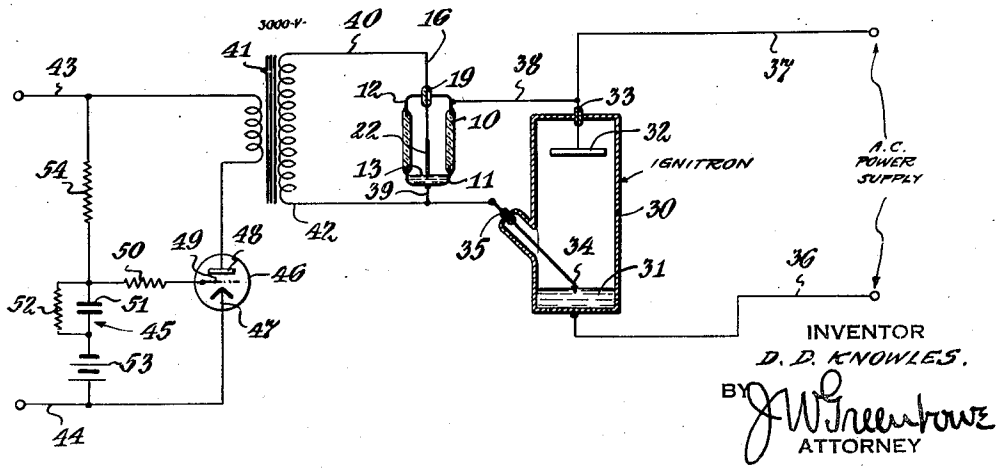


Fig. 3.



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2,302,373

IGNITOR FIRING TUBE

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7 Claims. (Cl. 250—27.5)

My invention relates to discharge devices and especially to the type of device utilizing a mercury pool cathode.

An object of the invention is to provide a small dimension tube capable of withstanding high current peaks.

Another object of my invention is to provide a firing tube for the ignitron type of discharge device.

Further objects and advantages of the invention will be apparent from the following description and drawing in which:

Fig. 1 is an elevational view of a preferred embodiment of the invention.

Fig. 2 is an enlarged cross-sectional view of the embodiment of Fig. 1.

Fig. 3 is a view partly diagrammatic and partly in cross section of a firing circuit for an ignitron and including the preferred embodiment of my invention.

One of the recent outstanding developments in arc discharge devices has been that of the ignitron which is described in Patent 2,069,283, issued February 2, 1937, to J. Slepian et al. One of the problems in connection with the utilization of the ignitron device has been the selection of a suitable tube to control the firing of this ignitron. While my invention has other uses, it is peculiarly adapted to utilization as the firing tube of these ignitrons.

Heretofore, hot cathode thyratrons were used for the firing of the igniters in ignitrons. The ignitron is inherently a quick starting tube, but the hot cathode thyratrons cannot be used until the cathode has become hot, and this generally necessitates several minutes delay or the continuous heating of the cathode when not in use. The hot cathodes are fundamentally limited in peak current capacity because of the danger to the coating on the cathode. While the average current in the firing circuit is small, yet because of the high amperage that may momentarily pass through the firing control tube, this tube must have large dimensions, which makes it expensive. The ignitron has practically no change in characteristics with the temperature, but the thyratron does change its characteristics with temperature and thus might impair the performance of the ignitron.

My invention, on the contrary, embodies a firing tube that is very small and yet fully capable of supplying high amperage peaks and yet is not affected by the temperature. It is also capable of starting instantly.

Figs. 1 and 2 illustrate a preferred embodiment of my invention. The envelope of my device is preferably that of a cylinder of borosilicate glass 10 with two end cups 11 and 12 sealed thereto. It will be noted in these figures that the major portion of the cylindrical surface in the device is of glass. The cups at either end are preferably of the nickel-cobalt-iron alloy sold under the trade name "Kovar," and as described in Patent 2,062,335, issued to Howard Scott, December 1, 1936, this alloy has 28% to 34% nickel, 5% to 25% cobalt, less than 1% manganese, and the remainder iron.

The cup 11 on the bottom acts as a container for the mercury pool cathode 13. The bottom portion of this cup may have a projection 14 if desired for the attachment of the cathode connection thereto. The upper cup 12 acts as an anode. The anode 12 has a central opening 15 for the passage of a conductor wire 16 therethrough. In order to most conveniently seal this conductor 16 through the anode, I preferably weld an eyelet 17 of this nickel-cobalt-iron alloy with a projecting sleeve 18 extending through a central opening in the cup 12. The wire 16, which is preferably of tungsten, but may be of the nickel-cobalt-iron alloy, has a sleeve of borosilicate glass 19 surrounding the portion passing through the anode for a slight way, and this sleeve of glass terminates in a bead 20 sealing the conductor 16 vacuum tight in the eyelet sleeve extension 18. If desired, the eyelet and cup 12 might be integral, but the two-part arrangement helps in the assembly of the device.

The conductor 16 extends downward to a point 21 below the surface of the mercury pool. From the point 21 to a distance above the surface of the mercury pool, the lower portion of this conductor 16 has a coating of insulation 22. This coating of insulation is preferably glass and may have a thickness of .005 inch, preferably of borosilicate glass. Tubulation for exhausting and filling the tube with mercury may be located at any portion of the envelope, but the most desired place is preferably that of the extension 14 in the lower cup 11.

In Fig. 3 I have illustrated one of the uses of my invention in the firing circuit of an ignitron. The ignitron 30 preferably has a metal casing containing a mercury pool 31 in the bottom portion thereof. An anode 32 is in the upper portion of this container and has a connection 33 that passes through an insulated portion of the container. An ignitor 34, preferably of boron carbide, is partially immersed in the mercury pool, and this ignitor has a connection 35 passing

through an insulated portion of the casing. An alternating current power supply, 36 and 37, is connected to the cathode and anode of the ignitron. While the ignitron 30 may be used as a rectifier, yet in this installation it is being used as a switch to make and break the circuit through 36 and 37 without the use of moving parts or wear on contacts that are present in mechanical switches.

My firing tube is preferably inserted in a firing circuit of the type illustrated although it may be utilized with other types. The anode 12 of my firing tube is connected by 38 to the anode connection 33, and the cathode 13 of my firing tube is connected through its cathode cup 11 by 39 to the ignitor connection 35 of the ignitron.

The insulation-covered auxiliary electrode of my firing tube has its exterior connection 16 connected by 40 to the secondary of a transformer 41. The other end of the secondary is connected by 42 to the cathode 11 of my firing tube and to the ignitor 34 of the ignitron. An alternating current supply circuit 43, 44, which may be of the usual 60 cycle 110 volt alternating current circuit, is connected to the transformer to supply energy for the firing circuit. I preferably insert a phase shift circuit 45 between the firing circuit power supply and the firing tube in order to start my firing tube very late in the cycle in order to induce a steep voltage wave in the coupling transformer 41. This steep voltage wave promptly fires my firing tube, which in turn fires the ignitron.

This phase shift circuit 45 includes a small thyratron or other peaking device 46 having its cathode 47 and anode 48 serially connected between one of the power lines 44 and the primary of the coupling transformer 41. The grid 49 of this peaking device 46 is connected through a resistance 50 to a capacitance 51, resistance 52, in parallel, and energized by current supply 53. A resistance 54 is inserted between the capacitance and resistance and the other side of the line 43. The phase shift circuit 45 determines the part of each cycle that the ignitron fires and can be regulated as desired. If 60 cycle current is used in the firing circuit, the ignitron will fire 60 times a second.

The power required to fire my firing tube is small and accordingly all parts in the energization circuit of my tube, including the peaking tube 46, may be very small and inexpensive.

When the peaking tube 46 passes the current through the transformer 41, the energy of this steep voltage impulse is applied to the auxiliary electrode 16 of the firing tube. The condenser effect through the bottom of the glass covered electrode 16 causes a discharge to rapidly form from the surface of the mercury to the exposed portion of the rod 16 and then transfer the arc to the exposed anode 12. The arc established between the anode 12 and the cathode 13 instantly energizes the ignitor 34 of the ignitron and the discharge is started between the cathode 31 and anode 32 of the ignitron.

The construction of my firing tube can be made of very small dimensions, such as approximately 1½ inches in length and ¾ of an inch in diameter. Because of these small dimensions, a fuse clip may be used to make the anode and cathode connections. In spite of these small dimensions, the sturdy construction of my device will permit it to easily withstand 100 amperes of peak current.

The peaking tube 46 is approximately the same size as my firing tube 16 and both in quantity production would cost only a few dollars. On the other hand, the arrangement would replace a nine inch high thyratron listing at present at $40.

Although I have illustrated a use of my firing tube in Fig. 3 in accordance with the patent statutes, I do not intend my tube to be limited to such particular use.

While I have mentioned peak voltages as applied to my firing tube, it is also possible to cause it to fire by the application of high frequency currents to the glass covered portion. The glass coating 22 may be replaced with titanium dioxide, as described in my copending joint application with Lee Sutherlin, Ser. No. 300,540, filed October 21, 1939, for "Covered ignitor" issued Jan. 21, 1941, as Patent #2,229,093.

While I have shown and described a preferred embodiment of my invention and a preferred application thereof, it is apparent that many modifications may be made therein, and accordingly I desire only such limitations to be imposed upon my invention as are necessitated by the spirit and scope of the following claims.

I claim:

1. A discharge device comprising a cylindrical container, a cylinder of glass forming the major portion of the cylindrical surface of said container, caps of a material sealing to glass being sealed to each end of said cylinder of glass, a mercury pool in one of said caps, and a make-alive sealed through the other cap and partially immersed in said mercury pool, the lower portion of said make-alive electrode having a thin coating of insulation.

2. A discharge device comprising a cylindrical container, a cylinder of borosilicate glass forming the major portion of the cylindrical surface of said container, caps of an alloy of 28% to 34% nickel, 5% to 25% cobalt, less than 1% manganese, and the remainder iron sealed to each end of said cylinder of borosilicate glass, a mercury pool in one of said caps, and a make-alive electrode sealed through the other cap and partially immersed in said mercury pool.

3. A discharge device comprising a cylindrical container, a cylinder of borosilicate glass forming the major portion of the cylindrical surface of said container, caps of an alloy of 28% to 34% nickel, 5% to 25% cobalt, less than 1% manganese, and the remainder iron sealed to each end of said cylinder of borosilicate glass, a mercury pool in one of said caps, and a make-alive electrode sealed through the other cap and partially immersed in said mercury pool, the lower portion of said make-alive electrode having a thin coating of insulation.

4. A discharge device comprising a cylindrical container, a cylinder of borosilicate glass forming the major portion of the cylindrical surface of said container, caps of an alloy of 28% to 34% nickel, 5% to 25% cobalt, less than 1% manganese, and the remainder iron sealed to each end of said cylinder of borosilicate glass, a mercury pool in one of said caps, and a make-alive electrode sealed through the other cap and partially immersed in said mercury pool, the lower portion of said make-alive electrode having a thin coating of glass.

5. An electron discharge device comprising opposed hollow metallic cups having the edges of side walls thereof directed toward each other, an intervening hollow glass member having its end edges sealed to the said edges of the side walls of

the cups and forming therewith a vacuum-tight envelope, a pool cathode in one of said metallic cups, and an ignitor depending from the other said cup.

6. An electron discharge device comprising opposed hollow metallic cups having the edges of side walls thereof directed toward each other, one said cup being at the top and the other at the bottom of said device, and the upper said cup constituting an anode, an intervening hollow glass member having its end edges sealed to the said edges of the side walls of the cups and forming therewith a vacuum-tight envelope, a pool cathode in the bottom cup, and an ignitor depending from the top cup.

7. An electron discharge device comprising a bottom closure, a side enclosure sealed thereto, a pool cathode in the bottom closure, an ignitor depending to operative relation with said pool cathode, and an upper cup member sealed to said side enclosure and constituting both a hollow anode and a support for said ignitor.

DEWEY D. KNOWLES.