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C. BOL ET AL

ELECTRIC DISCHARGE TUBE

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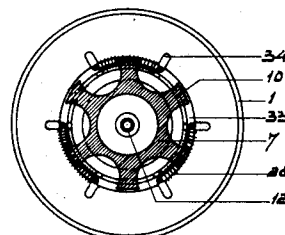
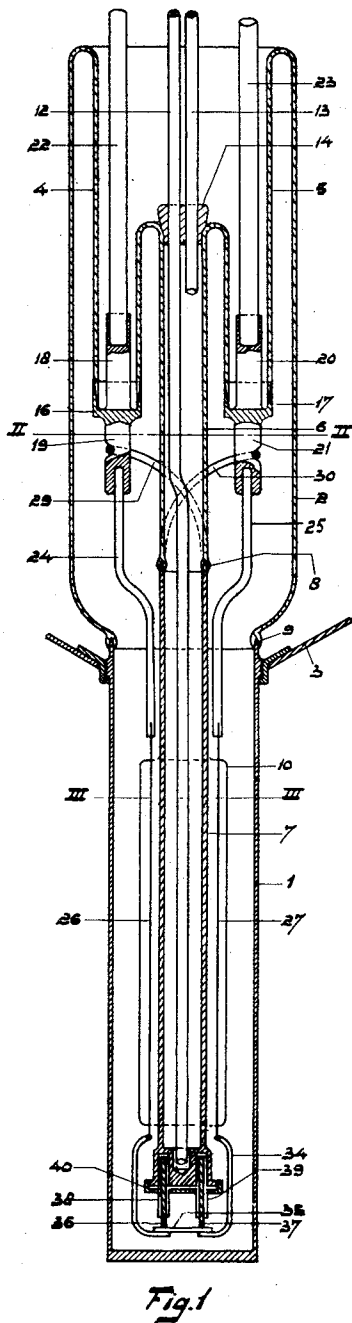


Fig. 4

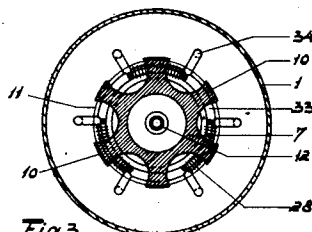


Fig. 3

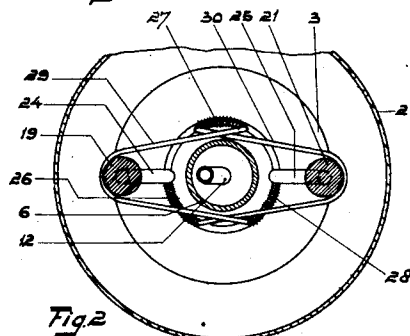


Fig. 2

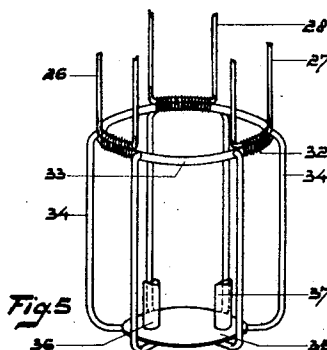


Fig. 5

Inventor

Cornelis Bol and Balthasar van der Pol
By: E. T. & J. F. Braunselma attorneys.

UNITED STATES PATENT OFFICE.

CORNELIS BOL AND BALTHASAR VAN DER POL, OF EINDHOVEN, NETHERLANDS, ASSIGNORS TO N. V. PHILIPS' GLOEILAMPENFABRIEKEN, OF EINDHOVEN, NETHERLANDS.

ELECTRIC DISCHARGE TUBE.

Application filed June 27, 1924, Serial No. 722,793, and in Netherlands July 13, 1923.

This invention has reference to electric discharge tubes having an incandescent cathode, an anode adapted to be cooled and one or more controlling electrodes, and more particularly to discharge tubes of this kind of high power as used for example in transmission stations for wireless telegraphy or telephony.

Discharge tubes of this kind in which the cooled anode may form part of the outer envelope of the tube can be constructed up to much greater power than discharge tubes the anode of which is not cooled and the maximum of the power of such tubes is no longer determined by the heating of the anode but by that of the controlling electrodes (grids) caused by the high positive value which the grid potential may attain during the operation of the tube.

To avoid overheating of the controlling electrodes, discharge tubes of the kind described are, according to the invention, characterized by one or more metal vessels forming part of the outer envelope of the tube and serving partly or wholly as controlling electrodes. Such electrodes may be cooled, for example, by circulating water, or by radiation.

If the discharge tube is provided with an anode that forms part of the outer envelope of the tube, a second metal vessel may be arranged within the said anode and likewise form part of the outer envelope of the tube, said vessel serving partly or wholly as a grid electrode. It must be mentioned that "the outer envelope of the tube" is to be understood to mean the wall separating the vacuum of the tube from the atmosphere. If the anode and the metal vessel serving partly or wholly as a grid electrode are arranged concentrically and cylindrically, the incandescent cathode may consist of a number of wires, stretched parallel to the axis of the other electrodes.

In this construction the metal vessel arranged within the anode may be provided with longitudinal grooves and a grid wire be wound on the ribs between the grooves, the incandescent cathode consisting of a number of wires extending in the longitudinal grooves between the metal vessel and the grid wire. The grid wire may be omitted

so that the incandescent cathode lies between the grid electrode and the anode. In this construction the grooves in the metal vessel which serves as a grid electrode, are preferably so shaped and the wires of the incandescent cathode so arranged in relation thereto that the distribution of the field at the surface of the wires is practically uniform.

Various other new characteristics of discharge tubes according to the invention will be apparent from the following description.

The accompanying drawing represents some embodiments of transmission triodes according to the invention. In the said drawing:

Figure 1 is a vertical section of a three electrode transmission triode having the grid arranged between the incandescent wire and the anode.

Figure 2 is a horizontal section on a large scale taken along the line II—II of Figure 1.

Figure 3 is a horizontal section taken on the line III—III of Figure 1.

Figure 4 is a horizontal section of a different form of execution having the incandescent wire arranged between the grid and the anode.

Figure 5 is a perspective view of a device for fixing the lower end of the incandescent wire.

The transmission triode according to the invention comprises a metal anode 1 forming part of the outer envelope of the discharge tube. The end of the vessel 1 is hermetically sealed to a glass sealing member 2. The vessel 1 is furthermore threaded so as to enable the anode of being located in a cooling vessel 3, partly shown in the drawing. The anode may consequently be cooled from the outside by any suitable cooling-means, for example by water enclosed within the vessel 3.

The vessel 2 has hermetically fused to it glass tubes 4 and 5 extending inwardly and also a centrally arranged tube 6. The latter has fused to its end a hollow metal vessel 7 carrying the grid wire. At the point of fusing 8, the thickness of the wall of the tube 7 is preferably slightly thinner so as to facilitate the fusing operation. The same remark applies to the point of fusing 9 of the vessel 1. The vessels 1 and 7 may be of

any suitable metallic material which is readily hermetically sealed to glass and is non-porous. In practice chrome iron of such composition that its coefficient of expansion corresponds to that of the glass gives excellent results.

The vessel 7 may be cooled from the inside by any suitable cooling means. A supply tube 12 and a discharge tube 13 put into the upper end of the tube 6 by means of a stopper 14, for example, of rubber serve for this purpose. The vessel 7 is provided with a number of ribs 10 and the grid wire 11 is helically wound on the said ribs (Figure 3). For the sake of clearness the grid wire is not shown in Figure 1. In order to facilitate the attachment of the grid-wire, grooves may be cut in the ribs 10.

For the hermetical introduction of the leading-in wires for the incandescent cathode, metal caps 16 and 17 are hermetically fused to the ends of the tubes 4 and 5. These caps may consist of material which is readily hermetically fused to glass, such for example as platinum. Very good results are also obtained by chrome iron of such composition that its coefficient of expansion corresponds to that of the glass.

On both sides of the cap 16 and 17 are fixed rods 18, 19 and 20, 21 respectively, which, if the caps are of chrome iron, are preferably of material that is readily welded to chrome iron, for example nickel. To the rods 18 and 20 are fixed leading-in wires 22 and 23, for example of copper, and to the ends of the rods 19 and 21 are connected leading-in wires 24 and 25, which preferably consist of highly refractory material, such for example as molybdenum.

The incandescent cathode consists of three wires 26, 27 and 28, for example of tungsten, mounted in parallel and shaped as a U with a deep indentation. Current is supplied to these wires not only by the aforesaid wires 24 and 25 but also by bent leading-in wires 29 and 30 which by welding, soldering, or in any other suitable manner are attached in grooves in the rods 19 and 21. The parallel legs of the incandescent wires lie in the grooves between the ribs 10, between the wall of the vessel 7 and the grid wire 11.

The three wires are at their lower ends fixed by small helices 32 to a ring 33, together with clips 34 (Figure 5). The clips are fixed to a plate 35 carrying small rods 36 and 37. These rods are capable of moving vertically in quartz tubes 38 and 39 mounted at the bottom of the vessel 7 by means of a small cover 40.

This construction prevents the incandescent wires from distorting and contacting with the vessel 7 and the grid wire 11, when expanding by heat.

Fig. 4 shows a cross-section of a different

form of execution. This construction has no grid wire on the ribs 10 of the vessel 7 and the incandescent wires 26, 27 and 28 consequently lie between the vessel 7 acting as a grid and the anode 1. The construction of the discharge tube may otherwise correspond to that shown in Figures 1, 2 and 3. As a rule the amplification factor in the arrangement shown in Figure 4 will be low, for example lower than 10.

In this construction the vessel 7 serving as a grid could be simply cylindrical without ribs, but this results in an unequal distribution of the field at the surface of the incandescent wire which may cause difficulties. For this reason the ribs 10 may be disposed as shown in Figure 4 so that the distribution of the field at the surface of the filament becomes more uniform.

If the amplification factor in an arrangement as shown in Figure 4 is low, this has the additional advantage that it is possible, without increasing the anode tension to an abnormally high extent, to choose such a negative grid tension that the grid does not become positive or at least only to a negligible extent when oscillating during the operation of the tube so that also the grid absorbs practically no energy.

Yet it may be desirable in such a construction having a low amplification factor to cool the grid, because in discharge tubes of very high power especially in an arrangement as shown in Figure 4, the grid may be heated to a very high extent by the heat radiation of the incandescent cathode and it is also important that the energy absorbed by the grid may be conducted away, when the grid-tension unexpectedly reaches positive values relative to the incandescent wire.

It must be mentioned that the amplification factor g is to be understood to mean the partial differential coefficient of the anode tension to the grid tension the anode current being kept constant

$$g = \left(\frac{\delta V_a}{\delta V_g} \right) i_a = \text{const.}$$

A discharge tube according to the invention in which the arrangement is such that the amplification factor is low, for example lower than 10, may be used in the usual circuit arrangements. If an oscillation circuit is interposed in the anode circuit and the self-induction of the former is coupled to a self-induction interposed in the grid circuit it will be necessary in connection with the low value of g to take care that the self-induction (L) in the anode circuit, the mutual induction (M) of the anode and grid circuit, the resistance (R) connected in the oscillation circuit in series with the self-induction, the capacity (C) in the oscilla-

tion circuit and the resistance (r) of the discharge tube have such a value that

$$\frac{CRr}{M} + \frac{L}{M} < g,$$

as this is the condition for oscillating. In this circuit arrangement it is very important that the grid obtains a sufficiently high negative potential, as there is a phase difference of 180° between the grid tension and the anode tension and consequently the lowest anode tension just corresponds to the highest grid tension, which of course assists to form grid currents. If g is low enough it will always be possible to find at the normal anode tension a grid tension having such a high negative value that no grid currents or hardly any occur during oscillation.

If a circuit arrangement without retroaction is chosen and a forced oscillation is impressed on the grid, the energy in the anode circuit will decrease it is true by choosing a low amplification factor, but this may be compensated by increasing the amplitude of the power oscillation, as the anode energy increases with the latter. This causes hardly any loss of energy, as the power oscillation impressed on the grid does not consume any energy because of the absence of any grid current.

What we claim is:

1. An electric discharge tube having an incandescent cathode, an anode adapted to be cooled, and at least one controlling electrode, characterized in that at least one metal vessel forming part of the outer envelope of the tube serves as controlling electrode.

2. A discharge tube having an incandescent cathode, an anode that forms part of the outer envelope, and at least one controlling electrode characterized in that within the anode is arranged a second metal vessel that likewise forms part of the outer envelope of the tube and serves as a grid electrode.

3. A discharge tube according to claim 2, characterized in that the metal vessel arranged within the anode and forming part of the outer envelope is provided with longitudinal grooves, a grid wire being wound on the ribs between the grooves, and that

the incandescent cathode consists of a number of wires extending in the longitudinal grooves between the metal vessel and the grid wire.

4. A discharge tube in which the anode and the metal vessel which, according to claim 2, serves as a grid electrode are arranged concentrically and cylindrically, characterized in that the incandescent cathode comprises a number of wires which are parallel to the axis of the other electrodes.

5. A discharge tube according to claim 2, characterized in that the metal vessel, which serves entirely as a grid electrode, is provided with longitudinal grooves, and the incandescent cathode comprises a number of wires which are arranged in the said grooves, the grooves and wires being preferably so shaped and arranged that the distribution of the field on the surface of the wires is practically uniform.

6. A discharge tube according to claim 2, in which the electrodes are cylindrically and concentrically arranged, characterized in that the anode has hermetically sealed to it a glass vessel provided with two inwardly extending tubes for the hermetical introduction of the leading-in wires for the incandescent cathode, and with a central tube extending upwardly and having hermetically sealed to its end the second metal vessel.

7. A discharge tube according to claim 2, in which the metal vessel arranged within the anode and forming part of the outer envelope is provided with longitudinal grooves, a grid wire being wound on the ribs between said grooves, and a plurality of incandescent cathode wires extending in said grooves between the metal vessel and the grid wire, characterized in that the incandescent wires extending between the anode and the grid electrode are united at one end by a ring provided with a number of clips which are so connected to the bottom of the metal vessel, from which they are insulated, that they can only move rectilinearly in the direction of the incandescent wire.

In testimony whereof we affix our signatures, at the city of Eindhoven, this 4th day of June 1924.

CORNELIS BOL.
BALTHASAR VAN DER POL.