

Jan. 17, 1939.

H. E. HOLLMANN

2,144,222

ELECTRON DISCHARGE DEVICE

Filed June 26, 1936

Fig. 1a

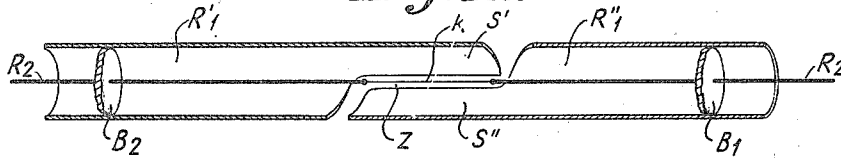


Fig. 1b

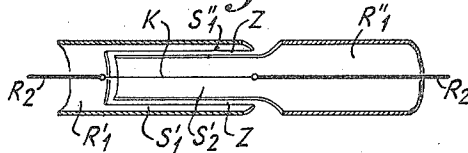


Fig. 2

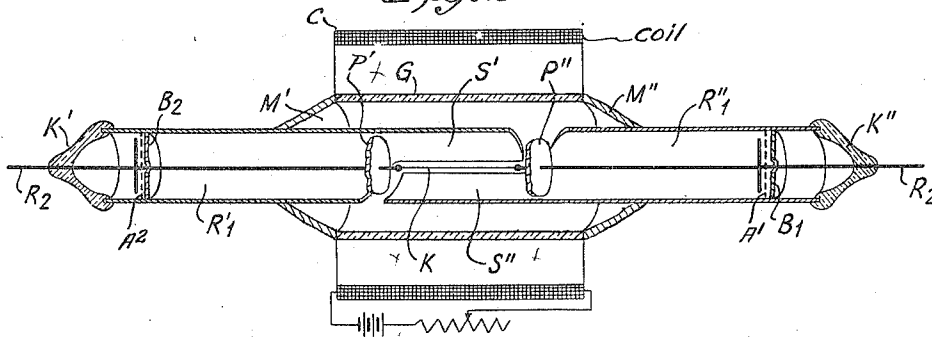
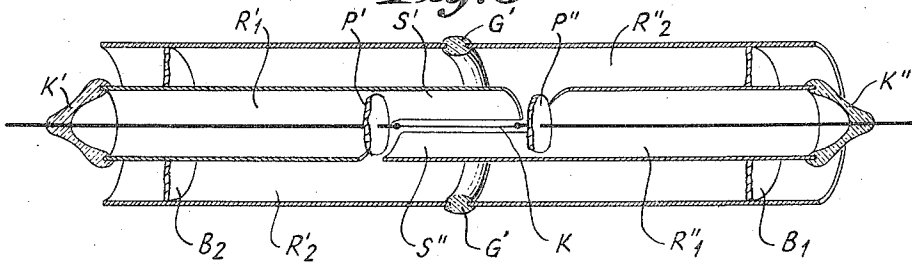


Fig. 3



INVENTOR
HANS ERICH HOLLMANN
BY *H. S. Sworer*
ATTORNEY

UNITED STATES PATENT OFFICE

2,144,222

ELECTRON DISCHARGE DEVICE

Hans Erich Hollmann, Berlin, Germany, assignor
to Telefunken Gesellschaft für Drahtlose Tele-
graphie m. b. H., Berlin, Germany, a corporation
of Germany

Application June 26, 1936, Serial No. 87,386
In Germany August 15, 1935

15 Claims. (Cl. 250—27.5)

It is known that by means of a concentric tubular line acting as a resonance circuit of an ultra-short wave transmitter, a much more favorable adaptation to the building up resistance of the oscillatory tube can be attained, than is possible with a simple double wire line. As a further advantage of the tubular line, it is found that by connecting or inserting tube electrodes, no places of irregularity appear, and that the uniform distribution of the capacity per unit length of the tubular line will not be disturbed by the tube electrodes if the latter are properly connected to or inserted in the tubular line. This property of a tubular line not only produces a notable improvement in the useful effect, but it also decreases the danger that due to reflections of the waves at irregular places existing in wire lines, side waves may be created thus detrimentally affecting the stability of the ultra-short wave transmitter.

The connection or insertion of a three pole tube to or in a concentric tubular line does not cause any particular difficulties, since the inner tube can simply terminate into the grid and the outer tube into the anode. The tube electrodes are connected in a simple manner to the tubular line by having the diameters of the tubular conductors conform exactly to the diameters of the electrodes; different diameters may also be used, it being necessary to take the precaution that the wave resistance (i. e., surge impedance) does not undergo a sudden change at the place of transition, but that it is the same for the tubular conductor and for the tube electrodes.

Also in case of the magnetron which operates with the greatest efficiency, as is known, in the ultra short wave range, a tubular conductor as an excited oscillatory system is found to be advantageous. In the case of a magnetron with solid anode, the problem of connecting a tubular conductor can be solved in a comparatively simple manner, since in this case the anode may simply terminate into the outer tubular conductor and the cathode into the inner tubular conductor, or both may form a part of the outer tubular conductor and inner conductor included in the concentric tubular line. The conditions are more difficult in case of a magnetron with slotted anode of the type proposed by Habann, in which, as is known, the anode cylinder is divided into two or several segments. The difficulties encountered in connecting these two segments or groups of segments with a tubular line, are caused by the fact that the segments are situated on a single cylinder surface from where they must be brought

to the two tubular conductors with different diameters. This can be accomplished only by complicated bends and the like, thereby producing places of irregularities which are just to be avoided by the tubular conductors. The claw-like anode segments S' and S'' of Fig. 1a and the segments S'_1 , S'_2 and S''_1 of Fig. 1b can be said to overlap each other, the term "overlap" not being limited to any particular arrangement whereby the segments face each other but being broad in its meaning to include any dovetail or over-reaching arrangement of segments.

In order to overcome these drawbacks in the present invention, an arrangement will be described in which the outer tubular conductor or the inner one of a concentric double line is composed of two parts having the same diameter, namely such that the axes of said parts form a straight through line. These two tubular pieces terminate at the ends facing each other into segments which engage each other in the manner of claws, and thereby form the anode of a Habann tube. Before describing the complete magnetron transmitter as completed by the second tubular conductor of the concentric line, this basic idea of the present invention will be elucidated by reference to Figs. 1a and 1b, which show details of an electron discharge device constructed in accordance with the invention. Figs. 2 and 3 show, except for the magnetic field, complete details of an electron discharge device in accordance with the invention.

In Figs. 1a and 1b, items R'_1 and R''_1 represent the two tubular pieces of equal diameter coaxially arranged. At their ends facing each other, they terminate into the segments S' and S'' of Fig. 1a, which are so dimensioned that they do not come in contact with each other, but leave therebetween the slots Z necessary for the production of oscillations. Fig. 1b shows the arrangement of four segments, whereby each tubular piece has two segments, the longitudinal cross section revealing, however, only three segments S'_1 , S'_2 and S''_1 .

In order to complete the entire tube thus produced to a concentric line by means of a second conductor, the arrangement may be such that the tubular conductors R'_1 and R''_1 form the outer tubular conductor or the inner tubular conductor. At first the simplest case will be described in which inside of tubular conductors R'_1 and R''_1 a coaxial conductor is arranged. The latter is designated by R_2 in Fig. 1, and is so constructed that it terminates in the center, i. e. within the segments, into the filament K. In order to

establish oscillation nodes at the ends of the concentric tubular line, two metallic closing discs B_1 and B_2 are provided by means of which the line will be short circuited. Putting it another way, discs B_1 and B_2 are short circuiting discs which have extremely low impedance to radio frequency currents.

In order to evacuate the space between the segments, the entire arrangement can be placed into a vacuum vessel, or parts of the tubular line may be formed as parts of the vacuum vessel and may be sealed up with suitable covers of glass and intermediate glass pieces. A construction in which this is possible is shown in longitudinal cross section in Fig. 2. Items R'_1 and R''_1 are again the two tubular pieces terminating into the segments S' and S'' , and in whose axis the central conductor R_2 with the filament K are placed. Items B_1 and B_2 are again the two closing bridges which in this case are capacitively subdivided to separate the plate potential. To achieve this end they consist of two metal discs, the one connected to the outer tubular conductors R'_1 and R''_1 , and the other one joining the inner tube central conductor R_2 , said metal discs being electrically separated from each other by means of an intermediate insulating disc A_1 or A_2 . Items P' and P'' are two metallic end plates connected only to R_2 and which serve in known manner for absorbing and deviating the electron current leaving the space between filament and segments by the action of the magnetic field in the axial direction. The two free ends of the outer tubular pieces R'_1 and R''_1 are now closed up vacuum tight by means of two glass caps K' and K'' . The central conductor R_2 is passed through them in order to supply the heating voltage. Over the segments there is placed a short tube G of glass or quartz, likewise connected vacuum tight with the two tubular pieces R'_1 and R''_1 by means of cone-shaped metal rings M' and M'' . In this manner a completely enclosed hollow space is produced that can be evacuated in the ordinary way. The magnetic field necessary in the axial direction is obtained in the simplest manner, by means of a coil C surrounding the tube.

The condition of oscillation will now become such that a voltage loop appears in the center between the two short circuit bridges B_1 and B_2 . Owing to the capacity between the segments, and in view of the uninterrupted central through conductor, the outer tubular conductor acts uniformly as regards the electric waves, i. e. the two segments S' and S'' will oscillate in equal phase. For the production of oscillations, in this case only the negative building up resistance between the segments, acting as a closed anode cylinder, and the filament play a part. In the slotted anode cylinder of the Habann tube, the negative building up resistance lies, however, between the segments, and optimum useful effect is obtained only when the oscillatory system to be excited by the magnetron lies between the segments and produces thereat high frequency potentials of opposite phase.

In order also to accomplish this in the arrangement herein described, a further mode of structure according to the idea of the invention is shown in Fig. 3, wherein the two tubes R'_1 and R''_1 together with their segments S' and S'' form the inner cylinder of a concentric tubular line, surrounded by a further metal tube which is again closed up by means of short circuit bridges B_1 and B_2 . This outer tube, just as in the case

of the inner tube, is divided into two halves R'_2 and R''_2 maintained at proper space, in the example of construction herein described, by means of a short spacer ring G' of glass. The space between the two outer tubular pieces, in other words the length of the spacer ring G' , will suitably be so chosen that the mutual capacity between R'_2 and R''_2 equals the capacity between the segments S' and S'' , in order that the state of oscillation of the tubular line will be possibly a symmetrical one. Thus the entire tubular line between bridges B_1 and B_2 is divided into two halves of which each can oscillate in $\lambda/4$, so that phase opposite high frequency voltages will be produced at the two segments S' and S'' , or at the corresponding groups of segments. The arrangement of the filament K and of the end electrodes P' and P'' have remained the same as in the case of Fig. 2. In this practical example, the vacuum vessel is formed of K' , R'_1 , B_1 , R'_2 , G' , R''_2 , B_2 , K'' , but this arrangement may also be provided with a glass enclosure surrounding only the inner tubular conductor, such as shown in Fig. 2, whereby the advantage is obtained that the two bridges B_1 and B_2 can be moved for the purpose of tuning.

It should be understood that the invention permits of numerous other combinations of elements not specifically disclosed herein. The feeding and the putting in operation of this transmitter takes place in exactly the same manner as in the hitherto known magnetron generators.

What is claimed is:

1. An electron discharge device comprising a pair of separated anodes in the form of two coaxial metallic tubes of substantially the same diameter placed end to end, portions of said anodes near their adjacent ends being cut away to provide overlapping separated segments, a cathode located in the axis of said anodes and having an effective portion in the region of said overlapping segments of said anodes, and means surrounding said anodes in the region of said segments for producing a magnetic field.

2. An electron discharge device comprising a pair of separated anodes in the form of two coaxial metallic tubes of substantially the same diameter placed end to end, portions of said anodes near their adjacent ends being cut away to provide overlapping separated segments, a cathode located in the axis of said anodes and having an effective portion in the region of said overlapping segments of said anodes, and a metallic plate connected to each terminal of the effective portion of said cathode for confining impact of said electrons to said segments.

3. An electron discharge device comprising a pair of separated anodes in the form of two coaxial metallic tubes of substantially the same diameter placed end to end, portions of said anodes near their adjacent ends being cut away to provide overlapping separated segments, a cathode located in the axis of said anodes and having an effective portion in the region of said overlapping segments of said anodes, and a metallic plate connected to each terminal of the effective portion of said cathode for confining impact of said electrons to said segments, said coaxial metallic tubes comprising the outer envelope of said device, and means surrounding said device at the location of said anode segments for producing a magnetic field.

4. An electron discharge device comprising two coaxial metallic tubes of substantially the same diameter placed end to end, the adjacent por-

tions of said tubes being cut away to provide for each tube a pair of separated segments facing each other, the segments of one tube occupying the spaces between segments of the other tube, a cathode located substantially in the axis of said tubes and having an effective portion in the region of said segments, said segments comprising anodes for said device, and means for producing a magnetic field in the space between said segments.

5. An electron discharge device comprising a pair of coaxial metallic tubes of substantially the same diameter placed end to end, each of the adjacent portions of said tubes having a segment forming an anode, a cathode located in the axis of said tubes and having an effective portion in the region of said segments, and means for producing a magnetic field in the space between said segments.

6. An electron discharge device comprising a pair of coaxial metallic tubes of substantially the same diameter placed end to end, each of the adjacent portions of said tubes having a segment forming an anode, a cathode located in the axis of said tubes and having an effective portion in the region of said segments, and leads extending in the same straight line as said cathode for connecting the terminals of said cathode to a circuit located externally of said device, each of said leads being located within one of said tubes, and means within said device having low impedance to radio frequency energy coupling each lead with its associated metallic tube surrounding it.

7. An electron discharge device in accordance with claim 6, wherein said low impedance means consist of metallic discs.

8. A magnetron comprising a pair of coaxial metallic tubes of substantially the same diameter placed end to end, each of the adjacent portions of said tubes having a segment forming an anode, a cathode located in the axis of said tubes and having an effective portion in the region of said segments, an envelope surrounding said tubes for a portion on both sides of said segments, means effectively closing the ends of said tubes remote from said segments whereby said tubes and envelope form an evacuated electron discharge device, and means for producing a magnetic field for influencing the path of travel of the electrons emanating from said cathode.

9. A magnetron in accordance with claim 8, wherein said envelope is made of glass and said tubes form walls for said evacuated electron discharge device.

10. An electron discharge device comprising a pair of coaxial metallic tubes of substantially the same diameter placed end to end, each of the adjacent portions of said tubes having a segment forming an anode, a cathode located in the axis of said tubes and having an effective portion in the region of said segments, a concentric outer conductive tube surrounding said coaxial tubes for the greater portion of their length, said concentric outer tube being divided into two por-

tions placed end to end and comprising a part of an evacuated envelope for said device, and means having low impedance to radio frequency energy located near each end of said coaxial tubes directly connecting same to said outer tube.

11. An electron discharge device comprising a pair of coaxial metallic tubes of substantially the same diameter placed end to end, each of the adjacent portions of said tubes having a segment forming an anode, a cathode located in the axis of said tubes and having an effective portion in the region of said segments, a concentric outer conductive tube surrounding said coaxial tubes for the greater portion of their length, said concentric outer tube being divided into two portions placed end to end which comprise a part of an evacuated envelope for said device.

12. An electron discharge device comprising a pair of coaxial metallic tubes of substantially the same diameter placed end to end, each of the adjacent portions of said tubes having a segment forming an anode, a cathode located in the axis of said tubes and having an effective portion in the region of said segments, a concentric outer conductive tube surrounding said coaxial tubes for the greater portion of their length, said concentric outer tube being divided into two portions placed end to end which comprise a part of an evacuated envelope for said device, and means of low impedance to radio frequency energy constituting metallic discs which are movable over the inner surface of said outer conductive tube and the outer surface of said inner tube.

13. An evacuated electron discharge device comprising inner and outer concentric electrically conductive tubes forming an oscillatory circuit, said inner tube being divided into two portions placed end to end, means near the outer ends of said portions of the inner tube and connected to both inner and outer tubes for tuning same, and electron emitting means located in the interior of said inner conductive tube.

14. An evacuated electron discharge device comprising inner and outer hollow concentric conductive tubes forming an oscillatory circuit, a concentrically arranged cathode located near the center of and within said inner tube, said inner tube being divided into two portions placed end to end, and means near the remotely located ends of said inner tube and connected to both hollow tubes for tuning same.

15. Magnetron transmitter comprising an evacuated electron discharge device including a concentric tubular line having two conductive tubes of the same diameter terminating at the ends facing each other into two overlapping segments, said segments being physically separated from one another and forming anodes for said device, a cathode located in the space between said segments, and a coil surrounding said electron discharge device for producing a magnetic field.

HANS ERICH HOLLMANN.