April 12, 1932. W. J. KIMMELL 1,853,687

DOUBLE GRID TUBE

Filed May 12, 1927

Fig. 1.

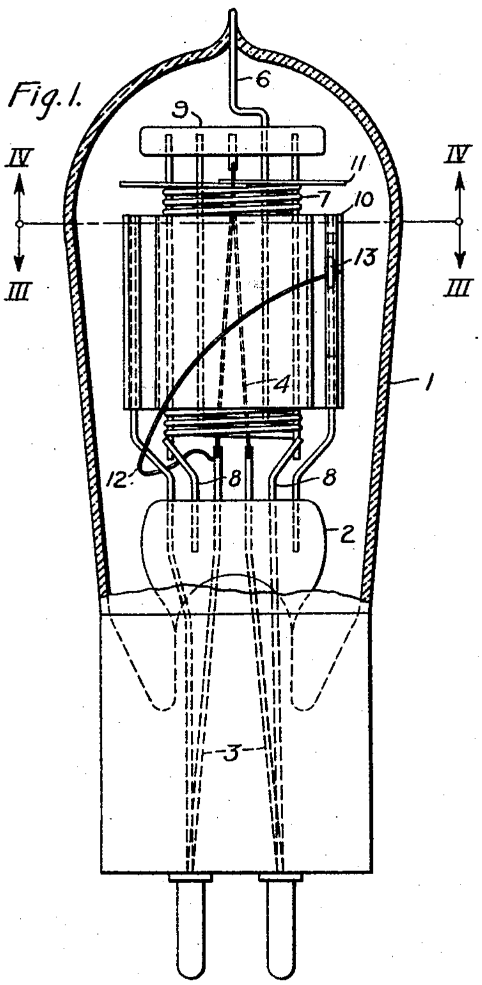


Fig. 2.

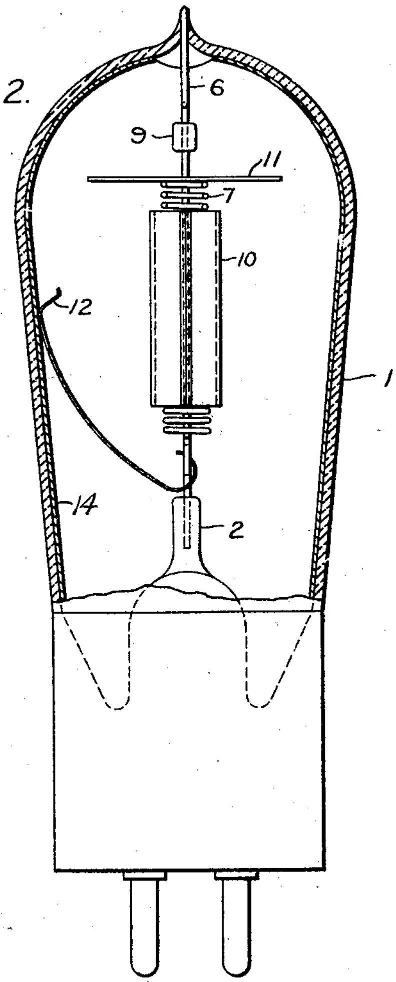


Fig. 3.

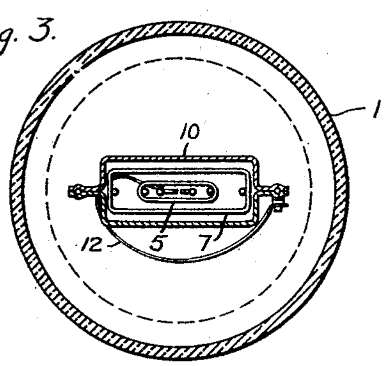
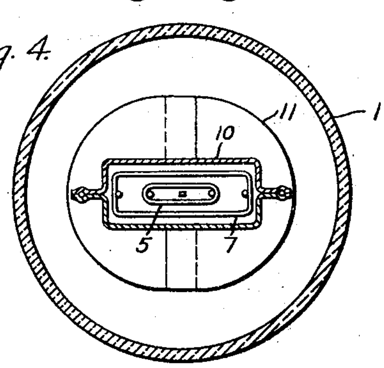


Fig. 4.



WITNESSES:

Chas. C. Crowne

F. W. Lyle.

INVENTOR

William J. Kimmell.

BY

Wesley G. Carr

ATTORNEY

Patented Apr. 12, 1932 **1,853,687**

UNITED STATES PATENT OFFICE

WILLIAM J. KIMMELL, OF TRAFFORD, PENNSYLVANIA, ASSIGNOR TO WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA

DOUBLE GRID TUBE

Application filed May 12, 1927. Serial No. 190,665.

My invention relates to vacuum tubes and to methods of constructing them. More particularly it relates to so-called screen-grid tubes for use as radio amplifiers and detectors.

One of the objects of my invention is to produce a radio amplifier and detector tube which shall have a minimum tendency to act as a source of undesired oscillations.

Another object of my invention is to produce a tube in which the effective capacity between the control electrode and the plate shall be a minimum.

Another object of my invention is to produce a tube which shall have its electrode positioned within a shielded enclosure maintained at ground potential, and thereby free from disturbing influences originating externally to the tube.

A further object of my invention is to devise a method of producing a shielding coating upon the interior of a tube and of connecting it to any desired electrode.

Other objects of my invention will be apparent from the following specification, taken in connection with the drawings, wherein

Figure 1 is a longitudinal section of a tube, embodying my invention, in the condition it is in prior to the deposition of a shielding coating upon its interior walls.

Fig. 2 is a longitudinal section of a tube after the deposition of the aforesaid coating and represents the tube in its finished and operative state.

Figs. 3 and 4 are sections taken on the lines III—III and IV—IV of Fig. 1, respectively.

As is well known, the ordinary three-electrode radio tube of the prior art has an appreciable electrostatic capacity between its anode and control-electrode, in consequence of which it is liable to produce undesired oscillations. The undesired oscillations impose a limitation upon the number of amplifying tubes which may be used in series, since these oscillations, generated because of the internal capacity of the tube, interact to produce the disturbances of audible frequencies which constitute the howling which is so troublesome in present-day radio receiving sets.

It has been found that, if an additional grid electrode be interposed between the anode and the control-grid of radio tubes of the conventional type and be maintained at a definite potential relative to the cathode, the capacity between the anode and control-electrode is greatly decreased, with the consequent diminution of the troublesome oscillations just described. However, it is found that there is a certain amount of residual capacity still left between the anode and control-electrode so that the above mentioned difficulties are not completely eliminated by the simple structure just described.

I have discovered that, if the interior wall of the radio tube in the vicinity of its operative electrodes be covered with a conducting coating connected to the cathode, or alternatively to the additional grid just mentioned, practically the entire residual capacity between the anode and control-electrode is eliminated, with the consequent complete elimination of the trouble from self-oscillation. I have further found that, by bringing the inleading wire to the control grid through the top of the tube rather than through the conventional press supporting the inleading wires at the lower end of the tube, and by interposing between the plate electrode and the upper control-electrode lead a metallic shield, the slight remnant of capacity between the anode and the control grid is done away with.

Referring to the drawings, 1 denotes a vacuum-tight glass radio tube of ordinary type having, at its lower end, a press 2 through which passes inleading wires 3 to a cathode 4 of conventional structure near the axis of the tube. Surrounding the cathode 4 is a control-grid 5 which may be of ordinary type except that its inleading wire 6 preferably enters the tube through the top instead of through the press 2. Surrounding the control-electrode, in turn, is a second or screen grid 7 which is supported on two vertical wires 8 having their upper ends fixed in an insulator 9 and their lower ends supported in the press 2. The screen grid is adapted to be connected to external circuits through one lead 8 passing through the press.

Surrounding the entire set of electrodes, just described, is an anode 10 of conventional type.

Supported on, and connected to the upper end of the screen grid is a shielding plate 11 which surrounds the control-grid lead 6 and shields its upper portion from electric fields due to anode 10. The control-grid lead extends through a small opening in this plate. As shown in Fig. 4, this plate may be formed of two semi-circular halves not making direct contact to each other, but individually welded to the screen-grid.

In the course of manufacture of this tube, the press 2 is first formed with the structure comprising cathode 4, control grid 5, screen grid 7, anchor 9, plate 11 and anode 10 supported thereon. The control grid lead 6 projects above the top of this electrode structure, but is, of course, not yet sealed into the enclosing tube. This entire structure is inserted through the flared lower end of the enclosing tube 1 and sealed in place therein, the control-grid lead 6 being inserted through the top of the tube 1 and sealed thereto at the same time.

At the time this electrode structure is assembled on the press, a thin flexible wire 12, preferably of tungsten, is welded either to one of the cathode leads 3 or to the lead 8 of the screen grid and is welded in such a position that, upon straightening out, its free end will press against the tube wall. However, for the time being, the other end of the flexible wire is welded to a small piece of metallic magnesium 13 which is, in turn, welded to the outside of the anode structure 10. The flexible wire is, therefore, held under tension out of contact with the tube walls.

The tube is exhausted in a fashion well known in the art of radio-tube manufacture and, when its vacuum has attained a satisfactory condition, an inductive heating coil of the type well known in the art is used to raise the temperature of the aforesaid magnesium to the point where it quickly melts and vaporizes. The vapor immediately condenses on the tube walls, producing the well known clean-up of residual gases and thereby perfecting the vacuum. In addition, the end of the flexible wire 12 which was held bound by the magnesium is freed and it snaps into contact with the magnesium coating 14 which is just then settling upon the tube walls. It is conducive to the success of this operation that the heating of the magnesium take place as rapidly as possible; in other words that a large input of power to the inductive heater be ensured.

It should also be provided that a sufficient quantity of magnesium be vaporized to produce a thick and readily conductive coating on the entire interior of the tube in the neighborhood of its electrodes. By locating the magnesium tab in the position shown in Fig. 1, the tube walls surrounding the electrode group will be heavily coated, but practically no coating will deposit where any of the inleading or support wires are sealed into glass. This prevents the magnesium coating from forming a short-circuit between any of the various electrodes.

The tube constructed in the foregoing manner is intended to be connected for use in the following way. The cathode is supplied with current from any convenient alternating-current or direct-current source. A source of unidirectional electromotive force may be connected between the cathode circuit and the lead of the screen grid, thereby maintaining the latter at a different and uniform potential with reference to the cathode. The input electromotive force is connected between the control grid lead 6 and the cathode 4, and the output circuit is connected to the leads from cathode 4 and anode 10 in any manner usual in the ordinary detector or amplifier circuit arrangements.

Because of the interposition of the screen grid between the anode and the control grid, it intercepts nearly all the lines of electric force which would otherwise tend to flow from the interior face of the anode to the control grid. Thus the electrostatic capacity between the interior face of the anode and control electrode is substantially zero.

The metallic coating formed upon the interior of the tube is connected in the embodiment here shown, by the flexible lead 12 to the cathode, and is, therefore, maintained always at the cathode potential. In consequence, any stray lines of electromotive force emanating from the exterior face of the anode 10 find a convenient terminus upon this coating and practically none of them terminate upon the control-grid lead. Furthermore, the shield 11, which is maintained at the potential of the screen-grid 7, intercepts lines of electric force tending to pass from the anode to the control-grid lead 6. Hence, the electrostatic capacity between the anode and the control grid is reduced practically to zero. In other words variations in the potential of either of these electrodes have practically no effect on the other.

As a result of the construction above described, I have produced a radio tube having practically zero capacity between its anode and grid electrodes. The presence of the screen-grid 11 also reduces practically to zero the conductance of the path within the tube from anode to the cathode. As a consequence, the flow of current through the output circuit including the anode is determined almost entirely by the value of the control-grid potential. As a result, there is no tendency for the tube to go into self-oscillation; neither is there any tendency for a feed-back of energy to take place from the anode circuit to the control grid circuit. The tube is, therefore, quite strictly a one-way transmitter of modulations.

If, as is ordinarily the case, a portion of the cathode circuit is grounded, the conducting deposit on the interior of the tube walls is likewise maintained at ground potential. The electrodes inside the tube are, therefore, almost completely screened from disturbances due to electrical effects originating externally to the tube.

It will be evident that, instead of connecting the interior coating of the tube to the cathode, I might arrange the flexible wire to connect it to one of the other electrodes, such as the screen-grid, for example.

It will furthermore be evident that, instead of coating the interior of the tube with a metallic deposit, I might attain a similar shielding effect by a conducting coating on the exterior of the tube connected in circuit in similar fashion. It will further be evident that, while I have described magnesium as the metal to form a fusible connection for the flexible wire 12, other readily fusible metals may be substituted therefor. In fact, magnesium is only one of the metals commonly vaporized in high-vacuum tubes and known in the art under the name of "getters". Any of these well known getters might be used for this purpose.

I have specified that the flexible wire shall be made of tungsten but it will be evident that materials other than tungsten might be arranged to spring or even to fall by gravity to form a conducting bridge between the cathode and the conducting coating.

Instead of connecting the internal coating of the tube directly to one of the electrodes, I may leave it disconnected but cover a portion of the exterior of the tube with a conducting coating connected to the desired electrode-lead. The exterior and interior coatings then comprise a condenser and the induced charges thereon produce similar effects to those described above in the case of conductive connection from cathode to coating as described above.

While I have described my method of shielding in connection with a screen-grid tube, it will be evident that many of its desirable effects are equally applicable to electron-discharge tubes of other types. It is, therefore, not limited in applicability to screen-grid tubes. It will further be evident that the screen-plate 11 and the coating on the interior of the tube are adjunctive features, and that either may be applied without the presence of the other.

I have, therefore, produced a tube which is almost completely free from the troublesome effects of electrode capacity and of disturbing influences originating in objects external to the tube.

While I have described a particular embodiment of my invention, it will be evident that the principles thereof may be applied to many types of apparatus differing from the one I have here illustrated. I desire, therefore, that the claims be accorded the broadest interpretation to which their language is reasonably susceptible and that their scope be limited only by their express terms and in accordance with the prior art.

I claim as my invention:

1. The method of producing an electrical discharge device in a vacuum-tight container having a plurality of electrodes therein which comprises attaching a resilient conductor to one electrode under an elastic force tending to force said conductor into contact with the wall of the container, opposing said elastic force by a link of fusible material, exhausting said container and melting said fusible material.

2. The method of producing an electrical discharge device in a vacuum-tight container having a plurality of electrodes therein which comprises attaching a resilient conductor to an electrode under an elastic force tending to bridge the gap between said electrode and the container wall, opposing said elastic force by a link of vaporizable metal, evacuating said container and vaporizing said metal.

3. In combination, a vacuum-tight container holding an electrode group comprising a cathode, a main electrode and a screen-electrode supported from one end thereof, a control-electrode, a support therefor from the other end of the container, a conducting shield on the walls of said container substantially enveloping said electrode group, a connection from said coating to the cathode and a shield between said control-electrode support and said anode and connected to said screen-electrode.

4. In combination, a vacuum-tight container holding an electrode group comprising a cathode, a main electrode, a screen-electrode and a control-electrode, a conducting coating on the interior of said container in the region of said electrode group and a resilient conductor connecting said coating to said cathode.

5. The method of constructing a vacuum tube having an anode member, a cathode member, a conductive coating on the inside of said vacuum tube and having said coating connected to one of said members which comprises forming said coating and connecting said cathode member to said coating by vaporizing a getter.

In testimony whereof, I have hereunto subscribed my name this 10th day of May, 1927.

WILLIAM J. KIMMELL.