June 8, 1948. H. W. G. SALINGER 2,442,862

PUSH-PULL AMPLIFIER TUBE

Filed Oct. 17, 1945 2 Sheets-Sheet 1

FIG. 1

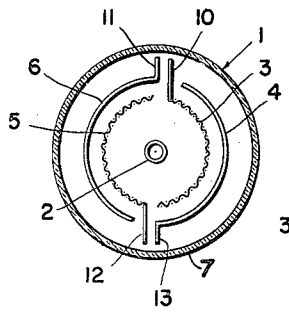


FIG. 3

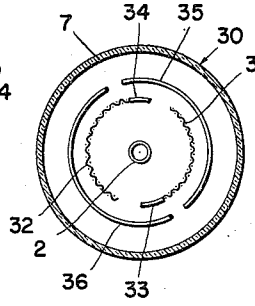


FIG. 4

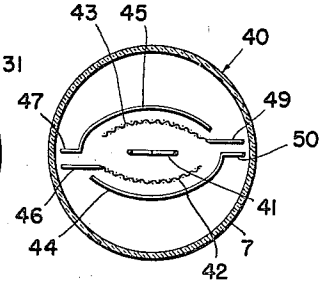


FIG. 2

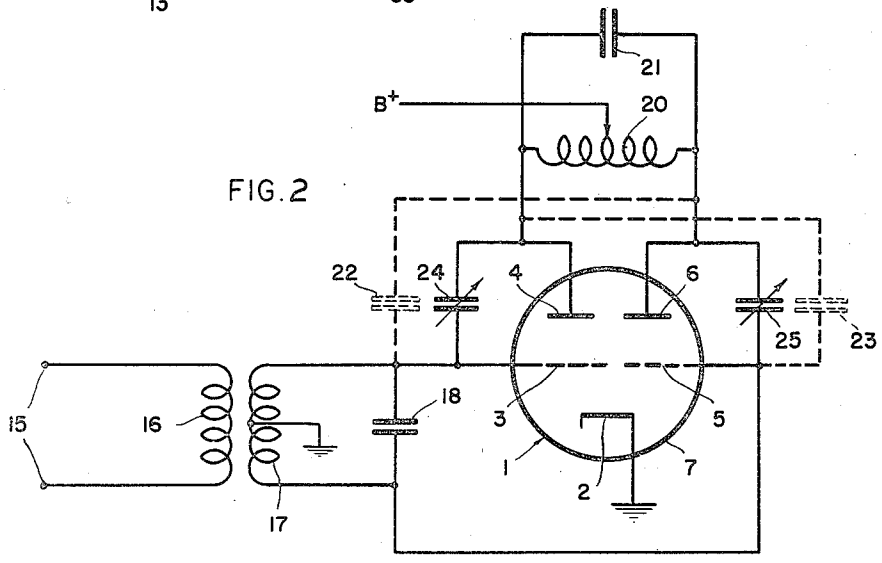
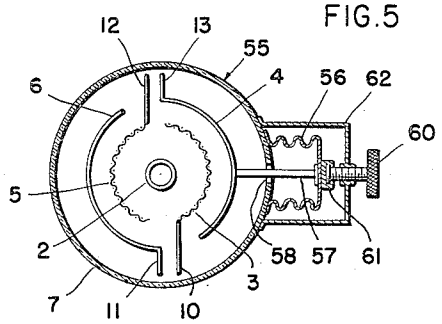


FIG. 5



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FIG. 6

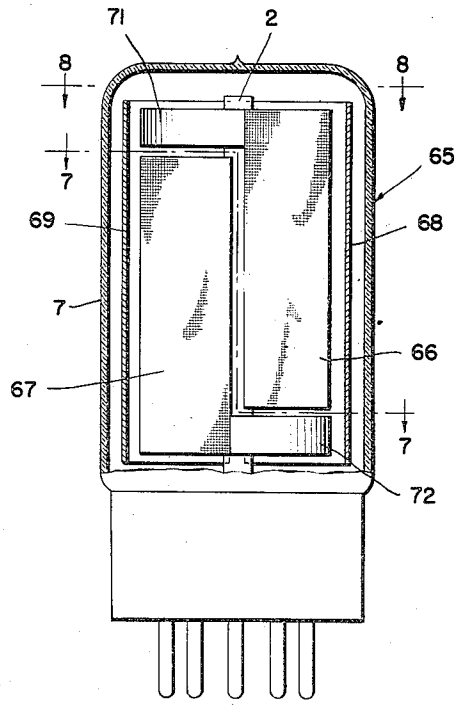


FIG. 7

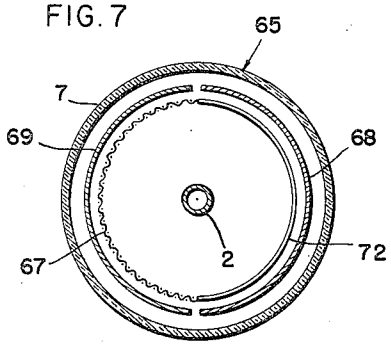
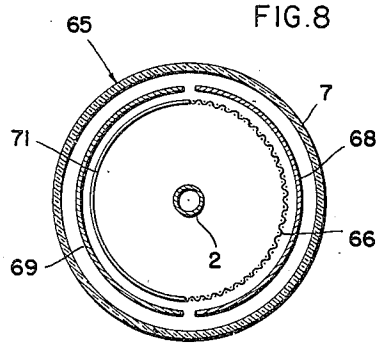


FIG. 8



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Patented June 8, 1948 2,442,862

UNITED STATES PATENT OFFICE

2,442,862

PUSH-PULL AMPLIFIER TUBE

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Application October 17, 1945, Serial No. 622,740

6 Claims. (Cl. 250—27.5)

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This invention relates generally to thermionic discharge devices, and more particularly relates to a push-pull duplex amplifier tube with internal and symmetrical neutralization.

Push-pull amplifier circuits combine negligible amplitude distortion with a large power output and, therefore, they are used frequently in the power amplifier stage of a modulated carrier transmitter. It is well understood that the interelectrode capacitances which exist in any amplifier tube result in a feedback between the anode and the control grid of the tube. At radio frequencies correction is required for these interelectrode capacitances, and at high and ultra high frequencies the compensation of the unwanted capacitances becomes a major problem. A push-pull amplifier stage is conventionally arranged for compensating or neutralizing the interelectrode capacitances by connecting condensers between the grid of one tube and the plate of the other tube. The equivalent circuit of a neutralized push-pull amplifier stage of this type may be considered as a bridge which is physically symmetrical because the four arms of the bridge connected between the two grids and the two anodes of the push-pull tubes all contain capacitances.

Neutralization of a push-pull amplifier stage by connecting condensers between the grid of one tube and the plate of the other tube has various drawbacks. The geometric arrangement of the two condensers is particularly awkward because the plate of each tube must be connected to the grid of the other tube so that the leads of the neutralizing condensers cross each other. Furthermore, the leads are usually arranged as tubings in order to reduce their inductance at high frequencies. In view of the thickness of the tubings the leads must be made comparatively long which in turn increases their undesired inductance.

At ultra high frequencies the inductances of the leads must be taken into consideration and particularly the inductances of the leads connecting the neutralizing condensers between the grids and anodes of the push-pull tubes. Thus, the inductances of the grid leads may be compensated by introducing suitable capacitances in series with the grid leads. It will, however, be seen that such an arrangement will only compensate the grid lead inductances at one frequency. When it is desired to amplify a modulated carrier signal having a wide side band, such as used for the transmission of television signals, the neutralization of the grid leads at the center of the side band is not sufficient because large grid voltages are induced at the edges of the side

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band. Various bridge circuits have been suggested for neutralizing the interelectrode capacitances as well as the inductances represented by the various leads, particularly the grid leads of the neutralizing condensers. However, in most circuits neutralization is only effected at one frequency or at the most within a limited frequency range only.

It is an object of the present invention, therefore, to provide a push-pull amplifier tube of the duplex type where neutralization is effected substantially without introducing grid leads.

Another object of the invention is to provide a thermionic duplex discharge tube having internal and symmetrical neutralization and suitable for push-pull amplification of high-frequency wide-band signals.

A further object of the invention is to provide a push-pull amplifier stage including a duplex triode having internal capacitances for neutralizing the circuit and including means for adjusting the value of the neutralizing capacitances.

In accordance with the present invention, there is provided an electric discharge device comprising an electron source. A first anode and a second anode are arranged for receiving electrons from the electron source. A first grid is arranged for controlling the flow of electrons between the electron source and the first anode and a second grid is arranged for controlling the flow of electrons between the electron source and the second anode. The first grid and the second anode are spaced and dimensioned relatively to each other in a manner to form a capacitance therebetween, while the second grid and the first anode are spaced and dimensioned relatively to each other in a manner to form a capacitance therebetween. A common envelope is provided for enclosing the electron source, both anodes and both grids. The capacitances formed between the first grid and the second anode and between the second grid and the first anode effect an internal neutralization of the discharge device. Accordingly, the necessity of providing leads for connecting external condensers between the respective grids and anodes is avoided.

For a better understanding of the invention, together with other and further objects thereof, reference is made to the following description, taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

In the accompanying drawings:

Fig. 1 is a cross-sectional view of a thermionic duplex tube embodying the present invention;

Fig. 2 is a circuit diagram of a neutralized push-

pull amplifier stage including means for adjusting the neutralizing capacitances in accordance with the invention;

Figs. 3 and 4 are cross-sectional views of modified push-pull duplex tubes in accordance with the invention;

Fig. 5 is a cross-section view of a duplex tube having means for adjusting one of its internal neutralizing capacitances according to the present invention;

Fig. 6 is a front elevational view, with parts broken away, of a modification of a push-pull duplex tube in accordance with the invention; and

Figs. 7 and 8 are sectional views taken on lines 7—7 and 8—8 of Fig. 6, respectively.

Throughout the figures like components are designated by the same reference numerals.

Referring now particularly to Fig. 1 of the drawings, there is illustrated thermionic discharge tube 1 of the duplex or twin type. Discharge tube 1 is provided with common cathode 2 which may be indirectly heated. Control grid 3 is formed by a semi-cylindrical foraminated surface having its axis in cathode 2. Anode 4 is also formed by a semi-cylindrical surface and arranged for cooperation with control grid 3. Cathode 2, control grid 3 and cathode 4 together form one section of duplex discharge tube 1. The other section of discharge tube 1 includes foraminated control grid 5 and anode 6 which are substantially identical with grid 3 and anode 4, respectively. It will be seen that control grids 3 and 5 together form substantially a foraminated cylinder having its axis in cathode 2. Similarly, anodes 4 and 6 form together substantially a cylinder which also has its axis in cathode 2. Envelope 7 encloses cathode 2, control grids 3, 5 and anodes 4, 6.

In accordance with the present invention, a capacitance is formed between control grid 3 and anode 6 and between control grid 5 and anode 4, respectively. To this end control grid 3 is provided with a solid straight extension 10 forming an angle with grid 3. Anode 6 is also provided with straight extension 11 forming an angle with anode 6 and arranged substantially parallel with grid extension 10. Grid extension 10 and anode extension 11 are spaced and dimensioned in a manner to form a capacitance of predetermined value therebetween. Similarly, control grid 5 is provided with a solid straight extension 12 spaced from and parallel with straight anode extension 13 to form a capacitance of predetermined value therebetween. The capacitances formed between grid extension 10 and anode extension 11 and between grid extension 12 and anode extension 13 are preferably of equal value and are introduced in a symmetrical manner.

Electron discharge tube 1 may be used with advantage in a push-pull amplifier stage of the type illustrated in Fig. 2. The circuit of Fig. 2 accordingly comprises discharge tube 1 having a common cathode 2 and two tube sections including, respectively, control grid 3 and anode 4 on the one hand, and control grid 5 and anode 6 on the other hand. The modulated carrier signal to be amplified is connected to input terminals 15 and impressed upon inductor 16 inductively coupled with inductor 17. Inductor 17 and condenser 18 form a parallel resonant circuit connected to control grids 3 and 5 so that the signal is impressed on the two grids in phase opposition. The mid point of inductor 17 is grounded as shown, but it is to be understood that a suitable grid bias supply may be connected to the mid point of inductor 17 instead. Cathode 2 is grounded as shown. Anodes 4 and 6 are connected to opposite terminals of inductor 20 forming a parallel resonant output circuit with condenser 21. The mid point of inductor 20 is connected to a suitable anode supply indicated at B+. The amplified output signals may be obtained from parallel resonant circuit 20, 21.

Capacitance 22, shown in dotted lines, is connected between control grid 3 and anode 6. Capacitance 22 corresponds to the capacitance formed by grid extension 10 and anode extension 11. Similarly, capacitance 23, also shown in dotted lines, is connected between control grid 5 and anode 4 and corresponds to the capacitance formed between grid extension 12 and anode extension 13. Adjustable or trimming condenser 24 provided externally of envelope 7 is connected between control grid 3 and anode 4, while adjustable or trimming condenser 25 also arranged externally of envelope 7 is provided between control grid 5 and anode 6. It will be understood that external trimming condensers 24 and 25 are connected by leads arranged outside envelope 7 between the grids and the anodes of the two tube sections. Trimming condensers 24 and 25 are each connected between the anode and the grid of the same tube section. Therefore their connections are much simpler than those of the neutralizing condensers of prior circuits.

The equivalent circuit of the push-pull amplifier stage of Fig. 2 may be considered as a bridge. Two adjacent arms of the bridge are formed by capacitance 22 and trimming condenser 24, while the other two adjacent arms of the bridge are formed by capacitance 23 and trimming condenser 25. The interelectrode capacitances between control grid 3 and anode 4 and between control grid 5 and anode 6, respectively, are in parallel with trimming condensers 24 and 25 in the electrical bridge. It will be seen that this bridge may be adjusted or neutralized either by adjusting capacitances 22 and 23 or by adjusting trimming condensers 24 and 25. Hence, it may be advantageous to adjust the circuit of Fig. 2 for the purpose of neutralization by means of trimming condensers 24 and 25.

The effect of the leads connecting trimming condensers 24 and 25 to the respective grids and anodes is not nearly as detrimental as the effect of leads of neutralizing condensers, such as 22 and 23 would be. This is due to the fact that trimming condensers 24 and 25 have very small capacitances which may be of the order of three micro microfarads or less. Accordingly, the current flowing through the leads of trimming condensers 24 and 25 is small compared with the space current flowing through tube 1. Adjustable condensers 24 and 25, as illustrated in Fig. 2, are shunted by the interelectrode capacitances between control grid 3 and anode 4 and between control grid 5 and anode 6, respectively. It will also be understood that in many cases it may not be necessary to adjust the value of neutralizing capacitances 22 and 23 so that trimming condensers 24 and 25 may be omitted.

Referring now to Fig. 3, there is illustrated a modified duplex triode 30 in accordance with the invention. Discharge tube 30 comprises indirectly heated cathode 2 surrounded by control grids 31 and 32 of semi-cyclindrical shape having their common axis in cathode 2. Grids 31 and 32 are foraminated and have each a solid extension 33 and 34, respectively. Control grids

31 and 32 are surrounded by semi-cylindrical anodes 35 and 36 which also have their common axis in cathode 2. Cathode 2, control grid 31 and anode 35 form one tube section while the other tube section includes control grid 32 and anode 36.

Control grids 31, 32 and anodes 35, 36 are arranged so that the plane passing between control grids 31 and 32 forms an angle with the plane passing between anodes 35 and 36. Accordingly, solid extension 33 of control grid 31 is arranged in overlapping relation to and adjacent a portion of anode 36 to form a neutralizing capacitance therebetween. The other neutralizing capacitance is formed between solid extension 34 of control grid 32 and an overlapping portion of anode 35. A common envelope 7 is provided for enclosing cathode 2, control grids 31, 32 and anodes 35, 36.

Discharge tube 30 operates in essentially the same manner as discharge tube 1. The neutralizing capacitances formed between extension 33 of control grid 31 and anode 36 and between extension 34 of control grid 32 and anode 35 may be adjusted in the manner illustrated in Fig. 2.

Referring now to Fig. 4, there is illustrated another modified discharge tube 40 embodying the present invention. Discharge tube 40 comprises cathode 41 of the filament type, the filament being arranged in the form of a V or a W. Control grids 42 and 43 are arranged symmetrically about cathode 41 in the form of foraminated surfaces. Anodes 44 and 45 are arranged about control grids 42 and 43. One tube section is formed by cathode 41, control grid 42 and anode 44, while the other tube section includes control grid 43 and anode 45. Control grid 42 is provided with solid straight extension 46 forming an angle with control grid 42 and arranged adjacent straight extension 47 of anode 45. Grid extension 46 and anode extension 47 are arranged substantially parallel to each other to form a capacitance therebetween. Similarly, solid straight extension 49 forms an angle with control grid 43 and is arranged parallel to straight extension 50 of anode 44 to form a capacitance therebetween. Common envelope 7 is provided for enclosing cathode 41, control grids 42, 43 and anodes 44, 45. Discharge tube 40 operates in the same manner as discharge tubes 1 and 30.

Referring now to Fig. 5, there is illustrated thermionic discharge tube 55 which is provided with mechanical means for adjusting one of its neutralizing capacitances. Discharge tube 55 is arranged substantially in the same manner as discharge tube 1 and comprises cathode 2, control grid 3 and anode 4 as well as control grid 5 and anode 6 all enclosed by common envelope 7. Extension 10 of control grid 3 is arranged adjacent extension 11 of anode 6 to form a capacitance therebetween. Similarly, control grid 5 is provided with extension 12 arranged parallel and adjacent to extension 13 of anode 4 to form a capacitance therebetween.

Mechanical means are provided for varying the relative distance between grid extension 12 and anode extension 13. To this end there is provided bellows 56 sealed to the outside of envelope 7. Rod 57, extending through opening 58 in envelope 7, has one end fastened to bellows 56 and its other end secured to anode 4. By compressing or stretching bellows 56, rod 57 may be moved to change the relative distance between anode extension 13 and grid extension 12. This is accomplished by thumb screw 60 having its end

rotatably mounted in socket 61 fastened to bellows 56. Thumb screw 60 is threaded through cap 62 rigidly secured to envelope 7. Accordingly, rotation of thumb screw 60 will vary the relative distance between anode extension 13 and grid extension 12, thereby to vary the capacitance therebetween.

It is to be understood that the relative distance between grid extension 10 and anode extension 11 may be varied in the same manner. However, in most cases it will be sufficient to provide means for varying the value of one of the neutralizing capacitances because a capacitance bridge may be balanced by adjusting only one of its four arms.

Referring now to Figs. 6 to 8, there is illustrated still another modification of the discharge tube of the invention. Discharge tube 65 comprises indirectly heated cathode 2 surrounded by foraminated semi-cylindrical grids 66 and 67 having their common axis in cathode 2. Grids 66 and 67 are surrounded by anodes 68 and 69 of semi-cylindrical shape forming together substantially a cylinder having its axis in cathode 2. One tube section is formed by cathode 2, control grid 66 and anode 68, while the other tube section includes control grid 67 and anode 69. Common envelope 7 encloses cathode 2, control grids 66, 67 and anodes 68, 69.

For the purpose of forming a neutralizing capacitance between control grid 66 and anode 69, control grid 66 is provided with a solid extension 71 which forms a cylinder with control grid 66. It will be observed that grid extension 71 forms a continuation of foraminated control grid 67. Grid extension 71 is arranged adjacent a portion of anode 69 to form a capacitance therebetween. Similarly, control grid 67 is provided with solid extension 72 forming a cylinder with control grid 67 and arranged as a continuation of foraminated control grid 66. Grid extension 72 is arranged adjacent a portion of anode 68 to form the other neutralizing capacitance therebetween. Discharge tube 65 operates in the same manner as discharge tubes 1, 30 and 40 illustrated, respectively, in Figs. 1, 3 and 4. The neutralizing capacitances formed between grid extension 71 and anode 69 and between grid extension 72 and anode 68 may be adjusted in the manner illustrated in Fig. 2.

While there has been described what are at present considered the preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. An amplifier tube comprising a cathode for emitting electrons, a first pair of semi-cylindrical surfaces electrically insulated from each other and having their common axis in said cathode and forming a first and a second anode, a space being formed between said first pair of surfaces, a second pair of foraminated semi-cylindrical surfaces electrically insulated from each other and forming a first control grid between said cathode and said first anode and a second control grid between said cathode and said second anode, a space being formed between said second pair of surfaces the plane passing through said space between said first pair of surfaces forming an angle with the plane passing through said space

between said second pair of surfaces so that a portion of said first grid is mounted adjacent a portion of said second anode to form a capacitance therebetween and a portion of said second grid is mounted adjacent a portion of said first anode to form a capacitance therebetween, and a common envelope enclosing said cathode, said anodes and said grids.

2. A push-pull amplifier tube comprising a cathode for emitting electrons, a first pair of semi-cylindrical surfaces electrically insulated from each other and having their common axis in said cathode and forming a first and a second anode, a space being formed between said first pair of surfaces, a second pair of foraminated semi-cylindrical surfaces electrically insulated from each other and having their common axis in said cathode and forming a first control grid between said cathode and said first anode and a second control grid between said cathode and said second anode, a space being formed between said second pair of surfaces, each of said grids having a solid extension, the plane passing through said space between said first pair of surfaces forming an angle with the plane passing through said space between said second pair of surfaces so that the solid extension of said first grid is mounted in overlapping relation to and adjacent a portion of said second anode to form a capacitance therebetween and the solid extension of said second grid is mounted in overlapping relation to and adjacent a portion of said first anode to form a capacitance therebetween, and a common envelope enclosing said cathode, said anodes and said grids.

3. A push-pull amplifier tube comprising a cathode for emitting electrons, a first pair of semi-cylindrical surfaces electrically insulated from each other and having their common axis in said cathode and forming a first and a second anode, a second pair of foraminated semi-cylindrical surfaces electrically insulated from each other and forming a first control grid between said cathode and said first anode and a second control grid between said cathode and said second anode, said first grid having a solid extension forming substantially a cylinder with said first grid and mounted adjacent a portion of said second anode to form a capacitance therebetween, said second grid having a solid extension forming substantially a cylinder with said second grid and mounted adjacent a portion of said first anode to form a capacitance therebetween, the extension of said first grid being in substantially the same cylindrical surface as said second grid, the extension of said second grid being in substantially the same cylindrical surface as said first grid, and a common envelope enclosing said cathode, said anodes and said grids.

4. An electron discharge device comprising an electron source, a pair of semi-cylindrical surfaces electrically insulated from each other, having a common axis and forming a first and a second anode surrounding said source, a pair of

foraminated semi-cylindrical surfaces electrically insulated from each other and forming a first control grid between said source and said first anode and a second control grid between said source and said second anode, said first grid having an extension forming substantially a cylinder therewith and mounted adjacent a portion of said second anode to form a capacitance therebetween, said second grid having an extension forming substantially a cylinder therewith and mounted adjacent a portion of said first anode to form a capacitance therebetween, and a common envelope enclosing said source, said anodes and said grids.

5. An electric discharge device comprising an electron source, a pair of semi-cylindrical surfaces having a common axis and forming a first and a second anode surrounding said source, a pair of foraminated semi-cylindrical surfaces forming a first control grid between said source and said first anode and a second control grid between said source and said second anode, said first grid having an extension in substantially the same cylindrical surface as said grids and mounted adjacent a portion of said second anode to form a capacitance therebetween, said second grid having an extension in substantially the same surface as said grids and mounted adjacent a portion of said first anode to form a capacitance therebetween, and a common envelope enclosing said source, said anodes and said grids.

6. An electric discharge device comprising an electron source, a pair of semi-cylindrical surfaces electrically insulated from each other having a common axis and forming a first and a second anode surrounding said source, a pair of foraminated semi-cylindrical surfaces electrically insulated from each other, having a common axis with said first pair of surfaces and forming a first control grid between said source and said first anode and a second control grid between said source and said second anode, said first grid having a solid extension in substantially the same cylindrical surface as said grids and mounted adjacent a portion of said second anode to form a capacitance therebetween, said second grid having a solid extension in substantially the same surface as said grids and mounted adjacent a portion of said first anode to form a capacitance therebetween, and a common envelope enclosing said source, said anodes and said grids.

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