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ELECTRON DISCHARGE DEVICE AND CIRCUITS FOR NEUTRALIZED COAXIAL LINE AMPLIFIERS

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Fig. 1.

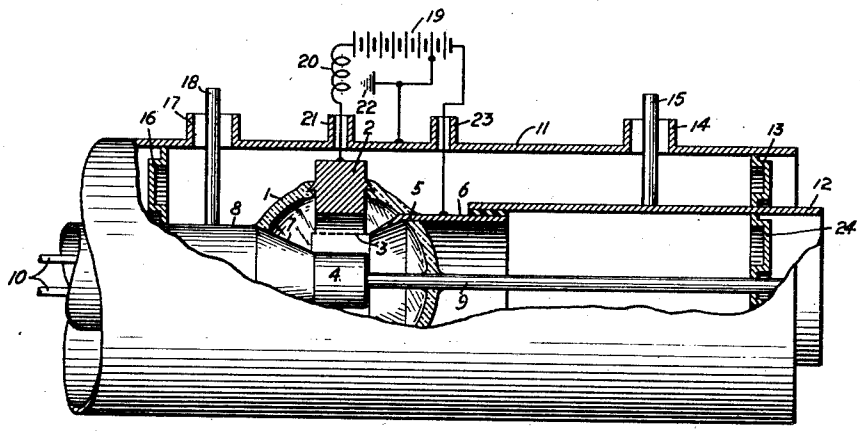


Fig. 2.

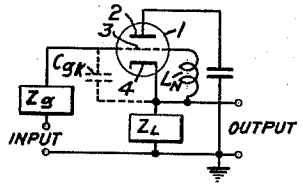


Fig. 4.

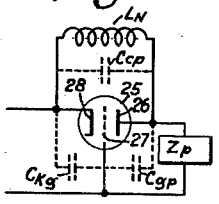
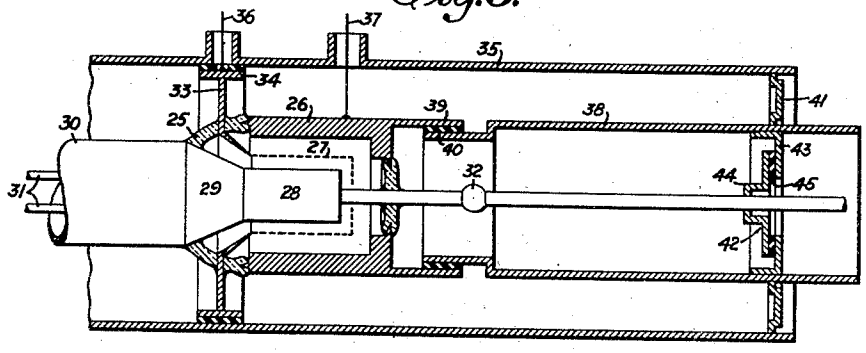


Fig. 3.



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ELECTRON DISCHARGE DEVICE AND CIRCUITS FOR NEUTRALIZED COAXIAL LINE AMPLIFIERS

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2 Claims. (Cl. 179—171)

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This invention relates to electron discharge devices and circuits particularly designed for neutralized coaxial line amplifiers.

In the use of amplifiers for very high frequencies and ultra-high frequencies particularly it is desired to use tubes which may be incorporated directly in coaxial lines to serve as amplifiers. To avoid instability of operation it is desirable that the amplifiers have incorporated circuits for neutralizing certain of the inherent tube capacities. Such neutralizing circuits have in the past presented quite a difficult design problem. The conventional electron tubes have a cathode lead at one end, only, and it has been necessary in many cases to provide complex grid and anode connections referred to as "grid bells" to secure the desired coupling for introducing a neutralizing inductance, or a feedback control in an oscillator.

It is an object of my invention to provide electron discharge devices designed for simple neutralizing connection in a coaxial line amplifier, or providing for proper feedback in an oscillator and to provide simple neutralizing or feedback circuits for amplifiers incorporating such electron discharge devices.

In accordance with a feature of my invention I provide in an electron discharge device having external connections for coupling coaxial line elements to anode and grid electrodes, and a concentrically mounted cathode, a lead connection to the cathode extending out of the opposite end of the envelope connecting to the normal cathode load. Coaxial line coupling can thus be readily made at both ends of the tube to the cathode.

In the normally so called grounded anode tube circuit having a cathode impedance output the neutralizing inductance or feedback control for the cathode-grid capacitance can be readily obtained between the cathode extension and the external grid connections without disturbing the anode-cathode output resonator.

In the so called grounded grid amplifier, the anode-cathode capacitance may be neutralized by a simple coupling between the extended cathode lead and anode external connections without disturbing or modifying the direct grid-cathode input circuit.

The above-mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will be best understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, in which:

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Fig. 1 is a diagram, partly in section, of an example of my invention, incorporated in a grounded anode amplifier or oscillator circuit.

Fig. 2 is the equivalent diagram of Fig. 1;

Fig. 3 is a diagram, partly in section, of an example of my invention applied to a grounded grid amplifier and

Fig. 4 is an equivalent circuit diagram of Fig. 3.

Turning first to Figs. 1 and 2, there is shown a vacuum tube 1 having an anode 2, a grid 3, and a cathode 4. The anode 2 may be in an annular form having a portion extending outside the envelope. Grid 3 may be supported on a grid cone 5 extending outside the envelope and provided with a further cylindrical extension 6. Cathode 4 may be supported on a conical extension 7 extending through the envelope which may be connected to a further cylindrical extension or cathode lead 8. On cathode 4 is connected a second cathode lead 9 extending outside of the envelope of tube 1 in the opposite direction from the lead 8. The cathode 4 may be heated by any type of the heater arrangement coupled to a heat source by means of leads 10.

It will be immediately apparent that this vacuum tube differs from the conventional type in that a second cathode extension lead 9 is provided. As shown in Fig. 1 the vacuum tube is incorporated in a coaxial line type of amplifier comprising an outer cylindrical conductor shell 11 to which the anode 2 of tube 1 is capacitively coupled and which may be considered as being at ground potential. The capacitance between anode 2 and the outer surface of shell 11 is sufficiently great that at the operating frequency the anode may be considered substantially to be at ground potential. Mounted within shell 11 is a further cylindrical conductor 12 which extends over the end of conductor 6 so as to provide substantial capacitance which is effectively short circuit for alternating current energy. However this capacitance serves as a D. C. blocking condenser keeping the ground potential off grid 1. An annular shiftable plunger 13 may be arranged between conductor 12 and the inner surface of shell 11 to provide a tuning resonator for the amplifier input. The resonator formed thereby is designated in Fig. 2 as the grid impedance Z_g. The input energy may be supplied to the amplifier by means of a coaxial line having its outer conductor 14 connected to shell 11 and its inner conductor 15 connected to conductor 12.

The output energy is taken across a cathode

impedance which comprises a resonator cavity formed by the inner surface of shell 11 and the outer surface of the cathode lead 8. The impedance of this circuit may be adjusted by means of the annular adjustable tuning plunger 16. The impedance of this resonator is shown in the equivalent diagram (Fig. 2) as Z_L. The output lead may consist of a second coaxial line having an outer conductor 17 connected to the outer shell 11 and an inner conductor 18 connected to lead 8.

In operation potentials for the tube may be supplied from a source, shown as battery 19, having its positive terminal coupled by way of a radio frequency choke 20 and coaxial line 21 to anode 2. An intermediate point of battery 19 and the outer surface of shell 11 are grounded as shown at 22. Negative biasing potential may be applied from battery 19 by means of the coaxial line 23, the inner conductor of which is coupled to the cylindrical extension 6 of the grid.

It will be seen that this structure as so far defined provides a so called grounded anode amplifier of the coaxial line type in which the output is taken across the cathode impedance. In order that the capacitance between the grid and cathode may be controlled in value or completely neutralised an annular tuning plunger 24 is provided interconnecting the inner surface of conductor 12 and the second or auxiliary lead 9 of cathode 4. This tuning plunger may be adjusted to such a position that the resonator formed within conductor 12 and extension 6 presents the desired inductance L_N (Fig. 2) to compensate for the inherent cathode grid capacitance C_{gk} (Fig. 2). If it is desired to let the tube circuit oscillate, the feedback neutralization may be made less than complete. Thus the normal high capacitance may be controlled to the desired degree.

It will be apparent from the foregoing description that by providing a tube having the additional extension on the cathode control or neutralising compensation may be very simply effected in the coaxial line amplifier. In the conventional type of amplifier wherein the cathode has lead lines from only one end of the tube a much more complex system is required to effect the compensation.

Turning now to Figs. 3 and 4 I have shown principles of my invention applied to a coaxial line vacuum tube amplifier of the grounded grid type. This arrangement comprises a vacuum tube 25 having an anode 26, a grid 27 and a cathode 28. Here again, the cathode is provided with a conventional input lead comprising a conical element 29 with a cylindrical extension 30 serving as a cathode lead. Heating conductor 31 may be provided for supplying the heat to the indirectly heated cathode. An extension 32 is provided which extends from the cathode 28 at the opposite end of the tube from lead 30. Grid 27 is provided with an annular flange 33 extending outside the envelope, which flange may be provided with an extended portion 34 to provide better capacitive coupling with the external circuit.

The amplifier circuit may comprise an outer coaxial conductor shell 35 which may be grounded. Shell 35 and the portion 34 of flange 33 are closely spaced to provide substantial grounding of the alternating current energy while providing a D. C. blocking for the grid bias supply. The grid bias potential may be applied to the grid by way of a coaxial line 36. The anode supply potential may be applied thereto by means of a coaxial line 37 as shown. Input energy may be supplied to the amplifier by way of the coaxial line composed of a portion of outer conductor 35 and conductor lead 30 so that input energy is applied between cathode and grid. The output energy may be taken from a coaxial line comprising shell 35 and a second conductor 38 which is capacitively coupled to anode 26 by means of an anode extension 39 and an extension 40 of conductor 38 overlapping therewith. The extensions 39 and 40 provide substantially a short circuit connection for alternating current energy but provide a blocking condenser for the direct current supply voltages for the tube. The anode grid output may be tuned to the desired impedance value by means of a tuning plunger 41 between inner surface of conductor 35 and conductor 38. This impedance provides the plate impedance Z_p (Fig. 4).

Here again, it will be seen there is provided a coaxial amplifier of the grounded grid type which may be provided with coaxial input and output leads. In this instance there exists within the tube unwanted capacitances which it is desired to neutralise designated as C_{cp}, C_{kg}, and C_{gp} (Fig. 4). In order to adjustably control or neutralise these capacities a tuning plunger is arranged as shown at 42 between the extension 32 and the inner surface of conductor 38. In order to preserve the desired blocking for the various direct current supply potentials tuning plunger 42 may be made in two parts comprising a portion 43 in conductive connection 38 and a portion 44 in conductive connection with lead 32, these portions being separated by an annular ring 4. By adjustment of the flange 42 to the desired position the inductive reactance L_N (Fig. 4) can be obtained.

It will be again noted that with the neutralised amplifier a controlled feedback oscillator of Fig. 3 may be quite simply obtained using the tube having the auxiliary cathode extension whereas the neutralising or controlling circuit for an amplifier using the conventional tube having a cathode lead from only one end is much more complex.

While I have illustrated my invention in connection with and applied to particular circuits it will be readily understood that the principles thereof are not limited to the precise embodiments and circuits as shown.

Many modifications and variations of my invention will readily be apparent to those skilled in the art.

While I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of my invention as set forth in the objects thereof and in the accompanying claims.

What I claim is:

1. An amplifier of the coaxial line type comprising an electron discharge device having an indirectly heated cathode, anode and grid electrode coaxially mounted, a resonator comprising an outer shell coupled to the anode electrode for alternating current transfer, a first hollow cathode lead concentric with said outer shell extending into said device from one end, heater leads within said hollow lead, a second cathode lead extending out from said device from the other end and concentric with said outer shell, conductor means within said shell and concentric

with said second cathode lead, means for coupling said conductor means with said grid electrode, adjustable plunger tuning means between said outer shell and said conductor means and between said conductor means and said second cathode lead, said plunger means between said conductor means and said second cathode lead being positioned to provide a neutralizing inductance of the desired degree for the grid-cathode capacitance of said electron discharge device, and a tuning plunger between said outer shell and said first cathode lead to provide an output resonator.

2. An amplifier according to claim 1, further comprising alternating energy input means coupled between said outer shell and said conductor

means, and alternating energy output means coupled to said output resonator.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,096,459	Kassner	Oct. 19, 1937
2,109,843	Kassner	Mar. 1, 1938
2,153,728	Southworth	Apr. 11, 1939
2,169,396	Samuel	Aug. 15, 1939
2,478,216	Varian	Aug. 9, 1949
2,554,502	Preist	May 29, 1951
2,579,820	Haller et al.	Dec. 25, 1951