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CROSS REFERENCE

SEARCH ROOM

FX-1144

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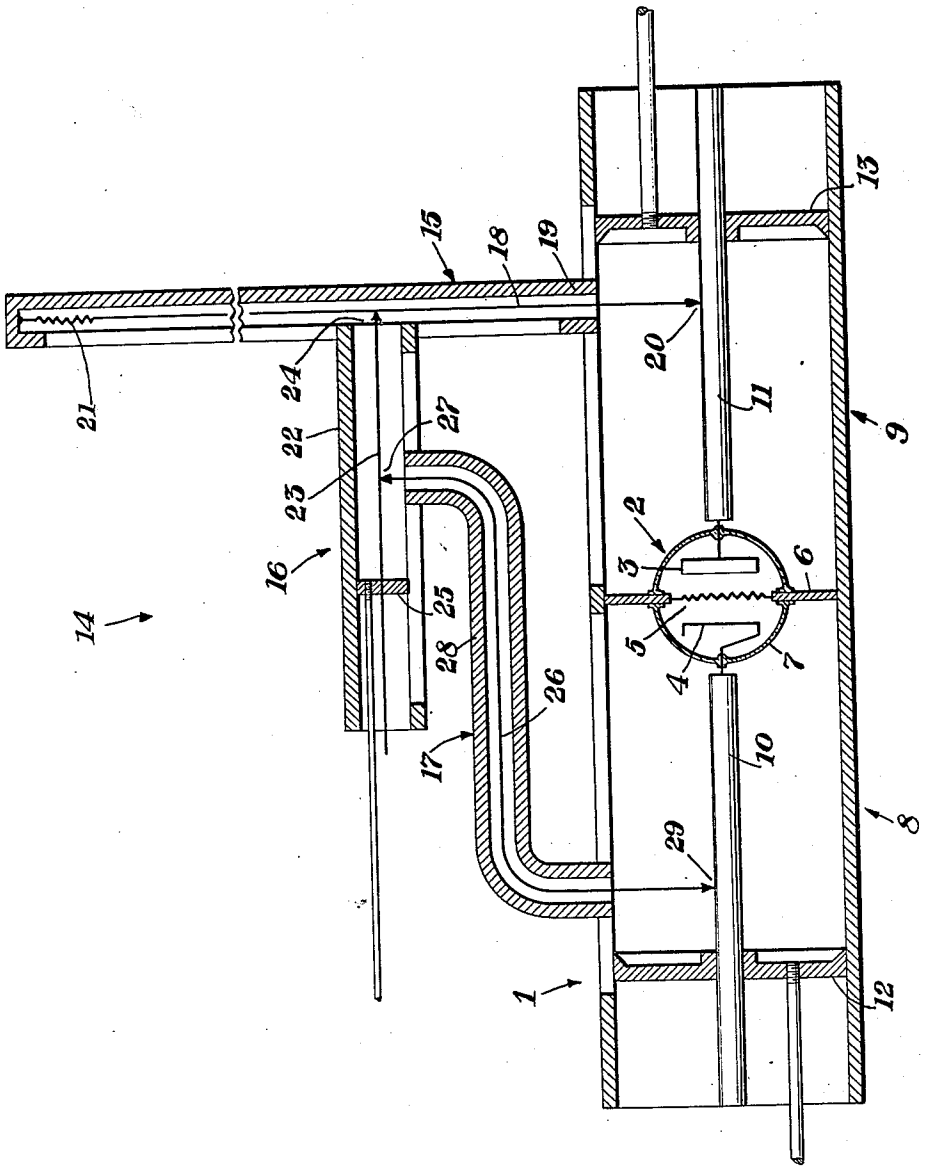
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FEEDBACK COUPLING CIRCUIT

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FEEDBACK COUPLING CIRCUIT

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This invention relates to electron discharge device circuits and particularly to the feed-back of energy from the output circuit to the input circuit thereof.

In certain electron discharge device circuits, energy is fed back from the output circuit to the input circuit. In oscillators, positive feed-back is used to produce oscillations and in amplifiers, negative feed-back is used among other things to prevent oscillation and produce greater stability of operation.

An object of the present invention is the provision in an electron discharge device circuit of improved feed-back means enabling improved control of the energy fed back.

Another object of the present invention is the provision of such improved energy feed-back means in which the phase and amplitude of the energy fed back are separately controlled.

In most electron discharge device oscillators, a slight amount of feed-back is usually sufficient to sustain oscillations. However, to obtain the maximum output from a given oscillator, it is essential that both the phase and the amplitude of the energy fed back be correct.

A further object of the present invention is the provision of an improved oscillator circuit having means for separately selecting the phase and the amplitude of the feed-back.

In most amplifier circuits, there is a tendency for energy to be fed back from the anode circuit to the grid circuit either through the interelectrode tube capacities or through the circuit external to the tube. If, however, energy from the anode circuit, equal in amplitude to the aforementioned feed-back energy but opposite in phase, is also fed back to the grid circuit, it will neutralize any tendency of the circuit to oscillate and provide greater stability of operation.

Still another object of the present invention is the provision of an improved amplifier circuit having means for feeding back energy to the grid circuit, which means, includes means for separately selecting the phase and amplitude of the energy fed back.

Amongst various forms of high frequency oscillator and amplifier circuits is the type referred to as the grounded grid type coaxial line arrangement in which the tube is arranged within a coaxial line and the grid substantially isolates the anode-grid and cathode-grid circuits, except for the common ground line.

A still further object of the present invention is the provision of an improved coaxial line oscillator particularly of the grounded-grid type.

Still another object of the present invention is

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the provision of an improved coaxial line amplifier, particularly of the grounded-grid type.

Other and further objects of the present invention will become apparent and the foregoing will be best understood from the following description of an embodiment thereof, reference being had to the drawing, in which the figure is a schematic diagram of one circuit embodying my invention.

The circuit illustrated in the figure may be used as either an amplifier or an oscillator as will be made clear hereinafter. The circuit consists primarily of an outer metal cylinder 1 within which is mounted, in some suitable manner, an electron discharge device such as a vacuum tube triode 2. Tube 2 is preferably of the type having oppositely positioned anode and cathode elements 3 and 4 respectively, and a centrally positioned grid 5 having a generally radially-extending terminal 6 passing through the surrounding envelope 7 of the tube. The terminal 6 is preferably secured to and electrically connected with the inner surface of cylinder 1 in any suitable manner. Where terminal 6 is of insufficient diameter to properly fit within cylinder 1, an annular member of greater diameter may be used to connect terminal 6 to the interior surface of outer cylinder 1 in a manner known in the art.

Outer cylinder 1 serves as the outer conductor of a pair of coaxial lines generally designated by the numerals 8 and 9 extending on opposite sides of terminal 6. The inner conductor 10 of coaxial line 8 is connected to the cathode 4 of tube 2 while the inner conductor 11 of coaxial line 9 is connected to the anode 3 of tube 2. It will thus be seen that terminal 6 and grid 5 serve to substantially isolate the anode-grid and cathode-grid circuits from each other. Coaxial lines 8 and 9 may be tuned by any suitable means such as, for example, shorting plungers 12 and 13 respectively.

In the arrangement thus far described, there is relatively little feed-back from the anode-grid circuit to the cathode-grid circuit, the former of which may be considered as the output circuit and the latter as the input circuit. In accordance with my invention, I provide means for feeding back energy from the anode-grid circuit to the cathode-grid circuit and this means includes means for controlling the phase of energy fed back and separate means for controlling the amplitude of said energy.

The feed-back circuit, generally designated by the numeral 14, is preferably comprised of three transmission lines, which for the sake of clarity will be referred to hereinafter as the phase line 15, amplitude or stub line 16, and connecting line 17.

Phase line 15, from which the phase of the feedback is selected, may be an unbalanced line, such as the coaxial line illustrated, or a balanced line, and is of a length preferably electrically equally to or greater than one wavelength at the maximum wavelength at which the circuit of the figure is designed to operate. Energy from coaxial line 9 is fed to phase line 15 by any suitable means. As illustrated in the figure, one way of doing this is by coupling the inner conductor 18 of phase line 15 to the inner conductor 11 of coaxial line 9 by means of a probe 20 which is preferably capacitively coupled to said inner conductor 11, the outer conductor 19 of phase line 15 being connected to the outer cylinder 1.

In order that maximum energy may be transferred from the anode-grid circuit to phase line 15, the point at which probe 20 is coupled to inner conductor 11 is preferably made variable in any suitable way. This may be accomplished by providing a longitudinal slot in outer cylinder 1 and probe 20 may be moved back and forth, as is known in the art, within the slot so that it is coupled to any desired point along inner conductor 11.

Phase line 15 is preferably a non-resonant line and may be terminated in a resistive impedance 21 which preferably matches the surge impedance of the line so that no standing waves are produced. The impedance 21 may consist in whole or in part of the load to which energy from the circuit shown in the figure is supplied.

It will be seen that along the length of line 15, the phase of the energy travelling therealong will vary, and by selecting the point along line 15 at which energy is derived therefrom, any selected phase may be obtained. Moreover, since phase line 15 is preferably greater than one wavelength, it will be seen that any phase angle from zero to 360° can thus be obtained. For the purpose of selecting the amplitude, amplitude line 16 may be connected to phase line 15 in the following manner. The outer conductor 22 of amplitude line 16 is connected to the outer conductor 19 of phase line 15 while the inner conductor 23 of line 16 is connected to the inner conductor 18 of line 15 by any suitable means, such as a probe 24, so that the probe 24 may be moved along inner conductor 18 and coupled to any selected point thereon. To permit moving of amplitude line 16 along phase line 15 in the above-described manner, the outer conductor 19 of phase line 15 may be slotted as is known in the art.

Amplitude line 16 from which is selected the desired amplitude of the feed-back is preferably a resonant line approximately a quarter wavelength long at the frequency at which the circuit of the figure is operated or an odd multiple thereof. Since the arrangement shown in the figure is adapted to be operated at various wavelengths by adjusting plungers 12 and 13 of coaxial lines 8 and 9, means are also preferably provided for tuning resonant line 16 so that it is a quarter wavelength at the selected frequency. Such means may consist of a plunger 25 adapted to vary the effective length of line 16.

As will be apparent to those versed in the art, the amplitude of the potential along the quarter wavelength line varies progressively from a maximum at the open end of said line to a minimum at the shorted end of said line. It will therefore be apparent that by selecting various points along the line, a voltage of a desired amplitude may be obtained. For this purpose, the

connecting line 17 is so coupled to line 16 that the point of such coupling may be varied. One way of accomplishing the foregoing is, as illustrated, by coupling the inner conductor 26 of connecting line 17 by means of a probe 27 to the inner conductor 23 of line 16 while the outer conductor 28 of line 17 is connected to the outer conductor 22 of line 16. Outer conductor 22 is preferably longitudinally slotted as is known in the art to permit the probe to be moved back and forth along inner conductor 23.

The connecting line 17 then delivers the energy which has been selected in phase by moving probe 24 and selected in amplitude by moving probe 27, to the cathode-grid circuit. For this purpose the outer conductor 28 of line 17 is connected to outer metal cylinder 1 while inner conductor 26 of line 17 is coupled to inner conductor 10 of line 8 by a probe 29. Probe 29 is adapted to be moved along the inner conductor 10 to select the precise point at which the energy feed-back to the cathode-grid circuit is supplied, thus enabling the selection of an optimum point for the feed-back of energy.

As stated hereinbefore, by moving probe 24 along the inner conductor 18 of phase line 15, a shift in phase of 360° can be obtained. If the circuit shown in the figure is to be used as an oscillator, the phase selected must be one in which the energy fed back to the cathode-grid circuit will be positive in direction, that is will be in a direction to sustain the oscillations, whereas if the circuit is to be used as an amplifier, the feed-back should be exactly 180° out of phase with the foregoing or should be negative in direction.

It will also be seen that the adjusting probe 27 along inner conductor 23, any desired amplitude of feed-back may be obtained and thus the energy derived from the anode-grid circuit may be apportioned to the impedance 21 and the cathode-grid circuit.

The application of the various direct current potentials is not here shown since it is well-known to those versed in the art. Other details not forming part of this invention are also omitted since they are likewise known in the art. For example, when the circuit illustrated in the figure is used as an amplifier, various well-known means may be used to apply the incoming signal to the cathode-grid circuit. Furthermore it will be realized that the feed-back circuit must not galvanically connect the anode and cathode, and that some form of blocking condenser arrangement should be employed in said circuit.

It will be seen that I have provided a circuit in which the feed-back is separately controlled in phase and in amplitude. While I have described the details of one circuit embodying my invention, it will be apparent that numerous modifications may be made without departing from the teachings thereof. For example, while I have stated that the impedance 21 should preferably match the surge impedance of the line so that no standing waves are produced, thereby obtaining a gradual and smooth transition in phase along line 15, it will be obvious that even if the impedance 21 does not match the line and standing waves exist on the line there will nevertheless be obtained a phase transition along said line enabling the selection of any desired phase.

Obviously various forms of coupling along a transmission line other than the probe arrangements here described may be used. Likewise the

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feed-back circuit may be reversed in its connections to the anode-cathode circuit such as, for example, by coupling phase line 15 to coaxial line 8 and coupling line 17 to coaxial line 9. Various additional tuning arrangements other than the plungers shown likewise may be substituted, and other electron discharge devices other than the grounded-grid triode may be used.

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 on the scope of my invention as set forth in the objects of my invention and the accompanying claims.

I claim:

1. In an electron discharge arrangement having an input circuit and an output circuit, means for feeding back energy to the input circuit from the output circuit comprising a first transmission line coupled to one of said circuits, means for effectively terminating said first line to suppress standing waves along said first line, said first transmission line having an electrical length equal to at least one wavelength at the operating frequency of said arrangement, a second transmission line having an electrical length equal to a quarter wavelength at said operating frequency for establishing standing waves along said second line, means for coupling said second transmission line to said first transmission line at selected intermediate points on said first transmission line, and means for coupling the other of said circuits to said second transmission line at selected intermediate points on said second transmission line.

2. In an electron discharge arrangement having an input circuit and an output circuit, means for feeding back energy to the input circuit from the output circuit comprising a first transmission line coupled to one of said circuits, said first transmission line having an electrical length equal to at least one wavelength at the operating frequency of said arrangement, a matching impedance terminating said line for suppressing standing waves along said line, a second transmission line having an electrical length equal to a quarter wavelength at said operating frequency for establishing standing waves along said second line, means for coupling said second transmission line to said first transmission line at selected intermediate points on said first transmission line, and means for coupling the other of said circuits to said second transmission line at selected intermediate points on said second transmission line.

3. In an electron discharge arrangement having an input circuit and an output circuit, means for feeding back energy to the input circuit from the output circuit, said means including means for selecting the phase of the energy fed back substantially independently of amplitude, said phase selecting means comprising a transmission line coupled to one of said circuits, said transmission line having an electrical length equal to at least one wavelength at the operating frequency of said arrangement, a matching impedance terminating said line for suppressing standing waves along said line and means for coupling the other of said circuits to said line at selected points along the line, said last named means comprising a resonant transmission line section for producing standing waves along said resonant section.

4. In an electron discharge arrangement of the grounded grid coaxial line type wherein the electron discharge device is mounted within an outer conductive cylinder to which the grid is coupled and the anode and cathode of said device are coupled to separate inner coaxial conductors, each of said inner conductors forming a separate coaxial line with the outer cylinder; means for feeding energy from one of said coaxial lines to the other of said coaxial lines, said means comprising a non-resonant transmission line, means for effectively terminating said line to suppress standing waves along said line, means for coupling said line to selected points on one of said coaxial lines, a resonant line coupled to said non-resonant line at variably chosen points on said non-resonant line to produce standing waves along said resonant line, and means for coupling said resonant line to selected points on the other coaxial line from variably chosen tapping points on said resonant line.

5. In an electron discharge arrangement having an input circuit and an output circuit, means for feeding back energy to the input circuit from the output circuit comprising means for selecting the amplitude of the energy fed back, and separate means for selecting the phase of said fed back energy comprising a fixed length of transmission line coupled to one of said circuits, a matching impedance terminating said line for suppressing standing waves along said line, and resonant transmission line means coupling the other of said circuits to selected intermediate points along said line.

6. In an electron discharge arrangement having an input circuit and an output circuit, means for feeding back energy to the input circuit from the output circuit at a given operating frequency comprising means for selecting the amplitude of the energy fed back, and separate means for selecting the phase of said fed back energy comprising a substantially fixed length of transmission line at said frequency coupled to one of said circuits, said transmission line having an electrical length at least equal to one wavelength at the operating frequency of said arrangement, a matching impedance terminating said line for suppressing standing waves along said line at said frequency, and means coupling the other of said circuits to selected intermediate points along said line, said last named means comprises a section of transmission line having a fixed length at said operating frequency whereby standing waves at said frequency are produced along the length of said section.

7. In an electron discharge arrangement having an input circuit and an output circuit, means for feeding back energy to the input circuit from the ouput circuit at a given operating frequency comprising a transmission line coupled to one of said circuits, means for terminating said transmission line in its characteristic impedance for suppressing standing waves along said line, and means for coupling the other of said circuits to variably chosen tapping points on said transmission line whereby the phase of energy fed back is controlled independently of its amplitude, said last named means comprises a section of transmission line having a fixed length at said operating frequency whereby standing waves at said frequency are produced along the length of said section.

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