Sept. 3, 1940. R. J. KIRCHER 2,213,398

VACUUM TUBE CIRCUIT

Filed July 22, 1938 2 Sheets-Sheet 1

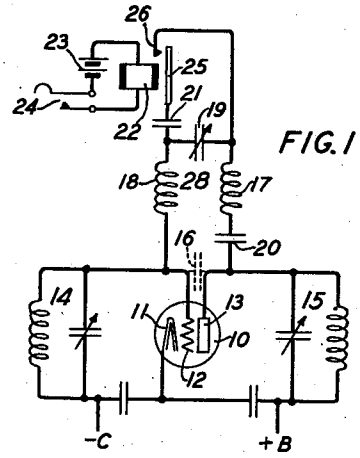

FIG. 1

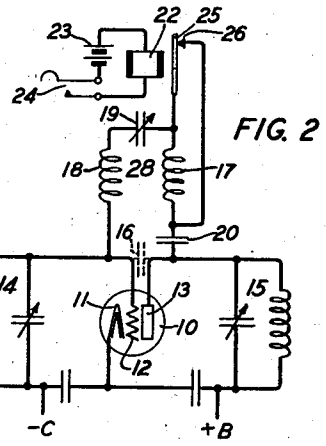

FIG. 2

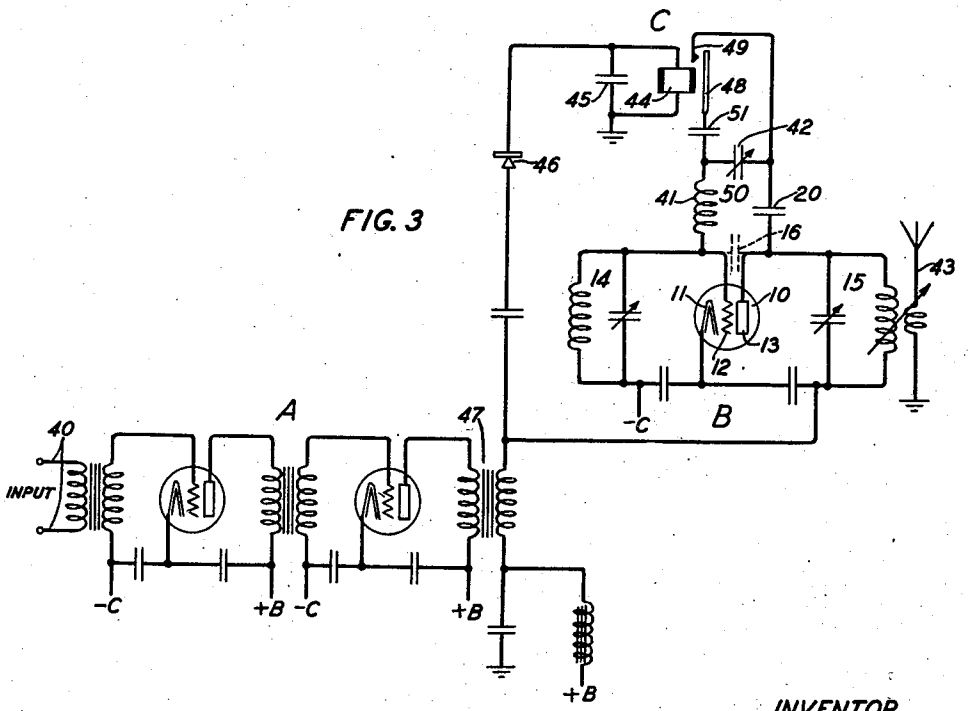

FIG. 3

INVENTOR
R. J. KIRCHER

BY
R. J. Fluskey

ATTORNEY

Sept. 3, 1940. R. J. KIRCHER 2,213,398

VACUUM TUBE CIRCUIT

Filed July 22, 1938 2 Sheets-Sheet 2

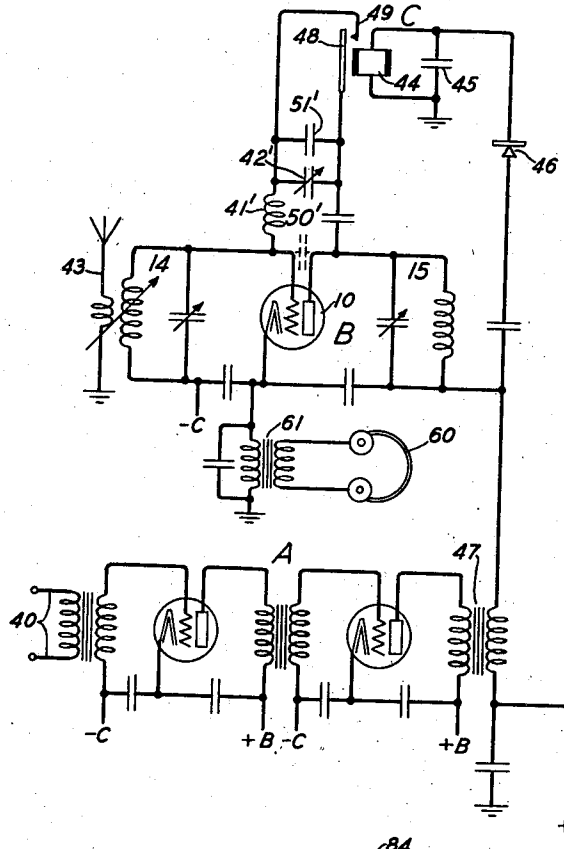

FIG. 4

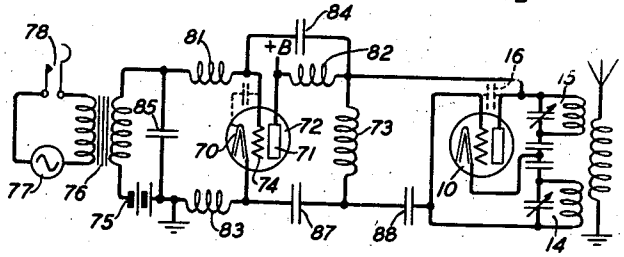

FIG. 5

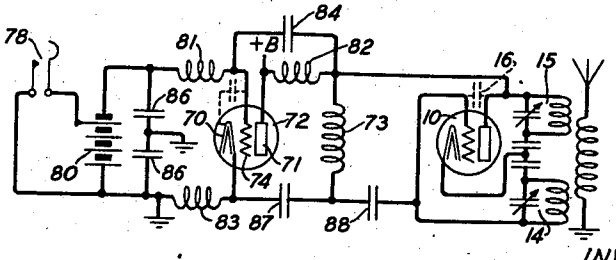

FIG. 6

INVENTOR
R. J. KIRCHER
BY
R. J. Fluskey
ATTORNEY

Patented Sept. 3, 1940

2,213,398

UNITED STATES PATENT OFFICE

2,213,398

VACUUM TUBE CIRCUIT

Reymond J. Kircher, Neptune, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application July 22, 1938, Serial No. 220,618

16 Claims. (Cl. 179—171.5)

This invention relates to vacuum tube circuits and more particularly to such circuits in which the interelectrode capacity between control grid and anode is or may be neutralized.

There is a need for a simple, inexpensive circuit arrangement capable of use either for receiving or transmitting purposes. A preferable condition is that the means used for one or the other purpose be usable for the other with some simple change or readily operated control. An object of this invention is to meet this need.

A feature of the invention comprises using an electron discharge device having inherent capacity between its control electrode and its anode, associating circuit means with such electrodes so that the interelectrode capacity is neutralized thereby preventing the occurrence of a condition of self-oscillation, and providing other means to alter the constants of the neutralizing circuit whereby the device functions as an oscillator.

A further feature of the invention comprises connecting circuit means between a pair of electrodes of an electron discharge device and providing relay means to change the characteristics of the circuit means to a desired extent, such relay means, for example, being manually or audio-frequency-operated or controlled.

Another feature of the invention comprises connecting circuit means between a pair of electrodes of an electron discharge device, said circuit means including a capacity element provided by a second electron discharge device.

A more complete understanding of this invention and its various features will be obtained from the detailed description which follows hereinafter, taken in conjunction with the appended drawings, wherein:

Figs. 1 and 2 show vacuum tube circuits embodying the invention,

Fig. 3 shows a vacuum tube transmitter circuit embodying the invention;

Fig. 4 shows a combined transmitter and receiver circuit embodying the invention; and

Figs. 5 and 6 show electronic means for keying the neutralizing circuit of a vacuum tube.

The circuit of Fig. 1 comprises an electron discharge device or triode 10 having a cathode 11, a control grid 12, and an anode 13. A tuned circuit 14 is connected to the grid-cathode and a second tuned circuit 15 is connected across the cathode-anode. A source of grid biasing potential and a source of plate potential are indicated. The cathode may be, as shown, of the indirectly heated type. The numeral 16 indicates the inherent capacity between the grid and anode that permits a feedback from the output circuit and may cause undesired oscillation of the device 10, particularly when it is being used, for example, as a detector, an amplifier, or a demodulator. Various arrangements have been proposed to neutralize this capacity, and when high frequencies, for example, of the order of hundreds of kilocycles or of megacycles, are involved, neutralizing by connecting an inductance between the control grid and anode has been found particularly effective. In Fig. 1, the neutralizing circuit 28 is shown as comprising inductances 17, 18, a variable condenser 19, and a blocking condenser 20. When the circuits 14, 15 and 28 are tuned to the same frequency the vacuum tube, as is known, will not oscillate.

If either the reactive or capacitive constants of the anti-resonant circuit between the grid and anode are altered, and all the other circuits remain unchanged, a condition of oscillation occurs at a frequency that may be within a few per cent of that at which neutralization occurred. This alteration in the L or C constants of the circuit 28 may be accomplished by the connection of condenser 21 in shunt with condenser 19 on completion of a circuit for the electromagnet or relay 22 and battery 23 by closure of the contacts of key 24, armature 25 engaging with contact 26 so long as the key is operated. The vacuum tube will oscillate until the contacts of key 24 are opened, releasing armature 25 and causing condenser 21 to be removed from the circuit between the grid and plate of the tube.

Instead of the tube normally being neutralized, it may normally be used as an oscillator with a portion of the neutralization circuit shunted out as shown in Fig. 2, the armature 25 and contact 26 being in engagement. When it is desired to place the tube in condition for use, for example, as a detector or as an amplifier, operation of the key to close a circuit for the electromagnet causes separation of the armature and associated contact to place the inductance 17 effectively in the neutralizing circuit, whereby the tube ceases to function as an oscillator.

In Fig. 3, the invention is embodied in a signal wave transmission circuit. An audio frequency amplifier A, having suitable speech or other audio signal input terminals 40, is transformer coupled to the normally neutralized vacuum tube circuit B, and to the neutralizing circuit control circuit C. The amplifier may be of any suitable type and is shown by way of illustration as a two-stage transformer-coupled amplifier embodying three electrode tubes of the indirectly heated

cathode type. The neutralizing circuit 50 for the tube 10 comprises an inductance 41, a variable condenser 42, and blocking condenser 20. The tuned circuit 15 comprises the output circuit for the neutralized vacuum tube and is coupled to the grounded antenna 43. The control circuit C comprises the relay or electromagnet 44, shunted by a by-pass condenser 45, in series with a rectifier 46, for example of the copper-oxide type, and the secondary winding of amplifier output transformer 47. An armature 48, normally disengaged from its associated contact 49, is controlled by the electromagnet, and condenser 51, upon engagement of the armature and associated contact, is adapted to be included in the neutralizing circuit to alter its constants to the end that the tube is no longer neutralized and functions as an oscillator. In operation, audio impulses are impressed on the input of the amplifier, and are amplified. A part of the amplied output is rectified by rectifier 46 to cause the control relay to close the circuit between the armature and associated contact to alter, in predetermined manner, the constants of the neutralizing circuit whereby the tube 10 oscillates. The plate of the tube is simultaneously modulated by the amplified audio signal output and the modulated oscillator output is impressed on the antenna and radiated therefrom. Upon cessation of the audio signal input, the electromagnet deenergizes, releasing the armature, and the tube 10 is returned to its non-oscillatory condition pending arrival of further amplified audio signals.

The circuit arrangement of Fig. 4 embodies the arrangement of Fig. 3, and includes means for receiving or detecting an incoming signal during the neutralized condition of the tube, in which period the tube 10 functions as a simple plate detector. The receiving means comprises a telephone headset 60 connected to the secondary of the audio transformer 61 whose primary winding is connected in the cathode circuit and by-passed for radio frequencies. The neutralizing circuit 50' differs slightly from that of Fig. 3. Condenser 51 is connected in shunt to condenser 42', the constants of the inductance 41' and the condensers being such that the grid-to-plate capacity is normally neutralized, engagement of the armature 48 and contact 49 altering the circuit so that the vacuum tube functions as an oscillator.

The circuits of Figs. 5 and 6 show electronic means for keying the neutralizing circuit of tube 10. The input capacity of the control electron discharge device or triode 72 forms a part of the neutralizing circuit of the tube 10 and is initially adjusted so that with the inductance 73 it neutralizes the inherent grid-to-plate capacity 16 of tube 10. This input capacity, as is known, may be expressed in the form $C_{gf}+(\mu+1)C_{gp}$, where C_{gf} is the geometrical capacity between control grid 74 and cathode 70, C_{gp} is the geometrical capacity between the grid and the anode 71, and μ is the effective voltage gain of the device 72. Variation of the biasing potential on the control grid 74 of tube 72 causes a variation in the input capacity thereof, thereby altering the constants of the neutralizing circuit a predetermined amount so as to cause the tube 10 to function as an oscillator. In the arrangement of Fig. 5, an initial grid bias is provided by battery 75 to give the initial desired input capacity. This initial bias may be changed to a desired degree by superimposing on the initial bias a low frequency wave through transformer 76, the primary winding of which is connected in series with a source 77 of low frequency current, for example, 1000 cycles per second, and a normally open key 78. Or, as shown, in Fig. 6, the initial grid bias may be furnished by battery 80, the bias being changed to a desired degree by closure of key 78 to effect a predetermined change in the input capacity whereby the neutralizing circuit no longer functions to prevent tube 10 from oscillating. Coils 81, 82, 83 are radio frequency chokes, condensers 84, 85 and 86 are radio frequency by-pass condensers, and condensers 87, 88 are blocking condensers.

Although this invention has been disclosed with reference to various specific embodiments, it is to be understood that it is to be considered as limited in scope by the appended claims only.

What is claimed is:

1. In combination, an electron discharge device comprising a plurality of electrodes and having such inherent capacity between a pair of said electrodes that it is capable of generating oscillations, means rendering said capacity effective to cause said device to generate oscillations, means for neutralizing the effect of the capacity between said electrodes, and audio frequency operated means for altering said second means so that said interelectrode capacity ceases to be neutralized and said device will generate oscillations.

2. In combination, an electron discharge device comprising a cathode, a control grid and an anode, said device having an inherent capacity between said control grid and anode enabling it to generate oscillations, means rendering said capacity effective to cause said device to generate oscillations, an anti-resonant circuit connected between said grid and anode for neutralizing the effect of the capacity between said electrodes, and relay means for altering the constants of said circuit to cause said capacity to cease to be neutralized and to enable said device to act as an oscillator.

3. In combination, an electron discharge device comprising a cathode, a control grid and an anode, said device having an inherent capacity between said control grid and anode enabling it to act as an oscillator, means rendering said capacity effective to cause said device to generate oscillations, an anti-resonant circuit connected between said grid and anode for neutralizing the effect of the capacity between said electrodes, and manually controlled relay means for altering the constants of said circuit to cause said capacity to cease to be neutralized and enabling said device to act as an oscillator.

4. In combination, an electron discharge device comprising a cathode, a control grid and an anode, said device having an inherent capacity between said control grid and anode enabling it to act as an oscillator, means rendering said capacity effective to cause said device to generate oscillations, an anti-resonant circuit connected between said grid and anode for neutralizing the effect of the capacity between said electrodes, and audio frequency controlled relay means for altering the constants of said circuit to cause said capacity to cease to be neutralized and enabling said device to act as an oscillator.

5. In combination, an electron discharge device comprising a cathode, a control grid and an anode, a tuned grid-cathode circuit, a tuned cathode-anode circuit, a tuned circuit across the grid and anode of said device, said circuits being normally tuned to the same frequency whereby

any tendency for said device to oscillate because of interelectrode capacity is neutralized, and means for modifying the constants of the grid-anode tuned circuit to cause said device to oscillate.

6. In combination, an electron discharge device comprising a cathode, a control grid and an anode, a tuned grid-cathode circuit, a tuned cathode-anode circuit, a tuned circuit across the grid and anode of said device, said circuits being normally tuned to the same frequency whereby any tendency for said device to oscillate because of interelectrode capacity is neutralized, and manually operated means for modifying the constants of the grid-anode tuned circuit to cause said device to oscillate.

7. In combination, an electron discharge device comprising a cathode, a control grid and an anode, a tuned grid-cathode circuit, a tuned cathode-anode circuit, a tuned circuit across the grid and anode of said device, said circuits being normally tuned to the same frequency whereby any tendency for said device to oscillate because of interelectrode capacity is neutralized, and audio frequency operated means for modifying the constants of the grid-anode tuned circuit to cause said device to oscillate.

8. In combination, an electron discharge device comprising a cathode, a control grid and an anode, a tuned grid-cathode circuit, a tuned cathode-anode circuit, a tuned circuit across the grid and anode of said device, said circuits being normally tuned to the same frequency whereby any tendency for said device to oscillate because of interelectrode capacity is neutralized, and relay means for modifying the constants of the grid-anode tuned circuit to cause said device to oscillate.

9. In combination, an electron discharge device comprising a plurality of electrodes, the inherent interelectrode capacity of said device being such that it may be used as a generator of oscillations, means rendering said capacity effective to cause said device to generate oscillations, circuit means including an inductance for neutralizing the effect of the capacity between said electrodes, and audio frequency operated means for changing said circuit means so that said capacity ceases to be neutralized and said device becomes a generator of oscillations.

10. In combination, an audio frequency amplifier, an oscillations generating vacuum tube circuit, means for neutralizing any tendency for the vacuum tube to generate oscillations, means responsive to a portion of the amplifier output to modify the characteristics of said neutralizing means so that the vacuum tube generates oscillations, and means connecting said amplifier and said circuit for modulation of the oscillations in accordance with the amplifier output.

11. In combination, an electron discharge device comprising a plurality of electrodes, means connected directly between a pair of said electrodes for neutralizing the effect of capacity between said pair of electrodes, said means including an electron discharge device, said second-mentioned device having a plurality of electrodes, and means independent of said first-mentioned device for varying the capacity between a pair of the electrodes of said second device.

12. In combination, an electron discharge device comprising a plurality of electrodes, means connected directly between a pair of said electrodes for neutralizing the effect of capacity between said pair of electrodes, said means including an electronic device providing a capacity element in said means, and means individual to said electronic device for adjusting the capacity of said capacity element.

13. In combination, an electron discharge device comprising a plurality of electrodes and having a tendency to oscillate because of inherent interelectrode capacity, circuit means for neutralizing said tendency, said means including an electron discharge device having a plurality of electrodes, the interelectrode capacity between which provides a capacity element in said neutralizing means, and means for changing the value of said capacity element to cause said first discharge device to generate oscillations.

14. In combination, an electron discharge device comprising a control grid, a cathode and an anode, the inherent capacity between said grid and anode tending to cause said device to generate oscillations, circuit means across the grid and plate to neutralize such tendency, said means including a space discharge device comprising a control grid, a cathode and an anode, the input capacity of said second device being a capacity element in said circuit means, and means for changing the bias on the second device's control grid to change said input capacity a predetermined amount so that the first device's oscillation tendency is no longer neutralized.

15. In combination, an oscillations generating electron discharge device, said device comprising a control grid, a cathode and an anode, circuit means including inductance and capacity elements connected between the grid and anode, means for impressing a modulating signal input on said device, and relay means for changing the constants of said circuit means to a predetermined extent, said relay means being responsive to a portion of the input to said device.

16. In combination, an electron discharge device comprising a control grid, a cathode and an anode, circuit means including inductance and capacity elements connected between the grid and anode, and audio frequency operated relay means for changing the constants of said circuit means to a predetermined extent.

REYMOND J. KIRCHER.