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AMPLIFIER AND OSCILLATOR CIRCUIT

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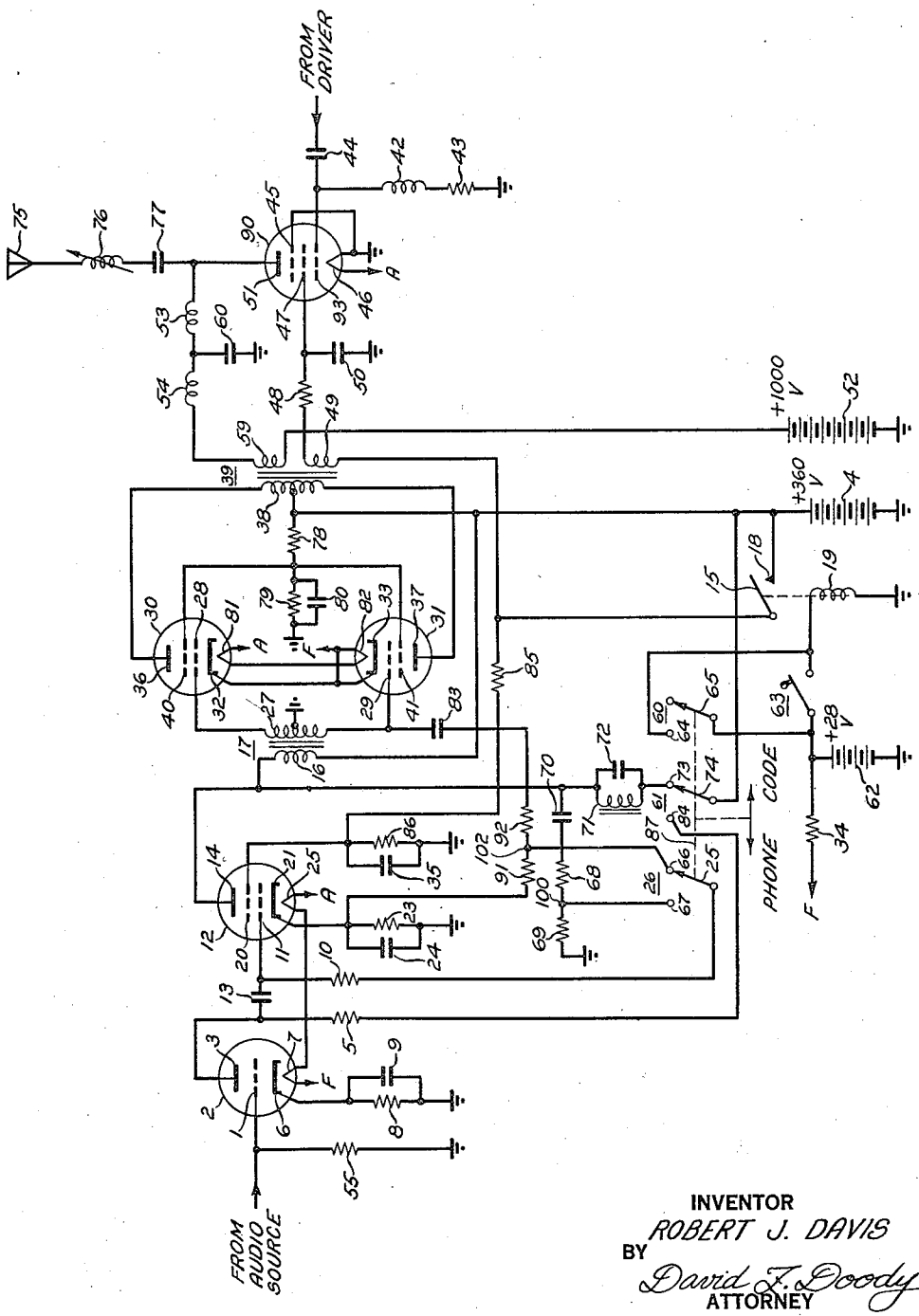

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AMPLIFIER AND OSCILLATOR CIRCUIT

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This invention relates to vacuum tube signal amplifiers and more particularly to vacuum tube signal amplifiers which may be optionally employed as generators of alternating current energy.

Present day radio transmitters are normally designed to emit a number of different types of radiation, among which are: voice modulated continuous waves, keyed continuous waves and keyed continuous waves with a steady modulation tone impressed. The generation of waves of the third type requires that a steady audio tone be generated within the equipment which is then utilized to modulate the transmitted energy. This is usually accomplished by the use of a separate oscillator tube generating the desired frequency which is set into operation and connected to the modulating amplifier when keyed MCW, as the third type of radiation is often designated, is to be transmitted. During periods of voice modulated transmission, the modulating oscillator is deenergized and the modulating amplifier is actuated by voice currents from the speech amplifier. In some cases, the modulating frequency is generated by disconnecting the speech amplifying or modulator tubes from their normal circuits and connecting them to a new set of circuit components arranged to provide sustained oscillations. In each of the above instances, the provisions made for generating the tone modulation frequency have added materially to the bulk, expense, and/or weight of the equipment as it has been necessary to provide additional tubes and circuit components.

One of the principal objects of this invention is to provide new and novel means for optionally utilizing a signal amplifier as an oscillation generator.

Another object of the invention is to provide new and novel means for optionally utilizing a vacuum tube as a degenerative signal amplifier and as an oscillation generator.

Still another object of the invention is to provide a radio transmitter capable of emitting both voice modulated continuous waves and keyed MCW having less bulk and weight than existing apparatus of this type.

The above objects and advantages of the invention are accomplished by providing means for selectively impressing energy from the output circuit of a vacuum tube amplifier on the input circuit of the same amplifier with a positive or negative feedback relationship. The positive feedback is of a magnitude producing sustained oscillations whose frequency may be controlled

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by a tuned circuit simultaneously connected in the output circuit or input circuit of the amplifier tube; and the negative feedback reduces the amount of distortion produced in the amplification process in the well known manner when the tube is acting as a signal amplifier.

Other objects and advantages will in part be disclosed and in part be obvious when the following specification is read in conjunction with the drawing which is a schematic diagram of a transmitter modulator unit incorporating the invention.

Referring to the drawing, the control grid 1 of the speech amplifier 2 is connected to ground through the grid leak resistor 55 and to a source of voice currents as indicated. Energy from this source is applied to the speech amplifier only when it is desired to transmit voice modulated carrier waves. The anode 3 of amplifier 2 is connected through the anode load resister 5 to a contact 84 of the switch section 61, and an arm 74, which is a part of the same switch section, is connected to the positive terminal of the intermediate voltage source 4 and is selectively movable between the contact 84 and a second contact 73. The source 4 may supply a direct current potential of 380 volts. The anode circuit of tube 2 is completed by the connection of the negative terminal of the source 4 directly to ground, and the connection of the cathode 6 to ground through the parallel combination of resistance 8 and capacity 9 to supply operating bias for the control grid 1. A heater 7 elevates the temperature of cathode 6 as required for functioning of the tube 2. The heater energizing circuits for this and the remainder of the thermionic tubes in the apparatus will be described in detail in a later paragraph.

The anode terminal of the resistor 5 is coupled by the capacitor 13 to the control grid 11 of the oscillator and driver tube 12, here shown to be of the tetrode type, and a grid resistor 10 is connected between the control grid 11 and the movable arm 25 of the switch section 25, selectively engageable with the contacts 66 and 67. Accelerating grid 20 of the amplifier 12 is excited from the source 4 through dropping resistor 85 and the contacts 15, 18 of the keying relay 19, while the anode 14 of this amplifier is connected with the source 4 through the primary 16 of the transformer 17. Connected in parallel between grid 20 and ground are the bleeder resistor 86 and bypass capacitor 35 to provide for adjustment of the direct grid current voltage and grounding for alternating currents. The cathode

21 is connected to ground through the resistor 23 and capacitor 24.

A resistive voltage dividing assembly 68, 69 is connected between the anode 14 and ground in series with the blocking capacitor 70, and the ungrounded terminal of the grounded resistor 69, junction point 100 is attached to the terminal 67 of switch section 26. The values of the resistors 68, 69 are selected to be large as compared with the impedance presented by the transformer 17, and the voltages appearing at the resistor junction point 100 are substantially 180 degrees out of phase with the voltages impressed on the control grid 11. Anode 14 is additionally connected to the terminal 73 of switch section 61 by the parallel circuit of inductance 71 and capacity 72, which are selected to be resonant at some desired frequency in the audio spectrum, usually approximately 1,000 cycles per second. This circuit determines the frequency at which the carrier is modulated when modulated continuous wave transmission is employed.

The output energy from the amplifier 12 is impressed on the transformer 17 having the center tapped secondary winding 27, whose outer terminals are connected individually to the control grids 28, 29 of the amplifiers 30, 31. The anodes 36, 37 of these amplifiers are connected to the outer terminals of the center tapped primary winding 38 of the modulation transformer 39 and the center tap of this winding is directly connected to the positive terminal of source 4. Excitation for the accelerating grids 40, 41 of the amplifiers 30, 31 is derived from the source 4 in series with the dropping resistor 78, and these grids are also connected to ground by the bleeder resistor 79 paralleled by capacitor 80, whose impedance is negligible at the operating frequencies. The exact values of the accelerating grid supply resistors are determined by the voltage of source 4 and the characteristics of the particular tube employed. Electron emission for the tubes 30, 31 is provided by the cathodes 32, 33 located adjacent the heaters 81, 82, respectively, and the cathodes are connected to the positive terminal of the heater 82, which is also connected to the positive terminal of the 28 volt source 62 through the filament dropping resistor 34. As the center tap of the winding 27 and the negative terminal of the source 62 are grounded, this connection provides the necessary bias for the control grids 28, 29. The two tubes 30, 31 serve as the conventional push-pull power amplifier delivering the necessary power to modulate the final amplifier stage of the radio frequency amplifier.

One of the terminals of the winding 27 of transformer 17 is connected by the blocking capacitor 83 and the resistors 91 and 92 in series to the cathode 21 of amplifier 12, and the potential at the junction point 102 of the two resistors is impressed on the contact 66 of the switch section 26. The connection of this combination to the winding 27 is selected to provide at contact 66 potentials which are substantially in phase with alternating current potentials impressed on the control grid 11, and the magnitude of the resistors is chosen to provide negligible loading of the secondary 27. The low potential end of resistor 91 may be considered at ground potential for alternating currents because of the bypassing action of capacitor 24, but is above ground potential for direct current because of its connection to the cathode 21.

Located in the transmitter, and excited by a radio frequency source not shown in the drawings, is the final radio frequency power amplifier 90. The radio frequency energy from the driver is coupled to the control grid 93 by the capacitor 44, and the resulting flow of grid current through resistor 43, connected in series with the choke 42 between grid 93 and ground, provides the operating bias. Choke 42 prevents excessive loss of radio frequency driving power to the resistor 43. Electron emission for the amplifier 90 is provided by the filament 46 having one terminal connected to ground and the other connected to the terminals of the heaters 25 and 81 marked "A." The heater and filament circuits thus comprise heaters 7 and 25 in series, connected in parallel with heaters 81 and 82 in series, which series-parallel combination is then connected to the source 62 in series with the dropping resistor 34 and the power amplifier filament 46.

Direct current excitation for the accelerating grid 47 is supplied from the source 4 through the keyed contacts 15, 18, secondary winding 49 of the modulation transformer 39, and a dropping resistor 48 whose grid end is connected to ground through capacitor 50 to insure the necessary shielding efficiency for stable amplification. The grid 45 of the tube shown in the diagram is a suppressor grid and is connected to ground for further improving internal shielding and diminishing secondary emission effects. The anode 51 is provided with power from the high voltage source 52, which may have a potential of 1000 volts, by connection through the output choke 53, filter choke 54 and the secondary winding 59 of the modulation transformer 39. The efficiency of choke 54 in eliminating radio frequency potentials from the winding 59 is improved by the connection of the capacitor 60 between the junction of chokes 53 and 54 and ground. The radio frequency power existing in the output circuit of the amplifier 90 is conveyed to the radiating antenna 75 by the blocking capacitor 77 and the variable loading inductor 76, which is varied to neutralize the residual reactance of the antenna proper.

It may be seen by inspection that amplifiers 12 and 90 are operative only when contacts 15 and 18 are in the closed position, as they are when the winding of keying relay 19 is energized. Operation of this relay may be controlled by the key 63 connected between the positive terminal of source 62 and the ungrounded terminal of the operating winding for relay 19. Since it is desired to have amplifiers 12 and 90 continuously in operationd uring telephone transmission, a switch section 60 is provided, having the arm 65 and contact 64 connected to the respective terminals of the key 63. During the time that switch section 60 is in the closed position, the operating winding of relay 19 is continuously excited, thereby maintaining amplifiers 12 and 90 in the desired continuously energized state. As shown in the diagram, switch sections 26, 60 and 61 are mechanically coupled by the member 87, and the switch sections are therefore simultaneously moveable. The composite switch thus formed may be termed the emission selector switch, as its position determines the type of intelligence radiated by the apparatus. When in the right hand position, the circuits are those required for the production of keyed modulated continuous waves, while with the emission selector switch in the left hand position, the circuit arrangement is that necessary for the radiation of telephonic signals. The operation of the switch assembly

may be readily visualized from the "Code-Phone" markings in the drawing.

With the foregoing in mind, the operation of the apparatus may now be readily understood. Assuming the emission selector in the "Code" position, the anode circuit for amplifier 2 is broken at the contact 84, thereby disabling the telephone input system, and the arm 74 is in engagement with the contact 73, thereby connecting the tuned circuit 71, 72 in shunt with the primary 16 of the transformer 17. Simultaneously, the cathode end of the grid resistor 10 is connected to the tap 102 on the voltage divider 91, 92 by the switch section 2, coupling anode circuit disturbances of the amplifier 12 back to the control grid 11 in aiding relationship to an extent causing the tube 12 act as an independent generator of oscillations when accelerating grid voltage is supplied. Optimum voltage conditions for oscillation are secured by the connection of the voltage divider to the cathode 21, which removes from the grid 11 the potential generated by the flow of anode current through the cathode bias resistor 23 and allows the control grid to assume an optimum value of bias generated by the flow of grid current through the grid resistor 10 which now functions in the same manner as the grid leak in conventional oscillator arrangements, and the frequency of oscillation is determined by the insertion of the resonant circuit 71, 72, peaking the transmission gain at its resonant frequency. As is well known, the oscillation frequency is that frequency at which the necessary phase relationships are obtained and the loop circuit gain is a maximum.

In the "Code" position of the emission selector, switch section 60 presents an open circuit, so that contacts 15, 18 of the keying relay 19 are open except for those intervals when the key 63 is depressed. With key 63 down, relay 19 is energized to close the contacts 15, 18 and connect the grid 20 to the source 4, whereupon tube 12 oscillates. During transmission, this oscillation exists intermittently, corresponding to the manipulation of the key 63. Considering the key condition for the moment, audio frequency oscillation energy from the tube 12 appears across the secondary 27 of the transformer 17 and is amplified in the usual manner by the tubes 30, 31 to provide in the output circuit thereof energy of the same frequency, but materially increased in power. This power is now used to vary or modulate the anode and screen potentials of the radio frequency amplifier 90, thus amplitude modulating the radio frequency energy radiated from the antenna 75. Impression of the modulating energy on both the anode and screen has been found to effect a material improvement in the linearity of the modulation characteristic. It will be noted that grid 47 also derives its power from the source 4 through the contacts of relay 19, so that with key 63 up, radiation of high frequency energy ceases together with the interruption of the modulating oscillations.

Upon placing the emission selector switch in the "Phone" position, the amplifier 2 is connected to its source of anode potential, and at the same time, the resonant peaking circuit is disconnected from its shunting position across the primary of transformer 17, restoring to this stage its normal uniformity of frequency response. Also, the cathode end of grid resistor 10 is disconnected from the point 102 and connected instead to the point 100, which causes anode circuit disturbances of the tube 12 to appear in the

control grid circuit in opposing relationship to provide degeneration or negative feedback, thereby improving the linearity of the amplifier response. As resistor 69 is connected to ground, there is now provided for the control grid 11 a negative operating bias equal in magnitude to the voltage drop across the cathode resistor 23 to fulfill the requisites for the faithful reproduction of the input wave form. Switch section 60 is moved into the closed position during this operation and shunts the key 63 to maintain the relay 19 in the energized position continuously.

Under this condition of operation, amplifier 2, functioning in the conventional manner, impresses on control grid 11 an enlarged replica of the wave present at grid 1, and this is, in turn, further amplified by the tube 12 with the excellence of linearity contributed by the presence of negative feedback, and fed to the modulators 30, 31. The output of these modulators is impressed, as before, on the final radio frequency amplifier 90, and provides a carrier amplitude modulated with the waveform of the original telephone or voice frequency input, which energy may then be radiated in the usual manner.

While this circuit, which may be alternatively employed as an amplifier and oscillator with the same elements at all times connected to the electrodes of the tube, has been described in conjunction with radio transmitting equipment and shown in use as a tone modulator, it will be recognized that its employment is of equal value in any apparatus where the alternate functions of signal amplification and the generation of a sustained wave of predetermined frequency are required.

It will be obvious that many changes and modifications may be made in the invention without departing from the spirit thereof as expressed in the foregoing description.

I claim:

1. In signal responsive apparatus, an electric discharge device having input and output circuits, means for selectively feeding back energy from said output circuit to said input circuit in phase with and in phase opposition with the energy in said input circuit, and means for peaking the response of said output circuit at a predetermined frequency when the output energy is fed back with an in phase relationship and eliminating said peaked response when the output energy is fed back in phase opposition.

2. In signal responsive apparatus, an electric discharge device having input and output circuits, means for selectively feeding back energy from said output circuit to said input circuit in phase with and in phase opposition with the energy in said input circuit, said in phase feedback being of a magnitude sufficient to cause sustained oscillations in said input and output circuits, and means for peaking the response of said output circuit at a predetermined frequency when the output energy is fed back with an in phase relationship and eliminating said peaked response when the output energy is fed back in phase opposition.

3. In signal responsive apparatus, an electric discharge device having a cathode, a control grid and an anode, means for impressing input energy on said control grid, a load impedance connected to said anode, a source of direct current energy connected between said cathode and the end of said load impedance remote from said anode, means for impressing a fraction of the alternating voltage between said anode and said cathode

on a contact member, means for impressing a fraction of the alternating voltage between said anode and said cathode on a second contact member with a phase substantially opposite to the phase of the voltage on said first mentioned contact member, a third contact member selectively engageable with said first mentioned and said second mentioned contact members, an impedance connected between said control grid and said third mentioned contact member, a circuit comprising parallel inductance and capacity, and means for connecting said circuit across said anode load impedance during the engagement of said second mentioned contact member by said third mentioned contact member and for disconnecting one terminal of said circuit from said anode load impedance during the engagement of said first mentioned contact member by said third mentioned contact member.

4. In radio transmitting apparatus, an amplifier tube having a cathode, a control grid and an anode, a transformer having primary and secondary windings, a connection between said primary winding and said anode, a resistive impedance connected to said anode and to ground, means for impressing a portion of the voltage across said resistive impedance on a contact member, means connecting one terminal of said secondary winding to ground, a resistive impedance connected between a second terminal of said secondary winding and ground, means for impressing a portion of the voltage across said second mentioned resistive impedance on a second contact member, a third contact member selectively engageable with said first mentioned contact member and said second mentioned contact member, a resistive impedance connected between said control grid and said third mentioned contact member, a parallel circuit of inductance and capacity resonant to a predetermined frequency, and means for connecting said parallel circuit in parallel with said primary winding when said third mentioned contact member is in engagement with said second mentioned contact member.

5. In radio transmitting apparatus, an amplifier tube having a cathode, a control grid, an accelerating grid and an anode, a transformer having primary and secondary windings, a connection between said primary winding and said anode, a resistive impedance connected to said anode and to ground, means for impressing a portion of the voltage across said resistive impedance on a contact member, means connecting one terminal of said secondary winding to ground, a resistive impedance connected between a second terminal of said secondary winding and ground, means for impressing a portion of the voltage across said second mentioned resistive impedance on a second contact member, a third contact member selectively engageable with said first mentioned contact member and said second mentioned contact member, a resistive impedance connected between said control grid and said third mentioned contact member, a parallel circuit of inductance and capacity resonant to a predetermined frequency, means for connecting said parallel circuit in shunt with said primary winding when said third mentioned contact member is in engagement with said second mentioned contact member, a source of direct current potential having positive and negative terminals, means connecting said negative terminal to said cathode, means connecting said positive terminal to the end of said primary winding remote from said anode, relay means connecting said accelerating grid to said positive terminal, and keying means controlling the operation of said relay means.

6. In radio transmitting apparatus, an amplifier tube having a cathode, a control grid, an accelerating grid and an anode, a transformer having primary and secondary windings, a connection between said primary winding and said anode, a resistive impedance connected to said anode and to ground, means for impressing a portion of the voltage across said resistive impedance on a contact member, means connecting one terminal of said secondary winding to ground, a resistive impedance connected between a second terminal of said secondary winding and ground, means for impressing a portion of the voltage across said second mentioned resistive impedance on a second contact member, a third contact member selectively engageable with the said first mentioned contact member and said second mentioned contact member, a resistive impedance connected between said control grid and said third mentioned contact member, a parallel circuit of inductance and capacity resonant to a predetermined frequency, means for connecting said parallel circuit in shunt with said primary winding when said third mentioned contact member is in engagement with said second mentioned contact member, a direct current source having positive and negative terminals, means connecting said negative terminal to said cathode, means connecting said positive terminal to the end of said primary winding remote from said anode, relay means connecting said positive terminal to said accelerating grid, keying means controlling the operation of said relay means, and means for disabling and keying means when said third memtioned contact is in engagement with said first mentioned contact.

7. In signal responsive apparatus, an electric discharge device having a cathode, a control grid and an anode, a transformer having primary and secondary windings, a connection between said primary winding and said anode, a direct current source having positive and negative terminals, a resistor connecting said cathode and said negative terminal, means connecting said positive terminal to the end of said primary winding remote from said anode, a resistive voltage divider connected to said negative terminal and connected to said anode by a capacitor, means connecting an intermediate point on said voltage divider to a contact member, a second resistive voltage divider connected to said secondary winding and connected directly to said cathode, means connecting an intermediate point on said second voltage divider to a second contact member, a third contact member selectively engageable with said first mentioned contact member and said second mentioned contact member, and a resistive impedance connected between said control grid and said third mentioned contact member.

8. In signal responsive apparatus, an electric discharge device having input and output circuits including a plurality of electrodes, an impedance connected at one end to said input circuit, means for applying electric potentials to said electrodes, means for selectively impressing energy from said output circuit on the other end of said impedance in aiding and opposing phase relationship with respect to the energy in said input circuit, and means for varying the potential applied to one of said electrodes from one value when said energy is coupled back in aiding relationship to another value when said energy is coupled back in opposing relationship.

9. In signal responsive apparatus, an electric discharge device having input and output circuits including a plurality of electrodes, means for applying electric potentials to said electrodes, means for selectively impressing energy from said output circuit on said input circuit in aiding and opposing senses with respect to the energy in said input circuit, and means for varying the potential applied to one of said electrodes from one value when said energy is coupled back in said aiding sense to another value when said energy is coupled back in opposing sense.

10. In signal responsive apparatus, an electric discharge device having input and output circuits including a plurality of electrodes, means for applying electric potentials to said electrodes, means for selectively feeding back energy from said output circuit to said input circuit in phase with and in phase opposition with the energy in said input circuit, said in phase feed back being of a magnitude sufficient to cause sustained oscillations in said input and output circuits, and means for varying the potential applied to one of said electrodes from one value when said feed back energy is in phase with the energy in said input circuit to another value when said fed back energy is in phase opposition with the energy in said input circuit.

11. In signal responsive apparatus, an electric discharge device having a cathode, a control grid and an anode, means for impressing input energy on said control grid, a load impedance connected to said anode, a bias resistor connected to said cathode, a direct current source of electric energy having its positive terminal connected to the free end of said load impedance and its negative terminal connected to the free end of said bias resistor, means for impressing a fraction of the alternating voltage between said anode and said cathode on a first contact member, means for impressing a fraction of the alternating voltage between said anode and said cathode on a second contact member with a phase substantially opposing the phase of the voltage on said first mentioned contact member, a third contact member selectively engaging with said first mentioned and said second mentioned contact members, a return impedance connected at one end to said control grid and at the other end to said third contact member, and means for connecting said other end of said return impedance to the negative terminal of said source when said first contact member and said third contact member are in engagement, and to said cathode when said second contact member and said third contact member are in engagement.

12. In radio transmitting apparatus, an electric discharge device having a cathode, a control grid and an anode, said cathode being connected to ground through a direct current impedance, a transformer having primary and secondary windings, a connection between said primary winding and said anode, a resistive impedance connected to said anode and to ground, means for impressing

a portion of the voltage across said resistive impedance on a first contact member, means connecting one terminal of said secondary winding to said cathode, a resistive impedance connected between a second terminal of said secondary winding and said cathode, means for impressing a portion of the voltage across said second mentioned resistive impedance on a second contact member, a third contact member selectively engageable with said first mentioned contact member and said second mentioned contact member, a resistive impedance connected between said control grid and said third mentioned contact member, and means for supplying electric energy to the anode circuit of said discharge device.

13. In radio transmitting apparatus, a first electric discharge device having a cathode, a control grid and an anode, a two terminal source of electric energy, a switch and impedance connected in series between one terminal of said source and said anode, means connecting said cathode to the other terminal of said source, means for impressing an input signal on said control grid, a second electric discharge device having a cathode, a control grid and an anode, a transformer having a primary and secondary winding, means connecting said primary winding between said one terminal of said source and the second of said anodes, resistive means connecting the second of said cathodes to said other terminal of said source, an impedance connected to the second of said anodes and to said other terminal of said source, means for impressing a portion of the voltage across said impedance on a first contact member, means connecting one terminal of said secondary winding to said other terminal of said source, an impedance connected between a second terminal of said secondary winding and the second of said cathodes, means for impressing a portion of the voltage across the second mentioned impedance on a second contact member, a third contact member selectively engageable with said first contact member and said second contact member, an impedance connected between the second of said control grids and said third contact member, a capacitor connected between the first of said anodes and the second of said control grids, and means for operating said switch synchronously with the operation of said third contact member.

ROBERT J. DAVIS.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,894,952	Gebhard	Jan. 24, 1933
2,006,440	Chireix	July 2, 1935
2,024,489	Van Der Pol et al.	Dec. 17, 1935
2,173,426	Scott	Sept. 19, 1939
2,173,427	Scott	Sept. 19, 1939
2,244,751	Werrmann	June 10, 1941
2,289,752	Bruck et al.	July 14, 1942

Certificate of Correction

April 20, 1948.

Patent No. 2,439,844.

ROBERT J. DAVIS

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows: Column 5, line 14, for "section 2" read *section 26*; line 17, after the numeral "12" insert *to*; line 45, after "key" second occurrence insert *down*; column 9, line 24, for "feed" read *fed*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 15th day of June, A. D. 1948.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.

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