Dec. 1, 1925. 1,563,342

F. CONRAD

SIGNALING SYSTEM

Filed April 1, 1922 2 Sheets-Sheet 1

Fig. 1

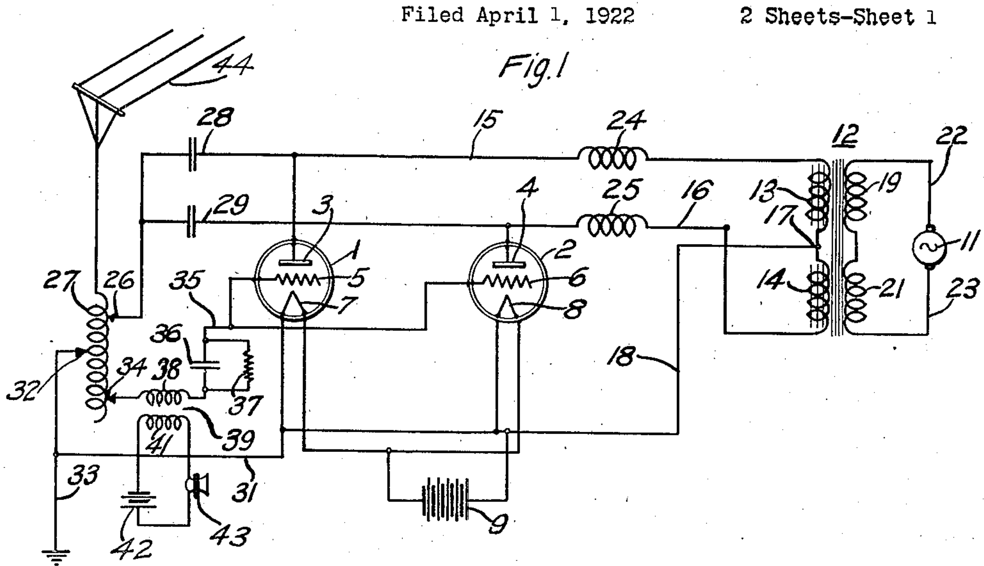

Fig. 2

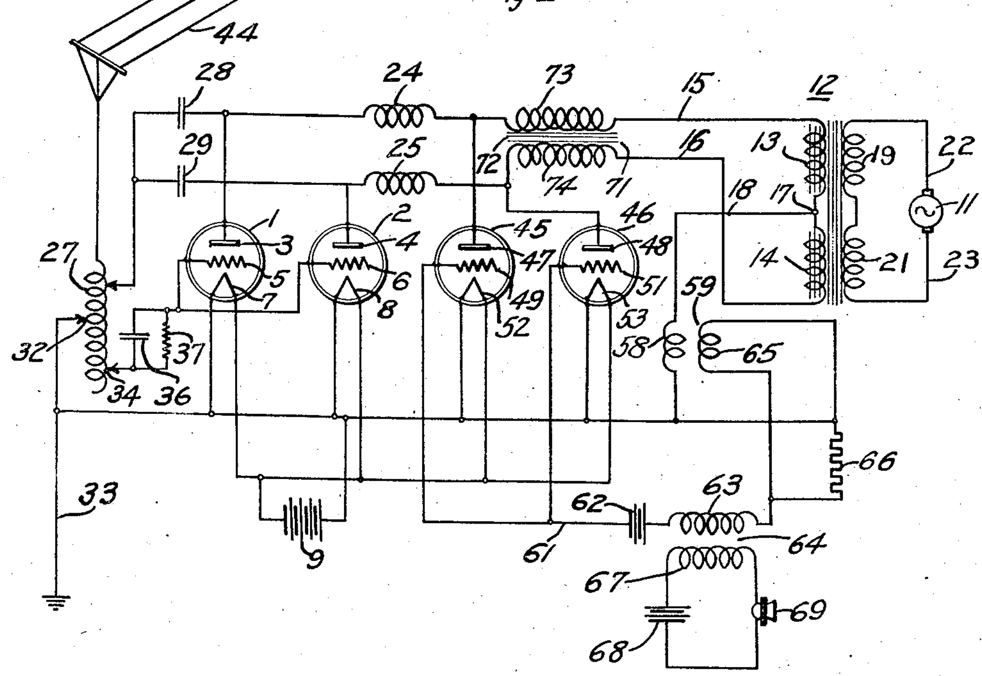

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Fig. 3.

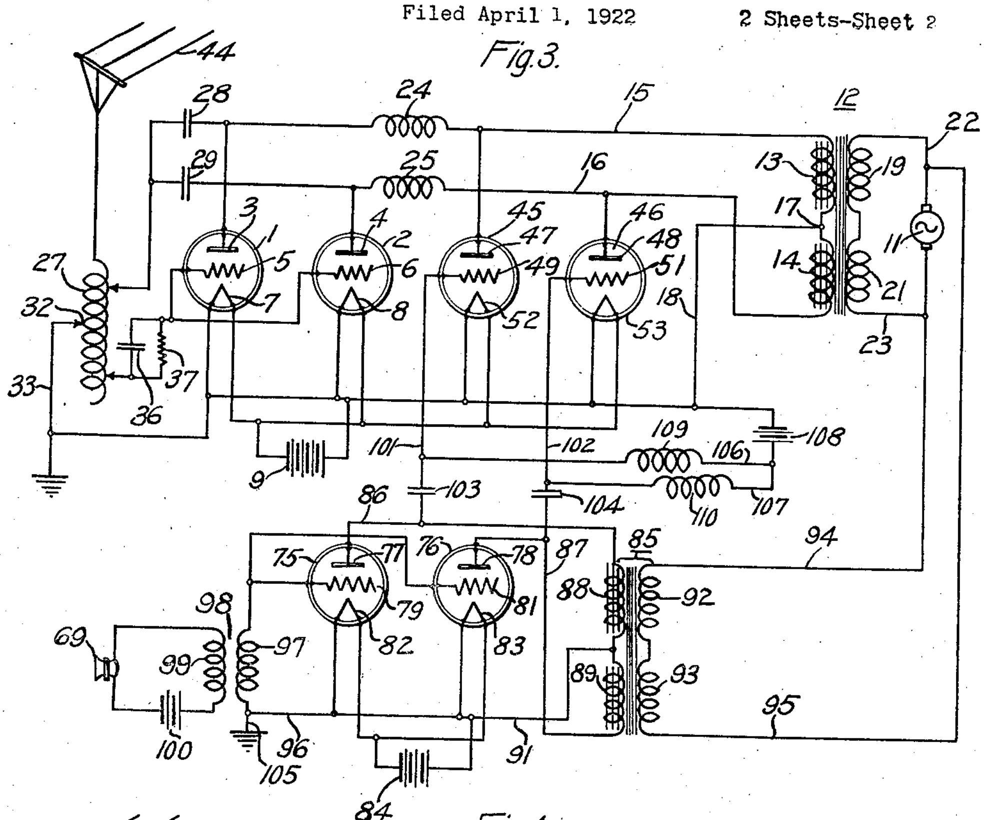
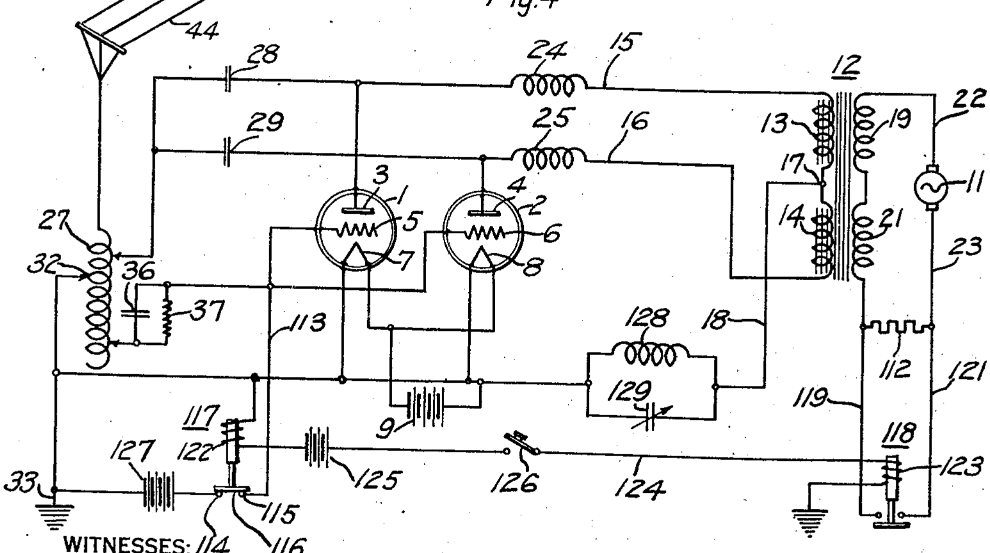


Fig. 4



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Patented Dec. 1, 1925. **1,563,342**

UNITED STATES PATENT OFFICE.

FRANK CONRAD, OF PITTSBURGH, PENNSYLVANIA, ASSIGNOR TO WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA.

SIGNALING SYSTEM.

Application filed April 1, 1922. Serial No. 548,679.

To all whom it may concern:

Be it known that I, Frank Conrad, a citizen of the United States, and a resident of Pittsburgh, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Signaling Systems, of which the following is a specification.

My invention relates to wireless transmission systems and more especially to oscillation generators adapted to be excited by alternating-current sources of energy.

One object of my invention is to provide an oscillation-generator system employing vacuum tubes as oscillation generators which admits of excitation directly by alternating currents of commercial frequency.

Another object of my invention is to so embody a sustaining inductance in the alternating-current supply system for the oscillator tubes as to maintain a substantially constant power supply to the oscillator tubes.

Inasmuch as it would require a sustaining inductance of infinite value in the alternating-current mains to completely smooth out the fluctuations in the power supply to the oscillator tubes, it is apparent that a residual fluctuation will remain.

A further object of my invention, therefore, is to eliminate the residual fluctuations just mentioned, thereby adapting my system for wireless telephony.

A still further object of my invention is to provide means whereby the generator system may be rendered oscillatory or non-oscillatory, at will, and, at the same time, provide means for limiting the supply currents of the tubes to safe values, thereby adapting my system for the transmission of wireless telegraph signals.

Other objects of my invention will appear more fully from the following description of the nature, mode of operation and various applications of my invention.

Heretofore, when employing alternating-current power for the excitation of oscillator-tube systems, it has been customary to employ a separate set of rectifier tubes. Such tubes are expensive and require care and attention, which is undesirable.

I find, however, that, by employing a system as hereinafter described, the rectifier tubes may be eliminated and the system may be energized directly from the alternating-current source of energy, hence causing the tubes to function both as oscillators and as rectifiers. By means of special balancing circuits, I am enabled to obtain a continuous high-frequency signaling wave which may be modulated in accordance with the varying intensity of sound waves by any of the well-known methods.

In addition, I provide special means in order to adapt my system for the transmission of wireless telegraph signals. The desired result may be obtained by simultaneously controlling, at will, the amount of grid-leak in the oscillatory circuit and the impedance of the alternating-current supply circuit.

With these and other objects and applications in view, my invention further consists in the mode of operation and the constructional details hereinafter described and claimed and illustrated in the accompanying drawing, wherein:

Figure 1 is a diagrammatic view of a simplified wireless telephone system embodying my invention;

Fig. 2 is a similar view showing means for balancing out the residual power fluctuations obtaining in the previous system;

Fig. 3 is a similar view, but showing still another means for removing the disturbing effects of the residual power fluctuations;

Fig. 4 is a view similar to that of Fig. 1, but showing my system so modified as to admit of the transmission of wireless telegraph signals.

In Fig. 1, a pair of thermionic tubes 1 and 2, which are caused to serve both as oscillation generators and as rectifiers, are shown as comprising anodes 3 and 4, grid members 5 and 6 and hot cathodes 7 and 8, respectively, the latter being energized from a common source of direct-current energy 9. The tubes 1 and 2 may be successively energized by alternate half cycles of an alternating-current source of energy 11 of commercial frequency through a transformer 12. The anodes 3 and 4 are connected to opposite terminals of a pair of series-connected secondary windings 13 and 14 of the transformer 12 by conductors 15 and 16, respectively. The hot cathodes 7 and 8 are connected to the common terminal 17 of the secondary windings 13 and 14 by a conductor 18. The primary transformer windings 19 and 21 are serially connected to the source of energy 11 by conductors 22 and 23, respectively.

Inasmuch as the distributed capacity of the transformer windings 13 and 14 may be of sufficient value to cause the dissipation of a considerable amount of radio-frequency energy therein, I have found it desirable to connect radio-frequency choke coils 24 and 25 in the anode leads 15 and 16, respectively.

The transformer 12 is so designed as to provide, for each anode conductor, a sustaining inductance of sufficient value to maintain the current in one conductor while that in the other conductor is building up to approximately its full value, that is to say, to so prolong the currents in each conductor that their sum is practically a constant quality at all times. One type of transformer for carrying the above desired result into effect is shown in my United States Patent No. 931,114, filed January 10, 1908, and assigned to the Westinghouse Electric & Manufacturing Company, and hence a detailed description thereof is unnecessary.

The oscillation-generator system comprises the usual plate-filament and grid-filament circuit connections. The anodes 3 and 4 are connected to an adjustable tap-point 26 of an inductance coil 27 through condensers 28 and 29, respectively. The condensers are provided in order to prevent the short-circuiting of the low-frequency currents. The filaments 7 and 8 are connected, by a conductor 31, to an adjustable tap-point 32 of the tuning inductance coil 27. A conductor 33 serves to connect this point to ground.

Grid elements 5 and 6 are connected, in parallel, to an adjustable tap point 34 of the inductance coil 27 by a conductor 35. The conductor 35 includes, in addition, a grid condenser 36 and a grid leak 37 connected in shunt relation thereto and a secondary winding 38 of a modulating transformer 39, the primary winding 41 of which is serially included in a modulating circuit comprising, in addition, a source of direct-current energy 42 and a microphone transmitter 43. The terminal of the inductance coil 27 adjacent the tap point 26 is connected to an antenna 44.

In operation, the tubes 1 and 2 alternately serve as oscillation generators with successive alternations in the polarity of the potentials impressed upon the anode elements 3 and 4 thereof. Hence, it can be seen that both half cycles of the alternating currents impressed upon the system are employed for the generation of high-frequency currents. The effect of the sustaining inductances, which are embodied in the transformer windings 13 and 14, is to prolong the power supply to one tube while that of the other tube is increasing to its maximum value, thereby removing, to a great extent, the residual power fluctuations.

Modulation of the radio-frequency currents generated by the oscillator tubes 3 and 4 is effected in a manner well known in the art upon speaking into the microphone transmitter 43. As hereinbefore stated, a residual fluctuation in the radio-frequency wave of power frequency will remain, inasmuch as to obtain a perfectly uniform high-frequency wave would necessitate the use of a sustaining inductance of infinite value.

I have found, however, that the residual power fluctuation may be substantially removed by superimposing, on the supply circuits to the tubes, a modulation frequency in the reverse direction, as shown in Fig. 2. It will be noted that the previous figure is herein modified by connecting a pair of modulator three-electrode tubes 45 and 46, comprising anodes 47 and 48, grids 49 and 51 and filaments 52 and 53, respectively, in shunt relation to secondary windings 13 and 14, anodes 47 and 48 being connected to conductors 15 and 16, respectively.

The filaments 52 and 53 are connected in parallel with the filaments 7 and 8 of the oscillator tubes and energized from the common source of energy 9. The conductor 18, which serves to connect the several filaments to the common terminal 17 of the transformer secondary windings, may include a primary winding 58 of a transformer 59. The grid elements 49 and 51 are connected, by a common conductor 61, to the several filaments. The conductor 61 may include a biasing source of energy 62, a secondary winding 63 of a modulating transformer 64 and a primary winding 65 of the transformer 59, a resistor 66 being connected in shunt relation to said primary winding 65 for a purpose hereinafter described. A primary winding 67 of the modulating transformer 64 is included in a circuit which may contain, in addition, a direct-current source of energy 68 and a microphone transmitter 69.

This system is further distinguished from that of Fig. 1 in the means for supplying the sustaining inductance to the oscillator-tube leads. Instead of relying entirely upon the transformer to supply the sustaining inductance, a special sustaining reactor 71 is provided comprising a magnetizable core member 72 and a pair of magnetizing windings 73 and 74, the latter being serially included in the anode leads 15 and 16, respectively.

The residual fluctuations of power frequency which traverse the primary winding 58 of the transformer 59 are translated into potential variations in the secondary winding 65 thereof and impressed upon the grid elements 49 and 51. The effect of such grid-potential variations is to produce such power fluctuations as to decrease the original fluctuations of the oscillator tubes 1 and 2, provided proper phase relation between the voltages obtains. This may be effected by means of the resistor 66 connected in shunt relation to the primary winding 65 of the transformer 59, though it is equally effective when connected in shunt to the secondary winding 58 thereof.

When voice waves enter the microphone transmitter 69, the potentials of the grids 49 and 51 are modulated in accordance with the varying intensity of the sound waves. During a one-half-cycle of the impressed electromotive force, when the tube 1 is functioning as an oscillator, the modulator tube 45 is effective, whereas, during the next half-cycle, when the tube 2 is functioning as an oscillator, the modulator tube 46 becomes effective. The operation and circuit arrangement of this system are otherwise as indicated for those of Fig. 1.

Referring to Fig. 3, the arrangement therein shown differ from that of Fig. 2 in the means for balancing out the residual power fluctuation. An additional pair of amplifier tubes 75 and 76 are herein employed for amplifying the effects of the microphone transmitter 69, as hereinafter described. The additional amplifier tubes 75 and 76 comprise anodes 77 and 78, grid electrodes 79 and 81, and hot cathodes 82 and 83, respectively, the latter being energized from a common source of direct-current energy 84.

The tubes are energized by means of a transformer 85 having transformer connections similar to the transformer 12. Anodes 77 and 78 are connected, by conductors 86 and 87, to opposite terminals of the series-connected secondary windings 88 and 89 of the transformer 85. The hot cathodes 82 and 83 are connected to the common transformer secondary terminal by means of a conductor 91. The primary windings 92 and 93 of the transformer 85 are serially connected, by conductors 94 and 95, to the source of alternating-current energy 11. The grid elements 79 and 81 are connected, by a common conductor, to the hot-cathode elements 82 and 83, through a secondary winding 97 of a modulating transformer 98, the primary winding 99 of which is serially included in a circuit containing, in addition, a source 100 of direct-current energy and the microphone transmitter 69.

The anodes 77 and 78 of the amplifier tubes 75 and 76 are connected, by conductors 101 and 102, to the grid elements 49 and 51 of the modulator tubes 45 and 46, through stopping condensers 103 and 104, respectively. The hot-cathode elements 82 and 83 of the amplifier tubes 75 and 76 are connected to the filaments 52 and 53 of the modulator tubes 45 and 46 and to ground by means of a ground conductor 105. The grid elements 49 and 51 of the modulator tubes 45 and 46 may be given a negative bias by means of conductors 106 and 107 which extend from said grid elements to the hot-cathode elements 52 and 53 and which include a common direct-current source of energy 108 and individual radio-frequency choke coils 109 and 110, respectively.

In the system shown in Fig. 3, the low-frequency fluctuations of power in the amplifier tubes 75 and 76 may be decreased by decreasing the sustaining inductances of the transformer 85, the adjustment being such that the main power-frequency fluctuations obtaining in the oscillator tubes 1 and 2 will be eliminated.

When voice-waves enter the microphone transmitter 69, the power supplied to the oscillator tubes 1 and 2 is modulated during successive half-cycles of the impressed electromotive force, thereby causing the resultant high-frequency currents in the antenna system to be correspondingly modulated, all as will be understood by those versed in the art. The operation and circuit arrangements of this system are otherwise as indicated for that of Fig. 2.

The arrangement shown in Fig. 4 distinguishes from that of Fig. 1 in that means have been provided, whereby the system may be employed for the transmission of wireless telegraph signals. In the several arrangements shown, the effect of the sustaining inductance of the transformer 12 supplying the oscillator tubes, or of the reactor 71 is such as to prevent sudden interruptions of the alternating-supply currents. Hence, certain switching systems of telegraphy, involving the opening of either the high-frequency or the low-frequency circuits to form the necessary dots and dashes, are ineffective.

In the arrangement shown in Fig. 4, to form the dots and dashes, I simultaneously short-circuit a resistor 112, which is normally included in circuit with the primary transformer windings 19 and 21 and the source of alternating current 11, and open-circuit a shunt path 113 around the grid condenser 36, and vice versa, as hereinafter described. The shunt path 113 extends from a point common to the grid elements 5 and 6 of the oscillator tubes to the ground conductor 33 and has serially included in circuit therewith stationary contact members 114 and 115 joined by a movable contact member 116 of a normally closed relay 117.

A normally open relay 118 is connected in shunt relation to the resistor 112 by conductors 119 and 121.

The resistor 112, which may be any form of impedance device, is of such impedance that the current supplied to the oscillator tubes 1 and 2 is suitably reduced during the non-signaling periods. Actuating windings 122 and 123 of the relays 117 and 118 are connected in series-circuit relation by a conductor 124 and ground. The conductor 124 may include a source of energy 125 and a controlling key 126.

In operation, when the key 126 is closed, the relays 117 and 118 are simultaneously energized to effect the short-circuiting of the resistor 112 and the open-circuiting of the grid-condenser shunt path 113. The system now oscillates in a well known manner. When the key 126 is opened, the relays 117 and 118 are deenergized, with the result that the grid condenser 36 is short-circuited and the resistor 117 rendered effective to limit the current supplied to the oscillator tubes 1 and 2. The system is now in a non-oscillatory state. As can readily be seen, the telegraph signaling system embodied in Fig. 4 may be readily applied to any of the foregoing wireless telephone systems.

As a further modification, I have included, in the shunt path 113, a source of energy 127, the effect of which is to decrease the impedance of the plate circuits of the oscillator tubes and hence decrease the power loss therein when the system is rendered non-oscillatory.

Inasmuch as the fluctuations in the supply circuits may consist of harmonics of power frequency, the balancing of the power fluctuations may be made more complete by including, in the supply circuit to the oscillator tubes 1 and 2, inductance devices tuned to particular harmonics. For the purpose of illustration, I have shown one such inductance device 128 in the filament return circuit 18 as shunted by a variable condenser 129 whereby the inductance device 128 may be tuned to the frequency of the harmonic which it is desired to eliminate.

While I have shown several embodiments of my invention, for the purpose of describing the same and illustrating its several applications, it is apparent that various changes and modifications may be made therein without departing from the spirit of my invention and I desire, therefore, that only such limitations shall be imposed thereon as are indicated in the prior art or are specifically set forth in the appended claims.

I claim as my invention:

1. In a radio signaling device, an electron-tube oscillator, a source of periodic current supplying said oscillator, and means whereby the current supplied to said oscillator is maintained substantially constant, said means including a transformer having large inductive reactance.

2. In a radio signaling device, an electron-tube modulating device, an electron-tube oscillating device, a source of periodic current supplying said devices and means whereby fluctuations caused by the periodic character of the current supply occurring in one of said devices is simultaneously counterbalanced by fluctuations in the other of said devices.

3. An electrical system comprising a source of alternating currents, a transformer having primary and secondary windings, conductors associating said primary winding with said source. a pair of electron tubes having plate, grid and filament elements, supply conductors connecting said plates to opposite terminals of said secondary windings, and a common supply conductor connecting said filament elements to an intermediate point in said secondary winding, said secondary winding being so designed as to have a large inductive reactance, whereby the sum of the currents in said supply conductors is practically a constant quantity at all times.

4. An electrical system comprising a source of alternating currents, a transformer having primary and secondary windings, conductors associating said primary winding with said source, a pair of oscillator tubes having plate, grid and filament elements, supply conductors connecting said plates to opposite terminals of said secondary winding, a common supply conductor connecting said filament elements to an intermediate point in said secondary winding, said secondary winding being so designed as to have a large inductive reactance, whereby the sum of the currents in said plate conductors is practically a constant quantity at all times, and means associated with said tubes for causing the same to function as oscillation generators.

5. An electrical system comprising an alternating-current source of power, a pair of oscillator tubes, means for so coupling said oscillator tubes to said source of power that both half-waves of the impressed electromotive forces may be employed, the resulting radio-frequency oscillations being modulated in accordance with the frequency of said source of power, inductive reactance means for reducing fluctuations in the supply to said tubes, whereby said modulation may be decreased, and means for balancing out the remaining part of said modulation.

6. An electrical system comprising an alternating-current source of power, a pair of oscillator tubes, means for so coupling said oscillator tubes to said source of power that both half-waves of the impressed electromotive forces may be utilized, the resulting radio-frequency oscillations generated by said oscillator tubes being modulated in accordance with the frequency of said source, inductive reactance means for reducing fluctuations in the power-supply to said tubes, whereby said modulation

is practically eliminated, and means for introducing, in said power-supply, a modulation comparable to the residual modulation and in phase-opposition thereto.

7. An electrical system comprising an alternating-current source of power, a pair of oscillator tubes, means for so coupling said oscillator tubes to said source of power that both half-waves of the impressed electromotive forces may be utilized, the resulting radio-frequency oscillations generated by said oscillator tubes being modulated in accordance with the frequency of said source of power, inductive reactance means embodied in said coupling means and operating to reduce fluctuations in the power supplied to said tubes, whereby said modulation is practically eliminated, a pair of modulator tubes parallelly associated with said oscillator tubes, and means for so modulating the impedance of said modulator tubes as to oppose the residual part of modulation.

8. An electrical system comprising an alternating-current source of power, a pair of oscillator tubes, means for so coupling said oscillator tubes to said source of power that both half-waves of the impressed electromotive forces may be utilized, the resulting radio-frequency oscillations generated by said oscillator tubes being modulated in accordance with the frequency of said source of power, inductive reactance for reducing fluctuations in the power supplied to said tubes, whereby said modulation is practically eliminated, a pair of modulator tubes parallelly associated with said oscillator tubes, means for modulating the impedances of said modulator tubes in accordance with the modulation but in phase-opposition thereto, and means for further modulating the impedances of said modulator tubes in accordance with a signal.

9. A system for producing oscillations comprising an alternating-current source of power, oscillator tubes connected thereto, means for reducing fluctuations in the power supplied to said oscillator tubes, a slight residual fluctuation remaining, amplifier tubes connected to said source, means for reducing fluctuations in the power supplied to said amplifier tubes, a slight residual fluctuation remaining, and means for so associating the oscillator and the amplifier tubes as to balance the residual fluctuations of the amplifier tubes against the residual fluctuations of the oscillator tubes.

10. A system for producing oscillations comprising an alternating-current source of power, oscillator tubes connected thereto, means for reducing fluctuations in the power supplied to said oscillator tubes, a slight residual fluctuation remaining, amplifier tubes, a transformer, connections for associating said transformer and said source of power, connections for so associating said amplifier tubes and said transformer as to utilize both half waves of the impressed electromotive forces, means associated with said connections for reducing fluctuations in the power supplied to said amplifier tubes, a slight residual fluctuation, and means for so associating said amplifier tubes and said oscillator tubes as to balance the residual fluctuation in the amplifier circuits against that in the oscillator circuits.

11. In an electrical system, an alternating current source of power, oscillator tubes, a transformer for so coupling said source and said tubes as to admit of the utilization of both half-waves of the impressed electromotive forces, means tending to substantially remove fluctuations in the power-supply to said tubes, amplifier tubes, a transformer so coupling said amplifier tubes and said source as to admit of the utilization of both half-waves of the impressed electromotive forces, means tending to substantially remove fluctuations in the power supply to said amplifier tubes and means so associating the oscillator and the amplifier tubes as to balance the amplifier-tube residual fluctuations against the oscillator-tube residual fluctuations.

12. In an electrical system, an alternating-current source of power, oscillator tubes, a transformer so coupling said source and said tubes as to admit of the utilization of both half waves of the impressed electromotive forces, inductive reactance means embodied in said transformer for substantially removing fluctuations in the power supplied to said tubes, amplifier tubes, a transformer so coupling said amplifier tubes and said source as to admit of the utilization of both half-waves of the impressed electromotive forces, inductive reactance means embodied in said last-mentioned transformer for substantially removing fluctuations in the power supplied to said amplifier tubes, and means so associating the oscillator and the amplifier tubes as to balance the amplifier-tube residual fluctuations against the oscillator-tube residual fluctuations.

13. In an electrical system, an alternating-current power supply, oscillator tubes, a transformer so coupling said power supply and said tubes as to admit of the utilization of both half-waves of the impressed electromotive forces, means tending to substantially remove fluctuations in the power supply to said tubes, amplifier tubes, a transformer so coupling said amplifier tubes and said power supply as to admit of the utilization of both half waves of the impressed electromotive forces, means tending to substantially remove fluctuations in

the power supply to said amplifier tubes and means associating said amplifier tubes with the control elements of said modulator tubes, whereby the amplifier residual fluctuations may be caused to balance the oscillator residual fluctuation.

14. In an electrical system, an alternating-current power supply, a pair of oscillator tubes, a modulator tube having a controlling electrode parallelly associated with each oscillator tube, a transformer so coupling said power supply and said tube as to admit of the utilization of both half waves of the impressed electromotive forces, a sustaining inductance embodied in said transformer winding tending to substantially eliminate fluctuations in the power supply to said tubes, amplifier tubes having control electrodes, means for supplying said amplifier tubes from said power supply with currents having residual fluctuations similar to those in said oscillator-tube circuits, circuit connections for impressing said amplifier fluctuations upon said modulator control electrodes, whereby the residual fluctuations in said oscillator circuits may be eliminated, and means carrying modulating currents associated with said amplifier control electrodes.

In testimony whereof, I have hereunto subscribed my name this 23rd day of March, 1922.

FRANK CONRAD.