

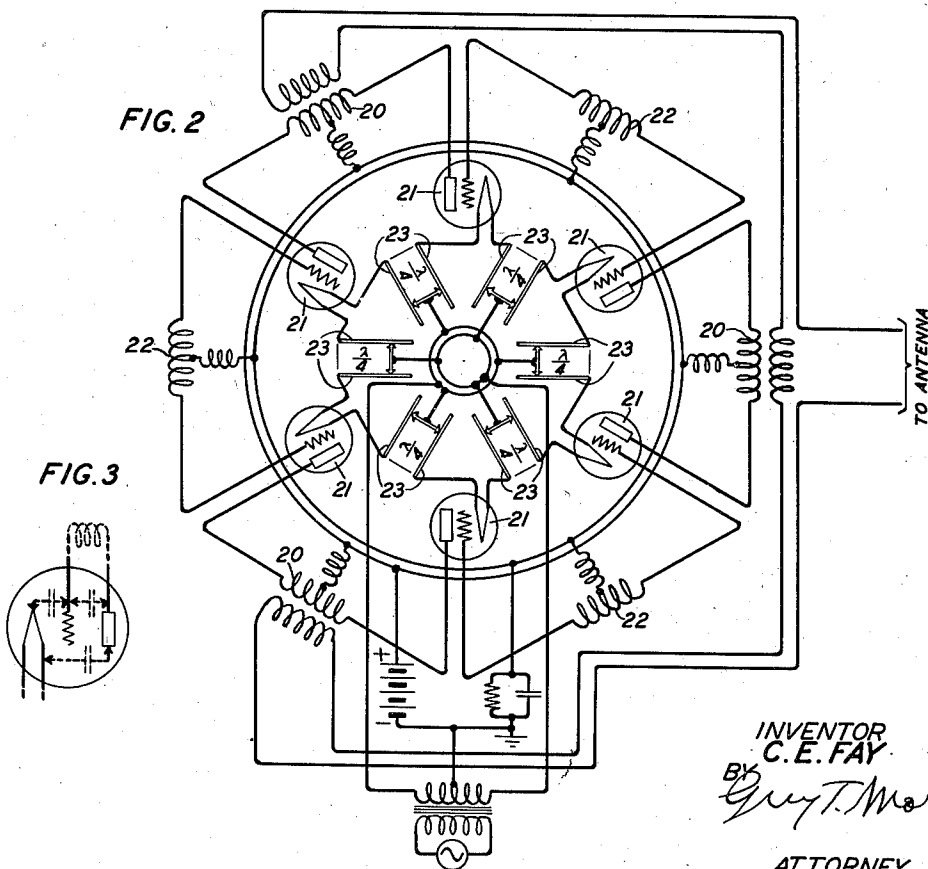
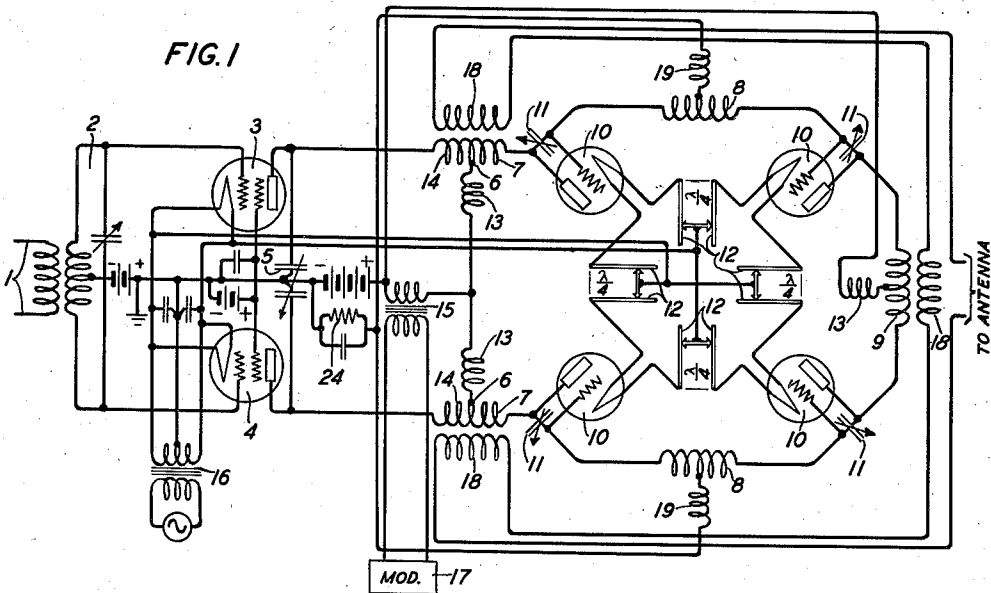
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HIGH FREQUENCY TRANSMISSION SYSTEM

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HIGH FREQUENCY TRANSMISSION SYSTEM

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12 Claims. (Cl. 250—36)

This invention relates to transmission systems, and more particularly to systems adapted to use at ultra high frequencies.

In general in the production of power at ultra high frequencies the upper limit of power is reached when the size of the generating vacuum tube becomes too great in relation to the wavelength to be generated, or when the connection of tubes in parallel in the conventional manner increases the total capacitance across the output circuit to a prohibitive value.

One object of this invention is to provide a means for obtaining larger amounts of power than is permitted by prior art arrangements, as above, of tubes and associated circuits. In the achievement of this object several tubes of a given type are connected such that their inter-electrode capacitances are effectively in series, thus allowing the circuit to be tuned to high frequencies even though it contains a large number of tubes.

Another object of this invention is to provide a means for increasing the power of controlled frequency obtainable in an amplifier circuit, this being achieved by inserting in the output circuit of said amplifier, oscillator tubes whose interelectrode capacitances are effectively in series.

A feature of this invention is the use of a variable condenser connected between the plate and grid terminals of each tube to provide a means for tuning the series oscillator circuit.

Another feature of this invention is the use of a connection between filaments which has a high impedance to the oscillator frequency, but a low impedance to the filament heating current.

Another feature of this invention is a proportioning of the inductances in the series oscillator circuit such that the filaments of the tubes are at voltage nodes and hence do not require high impedance circuits between one another.

Another feature of this invention is the application of plate voltage modulation to both the amplifier and oscillator tubes in the circuit in which the oscillator tubes are inserted in the output circuit of the amplifier.

The invention and the various features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing in which:

Fig. 1 is a circuit for an amplifier of radio frequency waves, in the output circuit of which are inserted oscillator tubes which will operate at the frequency determined by the amplifier input wave, providing the output circuit is tuned approximately to this frequency; and

Fig. 2 is a circuit for an oscillator or generator of radio frequency waves in which the oscillator tubes are connected so that their effective grid to plate inter-electrode capacitances are effectively in series, permitting the use of a large number of tubes in the circuit without appreciably increasing the difficulty of resonating the circuit at a high frequency; and

Fig. 3 shows the fundamental circuit in which each tube effectively operates in the arrangement of Fig. 2.

Referring to the drawing, Fig. 1, 1 is the output coil of a source of high frequency current which is inductively coupled to the tuned input circuit 2 of the screen grid amplifier tubes 3 and 4 which are connected as for a push-pull amplifier. In the conventional push-pull amplifier, the output circuit would be formed by connecting an inductance between the plates of tubes 3 and 4 in parallel with the variable condenser 5 as by joining points 6 together, omitting the elements shown from there on, and this circuit would be tuned to the frequency of the input wave in 1. In this event if proper balance were obtained, points 6 would be at a voltage node with respect to the alternating wave. Instead however, between points 6 are inserted inductances 7, 8, and 9 in series with the effective grid-plate capacitances of the tubes 10 which are shunted with variable condensers 11. The filaments of tubes 10 are isolated from each other with respect to the high frequency by means of the $\frac{1}{4}$ wave-length lines 12 which allow the low frequency heating current to be conducted to the filaments, but offer a high impedance to the high frequency currents. Thus with the filaments isolated, the effective grid-to-plate capacitance of a tube 10 becomes its direct grid-to-plate capacitance shunted by its grid-to-filament and plate-to-filament capacitances in series. If these capacitances and inductances inserted in series between points 6 are themselves in resonance at the input frequency of the amplifier, and the output circuit of the amplifier is tuned to resonance before inserting said capacitances and inductances, then the entire circuit is resonant at the input frequency. The condensers 11 provide a convenient means for insuring resonance at the correct frequency.

If the filaments of the tubes 3, 4, and 10 are energized by transformer 13, the mid-points of coils 3 are connected to ground through choke coils 19 and the grid leak and condenser 24, and plate voltage is applied through choke coils 13 at the midpoint of coil 9 and at points 6, tubes

10 will act as unit Colpitts type oscillators operating in series at the same frequency, or may be treated as jointly co-operating as a Colpitts type series oscillator having this frequency and held to this frequency by the input wave through the amplifier tubes 3 and 4. This oscillator is a vacuum tube oscillator of the series type because it combines a plurality of unit oscillators into a unitary whole in which the space paths of the unit vacuum tubes are in series and in which a single frequency determining circuit is used which combines in series the reactances including said space paths that would otherwise constitute the frequency determining reactances of the unit oscillators.

The output of the amplifier and oscillators (series oscillator) may be modulated by suitably inserting a modulating voltage in series with the plate supply voltage as by transformer 15 connected from the source of modulation 17. The output of the amplifier and oscillator may be transferred to an antenna or other load by coupling such load circuit to the coils 7, 9, and 14 as shown by coils 18. It will readily be appreciated that a greater or smaller number of oscillator tubes than shown in Fig. 1 may be used without altering the nature of the invention. An even number of oscillator tubes is preferable in order that no stopping condensers to separate the direct grid and plate voltages need be used in the high frequency circuit.

Fig. 2 is a diagram of an oscillator circuit alone in which the tubes are operated so that their grid-plate capacitances are in series. This circuit is similar to the series oscillator circuit of Fig. 1, in fact may be substituted for it, this figure being used to show the generality of the series oscillator principle and its use with an indefinitely larger number of tubes than in the oscillator of Fig. 1. Referring to Fig. 2:

The plate of each tube 21 is connected through an inductance 20 to the plate of the adjacent tube and the grid of the tube is connected through an inductance 22 to the grid of the tube on the opposite side. The filaments of adjacent tubes are isolated from each other by means of the $\frac{1}{4}$ wave transmission lines 23, which have a high impedance at their open ends to the high frequency. The low frequency heating current is transmitted to the filaments without difficulty. The potential which the filament assumes with respect to the high frequency potentials on grid and plate is then determined entirely by the grid-filament and plate-filament capacitances in the tube. The filaments and filament leads in the tube will carry very little high frequency current and therefore there will be very little loss of high frequency energy in the filaments.

Each tube becomes effectively an oscillator of the Colpitts type as indicated in Fig. 3. Since the reactance inside the tube is capacitive, that outside must be inductive in order for the circuit to be oscillatory. It will be apparent to one skilled in the art that the voltage at the plate of one tube will be opposite in phase to that at the plate of each adjacent tube, and thus there must be a voltage node at the center of each plate inductance coil 20. Similarly there must be one at the center of each grid inductance 22. Thus the direct voltage feed wires for plates and grids may be connected to the centers of the respective coils without the necessity of using choke coils in the leads although such choke coils are disclosed to illustrate the generality of the use of the circuit. Also since there are nodes between the terminals

of each series inductance, there must likewise be nodes between the terminals of each capacitance. If the filament could be made to be at this node, the $\frac{1}{4}$ wave lines in the filament circuits would be unnecessary although here, similarly as in the instance of the choke coils above, these $\frac{1}{4}$ wave lines are disclosed to illustrate the generality of the circuit. This may be brought about by making the ratio of the plate inductance 20 to the grid inductance 22 equal to the ratio of the grid-filament capacitance to the plate-filament capacitance.

In order to make the tuning of the circuit adjustable, variable condensers may be connected from grid to plate of each tube, as condensers 11 in Fig. 1, and the controls ganged to a single common control. These condensers will not affect the position of the voltage nodes of the circuit. Practical considerations, especially relating to phase relations of component electrical quantities in the network as a whole point to the desirability of a symmetry between the various units each composed of a tube and its immediately associated circuits. This being true the tuning of the imputed resonant circuit associated with each such unit will be the same as that of each other unit and the same as that of the circuit as a whole with all the inductances and capacitances being treated as parts of a single frequency determining circuit. This again indicates the propriety of thinking of each unit as comprising an individual oscillator of the Colpitts type, a plurality of such oscillators being connected in series.

It will be understood that while the circuit of Fig. 2 shows six tubes, either more or less may be used without changing the type of circuit or increasing the difficulty of tuning the circuit to a high frequency. An even number of tubes is preferable as the use of stopping condensers for the direct voltages can be dispensed with and the circuit kept balanced more easily. If an odd number of tubes is used, a capacitance simulating one tube in value is used in the circuit as a stopping condenser.

It will be understood that the method for bringing the filaments at voltage nodes in the circuit of Fig. 2 also applies to the series oscillator tubes of the circuit of Fig. 1 as does also the method of using an odd number of tubes.

What is claimed is:

1. A transmission system comprising in combination, a source of waves of given control frequency, a controlled oscillator adapted to independently generate a wave of approximately the control frequency, and means connecting said oscillator to said source, whereby the control wave coerces the oscillator to generate a controlled wave whose frequency is commensurable with that of the control wave, said oscillator comprising a plurality of unit three electrode vacuum tube oscillators connected so that their inter-electrode capacitances are in series and impedance means serially connecting the cathodes of each consecutive pair of said unit oscillator tubes and having a large impedance with respect to current of the characteristic oscillator frequency whereby said cathodes are effectively independent with respect to said current except as connected through the tubes.

2. A transmission system consisting of means for producing an exciting voltage of a given frequency, a substantially reactionless amplifier excited by said voltage and having an anti-resonant output circuit comprising a plurality of electric discharge devices each having a cathode, anode

and control electrode and disposed so that the effective control electrode-anode capacitance, including the series combination of control electrode-cathode and cathode-anode capacitances, of each of said devices is effectively in series with the corresponding capacitances of each of the other devices, inductances connecting each pair of consecutive devices, and connecting the terminal devices with the output electrodes of said amplifier, consecutive devices being relatively reversely connected to each other through said inductances, and means for utilizing the energy of said controlled oscillator circuit.

3. The system specified in claim 2 with, additionally, a variable tuning condenser connected between the control electrode and anode of at least one of the electric discharge devices.

4. The system specified in claim 2 comprising, additionally, means for supplying anode voltage and a modulating voltage in series through the anode-cathode circuits, in parallel, of the amplifier and oscillator electric discharge devices.

5. A transmission system comprising in combination, means for producing an exciting voltage of a given frequency, and a substantially reactionless amplifier excited by said voltage and having an anti-resonant output circuit which comprises a plurality of three-element oscillator tubes disposed so that the effective control electrode-anode capacitance of each of said tubes, including the series capacitances between the control electrode and cathode and between the cathode and anode, is effectively in series with the corresponding capacitances of the other oscillator tubes and also comprising inductances connecting each pair of consecutive tubes and connecting the terminal tubes with the output electrodes of the amplifier together with transmission lines connected between the cathodes of each consecutive pair of oscillator tubes each a $\frac{1}{4}$ effective wave-length long with respect to the operating wave-length of the circuit.

6. The transmission system specified in claim 5, comprising an even number of oscillator tubes, the tube capacitances with respect to the control electrode and anode elements of each tube being connected reversely in relation to each adjacent tube, with inductances connecting adjacent pairs of like cold tube elements, and means for supplying anode voltage to the oscillator tubes by connections in parallel to the mid-points of the inductances connecting the pairs of anodes and a similar anode voltage supply means for the amplifier.

7. A transmission system consisting of means for producing an exciting voltage of a given frequency, a push-pull amplifier excited by said voltage and having an anti-resonant output circuit which contains a plurality of oscillator tubes each containing a cathode, control electrode and anode, disposed so that the effective anode-control electrode capacitances of said tubes, including the series combination of control electrode-cathode and cathode-anode capacitances, are effectively in series with the corresponding capacitances of the other tubes and with the inductances constituting the inductive reactance of said anti-resonant circuit, said inductances being so disposed that an effective inductance connects the anode of each oscillator tube to the anode of an adjacent oscillator tube, another effective inductance connects the control electrode of each oscillator tube to the control electrode of the other adjacent oscillator tube and the remaining inductances connect the terminal

tubes with the output electrodes of said amplifier and in which the ratio of said effective inductances between anodes to the effective inductances between control electrodes is as the ratio of the control electrode-cathode capacitance to the anode-cathode capacitance of the oscillator tube used, means interconnecting the cathodes of said oscillator tubes for direct current but effectively relatively isolating them from each other for current of the oscillation frequency, and means for supplying anode voltage to said tubes in parallel through the mid-points of the connecting inductances.

8. The transmission system specified in claim 7 with additional means for supplying anode voltage to the amplifier anodes in parallel with the anode supply circuit for the oscillator tubes plus means for supplying a modulating voltage in series with the common anode voltage source.

9. A series oscillator circuit comprising a plurality of electric discharge devices, each having a cathode, a control electrode and an anode, and a frequency determining circuit comprised by the control electrode-anode capacitances of said devices, including the capacitances between the cathodes and anodes, in alternate series with inductances interconnecting the like cold elements of consecutive devices, and a transmission line a $\frac{1}{4}$ effective wave-length long with respect to the operating wave-length of the circuit serially connecting the cathodes of each consecutive pair of devices for effectively electrically isolating said cathodes from each other with respect to current of the operating frequency except through the electric discharge devices and said inductances.

10. A series oscillator circuit comprising a plurality of electric discharge devices, each having a cathode, a control electrode and an anode, so disposed that an effective inductance connects the anode of each tube to the anode of a next adjacent tube and another effective inductance connects the control electrode of the same tube with the control electrode of the other next adjacent electric discharge device, said cathodes being serially connected through impedances which are large with respect to current of the characteristic oscillator frequency for effectively electrically isolating said cathodes from each other with respect to current of the operating frequency except through the electric discharge devices and said inductances, the control electrode-anode capacitances, including the series combination of control electrode-cathode and cathode-anode capacitances, together with the connecting inductances constituting the frequency determining resonant circuit of the oscillator as a whole.

11. The series oscillator specified in claim 10 in which there is an even number of electric discharge devices and in which there is provided a common anode voltage source feeding the anodes in parallel by connections at the mid-points of the inductances connecting the pairs of anodes.

12. The series oscillator specified in claim 10 in which the corresponding elements have like electrical values and in which there is included, additionally, tuning condensers, each connected between a control electrode and anode of an individual electric discharge device, with means for insuring that said condensers simultaneously have equal values of capacitance.

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