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FREQUENCY MULTIPLICATION AND KEYING SYSTEM

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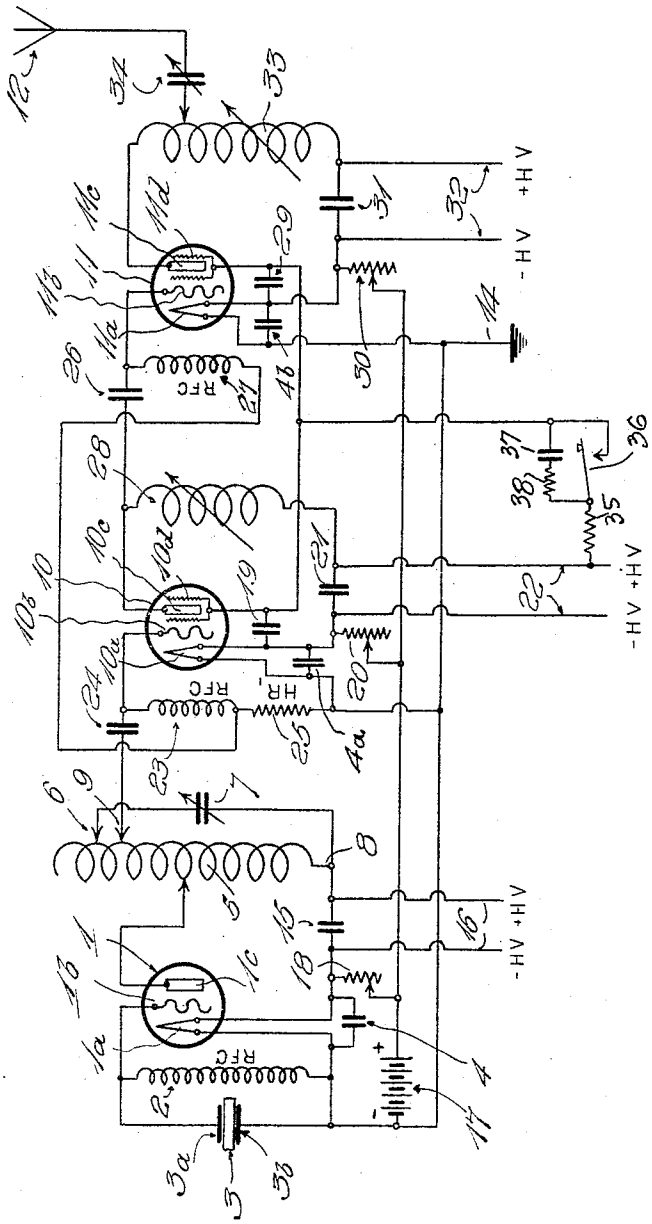

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UNITED STATES PATENT OFFICE

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FREQUENCY MULTIPLICATION AND KEYING SYSTEM

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My invention relates broadly to signal transmission systems and more particularly to an electron tube circuit arrangement for radio telegraph transmitters.

One of the objects of my invention is to provide an electron tube circuit for frequency multiplication in radio transmitters having means for keying the high frequency output of the frequency multiplier system without interrupting the source.

Another object of my invention is to provide a signaling control circuit for an electron tube transmitter system employing auxiliary circuits to an electrode in selected electron tubes in the system independent of the cathode, control electrode and plate system for effecting the transmission of telegraphic signals.

A further object of my invention is to provide a keying circuit for electron tube transmitters of the frequency multiplication type in which signals may be formed without the employment of a source of negative potential in the keying circuit, or on the control grids of the frequency multiplication tubes.

Other and further objects of my invention reside in the circuit arrangement for an electron tube transmitter as will be set forth more clearly in the specification hereinafter following by reference to the accompanying drawing which diagrammatically illustrates the principles of my invention applied to an electron tube transmitter.

Heretofore in the art it has been necessary in high frequency electron tube transmitters where frequency multiplication is employed to provide a separate source of potential, the negative terminal of which is connected with the electron tube circuits and utilized for blocking one or more of the tubes in the process of keying, as well as for producing the necessary high negative grid working voltage required in frequency multiplication circuits. In the case of a small installation of relatively low power, the addition of a separate direct voltage machine for this purpose is sometimes objectionable and in any event adds to the cost. Where the transmitter has had all of its different voltages supplied from alternating current to transformers and, where necessary, rectifiers, it is objectionable because a separate set of rectifier tubes, connections, etc., has to be provided. While the objection is not so potent in this case as in the case of a direct current installation, nevertheless it exists.

In the circuit arrangement of my invention, I provide a frequency multiplier system wherein the power supply is simplified and yet frequency multiplication by doubling obtained for high frequency signal transmission without requirement of the separate potential source heretofore required for furnishing negative potential to the tube circuits. I also employ in the circuit arrangement of my invention, a crystal controlled oscillator in the transmission system which may operate, for example, in the 4,000 kilocycle band followed by a shield grid power tube which is used either for singling or doubling the frequency of the oscillator according to the adjustment of the inductance in the plate output circuit of the tube. This tube is in turn followed by a similar tube which again can either single or double the frequency of the preceding tube circuit according to the tuning of its plate inductance. The output circuit is then connected by any suitable coupling methods to a radiating system.

For the purpose of illustrating my invention, I have shown the output circuit capacitatively coupled to an antenna system, although other coupling methods may be employed. I provide a high resistance leak path through separate radio frequency choke coils to the control grids of the amplifying and frequency multiplying tube. The keying circuit connects between the positive high voltage source and the shield grids of the amplifying and multiplying tubes which are disposed in parallel, and a potential derived and impressed upon the shield grids from the high potential plate source in such manner that when the key is up the shield grids serve to block both the amplifying and frequency multiplying tubes at the same time and while the key is down the shield grids assume the proper positive potential necessary for normal operation of the tubes.

Hence when the key is down, the transmitter radiates signaling energy.

Referring to the drawing in more detail, the oscillator tube is indicated by reference character 1, followed by an amplifying or frequency multiplying tube 10 which is in turn followed by an amplifying or frequency multiplying tube 11. The oscillator tube 1 includes cathode 1*a*, control grid 1*b*, and anode 1*c*. The control grid 1*b* is connected in the input circuit of the oscillator which includes the piezo electric crystal element 3 which is connected in the input circuit by means of contact plates 3*a* and 3*b*, which are in parallel with radio frequency choke 2. The cathode 1*a* is energized from any suitable source such as indicated at 17 and a radio frequency by-pass condenser 4 is placed in shunt with the cathode circuit. The cathode heating potential is controlled by adjustable rheostat 18. The output circuit of the oscillator 1 includes inductance 5, selected portions of which are connected in the plate circuit of the oscillator 1 for adjusting the circuits of the oscillator to the frequency which is determined by piezo electric crystal element 3. A tuning condenser 7 connected to a variable tap 6 on plate inductance 5 facilitates the tuning of the oscillator system. The low terminal 8 of inductance 5 connects the high potential source 16 to the output circuit of the oscillator tube 1, the high potential source being bridged by radio frequency by-pass condenser 15. The energy from the oscillator system is transferred to the first stage of amplification or frequency multiplication which includes electron tube 10 which is of the shield grid type. The electron tube 10 includes cathode 10*a*, control grid 10*b*, anode 10*c*, and shield grid 10*d*. Heating potential is applied to cathode 10*a* shunted by the by-pass condenser 4*a*, from any suitable source such as 17 and the potential varied by means of adjustable rheostat 20. Energy is supplied to the input circuit of the electron tube 10 from a tap 9 on inductance 5 through coupling condenser 24, the opposite side of the input circuit being completed through the cathode system. The output circuit of electron tube 10 includes adjustable inductance 28 and high potential source H. V. which is connected to leads 22 and bridged by radio frequency by-pass condenser 21. Energy is transferred from the output circuit of electron tube 10 to the input circuit of the succeeding electron tube 11 arranged for the amplification or frequency multiplication, control grid 11*b* of tube 11 being connected through coupling condenser 26 with a point on the inductance 28. Cathode 11*a*, of electron tube 11 is heated from the cathode heating source 17 and the temperature regulated by rheostat 30. Cathode 11*a* is shunted by by-pass condenser 4*b*. The anode 11*c* connects in the output circuit of the electron tube 11 through adjustable inductance 33 and high potential source H. V. which is connected to leads 32, the high potential source being bridged by radio frequency by-pass condenser 31. The shield grid 11*d* in electron tube 11 is connected in parallel with the shield grid 10*d* of electron tube 10 and arranged in the keying system for the control of the output of the several tubes with respect to the antenna system. The keying system includes a resistor 35 in series with a key 36, one terminal of the resistor 35 being connected to the high potential positive side of the plate source 22, and the opposite terminal of the resistor 35 being connected to the key 36. The key 36 has its contacts shunted by an absorption circuit which includes condenser 37 and series connected resistor 38 which operates to reduce arcing at the contacts of the key 36. The high resistance 35 placed in series with the key 36 insures when the key 36 is down that the shield grids 10*d* and 11*d* have their normal and proper potential. When the key is up, however, the shield grids assume a negative potential which tends to block both of the tubes 10 and 11 simultaneously, due to the repulsion of electrons which normally pass to the plate electrodes 10*c* and 11*c*. The negative charges on the shield grids 10*d* and 11*d* tend to repel the electrons which flow from the cathodes 10*a* and 11*a*. This action occurs irrespective as to whether the crystal oscillator system 1 is functioning or not. If the crystal circuit is functioning, the keying circuit will properly control the output of the transmitter for the radiation of telegraphic signals, the required negative C voltage being obtained by the drop developed across the high resistance 25 which connects to the negative side of the cathode heating source 17, and connects through radio frequency choke coils 23 and 27 with the control grids 10*b* and 11*b* of tubes 10 and 11, respectively. In order to start the transmitter in operation, it is first necessary to place the oscillator circuit 1 in a conditon of oscillation by which energy is supplied to the input system of amplifier tube 10 and to the circuit of the grid electrodes of each of the tubes 10 and 11 through resistance 25 for developing the required negative potential for operating tubes 10 and 11 at the proper points on the characteristic curves thereof. It is highly important that the working grids 10*b* and 11*b* be supplied with a voltage at negative potential to prevent the drawing of an excessive plate current by either of the tubes. This negative voltage is developed by the drop over resistor HR_1. In order to guard against the injurious effects of excessive plate current, suitable circuit breakers may be provided in the high voltage plate supply which can be made common to the two amplifiers if desired. Such circuit breakers are closed

in placing the transmitter in operation after the crystal circuit 1 is properly functioning and precaution is taken against the closing of the keying circuit until the crystal oscillator is properly functioning. The negative C potential is developed by the high frequency excitation current or rather by the rectified portion thereof supplied to the working grids, that is the control grids, by virtue of the fact that the grid leak resistance HR_1 is extraordinarily high; namely, of the order of between 100,000 and 200,000 ohms. The system inherently involves a new method of keying in shield grid circuit, involving the use of extra high grid leaks, and the omission of the usual negative C source.

The transmitter system of my invention has been operated in the 4,000 kilocycle band, the 8,000 kilocycle band, and in the 16,000 kilocycle band, but is not limited to these bands. In the first instance the amplifier tubes singled, in the second instance the first one doubled and the second one singled, and in the third instance both amplifiers were functioning at frequency doubling.

The fact that an independent source of direct current is unnecessary in the transmitting circuit shown herein for the control grid circuit or for the keying circuit, greatly simplifies the transmitting circuits. Very satisfactory and rapid keying has been found possible in the circuit arrangement of my invention.

It is essential, however, that shield grid tubes be employed in the system herein where the separate direct current source is eliminated. The proper tuning of the several stages of amplification for producing the required single or multiple frequencies for transmission is brought about by adjustment of inductances 28 and 33. The energy is radiated from antenna system 12 connected through tuning condenser 34 and adjustable inductance 33 to ground 14. Any form of radiating circuit may be provided and I have illustrated an antenna as being one type of radiating circuit which may be employed.

I desire that it be understood that while I have illustrated my invention in one of its preferred embodiments, that modifications may be made and that I intend no limitations upon my invention other than are imposed by the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. In a radio transmission system, a high frequency oscillator, a multiplicity of stages of electron tube amplification connected with said oscillator, each stage of amplification including an electron tube having a cathode, a control grid, an anode, and a shield grid therein, a cathode heating circuit, a source of potential for energizing said anode, the control grids of said tubes being connected together and the shield grids of said tubes being connected together, a keying circuit connected between the shield grids of said tubes and the positive side of said source of anode potential, and means for deriving a negative potential for biasing the control grids of said tubes from energy developed by said oscillator, said means comprising a high resistance connected between the control grids and the cathodes of said tubes.

2. A radio transmission system comprising a high frequency oscillator, a frequency multiplier and amplifier system connected with said oscillator, said frequency multiplier and amplifier system including electron tubes each having a cathode, a control grid, an anode, and a shield grid, a circuit for energizing the cathodes of said tubes, a high potential source for energizing the anodes of said tubes, said shield grids being connected in parallel, a keying circuit connected between said shield grids and one side of said high potential source for said anodes, and means for deriving from said oscillator a negative potential for the control grids of said electron tubes.

3. In a radio transmission system, a high frequency oscillator, a multiplicity of electron tubes connected in tandem and connected to said high frequency oscillator, each of said electron tubes including a cathode, a control grid, an anode, and a shield grid therein, a source of anode potential, a source of potential for energizing said cathodes, a circuit connected to one side of said source of potential and to each of said control grids in common for deriving from said oscillator a negative potential for impression on said control grids, said shield grids being connected together, and a keying system connected between said shield grids and said source of anode potential.

4. In a signal transmission system, a high frequency oscillator, a multiplicity of electron tubes connected in tandem and connected to said oscillator, each of said tubes including a cathode, a control grid, an anode, and a shield grid, means for energizing said cathodes, a circuit connected to one side of said means for deriving from said oscillator negative potential for impression upon each of said control grids in common, a source of anode potential, and a telegraphic keying circuit connected at one side to said shield grids in common and at the other side to said source of anode potential, whereby the operation of said last mentioned tubes may be blocked upon opening of said keying circuit.

5. In a radio transmission system, a high frequency oscillator, a multiplicity of electron tubes connected in tandem and connected to the output circuit of said oscillator, a transmission system connected with the output circuit of said last mentioned electron tubes, each of said electron tubes including a cathode, a

control grid, an anode, and a shield grid, a source of potential for energizing the cathodes of said electron tubes, means connected between said oscillator and said control grids for deriving from said oscillator a negative potential for impression upon the control grids of each of said electron tubes, a source of anode potential, and a keying circuit connected between one side of said source of anode potential and said shield grids connected in parallel for impressing a selected potential upon said shield grids when said keying circuit is closed for effecting transfer of energy from said oscillator to said transmission system while blocking the operation of said tubes upon the opening of said keying circuit.

6. In a system for transmitting telegraphic signals, a high frequency oscillator circuit, a multiplicity of electron tube circuits connected in tandem for multiplying the frequency of said oscillator circuit, a transmission circuit connected to said last mentioned electron tube circuits, each of said electron tube circuits including an electron tube having a cathode, a control grid, an anode, and a shield grid, a source of potential for energizing said cathodes, a high resistance leak path connected to each of said control grids and to one side of said source of potential, potential means for energizing said anodes, and a keying circuit including a resistor and a circuit interrupter in series, one end of said resistor being connected to the positive side of said anode potential source, one side of said circuit interrupter being connected to said shield grids in parallel for impressing positive potential upon each of said shield grids or cutting off said potential simultaneously for blocking the operation of said electron tubes for effecting the transmission of signals.

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