

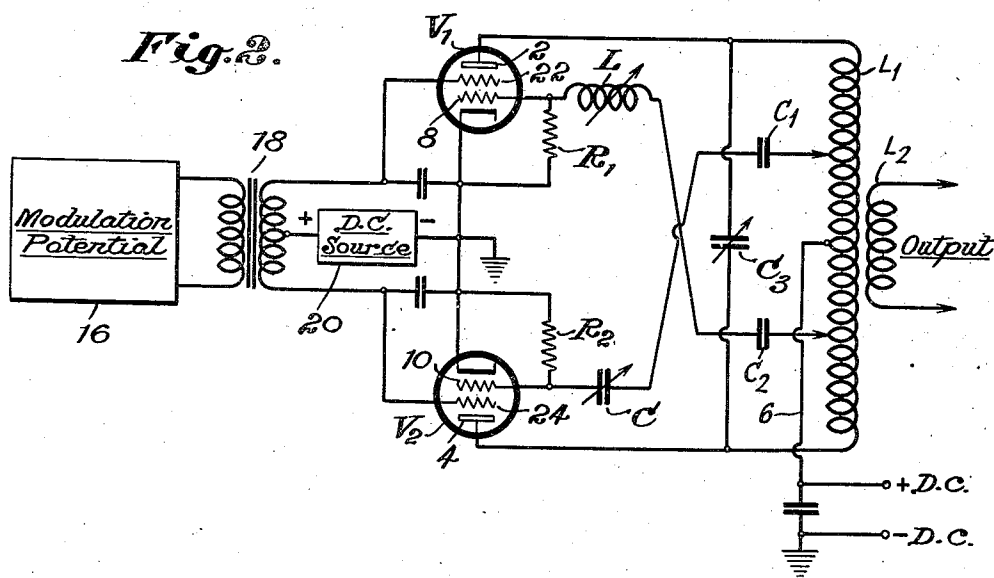
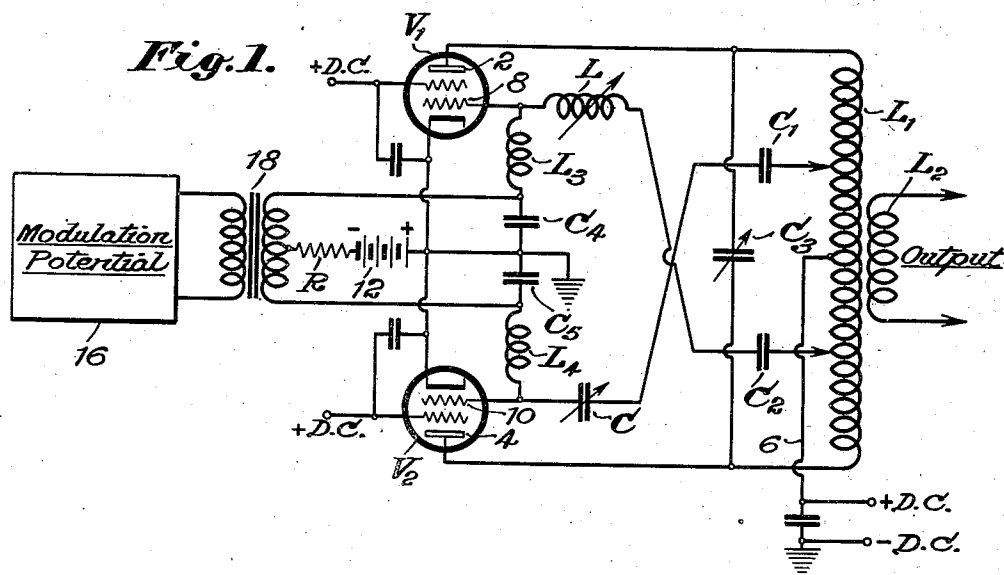
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FREQUENCY MODULATION

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FREQUENCY MODULATION

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This application concerns a new and improved means for generating wave energy and modulating the frequency of the same in accordance with signals such as, for example, telephony, telegraphy, photo radio, television, etc.

Briefly, my system includes a pair of electron discharge devices connected in a push-pull oscillation generator circuit of relatively low Q with phase displaced feed back circuits and push-pull modulation of the tubes to thereby modulate the frequency of the oscillations generated. Push-pull modulators have various advantages over single tube circuits because the modulation characteristic in a push-pull system is linear over a greater range than in a single tube system. Moreover, push-pull modulation with a balanced oscillator balances out amplitude modulation leaving only the desired frequency modulation. Another advantage is that fluctuations of power voltage which change electron discharge tube electrode potentials compensate in the push-pull arrangement and do not cause undesired frequency shifts or modulations, as would be the case in a single tube circuit. Other advantages which flow from the use of a simple balanced oscillator and modulator such as I have invented will appear in the following detailed description thereof, and still others will be apparent to those skilled in the art.

In describing my invention in detail reference will be made to the attached drawings, wherein Figures 1 to 3 each show somewhat diagrammatically the essential features of oscillation generators of the push-pull type with push-pull modulation thereof to modulate the generated frequency. In Figure 1, the phase shifting feedback circuits include respectively two inductive reactances and a capacity and an inductive reactance. In this modification a common bias resistance is used to supply the control grid bias. In Figure 2 the phase shifting feedback circuits include respectively a resistance and inductance and a resistance and capacity. In this modification the phase shifting resistances also serve as the grid biasing resistances. In the arrangement of Figure 1 modulation is applied to the control grids, whereas in the arrangement of Figure 2 modulation is applied to the screen grids. In Figure 3 the push-pull modulated oscillator is substantially similar to the one shown in Figure 2. In Figure 3, however, I have shown in greater detail the modulation circuits which include means for modulating by different types of signals.

Referring to Figure 1, tubes V1 and V2 have their anodes 2 and 4, respectively, coupled in

push-pull relation by a tank circuit comprising an inductance L1 and capacity C3, to which inductance L1 may be coupled an output circuit including an inductance L2. The screen grids of these tubes V1 and V2 are supplied with direct current potential as shown, and the anodes 2 and 4 are supplied with positive potentials by way of the inductance L1 and a lead 6. The control grid 8 of tube V1 is coupled to a point on the inductance L1 by way of coupling and blocking condenser C2 and phase shifting inductance L and to the cathode by phase shifting choke L3 including the tube V1 resistance between the grid and cathode in parallel to L3 and condenser C5. A similar phase shifting feedback circuit comprising coupling condenser C1, condenser C, and phase shifting inductance L4 including the tube resistance and condenser C5 coupling a point on inductance L1 to the control grid 10. The grid to cathode resistances of tubes V1 and V2 are in parallel with inductances L3 and L4 respectively. The control grid capacities of tubes V1 and V2 respectively tune out the inductance of chokes L3 and L4 respectively. As a consequence the phase shifting means are actually C and tube V2 grid resistance and L and tube V1 grid resistance.

Bias for the control grids 8 and 10 is supplied by source 12 and/or resistance R. Modulating potentials of the desired character are supplied from a source 16 through coupling means such as a transformer 18 to the control grids 8 and 10 in push-pull relation.

Oscillations are generated in the tubes V1 and V2 and their circuits in a well-known manner, the oscillator circuits being, except for differences pointed out hereinafter, conventional. The control grid 8 of tube V1 is excited by feedback potentials from one side of the midpoint of tank circuit L1, C3, while the control grid 10 of tube V2 is excited by feedback from the other side of this tank circuit. Disregarding the function of the phase shifting reactances L and L3, and C and L4, and the tube resistances the circuit described provides a conventional push-pull oscillator. However, in my novel system the excitation voltages fed back to grids 8 and 10 are shifted by phase shifting circuits L, etc. and C, etc. The voltages fed to the grid 8 are retarded by L and those fed to the grid 10 are advanced by C.

As stated above the phase shifting means in the control grid circuit of tube V1 are inductances L and L3 plus the tube resistance. The phase shifting means in the control grid of tube

V2 are condenser C and inductance L4 plus the tube resistance. Condensers C1 and C2 are large and have substantially no effect on the voltage passed thereby. Excitation feedback energy obtained through coupling condenser C2 from one end of the anode tank circuit C3, L1 is retarded in phase by phase shifting means L and L3 with the tube resistance when it reaches the control grid 8 of tube V1. This energy is amplified and reversed in phase by tube V1 and fed back to the opposite end of the tank circuit C3, L1. Excitation feedback energy obtained by way of coupling condenser C1 from the opposite end of the anode tank circuit C3, L1 is advanced by condenser C and inductance L4 with the tube resistance when it reaches the control grid 10 of tube V2. This latter energy is amplified and reversed in phase by tube V2 and fed back to the lower or opposite end of the anode tank circuit C3, L1.

The control electrodes 8 and 10 of tubes V1 and V2 are modulated in push-pull relation as stated above. When the tube V1 has its control grid 8 modulated less negative to deliver more energy to the anode tank circuit L1, C3 and the grid 10 of tube V2 is modulated less positive or more negative to deliver less energy to the anode tank circuit L1, C3, then, since the phase of the energy delivered by tube V1 is lagging and that delivered by tube V2 is leading, the phase and frequency of the oscillations in tank circuit C3, L1 will slow down to a lower frequency. Stating this another way, the tube V1 is supplying the greater amount of energy to the tank circuit L1, C3 and this energy is lagging in phase and frequency with respect to the smaller amount of energy supplied to the tank circuit L1, C3 by tube V2. As a consequence, the frequency of the energy in the tank circuit L1, C3 approaches the phase and frequency of the energy supplied by tube V1. When during modulation tube V2 is biased less negative and tube V1 is biased more negative, tube V2 is delivering more energy to the tank circuit and tube V1 is delivering less energy to the tank circuit. As a consequence, since the energy supplied by tube V2 is leading and that supplied by tube V1 is lagging, the phase and frequency of the oscillations in tank circuit L1, C3 speed up to a higher frequency and more nearly approach the phase and frequency of the energy supplied by the tube V2. The amount of this frequency deviation from the average carrier frequency is proportional to the amplitude of the signal oscillations and the frequency of deviation or frequency swing is the same as the frequency of the signal oscillations. The output energy of the modulator is fed to other modulators, amplifiers, and/or frequency multiplier stages not shown before it is delivered for use.

The arrangement of Figure 2 is similar to the arrangement of Figure 1 except that the inductances L3 and L4 of Figure 1 are replaced in Figure 2 by phase shifting and biasing resistances R1 and R2. In Figure 2, a source 20 supplies potential to the screen grid electrodes 22 and 24, and these electrodes are modulated in push-pull relation by potentials from source 16 and coupling transformer 18. The operation of the arrangement of Figure 2, except for the differences noted above, is similar to the operation of the arrangement of Figure 1.

In Figure 3, the oscillator comprising tubes V1 and V2, the tank circuit therefor, and the phase shifting feedback circuits therefor are similar in many respects to the corresponding tubes and circuit arrangements of Figures 1 and 2. In Fig-

ure 3 the grids 8 and 10 are tapped to points on the capacitive branch of the tank circuit. To do this I provide a capacity potentiometer including condensers C1 and C2 and condensers C6 and C7 which have their adjacent terminals grounded. The control grid electrodes 8 and 10 may be modulated by one type of signal, such as, for example, telephony signals, while the screen grid electrodes may be modulated. Electrodes 22 and 24 may be modulated by another type of signals, such as, for example, C. F. V. D., telegraphy signals, etc.

For convenience in describing the system of Figure 3, I have designated the modulated oscillator as a unit A, the telephony modulating means as a unit E, and the other modulating means as a unit B. The unit B comprises a tripping circuit, as will be described more in detail hereinafter, which operates on the screen grids of the frequency modulated oscillator A, and audio amplifier C operates on the control grids of the frequency modulated oscillator A. Ordinarily when either stage B or C is not in use, switches S1 or S2 may be open, respectively, to prevent the operation of the stage not required. The opening of switch S1 and S2 cuts off the cathode heater currents of the tubes. If these means are not sufficient to prevent reaction by the stage not in use, then the switches (X and Y) and (U and V) may one or the other be also opened to cut out the stage not in use.

The tripping circuit or stage B is used to provide and insure square wave balanced keying for the frequency modulator stage A. The incoming telegraph signals may be peaky and not square wave form and the signal amplitude may not be constant. The tripping circuit B is used not only to square up the keying wave form but also to limit the signals to constant amplitude. This provides a means for holding the transmitter signal frequency deviation to a certain adjustable limit.

The tripping circuit, which consists of tubes V3 and V4, and resistors 30, 32, 34, 36, 38 and 40 is not new in the art since it was shown in Finch Patent 1,844,950. Since the manner in which a tripping circuit functions has been described by others, I will describe only its use in connection with this invention. However, some of the details in the way that I use it here are believed new. Potentiometers 46 and 48 are provided in the tripping circuit B to couple in the keying potentials. A fixed bias source 50 is used through potentiometer 46 to hold the tripping circuit in the space condition when no mark (keying) potentials are applied. Switch 52 is used to short circuit all or part of potentiometer 46 (with the bias source 50 disconnected) to unbalance the tripping circuit sufficiently to hold it in the space condition when no signal mark potentials are being applied. The keyed telegraph potentials are applied to the tripping circuit through potentiometer 48. When sufficient negative mark potential is applied to 48 it overcomes the space bias effect and causes the circuit B to trip definitely to the mark condition. When marking potential is removed or is insufficient, the circuit B trips definitely back to the spacing condition. In this way the space and mark characters of the telegraph signals are made to operate the tripping circuit. The square wave form, constant amplitude signals in the tripping circuit B are coupled to the frequency modulator stage A through potentiometers 52 and 54 by way of leads 56 and 58 to the screen grids of tubes

V1 and V2. The outer ends of resistances 52 and 54 are connected to the anodes of tubes V3 and V4 in the tripping circuit. The adjacent ends of resistances 52 and 54 are both grounded through a common bypass condenser 56. The adjacent ends of resistances 52 and 54 are also connected to potentiometer 60 for positive bias supply for the screen grids of frequency modulator tubes V1 and V2. It can be seen that by moving the points connected to leads 56 and 58 in and out from the adjacent ends of potentiometers 52 and 54 various degrees of coupling and various amounts of signal may be obtained as desired.

Positive potential is supplied to the adjacent ends of resistances 52 and 54 from 60 to lighten the direct current load on the tripping circuit and to maintain the positive bias on the screen grids 22 and 24 as the leads 56 and 58 are moved toward the center or lower coupling position. Potentiometer 60 also provides a means of adjusting the screen grid bias which would be somewhat difficult to do otherwise. For instance, if variable signal coupling were to be obtained by tapping leads 56 and 58 on resistors 30 and 32, the positions of low coupling would be the points of highest screen grid bias potentials for tubes V1 and V2, which is not a desirable adjustment. Again, for instance, if the adjacent ends of 52 and 54 were grounded directly or left ungrounded, the positions of low signal coupling would be the points of lowest screen grid bias, which is also undesirable. In other words the adjustment of potentiometer 60 fixes a lower limit on the positive bias potential for the screen grids of tubes V1 and V2 as the coupling is lowered. It may be stated here that adjusting the coupling between the tripping circuit B and the frequency modulator A results in adjusting the amount of transmitter signal frequency deviation.

The condenser 64 if added to the circuit B has the effect of slightly rounding off the corner on one end of each square wave signal character. A more satisfactory way of rounding off the corners of the square wave signal characters would be to connect a low pass filter in series with each of the leads 56 and 58. The reason for rounding off the corners of the signal characters is to limit or reduce the frequency band width caused by harmonics.

The audio frequency or telephone amplifier E is more or less conventional. However, the circuit here is designed to fit the requirements of the frequency modulator stage A. The resistors 70 and 72 are connected across the secondary windings of transformer T1 to match the transformer output impedance to the tube input impedance and to prevent parasitic oscillations. Resistor 74 supplies grid-to-cathode bias by the cathode-to-ground resistor method. It may be noted that T2 is a step-down transformer. In the system operated a plate to line transformer was used and the resistors R3 and R4 in stage A were each 250 ohms, R1 and R2 being 2500 ohms. This arrangement was necessary since these resistors are a part of the phase shifting circuits of the frequency modulator and because of the low operating frequency of the modulator which was about 100,000 cycles. At higher operating frequencies of the modulator stage A, such as 2,000,000 cycles per second, condensers could be used in place of R3 and R4 without appreciable audio signal distortion. It was noticed that short circuiting bypass condenser 78 in the secondary center tap connection of trans-

former T2, by closing switch 80, affected the bias of stage A a small amount. No detrimental effects were observed whether the switch 80 was open or closed. It should be noted that it is desirable to keep the value of resistors R3 and R4 low in comparison to that of R1 and R2 and to have the secondary impedance of transformer T2 match the resistance of R3 and R4.

Although I have shown the feed back voltages fed to the grids 8 and 16 in Figures 1 and 2 as being taken from points on the inductive branch of the tank circuit and in Figure 3 as being taken from the capacitive branch of the tank circuit it will be understood that in each case it may be taken from either the capacitive or inductive branch.

I claim:

1. In a wave length modulation system, an oscillation generator including a pair of electron discharge tubes each having an anode, a cathode and a control grid, a single tank circuit having inductance, couplings between spaced points on the inductance of said tank circuit and the anodes of the respective tubes, a coupling between a point on said tank circuit and the cathodes of the tubes, a phase retarding inductive reactance coupling the control grid of one of said tubes to a point on the said tank circuit, a phase advancing capacitive reactance coupling the control grid of the other of said tubes to a point on said inductance of said tank circuit, said couplings being such that oscillations are generated in said tubes and tank circuit, and means for controlling the gain of the tubes in push-pull relation in accordance with modulating potentials to thereby modulate the wave length of the oscillations generated.

2. In a wave length modulation system, an oscillation generator including a pair of electron discharge tubes each having an anode, a cathode and two grids, a single tank circuit, couplings between the spaced points on said tank circuit and the anodes of the respective tubes, a coupling between a point on said tank circuit and the cathodes of the tubes, phase shifting reactances cross coupling corresponding grids of said tubes to points on said tank circuit, said couplings providing regeneration in said tubes to generate oscillations which appear in said tank circuit two sources of modulating potentials, means for coupling one of said sources of modulating potentials to corresponding grids of said tubes, and separate means for coupling the other of said source of modulating potentials to the other corresponding grids of said tubes.

3. In a signalling system, an oscillation generator including a pair of electron discharge devices of the pentode type, a single tank circuit coupling the anodes of said devices in push-pull relation, phase shifting reactances cross coupling the control grids of said devices to said tank circuit in push-pull relation whereby oscillations are generated in said devices and circuit, and means for modulating the potential on the screen electrodes of said devices in push-pull relation to thereby modulate the wave length of the oscillations generated.

4. In a signalling system, an oscillation generator including a pair of electron discharge devices each having an anode, a cathode, and control grid, a single tank circuit coupling the anodes of said devices in push-pull relation, phase shifting reactances cross coupling the control grids of said devices to said tank circuit in push-pull relation, phase shifting impedances coupling

the control grids of said devices to the cathodes of said devices whereby oscillations are generated by said devices and tank circuit, and means for modulating the potential on the control grid electrodes of said devices in push-pull relation to thereby modulate the wave length of the oscillations generated.

5. In a signalling system, an oscillation generator including a pair of electron discharge devices each having an anode, a cathode, and a control grid, a single tank circuit connecting the anodes of said devices in push-pull relation, phase shifting reactances cross connecting the control grids of said devices to said tank circuit, and means for modulating the potentials on corresponding electrodes of said devices to thereby modulate the frequency of the oscillations generated including a pair of tubes having input and output electrodes, impedances coupling the output electrodes of said tubes to corresponding electrodes of said devices, a source of potential connected through keying means to the input electrodes of one of said tubes, a source of signals coupled to the input electrodes of the other of said tubes and impedances cross connecting the input and output electrodes of said pair of tubes.

6. In a system of the nature described, a source of varying potential, a pair of electron discharge systems including at least two electron receiving electrodes and two electron flow control electrodes, an impedance connected between the electron receiving electrodes, impedances cross connecting the electron flow control and electron receiving electrodes, connections for applying a steady bias to one of said electron flow control electrodes, other connections for applying

said varying potential to said other electron flow control electrode, and means for deriving potentials produced in said first named impedance.

7. In a wave length modulator circuit, a push-pull tube generator having a single tank circuit with the tube grids and anodes coupled in push-pull relation thereby, a phase advancing reactance in the coupling between said tank circuit and an electrode of one of said tubes, a phase retarding reactance in the coupling between said tank circuit and the corresponding electrode in the other of said tubes, and means for modulating the impedances of the tubes in push-pull relation in accordance with signals to thereby modulate the length of the oscillations generated while maintaining substantially constant the amplitude thereof.

8. In a wave length modulation system, an oscillation generator including a pair of electron discharge devices each having an anode, a cathode, and control grid, a single tank circuit coupling the anodes of said devices in push-pull relation, connections cross coupling the control grids of said devices to said circuit in push-pull relation, a phase advancing reactance in the coupling between an electrode in one device and said tank circuit, a phase retarding reactance in the coupling between the corresponding electrode in the other device and said tank circuit, said couplings being such that oscillations are generated in said devices and tank circuit, and means for modulating the potential on corresponding electrodes of said devices in push-pull relation to thereby modulate the frequency of the oscillations generated.

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