May 8, 1945. M. G. CROSBY 2,375,527

WAVE LENGTH MODULATOR

Filed Oct. 29, 1941

Fig. 1.

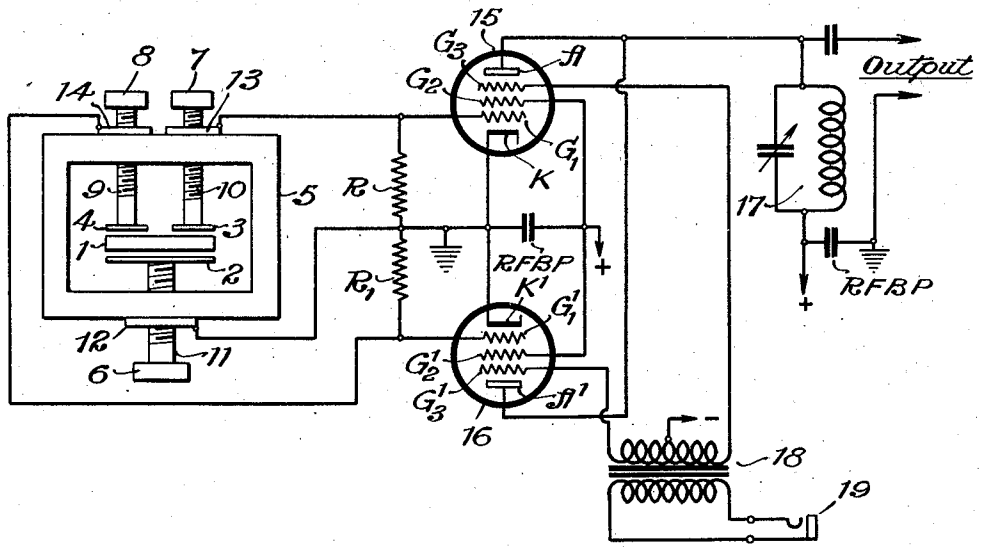
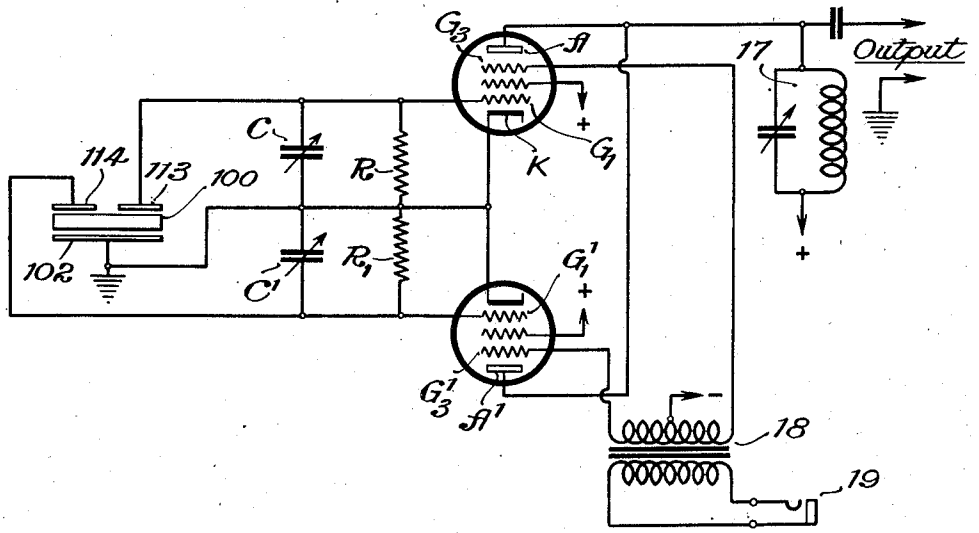


Fig. 2.



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WAVE LENGTH MODULATOR

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10 Claims. (Cl. 179—171.5)

This application concerns a new and improved wave length modulator of the locked oscillator type wherein two tube systems and their electrodes are connected in oscillation generating circuits such that each tube and its circuits considered separately and individually operates at a different distinct frequency, the circuits including common elements whereby the separate tube oscillators are entrained to operate at a single mean frequency intermediate the separate distinct frequencies. Oscillators of this type have frequency determining or controlling elements, and in my new and improved system a single crystal is arranged to control or determine the frequency of operation of the tube oscillators considered separately and as entrained. The tube systems are then differentially modulated to modulate their frequency of operation about said mean frequency and within said separate frequencies as limits.

In my improved system the single piezo-electric crystal is placed in a holder having three electrodes, one of which is common, so that the circuits of the two tube generators may be caused to operate at the distinct frequencies by adjusting the separate pairs of electrodes for different air gaps or by adjustment of external capacities associated with the crystals and their air gaps.

To my knowledge all prior system of this type use tuned circuits or transmission lines for control of the frequency of operation. In my system, as stated above, a single piezo-electric crystal is used for the frequency control element.

In describing my invention, reference will be made to the attached drawing wherein; Figure 1 illustrates schematically a wave length modulator of the entrained oscillator type arranged in accordance with my invention, while Figure 2 is a modification of the arrangement of Figure 1.

In the drawing, tubes 15 and 16 are the separate oscillation generating tubes which are locked in step. The anodes A and A' of these tubes are connected to a tuned circuit 17 common to the plate circuits of both tubes. The wave length modulation oscillations generated as described more in detail hereinafter may be supplied from tuned circuit 17 to amplifying, frequency multiplying, and transmitting means as desired. The grids G_1 and G_1' of the tubes are connected to the electrodes 3 and 4 of the holder for piezo-electric crystal 1. This holder is of a special type which allows different air gaps for the electrodes 3 and 4. The crystal holder includes an insulating member 5 in which are mounted screws 9, 10, and 11, upon which are mounted the electrodes 4, 3, and 2 respectively. The electrode 2 is common to both tube circuits and is connected by a conducting member 12 on the screw 11 to the cathodes K and K'. Crystal 1 is placed between the electrodes 2, 3, and 4, with electrode 2 being the common grounded electrode and electrodes 3 and 4 being the separate output electrodes. The connections between the grids G_1 and G_1' and electrodes 3 and 4, respectively, are made by way of metal collars 13 and 14 on the screws 10 and 9 respectively. The air gaps for electrodes 3 and 4 are adjusted if desired for different values by means of knobs 7 and 8. Knob 6 adjusts a lower electrode 2 so as to adjust both air gaps at once and thus vary the mean frequency of operation of the entrained generators.

The locked oscillator type of wave length modulator as stated above tends to operate at two different distinct frequencies so that two separate frequency determining circuits are required which if taken alone allow each separate oscillator to oscillate at different frequencies. In my arrangement, grid G_1 and anode A of tube 15 are connected by piezo-electric crystal 1 with contacts 2 and 3 in an oscillation generator of the type wherein the anode circuit 17 is tuned above the operating frequency and the feed back is between the anode A and grid G_1. This circuit may be considered one of the oscillator circuits. Tuned circuit 17, taken with grid G_1' and A' and piezo-electric crystal 1 and holders 2 and 4, may be considered the other oscillator. Since the crystal holder capacities are relatively detuned, the oscillators tend to operate at different frequencies. These two frequencies of operation are spaced just far enough apart so that when the two oscillators are coupled together they will lock in step and oscillate at one frequency. The common elements in the separate oscillator circuits entrain the two oscillators so that they operate at a common frequency.

The grids G_3 and G_3' are connected differentially to the secondary winding of a transformer 18, the primary winding of which is connected by jack 19 to a source of modulating potentials. Thus, by modulating the relative amplitude of oscillations of the two oscillation generators the oscillation frequency of the system shifts from the normal frequency of one oscillator to the normal frequency of the other oscillator.

In accordance with my invention, the frequency of one of the oscillators is tuned to be different from that of the other oscillator by making the air gaps produced by electrodes 3 and 4 different. It is known that the frequency of oscillation of a crystal is dependent upon the air gap between the

crystal and its electrodes. For instance, at present there is on the market a variable air gap crystal which will vary the frequency of oscillation of the crystal as much as 12 kilocycles at 3 megacycles.

As stated above, modulation is applied by means of transformer 18 connected in push-pull relation to the space grids G_3 and G_3' to modulate the tubes in push-pull relation so that when one tube is modulated upward the other tube is modulated downward to thereby modulate the frequency of operation of the system.

In Figure 2, I have shown a modification in which a three-electrode crystal holder is also used. Here, however, instead of varying the relative air gaps of the electrodes 113 and 102 and 114 and 102, I vary the capacity of two condensers C and C' in shunt respectively to the electrodes 113 and 102 and 114 and 102. These condensers C and C' are placed across the crystal outputs and are adjusted for the frequency at which the tube generators, when considered separately and individually, are to operate. In this modification the separate generators are, as before, entrained to operate at a common frequency. It is well known that the oscillating frequencies of a crystal may be varied by varying external capacities in this manner.

What is claimed is:

1. In a wave length modulation system, a pair of electron discharge tubes each having oscillation generating electrodes, a piezo-electric crystal having three electrodes, connections including two of said crystal electrodes coupling the oscillation generating electrodes of one of said tubes in a regenerative circuit including said crystal as a frequency determining element, connections including the remaining crystal electrode and one of said two crystal electrodes coupling the oscillation generating electrodes of the other of said tubes in a regenerative circuit including said crystal as a frequency determining element, means including at least a pair of said crystal electrodes for tuning said crystal to operate at one frequency in one regenerative circuit and to operate at a second frequency in the other regenerative circuit, means for differentially modulating said tubes in accordance with signals, and an output circuit coupled to said regenerative circuits.

2. In a wave length modulation system, a pair of electron discharge tubes having output electrodes coupled with a common output circuit, said tubes having input electrodes, a piezo-electric crystal having three electrodes and having means for adjusting the distance between at least two of said electrodes, connections including two of said crystal electrodes coupling the input and output electrodes of one of said tubes in a regenerative circuit including said crystal, connections including the remaining crystal electrode and one of said two of said crystal electrodes coupling the input and output electrodes of the other of said tubes in a regenerative circuit including said crystal, and connections for modulating the impedances of said tubes in phase displaced relation in accordance with signals.

3. In a wave length modulation system, a pair of electron discharge devices having output electrodes coupled with a common output circuit, said devices having input electrodes, a piezo-electric crystal in a holder having three electrodes and having means for adjusting the distance between at least two of said holder electrodes, connections coupling one of said holder electrodes to the cathodes of said devices, connections coupling another of said holder electrodes to an electrode of one of said devices, connections coupling the third of said holder electrodes to a corresponding electrode of the other of said devices, and circuit connections for modulating the impedances of said devices in phase displaced relation in accordance with signals.

4. In a wave length modulation system, a pair of electron discharge tubes each having oscillation generating electrodes, a piezo-electric crystal having a plurality of electrodes, connections including two of said crystal electrodes connecting the oscillation generating electrodes of one of said tubes in a regenerative circuit including said crystal as a frequency determining element, connections including the remaining crystal electrode and one of said two crystal electrodes connecting the oscillation generating electrodes of the other of said tubes in a regenerative circuit including said crystal as a frequency determining element, capacitive means for tuning said crystal to operate at one frequency in one regenerative circuit and to operate at a second frequency in the other regenerative circuit, means for differentially modulating said tubes in accordance with signals, and an output circuit coupled to said regenerative circuits.

5. In a wave length modulator, two electron discharge systems each having oscillation generating electrodes, a piezo-electric crystal having a plurality of electrodes, connections including two of said crystal electrodes connecting the oscillation generating electrodes of one of said systems in a regenerative circuit including said crystal as a frequency determining element, connections including two of said crystal electrodes connecting the oscillation generating electrodes of the other of said systems in a regenerative circuit including said crystal as a frequency determining element, there being reactance included between said crystal electrodes in said connections, means for varying the reactance between the two crystal electrodes in at least one of said regenerative circuits and connections for differentially modulating said systems in accordance with signals.

6. A modulator as recited in claim 5 wherein said reactance comprises the capacity between crystal electrodes and wherein adjustable mountings are provided for at least one of the crystal electrodes in said one of said regenerative circuits for varying said reactance.

7. A modulator as recited in claim 5 wherein said reactance between the two crystal electrodes in at least one of said generating circuits comprises a variable condenser.

8. In a wave length modulation system a pair of electron discharge tubes each having oscillation generating electrodes, a piezo-electric crystal in a three electrode crystal holder, connections including a pair of said crystal electrodes coupling the oscillation generating electrodes of one of said tubes in a regenerative circuit including said crystal, connections including one of said first pair of crystal electrodes and the remaining crystal electrode coupling the oscillation generating electrodes of the other tube in a regenerative circuit including said crystal, a tuning capacity shunting at least a pair of said crystal electrodes for tuning said crystal to operate at one frequency in one of said regenerative circuits and to operate at a different frequency in the other of said regenerative circuits, means in said circuits for entraining the same to operate at a third frequency, means for differentially modulating said tube impedances

in accordance with signals and an output circuit coupled to said regenerative circuits.

9. In a wave length modulation system a pair of electron discharge devices each having a control electrode and output electrodes including a cathode electrode, a piezo-electric crystal in a holder having three electrodes, a coupling between one of said crystal holder electrodes and the cathodes of said devices, a coupling between a second one of said crystal holder electrodes and the control electrode of one of said devices, a coupling between the third of said crystal holder electrodes and the control electrode of the other of said devices, a capacity shunting at least the crystal holder electrode coupled to the cathodes of said devices and another of said crystal electrodes for tuning said crystal to operate at one frequency in one of said couplings and to operate at a second frequency in the other of said couplings, said crystal and couplings being entrained to operate at a third frequency, an output circuit coupled to said devices and means for modulating the impedances of said devices in phase displaced relation in accordance with signals.

10. In a wave length modulation system a pair of electron discharge devices each having oscillation generating electrodes including a cathode, a control electrode and an additional electrode serving as an anode, a piezo-electric crystal having three electrodes, a coupling between one of said piezo-electric crystal electrodes and the cathodes of said devices, a coupling between a control electrode of the other of said devices and a second one of the crystal electrodes, a coupling between the control electrode of the other device and the third crystal electrode, a tuned output circuit coupled to electrodes of said devices, each of said devices being in a regenerative circuit including said crystal and operating to generate oscillations, a variable capacity for tuning the pair of crystal electrodes between the control electrode and cathode of one of said devices to be resonant at a first frequency, a variable capacity for tuning the crystal electrodes coupled to the control electrode and cathode of the other of said devices to be resonant at a second frequency, said devices and couplings and crystal being entrained to operate at a third frequency intermediate said first and second frequencies, and means for differentially modulating said devices in accordance with signals.

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