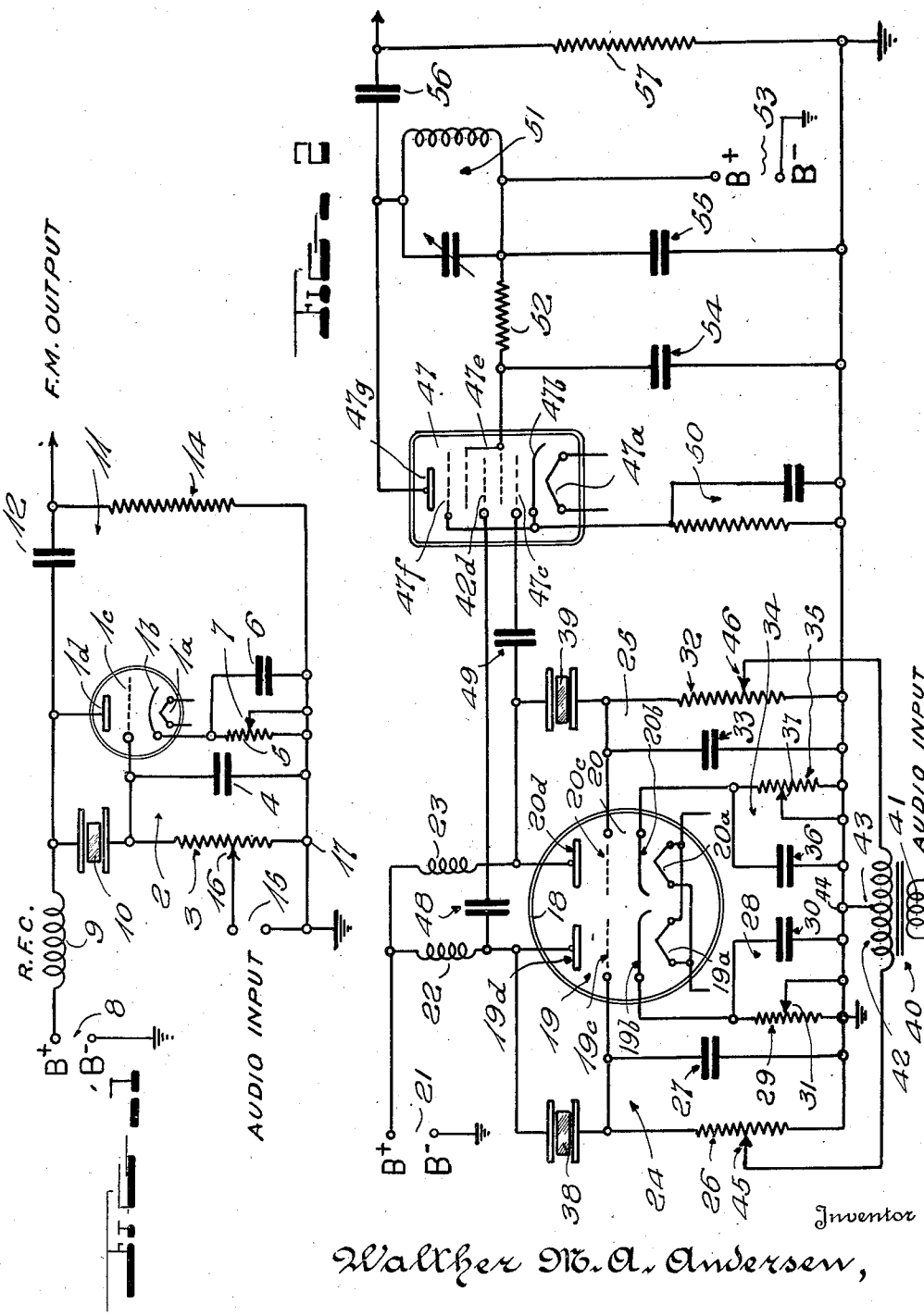
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CRYSTAL CONTROLLED FREQUENCY MODULATION SYSTEM

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CRYSTAL CONTROLLED FREQUENCY MODULATION SYSTEM

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My invention relates broadly to modulation systems, and more particularly to an improved circuit arrangement for a crystal controlled frequency modulation system.

One of the objects of my invention is to provide an improved circuit arrangement for a frequency modulation circuit which is extremely simple in construction and which has excellent fidelity of modulation.

Another object of my invention is to provide a construction of frequency modulation system in which a minimum number of tubes are utilized for producing frequency modulations under control of amplitude modulations.

Another object of my invention is to provide a circuit arrangement for modulating crystal controlled oscillator systems for developing oscillations which are impressed upon a mixer circuit for deriving a frequency modulated difference frequency with respect to the frequencies of the crystal controlled oscillator systems.

Still another object of my invention is to provide a circuit arrangment for amplitude modulating a twin three electrode electron tube for producing frequency modulations of extremely high fidelity.

Other and further objects of my invention reside in a circuit arrangement for a frequency modulation system as set forth more fully in the specification hereinafter following in which Fig. 1 schematically illustrates a circuit arrangement embodying the modulation system of my invention, and Fig. 2 shows an application of a modified form of the circuit arrangement embodying my invention.

My invention is directed to a circuit arrangement for obtaining frequency modulation with a simple piezo-electric crystal controlled circuit. The advantages of my circuit are its extreme simplicity and the excellent fidelity of modulation. I provide a piezoelectric crystal controlled circuit in which an audio modulating voltage of small magnitude is arranged to vary the bias potential applied to the crystal controlled circuit in such manner that frequency deviation of the crystal is controlled with corresponding high fidelity of modulation of the circuit. In one of the applications of the system of my invention two crystal controlled oscillator circuits of the type hereinbefore described are combined to produce wide band frequency modulation. Two piezoelectric crystals of different frequencies are modulated in opposite directions by the push-pull audio input circuit of an amplitude modulated

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system. The frequency deviation is doubled in the output of an associated mixer circuit. The adjustment of cathode bias potentiometers in the circuits of the two crystal controlled oscillators will determine the frequency deviation and the fidelity of modulation. Such modulation may vary with different tubes and piezoelectric crystals, and the circuits of my invention provide compensation for all such variations.

Referring to the drawings in detail reference character 1, Fig. 1, discloses a three electrode electron tube including a heater 1*a*, a cathode 1*b*, a control grid 1*c*, and an anode 1*d*. The grid 1*c* and cathode 1*b* are connected through a high impedance circuit designated as 2, as including a resistor 3 and shunt connected condenser 4. The resistor and condenser combination are connected into the cathode circuit through the bias resistor 5 shunted by condenser 6. The bias resistor 5 has an adjustable tap 7 movable thereover for rendering a selected portion thereof ineffective for controlling the bias potential supplied to the control grid 1*c*. Suitable means are provided for activating cathode 1*a*. The anode 1*d* is energized from a suitable potential source connected to terminals 8 through radio frequency choke coil 9. A piezoelectric crystal 10 is connected across control grid 1*c* and plate 1*d*. An output circuit 11 is connected between plate 1*d* and cathode 1*b*, comprising as shown, the capacity 12 and resistor 14. An audio frequency control circuit 15 is connected across a portion of the high impedance circuit, accomplished by providing an adjustable tap 16 on high resistance 3 and connecting the adjustable tap to one side of the audio frequency control circuit, where the other side of the audio frequency control circuit connects to the end of the resistance 3 as represented at 17.

Oscillations at the frequency of piezo-electric crystal 10 are sustained in the electron tube circuit including the high impedance path 2. These oscillations are modulated by the audio frequency variations impressed through circuit 15 across a portion of high impedance circuit 2 which varies the bias potential on control grid 1*c* and develops frequency modulations in the output circuit 11. Output circuit 11 connects to harmonic multipliers and power amplifiers of a frequency modulation system.

The effective energy developed by the piezoelectric crystal 10 deviates in frequency as the load varies in the high impedance circuit 2, thus the audio frequency variations impressed

through circuit 15 directly control the deviation in frequency of piezoelectric crystal 10 and develops frequency modulations in the output circuit 11.

In Fig. 2 I have shown a system in which a high degree of precision is obtained in wide band frequency modulation. In this arrangement I employ a twin three electrode electron tube represented at 18, containing two sets of electrodes indicated at 19 and 20. The set of electrodes 19 is constituted by heater 19*a*, cathode 19*b*, control grid 19*c*, and anode 19*d* arranged in the order shown. The set of electrodes 20 includes heater 20*a*, cathode 20*b*, control grid 20*c*, and anode 20*d*. Suitable means are provided for activating cathodes 19*a* and 20*a*. The anodes 19*d* and 20*d* are energized from a suitable potential source connected to terminals 21 through radio frequency choke coils 22 and 23 respectively.

The input circuits for each of the twin sets of electrodes are both of high impedance represented at 24 and 25. The input circuit 24 includes high resistance 26 shunted by condenser 27 and connected to the control grid 19*c* and cathode 19*b* through the bias control circuit 28. The bias control circuit 28 includes high resistance 29 shunted by condenser 30. The effective value of resistance 29 is controlled by movement of an adjustable tap 31 along resistance 29, thereby controlling the potential applied to control grid 19*c*.

The high impedance input circuit 25 consists of high resistance 32 shunted by condenser 33 and connected at one end to control grid 20*c* and at the other end to cathode 20*b* through the bias control circuit 34, which contains high resistance 35 shunted by condenser 36. An adjustable tap 37 on resistance 35 controls the effective value of resistance 35 for correspondingly controlling the bias potential on control grid 20*c*.

Two piezo-electric crystals 38 and 39 are employed in the oscillation system of my invention. Piezo-electric crystal 38 connects between control grid 19*c* and anode 19*d*. Piezo-electric crystal 39 connects between control grid 20*c* and anode 20*d*. These crystals are of different frequencies, displaced from each other in the frequency spectrum to provide for a beat frequency therebetween. The crystal frequencies are modulated in opposite directions by a push-pull audio frequency input. I have illustrated the modulation circuit as including an audio frequency input at transformer 40, having a primary winding 41 connected to the audio frequency modulation circuit, and a secondary winding 42 coupled thereto. The secondary winding 42 has a central tap 43 connected to an intermediate point 44 between the cathodes 19*b* and 20*b* through the bias control circuits thereof. The opposite ends of secondary winding 42 are connected to adjustable taps 45 and 46 which are adjustable along high resistances 26 and 32. Thus, a portion of the high resistances 26 and 32 in the high impedance circuits 24 and 25 are rendered ineffective by short circuit between the ends which connect with the intermediate point 44 between the cathode circuits and the positions of the adjustable taps 45 and 46.

Circuits 24 and 25 are aperiodic in character and oscillations are sustained through the electron discharge paths across the respective sets of electrodes 19 and 20, at frequencies corresponding to the frequencies of piezo-electric crystals 38 and 39. These oscillations are impressed upon a mixer circuit which consists of pentagrid

tube 47 having a heater 47*a*, a cathode 47*b*, a pair of control grids 47*c* and 47*d*, an output grid 47*e*, a space charge grid 47*f*, and a plate 47*g*. The anodes of the oscillator tube 18 at 19*d* and 20*d* are respectively connected to control grids 47*b* and 47*c* through coupling condensers 48 and 49. The cathode 47*b* is connected through bias control circuit 50 with the opposite end of the output circuit of the oscillator tube 18.

The mixer tube 47 has a tank circuit 51 connected across plate 47*g* and the output grid 47*e* thereof through impedance path 52 as shown. The tank circuit 51 is disposed in the output circuit of tube 47 in circuit with high potential source connected with terminals 53. The output grid 47*e* has condensers 54 and 55 connected in circuit therewith on opposite sides of high impedance 52 and leading to the cathode side of the mixer tube. An output circuit is connected to the circuit 51 as represented by condenser 56 and high impedance 57 from which connections lead to harmonic multipliers and power amplifiers of a frequency modulation system.

In the circuit of Fig. 2 audio frequency variations impressed upon the primary winding 41 change the effective bias potential on control grids 19*b* and 20*b*, thereby controlling the effective energy developed by the piezo-electric crystals 38 and 39 and the impression thereof upon the mixer circuit 47. The output frequencies will deviate as the sum of the deviation of the two crystal oscillators. The frequency deviation is double in the output circuit 56—57 of the mixer circuit of tube 47, the two frequencies from piezo crystals 38 and 39 producing a beat frequency in the electronic path in tube 47 deriving a stabilized frequency modulated signal in the output system 56—57.

I have found the circuits of my invention highly effective in operation and while I have disclosed my invention in certain preferred embodiments I realize that modifications may be made and I intend no limitations upon my invention other than may be imposed by the scope of the appended claims.

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

1. A frequency modulation system comprising a twin three electrode tube, including sets of cathode grid and plate elements, means for activating said cathodes, means for energizing said plates, a high impedance path connected between the grid and cathode of each of said sets of elements, a piezo-electric crystal connected between the grid and plate of each of said sets of elements, said piezo electric crystals being displaced in frequency for producing a beat frequency therebetween, a tap in each of the high impedance paths associated with said grid and cathode elements, an audio frequency control circuit connected between said taps and to a point intermediate said cathode elements and a mixer circuit comprising a pentagrid tube including a cathode, a pair of control grids, an output grid, an anode and a space charge grid, a tank circuit tuned to the difference frequency between the aforesaid piezo-electric crystals and connected between said output grid and said anode and connections between said plate elements of said twin three electrode tube and the respective control grids.

2. A frequency modulation system comprising a twin three electrode tube, including sets of cathode grid and plate elements, means for activating said cathodes, means for energizing said plates, a high impedance path connected between the

grid and cathode of each of said sets of elements, a piezo-electric crystal connected between the grid and plate of each of said sets of elements, said piezo electric crystals being displaced in frequency for producing a beat frequency therebetween, a tap in each of the high impedance paths associated with said grid and cathode elements, an audio frequency control circuit connected between said taps and to a point intermediate said cathode elements and a mixer circuit comprising a pentagrid tube including a cathode, a pair of control grids, an output grid, an anode and a space charge grid, a tank circuit tuned to the difference frequency between the aforesaid piezo-electric crystals and connected between said output grid and said anode connections between said plate elements of said twin three electrode tube and the respective control grids, and a condenser disposed in series with each of said last mentioned connections and operating as capacity coupling members.

3. A frequency modulation system comprising a twin three electrode tube including sets of cathode grid and plate elements, means for activating said cathodes, means for energizing said plates, a high impedance path connected between the grid and cathode of each of said sets of elements, a piezo-electric crystal connected between the grid and plate of each of said sets of elements, said piezo electric crystals being displaced in frequency for producing a beat frequency therebetween, an adjustable tap in each of the high impedance paths associated with said grid and cathode elements, an audio frequency control adjustable circuit connected between said taps and to a point intermediate said cathode elements, and a mixer circuit comprising a pentagrid tube including a cathode, a pair of control grids, an output grid, an anode and a space charge grid, a tank circuit tuned to the difference frequency between the aforesaid piezo-electric crystals and

connected between said output grid and said anode and connections between said plate elements of said twin three electrode tube and the respective control grids

4. A frequency modulation system comprising a twin three electrode tube including sets of cathode grid and plate elements, means for activating said cathodes, means for energizing said plates, a high impedance path connected between the grid and cathode of each of said sets of elements, a piezo-electric crystal connected between the grid and plate of each of said sets of elements, said piezo-electric crystals being displaced in frequency for producing a beat frequency therebetween, a tap in each of the high impedance paths associated with said grid and cathode elements, an audio frequency control circuit connected between said taps and to a point intermediate said cathode elements, adjustable means for controlling the bias potential on each of said grid elements and a mixer circuit comprising a pentagrid tube including a cathode, a pair of control grids, an output grid and an anode, a tank circuit connected between said output grid and said anode, connections between the plate elements of said twin three electrode tube and the respective control grids of said pentagrid tube and means in said tank circuit for adjustably tuning said tank circuit to the difference frequency between the frequency of each of said piezo-electric crystals.

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