March 19, 1935. W. A. MARRISON 1,994,658

SELECTIVE WAVE TRANSMISSION

Filed June 7, 1927

FIG. 1.

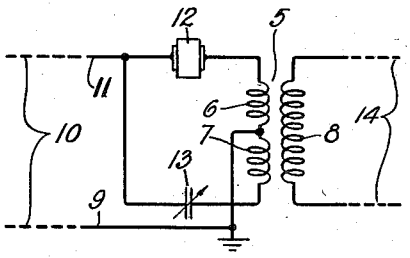


FIG. 2.

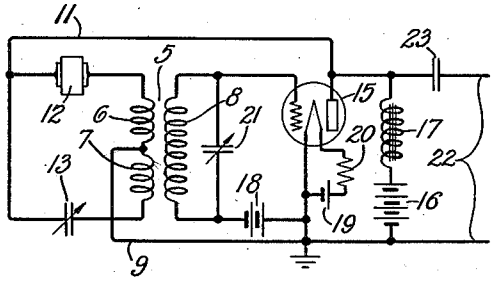


FIG. 3.

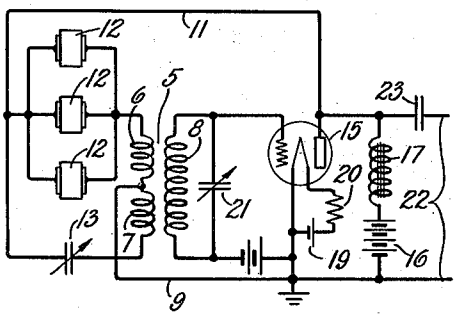


FIG. 4.

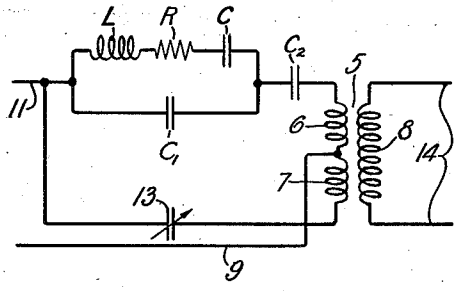
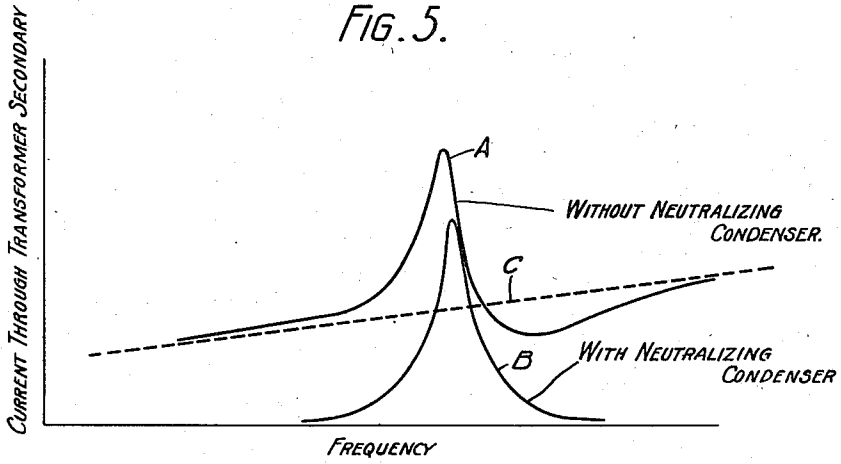


FIG. 5.



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SELECTIVE WAVE TRANSMISSION

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Application June 7, 1927, Serial No. 197,031

18 Claims. (Cl. 250—36)

This invention relates to selectivity of electric waves in electric circuits with mechanical elements therein and more particularly to means for utilizing the resonant vibration of piezo-electric crystals to control selectivity.

It has heretofore been known that an electric circuit may be made selective of a particular frequency by placing in the circuit a piezo-electric crystal, the natural frequency of which is that which it is desired to select. The present invention is based upon the discovery that such a crystal has what appears to be an inherent capacity and that the resonant characteristic may be improved by neutralizing the effect produced by the component of this capacity which corresponds to the static condition of the crystal. The specific embodiment of the invention herein chosen for purposes of illustration comprises, specifically stated, a main circuit having two branches, one branch containing the crystal and the other branch a variable condenser. An output circuit is coupled with the two branches through a transformer having a divided primary, each of said branches containing a portion of the primary. The effect of the static capacitance of the crystal is thus neutralized with respect to the output circuit by the effect of the variable condenser. Due to the divided input circuit no current is present in the secondary winding of the transformer corresponding to the quiescent electrostatic capacitance of the crystal. The selectivity of such arrangement is dependent solely upon the mechanical vibration of the crystal. The vibration may occur in a plurality of modes, or a plurality of crystals having different frequencies of vibration may be used and thus make possible transmission of current of a plurality of frequencies.

A modified form of the invention is a vacuum tube oscillator in which a selective circuit of the type just described is used in the oscillation producing feed back circuit. A variable condenser connected in parallel with the secondary of the transformer in the input circuit of the vacuum tube may be used to determine which crystal vibration frequency shall produce oscillation.

Obviously, the invention may be embodied in other specific forms.

A more detailed description of the invention follows and is illustrated in the accompanying drawing.

Fig. 1 is a transmission circuit embodying the invention.

Fig. 2 is a vacuum tube oscillator embodying the invention.

Fig. 3 is a modified form of oscillator.

Fig. 4 is an equivalent electrical circuit corresponding to Fig. 1.

Fig. 5 shows curves explanatory of the invention.

The same reference characters are used for identical elements in the several figures.

The transmission circuit of Fig. 1 comprises a transformer 5 having a divided primary winding 6, 7 and a secondary winding 8. One conductor 9 of a transmission circuit 10 is connected to the junction point of the windings 6 and 7. The other conductor 11 is connected to the other terminal of winding 6 through a piezo-electric crystal 12 and to the other terminal of winding 7 through a variable condenser 13, which is non-polarized, that is, having no direct current potential applied thereto. The secondary winding 8 of transformer 5 is connected to transmission circuit 14.

The piezo-electric crystal 12 is of well known type and for a more detailed description reference is made to the copending application of W. A. Marrison, Serial No. 730,165, filed August 5, 1924.

With respect to the terminals of transformer 5 connected to the crystal 12 and the condenser 13, the windings 6 and 7 are in series aiding relationship. It therefore follows that windings 6 and 7 are in parallel opposing relationship viewed from the transmission conductor 9 and the other two terminals. The condenser 13 is adjusted to have a capacitance equal to that of the crystal 12 when quiescent, that is, when the crystal is not in a state of mechanical vibration. Under this condition and since the windings 6 and 7 are equal, current in conductors 9 and 11 will not cause any current in transmission circuit 14 corresponding to the quiescent electrostatic capacity of the crystal. The flux in the transformer core produced by the component of current traversing the crystal 12 and the winding 6 due to the quiescent capacitance of the crystal 12 will be neutralized by the current flowing through the condenser 13 and the winding 7.

The arrangement of Fig. 1 is in fact a balanced bridge arrangement in which the crystal 12 forms one arm and the condenser 13 another, the transmission line 10 being conjugate to the transmission line 14. The circuit extending from transmission line 10 to transmission line 14 is therefore highly selective and the frequency components of the current transmissible therethrough is dependent solely upon the mechanical vibration of the crystal 12.

In Fig. 2, the highly selective circuit of Fig. 1

forms an element in the oscillation producing feed back circuit of a vacuum tube oscillator. Vacuum tube 15, which is supplied with space current from battery 16 through a choke coil 17 has its anode or plate connected through conductor 11 to the piezo-electric crystal 12 and the condenser 13. A cathode or filament is connected by conductor 9 to the junction between windings 6 and 7. The secondary winding 8 of transformer 5 is connected to the input circuit of the vacuum tube 15, one terminal being connected to the impedance controlling element or grid and the other terminal to the cathode through a grid polarizing battery 18. The filament is heated by battery 19 in circuit with a resistance 20. A variable condenser 21 is connected across the secondary winding 8 for determining which frequency of vibration of the crystal 12 is to control the generated oscillations. A work circuit 22 for the oscillation generator may be connected to the cathode and plate of vacuum tube 15 through stopping condenser 23.

In Fig. 3 an oscillation generator similar in many respects to that of Fig. 2 is provided with a plurality of piezo-electric crystals 12. The condenser 13 is adjusted to have a capacitance equal to that of the plurality of crystals when all of the crystals are quiescent. If the several crystals have different frequencies of vibration, it follows that the generation of waves of a larger number of different frequencies is possible.

The operation of oscillation generators which rely upon the feed back of energy from the output circuit of a three-electrode vacuum tube amplifier to the input circuit is well known and it is, therefore, unnecessary to give a further detailed description of the operation.

In accordance with this invention an oscillator like that of Fig. 3 was constructed, the following values for the several circuit elements being used. Two crystals having frequencies in the neighborhood of 50 kilocycles were used instead of three. The winding 8 was a two-layer 200 turn (bank wound) coil on a 4.5'' tube. The halves of a 100 turn coil on a 3'' tube with center tap constituted the windings 6 and 7. Condenser 13 was a variable condenser having a maximum capacity of the order of 100 microfarads. Condenser 21 was variable having a maximum capacity of 0.004 of a microfarad. A commercial vacuum tube operable with a plate voltage of from 130 to 300 volts was used.

In Fig. 4 an electrical network equivalent to the circuit of Fig. 1 is shown as an aid in understanding the operation of the actual circuit. The operation of the actual circuit, however, is not dependent upon the correctness of this theoretical explanation. In the circuit of Fig. 4 the equivalent electrical circuit of the crystal 12 consists of an inductance L, a resistance R and a capacity C in series, shunted by a condenser C_1, this parallel circuit being connected in series with a capacity C_2. The equivalency of such a circuit is fully discussed by Mr. D. W. Dye in a paper entitled "The piezo-electric quartz resonator and its equivalent electrical circuit", published by the Proceedings of the Physical Society of London, Vol. XXXVIII, page 399. The capacity C_1 represents the quiescent electrostatic capacity of the crystal. The capacity C_2 represents the capacity of the air gaps between the electrodes and the crystal. The condenser 13 is adjusted to have a capacitance equal to that of the condensers C_1 and C_2 in series. In this arrangement it is seen that the flux in the core of transformer 5, due to the current flowing through the capacities C_1 and C_2 in series and the primary winding 6, is neutralized by the flux produced by the current flowing through the condenser 13 to the primary winding 7.

Referring now to Fig. 5 it is evident that the current flowing in the secondary winding 8 for a given voltage impressed upon the system by way of conductors 9 and 11 will be different with than without the condenser 13. Curve A of Fig. 5 shows about how the current in the secondary 8 of transformer 5 varies with the frequency of the current flowing in conductors 9 and 11 if condenser 13 is omitted. Curve B shows the current in the secondary 8 when the condenser 13 is adjusted to neutralize the effect of the condensers C_1 and C_2. The dotted curve C shows the absolute value of the current in the secondary 8, if the crystal network is omitted. Curve B may be obtained from curve A by subtracting curve C from curve A vectorially, taking account of the phase variation as resonance is passed through. It is seen that the selective quality of this circuit is very much increased by the addition of condenser 13, the circuit acting as though a very slightly damped series resonant circuit were connected in series with the primary of the transformer.

What is claimed is:

1. A selective circuit, a piezo electric device therein, a translating device upon which energy selected by said circuit is impressed, and means including a non-polarized variable condenser for neutralizing the effect of the static capacitance of said piezo electric device upon said translating device.

2. A selective circuit, a piezo electric device therein, a translating device upon which energy selected by said circuit is impressed, and means including a non-polarized condenser for neutralizing the effect of the static capacitance of said piezo electric device upon said translating device.

3. A selective circuit, a piezo electric device therein, a translating device upon which energy selected by said circuit is impressed, and means including a non-polarized variable condenser connected in parallel relation to said piezo electric device with respect to said circuit for neutralizing the effect of the static capacitance of said piezo electric device upon said translating device.

4. In a transmission system, a balanced bridge arrangement, a piezo electric device connected in one arm of said bridge, and a non-polarized variable condenser connected in another arm of said bridge.

5. In a transmission system, a balanced bridge arrangement having conjugate bridge circuits, a piezo electric device connected in one arm of said bridge, a non-polarized variable condenser connected in another arm of said bridge, an input circuit adapted to impress alternating current energy upon one of said conjugate bridge circuits, and a load circuit connected to the other of said conjugate bridge circuits.

6. In a wave transmission system, a transformer having two primary windings connected in series aiding relationship and a secondary winding, an input circuit having one terminal connected to the junction between said primary windings and the other terminal connected through a piezo electric device to the other terminal of one primary winding and through a condenser to the other terminal of the other

primary winding, and an output circuit connected to said secondary winding.

7. In a wave transmission system, a transformer having two primary windings and a secondary winding, an input circuit connected to said primary windings in parallel opposing relationship, a piezo electric resonator connected in series with one of said windings, a condenser having a capacitance equal to the inter-electrode capacitance of the resonator when quiescent connected in series with the other of said windings, and an output circuit connected to said secondary winding.

8. An oscillation generator comprising a space discharge device having an output and an input circuit, a piezo electric crystal, means to feed back energy from said output to said input circuit through said crystal, and means independent of the discharge device to prevent the feeding back of the portion of such energy which is due to the static capacitance of said crystal.

9. In an oscillation generator, a three-electrode space discharge amplifier having an output and an input circuit, a plurality of piezo electric crystals, means to feed back energy from said output to said input circuit through said plurality of piezo electric crystals, and means to prevent the feeding back of the portion of such energy which is due to the static capacitance of said crystals.

10. In an oscillation generator, a three-electrode space discharge amplifier having an output and an input circuit, a transformer having two primary windings and a secondary winding, means to connect said primary windings in parallel opposing relationship to the output circuit of said amplifier, a piezo electric resonator connected in series with one of said windings, a condenser having a capacitance equal to the inter-electrode capacitance of said resonator when quiescent, connected in series with the other of said windings, and means to connect said secondary winding to the input circuit of said amplifier.

11. In an oscillation generator, a three-electrode space discharge amplifier having an output and an input circuit, a transformer having two primary windings and a secondary winding, means to connect said primary windings in parallel opposing relationship to the output circuit of said amplifier, a plurality of piezo electric resonators connected in series with one of said windings, a condenser having a capacitance equal to the interelectrode capacitance of said resonators when quiescent, connected in series with the other of said windings, and means to connect said secondary winding to the input circuit of said amplifier.

12. An oscillation generator comprising a space discharge device having an output and an input circuit, a piezo electric crystal, means to feed back energy from said output to said input circuit through said crystal, means independent of the discharge device to prevent the feeding back of the portion of such energy which is due to the static capacitance of said crystal, and means to determine the mode of vibration of the crystal controlling the frequency of the generated waves.

13. In an oscillation generator, a space discharge amplifier having an output and an input circuit, a plurality of piezo electric crystals, means to feed back energy from said output to said input circuit through said plurality of piezo electric crystals, means to prevent the feeding back of the portion of such energy which is due to the static capacitance of said crystals, and means to determine the one of said plurality of crystals controlling the frequency of the generated waves.

14. An electrical filter for discriminating between a plurality of different frequencies comprising in combination one or more piezo-electric crystals connected between and serving to couple an input circuit and an output circuit, and means comprising a variable condenser for neutralizing the effective capacity of the piezo-electric crystal or crystals.

15. In electrical apparatus, a reactance, a piezo-electric crystal in series with one portion of the reactance, and, another reactance connecting the crystal in series with all of said first mentioned reactance.

16. In an electrical apparatus, a bridge circuit having a reactance in each of three arms of the bridge, and, a plurality of piezo-electric crystals and associated electrodes therefor in the fourth arm of the bridge, and, input and output circuits across opposite corners of the bridge.

17. A frequency selective network comprising a plurality of piezo-electric crystals electrically connected in parallel and having different resonance frequencies, and means for neutralizing the inter-electrode capacity of the crystals.

18. In combination, a wave receiving circuit, a loop circuit connected serially in said receiving circuit and therefore in such manner that the wave in said receiving circuit flows through the loop in two parallel branches, a piezoelectric device in one branch of the loop and an impedance means in the other branch of the loop, the electrical characteristics of said impedance means relatively to the static characteristics of said piezoelectric device being such that the respective portions of the received wave flowing in said branches of the loop tend to mutually oppose each other in the circulatory path constituted by the loop.

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