

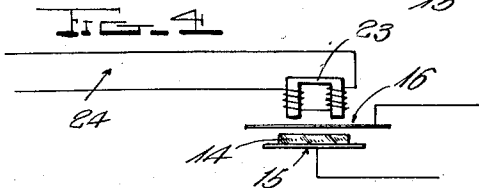
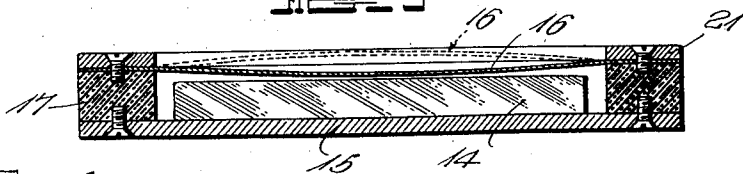
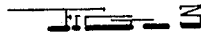
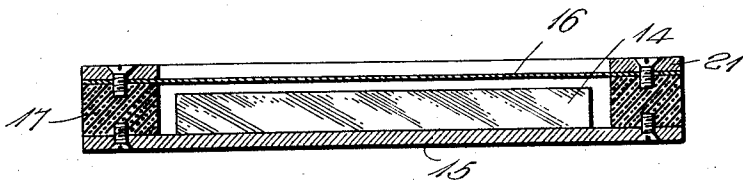
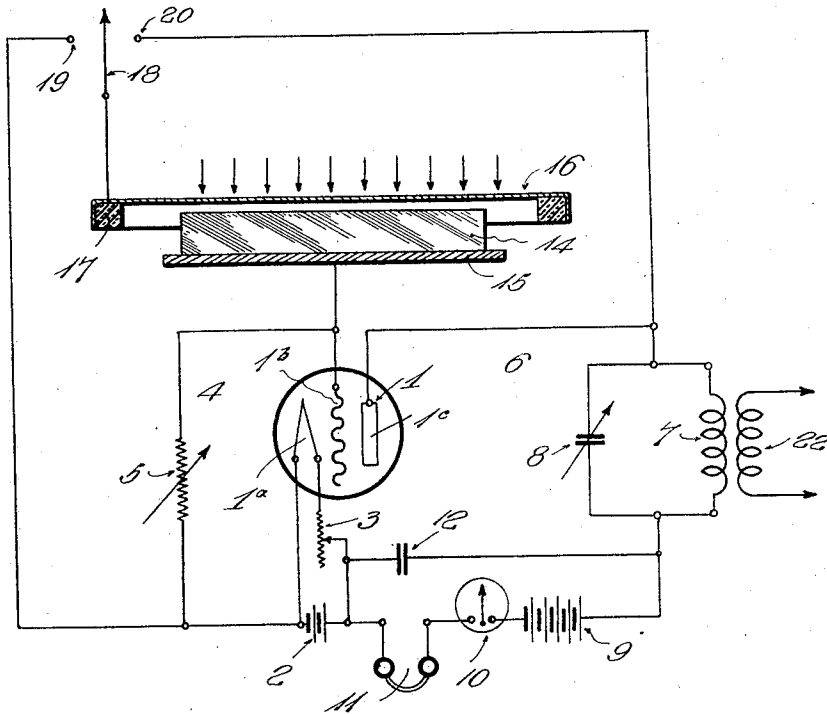
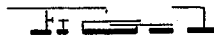
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MODULATION SYSTEM

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MODULATION SYSTEM

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36 Claims. (Cl. 179—171)

My invention relates broadly to a system for generating and modulating high frequency oscillations and more particularly to a piezo electric crystal system for controlling the operation of an electron tube system in an oscillatory state.

One of the objects of my invention is to provide a piezo electric crystal system by means of which the carrier frequency as well as the modulation frequencies may be initiated in the same electron tube circuit system.

Another object of my invention is to provide a piezo electric crystal apparatus arranged for connection in an electron tube circuit for sustaining oscillations in the electron tube circuit in accordance with the characteristic frequency of the piezo electric crystal element with means for varying the electrical capacity in shunt with the piezo electric crystal device for modulating the oscillations sustained thereby.

Still another object of my invention is to provide a circuit arrangement for a piezo electric crystal device in an electron tube system whereby oscillations generated by the piezo electric crystal device may be sustained by the electron tube system and such oscillations modulated by a change in capacity across the piezo electric crystal device.

Yet another object of my invention is to provide a piezo electric crystal device for sustaining high frequency oscillations in an electron tube circuit where the piezo electric crystal element is mounted in capacity relationship with a movable electrode the position of which may be changed in accordance with sound vibrations for displacement as a reflecting surface with respect to the upper face of the piezo electric crystal element for effecting modulation of the high frequency oscillations sustained by the piezo electric crystal element.

A further object of my invention is to provide a piezo electric crystal device for modulating the oscillations sustained by the piezo electric crystal device by both a frequency change and an amplitude change in the resultant signaling energy.

A still further object of my invention is to provide a mounting for a piezo electric crystal element in association with a pair of conductive plate elements where one of the plates is arranged to be bodily moved with respect to one face of the piezo electric crystal element in accordance with voice vibrations for effecting a corresponding change in the electrical capacity between the face of the piezo electric crystal element and the movable conductive plate, whereby

electrical oscillations may be varied both as to frequency and amplitude for controlling a signaling system.

My invention will be more clearly understood from the specification hereinafter following by reference to the accompanying drawing in which:

Figure 1 is a diagrammatic view illustrating the principle of my invention; Fig. 2 is a cross-sectional view showing one form of piezo electric crystal apparatus employed in the circuit system of my invention; Fig. 3 is a view illustrating the displacement of the upper electrode of the piezo electric crystal apparatus in accordance with sound vibrations; and Fig. 4 shows a system of distant control embodying the principles of my invention.

My invention contemplates the generation of high frequency oscillations in an electron tube system by virtue of the natural ability of quartz plates to generate high frequency oscillations and my invention resides in the modulation of the oscillations thus sustained both as to frequency and amplitude whereby high power signaling apparatus may be controlled. I provide an electron tube system arranged to sustain the high frequency oscillations generated by a selected piezo electric crystal element. The piezo electric crystal element is connected in the electron tube circuit with a capacity relationship existing between one face of the piezo electric crystal element and one of the electrodes by which the element is included in the electron tube circuit. This electrode is in the form of a flexible metallic plate which may be moved by sound vibrations striking the plate or displacing the plate with respect to one face of the piezo electric crystal element for effecting a physical change in the reflecting surface above the piezo electric crystal element as well as a change in electrical capacity across the piezo electric crystal apparatus. Sound waves which are directed against the flexible plate by speaking against the plate serve to displace the position of the flexible metallic conductor with respect to the face of the piezo electric crystal element, as a result of which the high frequency oscillations which are normally sustained by the piezo electric crystal element are modulated both with respect to frequency and amplitude. It therefore becomes unnecessary for several independent electrical circuits to be employed, one for the generation of high frequency oscillations and the other for the modulation thereof, as in my arrangement I provide means for effecting these several operations in the same circuit, and by

reason of the characteristic frequency of the piezo electric crystal element the carrier frequency which is finally impressed upon the signaling circuit is maintained at a constant value.

Referring to the drawing in more detail, reference character 1 designates an electron tube having cathode 1a, grid electrode 1b and plate electrode 1c. Cathode 1a is heated from battery 2 under control of adjustable rheostat 3. The input circuit of the electron tube 1 is represented at 4 across which the adjustable grid leak 5 is positioned. The output circuit is represented at 6 including the inductance 7, shunted by variable condenser 8, high potential battery 9, indicating meter 10 and head set 11. A radio frequency bypass condenser 12 is connected across elements 9, 10 and 11 for providing a path for the high frequency oscillations sustained by the piezo electric crystal element 14. The element 14 rests upon the conductive plate 15 and directly over the upper face of the piezo electric crystal 14 I arrange the flexible conductive plate 16 suitably supported by an insulated ring member 17.

The upper metallic plate 16 is connected through switch member 18 in such manner that the piezo electric crystal element 14 may be included across the grid and filament electrodes when switch 18 is moved to contact 19 or across the grid and plate electrodes when switch 18 is moved to contact 20. In Figs. 2 and 3 I have shown the flexible metallic plate 16 secured in position by means of a ring member 21 which grips the outer periphery edge of the flexible metallic plate 16 although allowing movement of the metallic plate.

The piezo electric crystal apparatus is so arranged in circuit with the electron tube system that the carrier frequency as well as the modulation frequency are impressed directly on a piezo electric crystal element. The electric field which is due to the electric vibrations of the piezo electric crystal plate is actually distorted in the modulation of the electron tube circuit by the movement of the upper electrode under the action of sound waves.

It will thus be seen that the apparatus of my invention may be caused to function as a combined microphone and oscillator wherein the piezo electric crystal controls the frequencies at which electrical oscillations are generated and the spaced electrode, when responding to sound vibrations, functions in combination with the crystal to modulate the carrier frequency of the oscillator.

The separation between the upper electrode and the upper face of the piezo electric crystal element is minute, that is, for example, one third of one millimeter and as this distance varies under the influence of sound waves the capacity with respect to the piezo electric crystal element as well as the reflecting surface with respect to the upper face of the piezo electric crystal element is changed. By reason of this operation the resultant modulation is due partially to an amplitude variation. That is the modulation produces the usual side band frequencies. Where the carrier frequency may be 100 kilocycles and the side band frequencies by virtue of the modulation 100 plus 1 kilocycle or 100 minus 1 kilocycle the piezo electric crystal oscillating system functions to control the output of a signal transmission system at relatively high power. It will be understood that I do not depend upon the characteristic of the electron tube circuit for generating the high frequency

oscillations but that the piezo electric crystal element is utilized to sustain the high frequency oscillations in the tube system.

Where it is desired to control the piezo electric modulator of my invention from a distance such as by a line wire system leading from a control microphone, I provide an arrangement as illustrated in Fig. 4 wherein the upper metallic plate 16 is in the form of a magnetic diaphragm actuated by the electromagnetic system 23 controlled by the line wire system 24 from any desired point. In this manner a broadcasting station may be equipped with the system of my invention and controlled from any point by suitable arrangement of the pick-up circuit.

Various modifications of the electron tube circuit may be made, and 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. An electron tube system including an electron tube having grid filament and plate electrodes, a piezo electric crystal element, electrical connections between said piezo electric crystal element and the electrodes of said electron tube, one of said connections including a flexible metallic plate member spacially related to said piezo electric crystal element and arranged to be varied in its physical position with respect to said piezo electric crystal element in accordance with sound vibrations while maintaining a spaced relation with respect to the surface of said piezo electric crystal element.

2. A combined generator and modulator of high frequency oscillations comprising an electron tube having grid filament and plate electrodes, input and output circuits interconnecting said electrodes, a piezo electric crystal element, a pair of metallic conductive plates, one of said plates being arranged in electrical contact with one face of said piezo electric crystal element and the other of said plates being variable in position in accordance with sound vibrations for effecting a change in capacity across said piezo electric crystal element whereby said piezo electric crystal element operates to sustain high frequency oscillations in said circuits, said oscillations being modulated in accordance with the movement of said second mentioned metallic conductive plate.

3. A control circuit for a signal transmission system comprising in combination an electron tube having grid filament and plate electrodes, input and output circuits interconnecting said electrodes, a piezo electric crystal element connected with said circuits for sustaining high frequency oscillations therein of the frequency of said piezo electric crystal element, a pair of metallic plate members for completing connection between said circuits and said piezo electric crystal element, one of said plate members being spacially related to said piezo electric crystal element and arranged to be physically moved in accordance with sound vibrations for varying the electrical capacity across said piezo electric crystal element and changing the position of the reflecting surface with respect to said piezo electric crystal element for modulating the high frequency current generated in said circuits while maintaining a predetermined minimum spacial relation with respect to the surface of said piezo electric crystal element.

4. In a control circuit for a signal transmission system the combination of an electron tube

having grid filament and plate electrodes, input and output circuits interconnecting said electrodes, a piezo electric crystal element, a conductive plate for supporting said element and establishing connection with said input circuit, a separate conductive plate flexibly suspended over said piezo electric crystal element in spaced relation thereto and electrically connected with another portion of said circuits, said second mentioned plate being arranged to bodily move with respect to the upper surface of said piezo electric crystal element for modulating the high frequency currents sustained in said circuit by said piezo electric crystal element while maintaining a predetermined minimum displacement with respect to the surface of said piezo electric crystal element.

5. A piezo electric crystal apparatus comprising in combination a metallic supporting plate, a piezo electric crystal element having one face thereof contacted with said supporting plate, an insulated housing surrounding said piezo electric crystal element and a flexible metallic cover secured to said housing and spaced from the upper face of said piezo electric crystal element in position where sound vibrations directed against said flexible metallic cover operate to vary the spacial relation between said cover and said piezo electric crystal element.

6. In a radio transmitting system, an oscillation generator comprising a thermionic tube, means, comprising a piezo-electric crystal, for determining the oscillation frequency, and means capable of being actuated by signal impulses for varying the frequency at which the crystal tends to oscillate.

7. A modulating system comprising an oscillator, and piezo-electric means for varying and controlling the frequency of the oscillator in accordance with modulating energy.

8. The method of frequency modulation in the oscillator controlled by a piezo-electric crystal vibrating between end plates; which consists in varying the distance between the piezo-electric crystal and its end plates in accordance with modulating energy, and simultaneously varying the frequency of the oscillator in accordance with variations in the distance between said end plates.

9. The method of varying the frequency of an oscillator in accordance with speech by means of a device of piezo-electric character freely vibrating between two terminals, which consists in varying the distance between the piezo-electric device and its terminals in accordance with speech, and simultaneously varying the frequency of the oscillator in accordance with the variations in the distance between the piezo-electric device and its terminals.

10. The method of varying the frequency of an oscillator in accordance with signals of varying amplitude by means of a device of piezo electric character which freely vibrates between two terminals, one of said terminals being fixed to one face of the piezo-electric device and the other terminal being movable with respect thereto, which consists in varying the distance between the movable terminal and the piezo-electric crystal in accordance with the amplitude variations of the signals, and simultaneously varying the frequency of the oscillator in accordance with the variations in said distance.

11. In a transmitting system, a piezo-electric-crystal controlled oscillation generator, and signal-responsive means inherently periodic in ac-

tion for altering the frequency of the oscillations generated.

12. In combination, a thermionic device arranged to generate oscillations, a piezo-electric crystal arranged to control the frequency of the oscillations generated, and means for causing the effective frequency of the crystal to vary in response to sound-frequencies.

13. In combination, a thermionic device arranged to generate oscillations, a movable diaphragm connected to an element thereof, an electrode connected to another element thereof, a piezo-electric crystal supported between said diaphragm and said electrode, and electromagnetic means for actuating said diaphragm.

14. An oscillation-controlling device comprising an electrode, a vibratory diaphragm constituting a second electrode, a piezo-electric crystal interposed between said electrodes, and electromagnetic means for actuating said diaphragm.

15. In a vacuum tube oscillator, the frequency of which is controlled by a piezo-electric device vibrating between two plates, the method of modulation which consists in varying the distance between the piezo-electric device and its plates in accordance with signals, and simultaneously varying the frequency of the oscillator in accordance with the varying distance between the piezo-electric device and its plates.

16. A system of modulation comprising an oscillator, a piezo-electric crystal vibrating between end plates for controlling the frequency of the oscillator, a source of modulating energy, means of varying the distance between the piezo-electric crystal and its end plates, and means for simultaneously varying the frequency of the oscillator in accordance with the variations in the distance between the piezo-electric crystal and its end plates.

17. In a transmitting system, a piezo-electric crystal controlled oscillation generator and means whereby the oscillation-frequency determining action of the crystal may be varied by signal-responsive means inherently periodic in action.

18. In a transmitting system, a piezo-electric crystal controlled oscillation generator, and sound-responsive means for causing the effective oscillation frequency of the crystal to vary periodically, whereby the frequency of the oscillations generated varies with the signal.

19. In combination, a thermionic device arranged to generate oscillations, a piezo-electric crystal associated with said thermionic device to control the frequency of the oscillations generated and means for causing the effective frequency of said crystal to change proportionately to sound frequencies.

20. In combination, a thermionic device arranged to generate oscillations, a piezo-electric crystal associated with a plurality of electrodes connected to said thermionic device, and signal-responsive means inherently periodic in action for altering the relation of one of said electrodes to said crystal.

21. In combination, a thermionic device arranged to generate oscillations, a piezo-electric crystal associated with a plurality of electrodes connected to said device and means responsive to sound frequencies for changing the space relation between one of said electrodes and the crystal whereby the frequency of the oscillations generated varies with said signal frequency.

22. In combination, a thermionic device having input and output circuits, a piezo-electric crystal

associated with a plurality of electrodes connected to said input circuit, and means responsive to sound frequencies for altering the frequency at which the crystal oscillates.

- 5 23. In combination, a thermionic device arranged to generate oscillations, a movable diaphragm connected to an element thereof, an adjustable electrode connected to another element thereof, a piezo-electric crystal supported by said
10 movable electrode adjacent said diaphragm and electro-magnetic means for vibrating said diaphragm in response to signal frequencies.

24. An electric discharge oscillator including a piezo electric device to determine the normal frequency of the oscillations produced by said oscillator and signaling means associated with said device to cause the oscillator at signaling instants to deliver output oscillations of other than said normal frequency.

- 20 25. In a piezo-electric-crystal-controlled oscillation generator, mechanical means for varying the frequency at which the crystal tends to oscillate.

26. In a radio transmitting system, an oscillation generator comprising a thermionic tube and associated circuits, means comprising a piezo-electric crystal for determining the oscillation frequency, and a movable element for varying the frequency at which the crystal oscillates.

- 30 27. In a radio transmitting system, an oscillation generator comprising a thermionic tube, an input circuit for said tube comprising means having a definite mechanical oscillation frequency, and means for varying the oscillation frequency in response to signal impulses.

- 35 28. In a piezo electric crystal controlled oscillation generator, electrodes for the crystal element thereof, and means to which one of said electrodes impulsively reacts for varying the frequency at which the crystal tends to oscillate.

- 40 29. In a radio transmitting system, a piezo electric crystal, an oscillator controlled thereby and frequency modulating means for said crystal comprising a spaced electrode responsive to modulating impulses.

- 45 30. In a device of the class described, a piezo electric crystal, a support therefor, a movable

element associated therewith, the movable element and the support constituting the plates of a condenser the dielectric of which includes the crystal, an oscillator the frequency of which is controlled by said crystal and means responsive to signals for varying the thickness of said dielectric, whereby the frequency of said oscillator is modulated.

31. In a radio transmitting system, an oscillation generator comprising a piezo electric crystal for determining the oscillation frequency, and a pair of electrodes for said crystal at least one of which is responsive to the effects of modulating energy for varying the frequency at which the crystal tends to oscillate.

32. In a device of the class described, an electron tube oscillator, means including a piezo electric crystal for fixing the carrier frequency of said oscillator and means including the same piezo electric crystal for modulating the frequency initiated in said electron tube oscillator.

33. A device in accordance with claim 32 having means including a tuning condenser in the output circuit of said oscillator for sharply tuning the electrical output thereof.

34. A device in accordance with claim 32 in which the means for modulating the frequency initiated in the electron tube oscillator includes a source of voice modulated signals.

35. In a high frequency modulating system, a piezo-electric-crystal-controlled oscillation generator, signal responsive means including said crystal and one electrode therefor, and a second electrode for said crystal the space-relation between which and the crystal is varied in accordance with the signal response for altering the frequency of the oscillations generated.

36. In a device of the class described, a microphone having a piezo electric crystal and a spaced electrode responsive to audio-frequency impulses, and means to generate electrical oscillations of modulated carrier frequencies, said frequencies being determined by the vibratory characteristics of said crystal when influenced by the action of said spaced electrode.

AUGUST HUND.

DISCLAIMER

1,933,735.—*August Hund*, Bethesda, Md. MODULATION SYSTEM. Patent dated November 7, 1933. Disclaimer filed January 10, 1936, by the assignee, *Wired Radio, Inc.*

Hereby enters a disclaimer to claims 25 and 26 of said patent, which are in the following words, to wit:

"25. In a piezo-electric-crystal-controlled oscillation generator, mechanical means for varying the frequency at which the crystal tends to oscillate.

"26. In a radio transmitting system, an oscillation generator comprising a thermionic tube and associated circuits, means comprising a piezoelectric crystal for determining the oscillation frequency, and a movable element for varying the frequency at which the crystal oscillates."

[*Official Gazette February 4, 1936.*]