

June 24, 1930.

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1,766,045

PIEZO ELECTRIC CRYSTAL MODULATION

Filed Jan. 25, 1927

2 Sheets-Sheet 1

Fig. 1

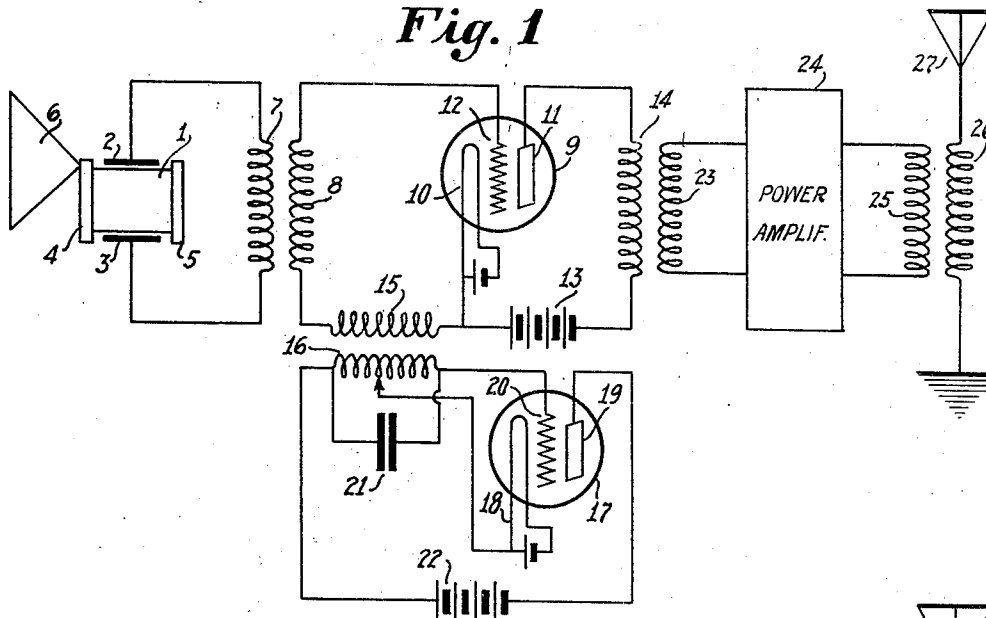


Fig. 2

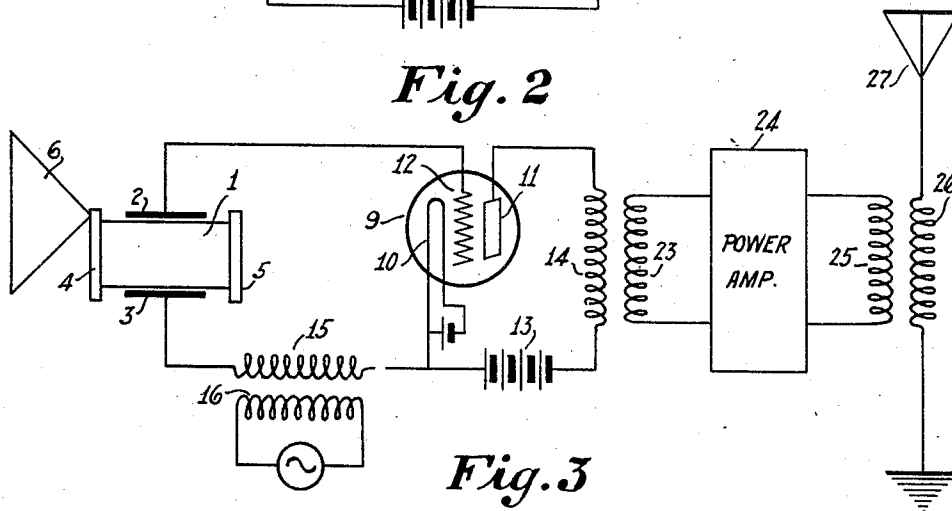
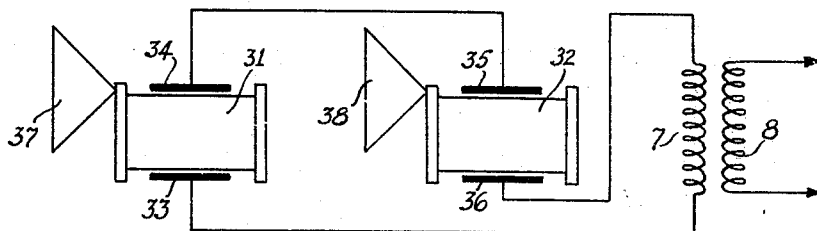


Fig. 3



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BUT LITTLE
HERE BELOW*

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2 Sheets-Sheet 2

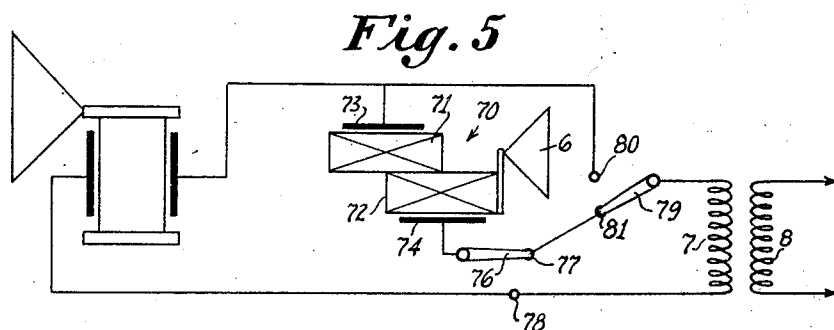
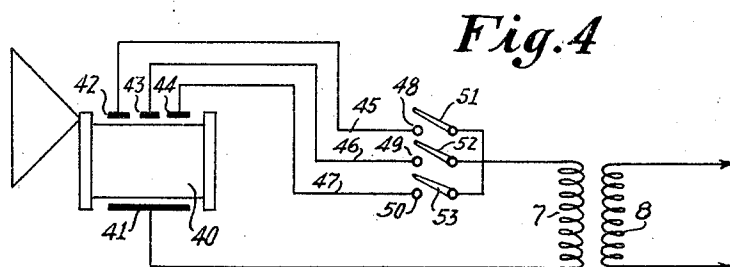


Fig. 6

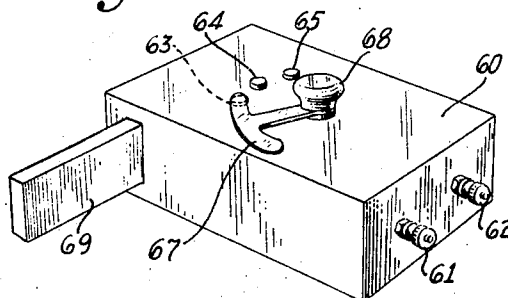
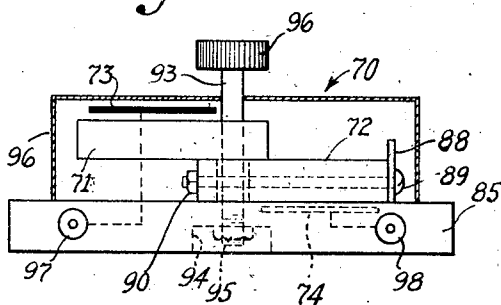


Fig. 7



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UNITED STATES PATENT OFFICE

ALEXANDER McLEAN NICOLSON, OF NEW YORK, N. Y., ASSIGNOR, BY MESNE ASSIGNMENTS, TO FEDERAL TELEGRAPH COMPANY, A CORPORATION OF CALIFORNIA

PIEZO-ELECTRIC CRYSTAL MODULATION

Application filed January 25, 1927. Serial No. 163,323.

This invention relates to apparatus for modulating relatively high frequency electrical oscillations, such for example, as oscillations having a frequency suitable for so-called "carrier current" telephony, or radio signalling, by relatively low frequency oscillations and more particularly by such oscillations corresponding to speech or music, which it may be desired to transmit.

It is an object of this invention to provide apparatus of the class described, utilizing one or more piezo-electric crystal devices for converting the speech, music or other signals which it is desired to transmit, into electrical oscillations corresponding thereto, and adapted to be used to modulate the high frequency signalling oscillations.

It is still a further object of this invention to provide apparatus of the class described, utilizing as many piezo-electric crystal devices as may be desired, placed at suitable or desired positions to provide the most advantageous "pick up" of the matter to be transmitted, together with means for controlling the strength of output of the various crystal devices utilized, and for establishing the optimum circuit arrangement.

It is still a further object of this invention to provide a generally improved system of the class described, capable of transmitting speech, music and other signals with the highest possible quality. Still other objects will be apparent from the specification.

The features of novelty which I believe to be characteristic of my invention are pointed out with particularity in the appended claims. My invention itself, however, both as to its underlying principles and as to its practical applications, will best be understood by reference to the specification and accompanying drawing, in which:

Fig. 1 is a diagrammatic view of apparatus according to my invention.

Fig. 2 is a similar view of a modified form thereof.

Fig. 3 is a detailed circuit diagram of audio frequency circuits and apparatus.

Fig. 4 is a diagrammatic view thereof, showing apparatus for controlling the output of the crystal devices.

Fig. 5 is a circuit diagram of another form of audio frequency apparatus.

Fig. 6 is a perspective view of a crystal device provided with a housing according to my invention.

Fig. 7 is a front elevation partly broken away, of another form thereof.

In accordance with my invention, I provide means for producing electrical oscillations of relatively high frequency suitable for use in so-called "carrier current" signalling, or radio signalling, together with apparatus utilizing piezo-electric crystal devices for converting audible signals such as speech, music, and the like, into electrical oscillations corresponding thereto, for modulating the high frequency signalling oscillations.

This apparatus will be arranged so as to produce modulated high frequency signalling oscillations, which may be amplified to the extent desired and impressed upon a load circuit such as a wire line or an antenna.

According to one form of my invention, I may utilize a piezo-electric crystal device provided with electrodes, and if desired, with some form of acoustic diaphragm connected thereto, the electrodes being connected in a circuit physically separated from but electrically associated, as by an inductive coupling, with a second circuit to which are supplied electrical oscillations of carrier frequency.

The second circuit will be provided with apparatus for combining the low frequency oscillations, corresponding to the signal, with the high frequency oscillations to produce the modulated carrier oscillations, and suitable amplifying apparatus, also will be provided for the purpose of amplifying the modulated oscillations to the extent desired.

In accordance with another form of my invention, I may provide a piezo-electric crystal device in the same circuit to which are supplied high frequency signalling oscillations.

For the purpose of providing optimum "pick-up" of the signals to be transmitted, I prefer to provide a plurality of piezo-electric crystal "pick-up" devices connected in series and disposed at different points with respect to the signal to be transmitted, in such

manner that substantially different signals are picked up by each crystal device. For example, in the transmission of services from a church, I may provide a "pick-up" device in front of the pulpit, another in front of the choir, and still another in front of the organ, all of which will preferably be connected in series and associated with the circuits in which are flowing the high frequency signaling oscillations.

Under certain conditions, also, I may prefer to utilize a control device for controlling the output of the individual crystal devices. For example, I may provide a crystal device with a plurality of electrode sections, any or all of which or any combination of which may be selected to be connected in the "pick-up" circuit.

Also, I may utilize crystal devices having variable cooperating crystal areas, and circuit arrangements whereby such crystal devices may be connected either in series or parallel with the other crystal devices in the "pick-up" line.

Also, for the purpose of insuring reliability and continuous operations of the system, I prefer to provide these variable crystal devices with housings protecting them from external conditions and provided with operating members mounted on the outside of said housings by means of which the operating conditions may be controlled.

Referring now more particularly to Fig. 1, 1 designates a piezo-electric crystal device, such for example as a crystal of Rochelle salt exhibiting the well-known "hour glass" configuration or a cast piezo-electric device such as described in my copending application entitled "Cast piezo-electric device", Serial No. 155,897, filed Dec. 20th, 1926, or composite devices as described in my copending applications, entitled:

Composite piezo-electric crystal device, Serial No. 155,898, filed Dec. 20, 1926;

Composite piezo-electric crystal device, Serial No. 160,358, filed Jan. 11, 1927;

Internally-clamped composite piezo-electric acoustic device, Serial No. 160,359, filed Jan. 11, 1927;

Orientation of component crystals in composite piezo-electric devices, Serial No. 155,902, filed Dec. 20, 1926;

provided with a pair of electrodes 2 and 3 associated therewith in any suitable manner, and such for example as an internal electrode and an external electrode, or a pair of external electrodes, and provided, if desired, with mounting plates 4 and 5. A suitable acoustic device, such for example as cone 6 is associated with the crystal device in such manner as to set the same into vibration corresponding to sound waves impinging upon the cone 6. The electrodes 2 and 3 may be connected through coil 7, which may be coupled to a second coil 8 connected in

series with coil 15 between the control electrode 12 and the cathode 10 of a thermionic amplifying system 9, comprising as many stages as may be desired, but herein diagrammatically shown as a single tube having in its output circuit a coil 14 and a source of potential 13.

The coil 15 is coupled to a second coil 16, preferably shunted by a condenser 21, and connected to a second thermionic amplifier 17, in such manner as to form a feed back circuit, well-known in the art, for the purpose of generating continuous oscillations of the high frequency desired to be modulated in accordance with the audible signals. One end of coil 16 and one side of condenser 21 may be connected together and to the control electrode 20 of the amplifier 17. The other terminal of the coil and condenser may be connected together and to one terminal of a suitable source of potential 22, the other terminal of which is connected to the anode 19. A suitable intermediate point of the coil 16 may be connected to the cathode 18.

The coil 14 may be inductively coupled to coil 23, forming the input circuit of a suitable power amplifier 24 adapted to supply to the output coil 25 amplified currents of the power desired. These currents may be impressed upon a load circuit such as an antenna 27, or a wire line, by means of coil 26 connected in the load circuit and coupled to coil 25.

It will now be understood that by energization of the thermionic amplifier 17 and adjustment of the intermediate tap, oscillations may be produced as is well known in the art. These oscillations will be impressed upon coil 15 and thereby upon the input circuit of amplifier system 9: and if no sound waves are impinging on the cone 6, the high frequency oscillations will not be modulated and continuous unmodulated oscillations will be supplied to the load circuit. If, on the other hand, acoustic disturbances actuate the cone 6, such for example as speech, music and the like, the crystal device 1 will be vibrated and electrical oscillations corresponding thereto will be caused to flow through the coil 7 and impressed upon the control circuit of amplifier 9 by means of coil 8. This amplifier will therefore be controlled in accordance with the high frequency and low frequency oscillations, and the high frequency oscillations will be modulated at the low frequencies supplied thereto.

Referring now more particularly to Fig. 2, I have shown a modified form of the apparatus illustrated in Fig. 1, in which the crystal device 1 is connected directly in the input circuit of amplifier 9 instead of being inductively associated therewith. If the crystal device 1 comprises Rochelle salt, it will not be necessary usually to provide means for shunting the high frequency around the crystal device, since the dielectric constant of

operating Rochelle salt may be as high as approximately 900, whereby it will be seen that the capacitive impedance offered to the flow of high frequency oscillations will be extremely small, since the crystal device itself acts as a condenser.

Referring now more particularly to Fig. 3, it may be desired to provide a plurality of pick-up devices for the sound waves to be transmitted: in this instance, I have shown crystal device 31 and crystal device 32, the former being provided with electrodes 33 and 34, and the latter with electrodes 35 and 36: suitable acoustic diaphragms such as cones 37 and 38 will be associated with each of the devices in a manner to vibrate them in accordance with the signals it is desired to transmit. In this instance, I have shown the crystal device as connected both in series with the output coil 7 associated with coil 8 in the input circuit of amplifier 9.

Referring now to Fig. 4, it may be desired to control the output of the piezo-electric device. This may be done for example by providing the crystal device 40 having an electrode 41 associated with one electrical pole of the device and a plurality of additional electrodes 42, 43, and 44, which may be sectional electrodes placed along an opposite electrical pole and connected by means of leads 45, 46 and 47 to contacts 48, 49 and 50. Suitable switching means 51, 52 and 53 may be provided by means of which any of the electrodes or any combination thereof, may be established in the circuit. The switching devices 51, 52 and 53 may all be connected together and to one terminal of coil 7, the other terminal of which is connected to electrode 41.

Referring now more particularly to Fig. 5, I have shown a slightly different arrangement in which the output of the piezo-electric crystal device is controlled in a different manner. In this instance, a variable crystal device 70 is provided comprising a fixed crystal device 72, having a second crystal device 71 adapted to be variably positioned with respect thereto, for example, by being rotated thereupon.

The crystal device 71 may be provided with an electrode 73, and the crystal device 72 with an electrode 74. A suitable acoustic device such as cone 6 may be secured to the crystal device 70 in such manner as to cause the same to be vibrated in accordance with signals which it is desired to transmit. In this figure, also, I have shown an arrangement for quickly changing the circuit arrangement from a series connection of the crystal devices and coil 7, to a parallel connection of the same. This may be done, for example by connecting electrode 73 to contact 80 and electrode 74 to switch plate 76. A pair of switch terminals 77 and 78 are provided to be en-

gaged selectively by switch plate 76 and a second pair of terminals 80 and 81 are also provided for selective engagement by switch plate 79 connected to one terminal of coil 7. Contact 78 is connected to the other terminal thereof. A connection is provided between contact 77 and 71 whereby it will be seen that in the position shown, a series circuit is established. If the switches are thrown to the other position, a parallel circuit will be established. The switches may be mechanically connected so that the operation of the one causes operation of the other, if desired, as by the use of a double pole switch.

Referring now more particularly to Fig. 6, I have shown a form of housing adapted to contain such a piezo-electric crystal device as shown and described with reference to Fig. 4. In this instance, there may be provided a hollow housing 60 of any suitable material such for example as metal or phenol condensation products or other insulating materials, adapted to contain the crystal device: terminals 61 and 62 may be provided externally on the housing by means of which a connection may be made to the electrodes of the crystal device. For the purpose of establishing various connections, there may be provided suitable switch contacts 63, 64 and 65 upon the exterior of the housing connected to electrode sections 42, 43 and 44, and adapted to be engaged by arm 67 connected to one of the terminals 61 and 62, and which may be rotated by knob 68 mounted upon a suitable shaft. A stress plate 69 may be arranged to pass into the housing, which stress plate may be secured to the crystal device thereon, and may carry an acoustic diaphragm such as cone 6. The housing may, if desired, be constructed in such manner as to be air and moisture proof.

Referring now more particularly to Fig. 7, I have illustrated a form of housing which may be adapted to contain the crystal device 70. A base plate 85 may be provided having mounted thereon a fixed crystal device 72 having electrode 74 associated therewith. A stress plate 88 may be secured to the crystal 72 by suitable bolts 89 and cooperating nuts 90. A shaft 93 may be arranged to control the position of movable crystal 71 provided with electrode 73. The shaft 93 may be secured in position by passing through the base plate 85 into a depression 94 where it may be engaged by a suitable nut 95. The shaft may terminate in an operating knob 96 by means of which the position of the crystal may be controlled. Suitable terminals 97 and 98 may be provided on the base plate and connections may be taken therefrom to the respective electrodes. A housing 96 may be arranged to enclose the crystal device and the operating parts of the rotary shaft and crystal system.

While I have shown and described certain preferred embodiments of my invention, it

will be apparent that modifications and changes may be made, as will be understood by those skilled in the art, without departing from the spirit and scope of my invention.

I claim:

5 1. A pick-up system for converting sound into electrical oscillations corresponding thereto, said system comprising a plurality of piezo-electric crystal devices arranged to
10 convert sound waves into electrical oscillations disposed at different acoustic positions with respect to the source of sound and connected in series, and means for varying the piezo-electric effect of the individual piezo-
15 electric crystal devices.

2. A pick-up system for converting sound into electrical oscillations corresponding thereto, said system comprising a plurality of piezo-electric crystal devices arranged to con-
20 vert sound waves into electrical oscillations disposed at different acoustic positions with reference to the source of sound and connected in series, and means for controlling the piezo-electric effect of individual crystal devices.

25 3. A pick-up system for converting sound into electrical oscillations corresponding thereto, said system comprising a plurality of piezo-electric crystal devices arranged to convert sound waves into electrical oscillations,
30 disposed at different acoustic positions with reference to the source of sound and connected in series, and means for varying the piezo-electric constants of individual crystal devices.

35 4. A pick-up system for converting sound into electrical oscillations corresponding thereto, said system comprising a plurality of piezo-electric crystal devices arranged to convert sound waves into electrical oscilla-
40 tions, disposed at different acoustic positions with reference to the source of sound and connected in series, and means for varying the effective electrode area of individual crystal devices.

45 In testimony whereof I hereunto affix my signature.

ALEXANDER McLEAN NICOLSON.

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