

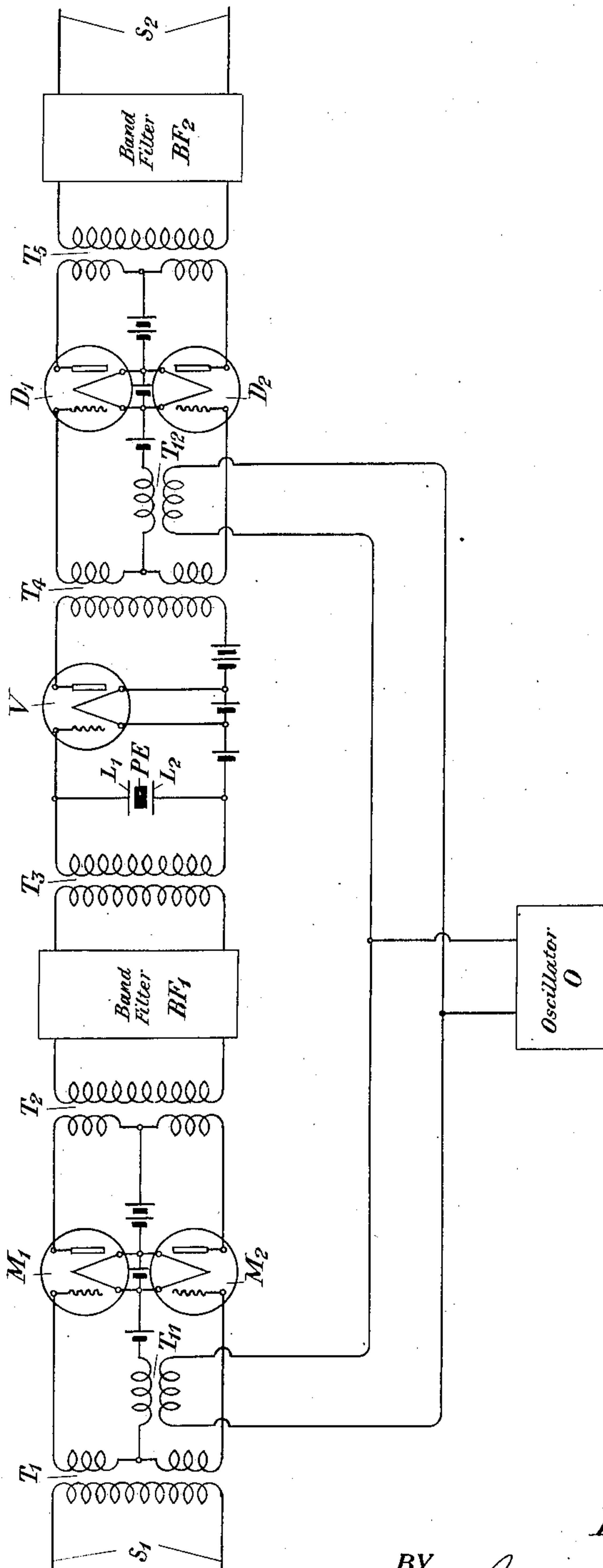
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PIEZO ELECTRIC INTERFERENCE ELIMINATOR

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PIEZO-ELECTRIC INTERFERENCE ELIMINATOR

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This invention relates to transmission systems, and particularly to arrangements in such systems for eliminating interference.

In connection with carrier and radio and other signaling systems, it is desirable to prevent the interference caused by the superimposition of foreign waves upon a band of signals to be transmitted by the particular system. These interfering waves may be present in the system in frequencies which are within the limits of the band to be transmitted. Tuned circuits have been developed for balancing this interference out, but these are only partly successful in practice because they require very frequent adjustments to compensate for changes in the phase and in the magnitude of the balancing or interfering current. Moreover, the absorption of interfering waves by resonant circuits tuned to the interfering frequencies is very difficult. An insurmountable objection to the use of tuned circuits as absorbing elements is apparent from the frequency characteristics of the tuned circuits, which are so broad as to absorb an appreciable part of the signal band along with the interfering waves.

Accordingly it is an object of this invention to provide a quartz crystal, or other device of piezo-electric character, which will furnish an absorbing circuit sufficiently sharp in its frequency characteristic so as to have a comparatively small or negligible effect on the band of signals to be transmitted. Moreover, if there are two or more interfering frequencies within the limits of a band of signals, it is the object of this invention to provide two or more of such piezo-electric devices to act as the absorbing bodies, one corresponding to each of the interfering waves, these piezo-electric devices being mutually non-reactive.

There might be considerable difficulty in adjusting the natural frequency of a piezo-electric crystal to be approximately equal to that of an interfering wave. The frequency adjustment of a piezo-electric crystal may be accomplished by carefully grinding the crystal according to cut and try methods until the frequency of the piezo-electric crystal equals that of the interfering wave. This

would be difficult and time-consuming. Accordingly, it is another object of this invention to provide an arrangement for changing the frequency of an interfering wave so that the resulting wave will have a frequency substantially equal to that of the piezo-electric crystal, whereupon the piezo-electric crystal may be employed to absorb the energy of the interfering wave.

While the invention will be pointed out with particularity in the appended claims the invention itself, both as to its further objects and features, will be better understood from the detailed description hereinafter following, when read in connection with the accompanying drawing, showing one embodiment of the invention merely for the purpose of illustration.

A band of signals may be originated by a device such as a telephone transmitter (not shown). Also, the voice band of such a device may, if desired, be converted to a higher frequency range by a suitable modulator (not shown). In either case, the band, after being transmitted over a medium in which interfering waves are present, may then be transmitted to an input circuit S_1 . This band of signals may then be impressed through a transformer T_1 upon a modulator, which may be of any well known type, preferably of the balanced tube type, as shown. The modulator comprises two three-electrode vacuum tubes M_1 and M_2 . An oscillator O of any well known type, preferably of the vacuum tube type, supplies the carrier current to the modulator through a transformer T_{11} . The output circuit of the modulator is connected through a transformer T_2 to a band filter BF_1 which may be adjusted to suppress one of the side bands resulting from modulation, the carrier component being suppressed by the balanced arrangement of the modulator, as is well known in the art. The band filter transmits one side band resulting from modulation, this side band corresponding to the band of signals in the input circuit S_1 , except that the band is shifted in the frequency spectrum. Moreover, the band filter suppresses all intermodulation components which are above and below the limits of the band filter. Yet

it transmits a wave or waves which interfere with the band of signals, which wave or waves have frequencies within the limits of the band. Moreover, the frequency of one of the interfering waves is changed by its modulation with the frequency of the oscillator O, so that the frequency of the wave resulting from such modulation corresponding to the interfering wave equals the frequency of vibration of the piezo-electric device PE.

This band of signals, including the interfering wave, which has a frequency within the limits of the band, is transmitted through a transformer T_3 to the input circuit of a vacuum tube V, the piezo-electric device being connected in said input circuit. The piezo-electric device PE is connected through its conductive plates L_1 and L_2 between the grid and cathode of the vacuum tube V. It is so arranged that it may freely vibrate therebetween at one or more of its natural frequencies. The crystal may be made of quartz, or other piezo-electric material, cut along an axis of symmetry. It is a well known property of a crystal so cut that when subjected to a physical stress from the sides of the crystal, plus and minus charges appear on the faces of the crystal. Conversely, when the crystal is subjected to an electrostatic field a physical deformation occurs along the axis of the crystal. The signs of the charges produced in the first case depend upon the character of the stress, that is, whether the stress is tension or compression, whereas in the second case the physical deformation is due to the direction of the electrostatic field. If the physical stress changes from compression to tension, or vice versa, the signs of the electric charges on the faces of the crystal are reversed. On the other hand if the direction of the electrostatic field is alternately reversed the crystal undergoes contraction and elongation alternately in the direction of the axis. In other words, the crystal vibrates in an electrostatic field in which the charge is alternately reversed.

At any frequency different from a natural frequency of the piezo-electric device PE, the impedance of this piezo-electric device is very high as compared to the impedance between the grid and cathode of the vacuum tube V. Yet at a frequency substantially equal to the frequency of resonance, the impedance of the piezo-electric device drops considerably so that its impedance is small as compared to the impedance of the grid and cathode of the vacuum tube V. In accordance with this invention the frequency of an interfering wave is brought to the frequency of the piezo-electric device PE. Consequently the current of the interfering wave is shunted through the circuit including the piezo-electric device PE, whereupon its effect upon the band of signals is substantially suppressed.

The band of signals changed in the fre-

quency spectrum and free from the effect of an interfering wave, or waves, is transmitted through transformer T_4 to a demodulator of any well known type, preferably of the balanced tube type. This demodulator comprises two three-element vacuum tubes D_1 and D_2 . This demodulator is supplied through transformer T_{12} with a homodyne frequency from the oscillator O, identical with that originally transmitted through transformer T_{11} to the modulator. Accordingly the band of signals is returned to its original position in the frequency spectrum free from interfering waves. A band filter BF_2 is connected to the output circuit of the demodulator through a transformer T_5 so that any intermodulation components outside of the limits of the band will be substantially suppressed. The output circuit S_2 receives the band of signals as transmitted by the band filter BF_2 .

It is to be understood that it is within the scope of this invention to employ a single piezo-electric device having a plurality of natural frequencies so that each of these natural frequencies may be used to suppress one of the interfering waves.

It is to be understood that in systems in which there are a plurality of interfering waves superimposed upon a band of signals, these interfering waves having frequencies within the limits of the band of signals, a plurality of piezo-electric devices may be employed within the scope of this invention, one piezo-electric device corresponding to each of the interfering waves, so that the distorting effect of the interfering waves upon the band of signals will be substantially eliminated.

It will further be understood that although the piezo-electric device has been illustrated as connected between the grid and cathode of a demodulator tube, the object of this invention may be carried out by connecting the said device at other points in the circuit, as, for example, between the anode and cathode of a tube used to amplify the side band arriving at the receiving station.

The term "piezo-electric" as employed herein refers to that property of a body or substance by which an electro-motive force results from pressure, and vice versa.

It will be understood that while this invention has been shown and described in one particular embodiment merely for the purpose of illustration, the general principles of this invention may be applied to other and widely varied organizations without departing from the spirit of the invention or the scope of the appended claims.

What is claimed is:

1. The method of suppressing an alternating current wave of definite frequency by means of a piezo-electric device of substantially different frequency, which consists in heating the alternating current wave of definite frequency with another wave so as

to produce a third wave having a frequency characteristic of the piezo-electric device, whereupon the piezo-electric device becomes absorbent to said third wave.

2. The method of suppressing an alternating current wave of definite frequency by means of a piezo-electric device of substantially different frequency, which consists in modulating the alternating current wave of definite frequency with another wave so as to produce a third wave having the frequency of the piezo-electric device, and substantially suppressing the other products of modulation to the exclusion of said third wave, whereupon the piezo-electric device becomes absorbent to said third wave.

3. The method of absorbing the energy of an alternating current wave of one frequency by a device of piezo-electric character having a substantially different natural frequency, which consists in deriving from said wave another wave having a frequency equal to that of the piezo-electric device, and absorbing the energy of the latter wave.

4. The combination of a circuit transmitting a band of signals upon which an interfering frequency is superimposed, a piezo-electric device having a characteristic natural frequency, means for modulating said band of signals and the wave of interfering frequency with a wave of another frequency so as to produce a wave having a frequency equal to the natural frequency of the piezo-electric device, and means for rendering the piezo-electric device absorbent to the latter wave.

5. The combination of a circuit transmitting a band of signals upon which an interfering frequency is superimposed, a piezo-electric device having a characteristic natural frequency, and means for modulating the wave of the interfering frequency with the wave of another frequency so as to produce a wave having a frequency equal to the natural frequency of the piezo-electric device, whereupon the piezo-electric device absorbs the energy of the resultant wave.

6. The combination of a circuit transmitting a band of signals, energy interfering with said band of signals of definite frequency characteristics and lying within said band, piezo-electric means of different frequency characteristics, and means for changing the frequency characteristics of the interfering energy so as to equal the frequency characteristics of the piezo-electric means, thereby rendering the piezo-electric means absorbent to the interfering energy so that said interfering energy may become ineffective in the circuit transmitting said band of signals.

7. An arrangement for absorbing energy, comprising means of piezo-electric character of definite frequency characteristics, interfering energy of substantially different frequency characteristics, and means for bring-

ing the frequency characteristics of said interfering energy into synchronism with the frequency characteristics of the piezo-electric means.

8. A combination of a circuit transmitting a band of signals, energy of definite frequency characteristics interfering with said band of signals, piezo-electric means of definite frequency characteristics, means for converting the frequency characteristics of the band of signals and the frequency characteristics of the interfering energy so that the frequency characteristics of the interfering energy become similar to the frequency characteristics of the piezo-electric means, and means for reconvertng the band of signals into its original frequency characteristics free from the interfering energy.

9. A system for suppressing an alternating current wave of a definite frequency, comprising a device of piezo-electric character of a substantially different frequency, and means for simultaneously converting the frequency characteristic of the alternating current wave into a wave having a frequency substantially equal to the frequency characteristic of the piezo-electric device, whereupon the piezo-electric device becomes absorbent to the alternating current wave.

10. A system for absorbing the energy of an alternating current wave, comprising a device of piezo-electric character having a natural frequency substantially different from the frequency of the alternating current wave, means for deriving from said alternating current wave another wave having a frequency substantially equal to that of the piezo-electric device, and means for rendering the piezo-electric device absorbent to the alternating current wave of substantially the same frequency.

11. The method of suppressing the energy of an alternating current wave superimposed upon a band of signals and having a frequency within the limits of said band, with the aid of a piezo-electric structure having a vibratory frequency without the limits of said band, which consists in separating the superimposed energy of the alternating current wave from said band of signals and converting that energy into other energy having a frequency substantially the same as that at which the piezo-electric structure may vibrate in order that said converted energy may become effectively suppressed.

In testimony whereof, I have signed my name to this specification this 16th day of July, 1926.

HERMAN A. AFFEL.