Jan. 7, 1930. W. H. T. HOLDEN 1,742,252

PIEZO ELECTRIC FREQUENCY ELIMINATOR

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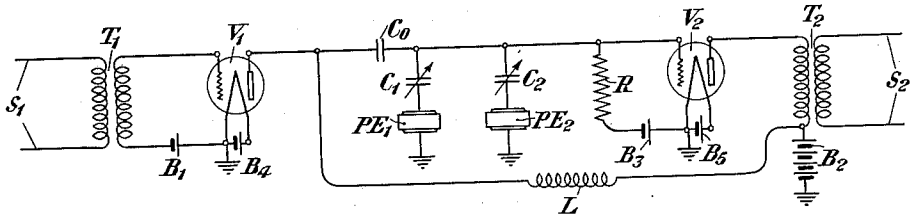

Fig. 1

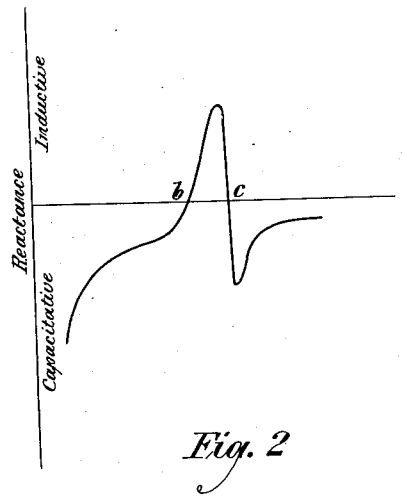

Fig. 2

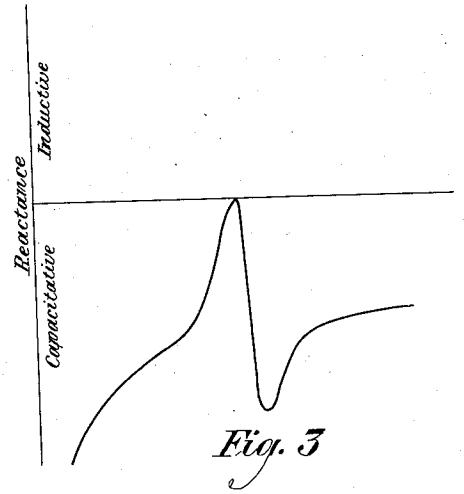

Fig. 3

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UNITED STATES PATENT OFFICE

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PIEZO-ELECTRIC FREQUENCY ELIMINATOR

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This invention relates to transmission systems, and particularly to arrangements in such systems for eliminating or substantially suppressing one or more undesirable frequencies.

In connection with carrier, radio and other signaling systems, it is often desirable to prevent the transmission of one or more frequencies which may, for example, be interference caused by the introduction of foreign frequencies into a band of signals, which is to be transmitted by the particular system. These interfering or undesirable frequencies may emanate from radio telegraph stations, and may be present in the system at frequencies which lie within the limits of the band to be transmitted. Special circuits have heretofore been developed for balancing out these undesirable or interfering frequencies, 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 undesired or interfering current. Moreover, the absorption of such frequencies by resonant circuits, for example, tuned thereto is very difficult. An insurmountable objection to the use of tuned circuits as absorbing elements is apparent from the well-known frequency characteristics of tuned circuits which are so broad as to absorb an appreciable part of the signal band along with the undesirable or interfering frequencies.

Accordingly, it is an object of this invention to provide a piezo-electric device to furnish an absorbing circuit sufficiently sharp in its frequency characteristic as to have a comparatively small or negligible effect on a band of signals to be transmitted. Moreover, wherever there are two or more undesirable frequencies, or, in general, wherever there are two or more undesirable bands of frequencies, it is an object of this invention to provide two or more of such piezo-electric devices to act as the absorbing bodies, one corresponding to each undesirable wave or to each undesirable band, these piezo-electric devices functioning independently.

It is another object of this invention to so relate elements of reactance to the piezo-electric devices that the absorbing circuits, which include the piezo-electric devices and the corresponding reactance elements, will have a very low or a minimum of impedance at the undesirable frequencies.

While this 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, in which Figure 1 represents one embodiment of the invention, shown merely for the purpose of illustration; Fig. 2 shows a reactance curve of a piezo-electric device, and Fig. 3 shows the reactance curve of a piezo-electric device, the form of which is modified by suitable reactance elements.

Referring to Fig. 1 of the drawing, a source S_1 represents diagrammatically any source for supplying currents having various frequencies, such as a telephone system, one or more of the frequencies of which are to be substantially suppressed. The source S_1 supplies currents to the vacuum tube V_1, which may be of the three-electrode type, through a transformer T_1. The grid of the vacuum tube V_1 may be maintained at a suitable negative potential by means of a battery B_1. The plate of the vacuum tube V_1 is supplied with space current by a battery B_2 through a choke coil L. Another vacuum tube V_2 is connected in tandem with the vacuum tube V_1. The battery B_3 provides the grid of the latter vacuum tube, through resistance R, with suitable negative potential. A condenser C_0 has one terminal directly connected to the plate of the vacuum tube V_1, and another terminal directly connected to the grid of the vacuum tube V_2, and serves, first, to confine currents from the batteries B_2 and B_3 to their respective circuits, and, second, to pass alternating currents from the output circuit of vacuum tube V_1 to the input circuit of vacuum tube V_2. The plate of the vacuum tube V_2 is supplied with space current from the battery B_2 through the primary winding of the transformer T_2. Currents in the plate circuit of the vacuum tube V_2 are transmitted to an output circuit S_2

through transformer T_2. Batteries B_4 and B_5 heat the filaments of the vacuum tubes V_1 and V_2, respectively, to electron-emitting temperatures, the negative terminals of these batteries being grounded. Obviosuly, a single battery may replace batteries B_4 and B_5. Two absorbing circuits are connected from the right-hand terminal of the condenser C_0 to ground. These absorbing circuits comprise piezo-electric devices PE_1 and PE_2, and suitable reactance elements shown herein as variable condensers C_1 and C_2, respectively.

A frequency or frequencies, which may be undesirable, may lie within the band or bands of signals to be transmitted by the system. The absorbing circuits comprising the piezo-electric devices and the corresponding series reactance elements are introduced to provide means for substantially suppressing the undesirable wave or waves so that their effects upon the bands of signals to be transmitted by the system will be substantially eliminated, as will be shown more fully hereinafter. All frequencies coming in from the source S_1 are impressed on the input circuit of the vacuum tube V_1 through the transformer T_1. These voltages are amplified in a manner well known in the art and appear in amplified form in the output circuit of the vacuum tube V_1. These frequencies pass through the condenser C_0 and are impressed on the input circuit of the vacuum tube V_2. These frequencies are further amplified by the vacuum tube V_2 and appear in its output circuit, whereupon they are transmitted to the circuit S_2 through the transformer T_2.

The series circuits comprising the piezo-electric devices and the corresponding reactive elements are arranged so as to have very small or negligible impedances at the frequencies which are to be suppressed. Current appearing in the output circuit of the vacuum tube V_1, that has a frequency equal to the frequency at which one of these absorbing circuits has a very low impedance as compared to the impedance between the grid and filament of the vacuum tube V_2, will be shunted through that absorbing circuit, so that its effect upon the band or bands of signals to be transmitted by the system will be substantially suppressed.

Fig. 2 represents a characteristic reactance curve of a piezo-electric crystal. This curve indicates that as the frequency impressed across the piezo-electric crystal increases, the reactance is capacitative and of a decreasing order. At the frequency corresponding to point *b*, the reactance is zero, and at frequencies somewhat higher than the frequency corresponding to point *b*, the reactance becomes inductive and increases at a rather rapid rate until the inductive reactance reaches its maximum value. Thereafter, the reactance changes from a very high inductive value to a very high capacitative value within an exceedingly small range of the frequency spectrum, the change taking place about the frequency corresponding to the point *c*. As the frequency increases, the piezo-electric device exhibits a capacitative reactance of a decreasing order.

Fig. 3 shows another reactance curve of a piezo-electric device, modified due to the interposition of suitable reactance. In the case taken for illustrative purposes, the reactance comprises a series capacity. By putting capacity in series with the piezo-electric device, an arrangement can be provided which never exhibits an inductive reactance, or which shows, at the most, a small inductive reactance. In the arrangement having the reactance curve shown in Fig. 3, the reactance never attains an inductive value. The peak of the reactance curve in Fig. 3 coincides with the line of zero reactance, and, at the frequency corresponding to this peak and at frequencies adjacent to the frequency corresponding to the peak, the arrangement will have a minimum of impedance, while at other frequencies substantially different from the frequency corresponding to the peak, the impedance will be high. Such an arrangement shunted across one of the circuits of a transmission system will greatly attenuate and, in effect, substantially suppress the frequency corresponding to the minimum impedance of the crystal as well as a small band of frequencies immediately adjacent the latter frequency. In Fig. 1, the grid circuit of the vacuum tube V_2 is designed to have a high impedance as compared to the combined impedance of the piezo-electric device and the associated reactive element.

It will be understood that while only two vacuum tubes have been shown herein in an amplifying system, any number of vacuum tubes may be similarly connected, in which suitable combinations of piezo-electric devices and reactive elements may be associated to substantially suppress a plurality of single frequencies or a plurality of bands of frequencies without materially affecting the transmission or amplification of other frequencies or other bands of frequencies. It will be distinctly understood that although the absorbing circuits have been illustrated as connected between the grid and filament of one of the vacuum tubes, the object of this invention may be carried out by connecting the absorbing circuits at other points in the system, as, for example, between the plate and filament of a vacuum tube.

The sharpness of a piezo-electric device is particularly advantageous for the suppression of undesirable frequencies, because the electrical circuits heretofore employed for this purpose have been inherently of such high decrement that a considerable range of frequencies on either side of the undesired

frequencies were also substantially suppressed. The use of a piezo-electric device without a reactance element of suitable magnitude may lead to oscillation at the frequency intended for suppression. If, in the example of Fig. 1, the reactance of the plate circuit of the vacuum tube V_2 bears a definite relationship to the reactance in the grid circuit of that vacuum tube at the particular frequency involved, that frequency will be transmitted. Obviously, by rendering the reactance of the crystal circuit capacitative, or, at the most, only slightly inductive, it will be clear that the undesired frequency or frequencies will be substantially suppressed, and their effects upon the other frequencies will be nullified. It is to be noted that a further reduction in the amplitude of an undesirable frequency may be attained by introducing regeneration so as to compensate for the unnecessary and unavoidable resistance (due to the viscosity and damping of the crystal), and accordingly still further reduce its effective impedance by the negative resistance introduced by the regeneration.

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

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

What is claimed is:

1. The method of substantially eliminating the effect of a plurality of undesirable frequencies which lies within the limits of a band with a plurality of mechanically vibrating bodies and a plurality of reactive elements, one mechanically vibrating body and one reactive element corresponding to each of the undesirable frequencies, which consists in vibrating said plurality of mechanically vibrating bodies, and so controlling the magnitude of the reactances of the various reactive elements that the undesirable frequencies will become absorbed therein.

2. The method of substantially eliminating the effect of a plurality of undesirable frequencies which lie within the limits of a band with a plurality of piezo-electric bodies, one corresponding to each undesirable frequency, which consists in vibrating said plurality of piezo-electric bodies, and substantially decreasing the magnitude of the reactance of each piezo-electric body at the corresponding undesirable frequency so that each piezo-electric body forms a path of low impedance for said corresponding undesirable frequency.

3. The combination of means for generating a band of signals, some of the frequencies of which are to be substantially suppressed, a plurality of piezo-electric devices, one corresponding to each of the frequencies to be suppressed, and a plurality of reactive elements, one corresponding to each piezo-electric device, all of the piezo-electric devices and the corresponding reactive elements being coupled to said generating means and providing parallel paths of low impedance for the respective frequencies to be substantially suppressed.

4. The combination of means for generating a band of signals, an amplifying system for amplifying said band of signals, a piezo-electric device, and a reactive element, said piezo-electric device and said reactive element being coupled to the amplifying system so that all frequencies within a small portion of said band will be substantially suppressed without disturbing the nature of the band of signals being amplified.

5. The combination of a source of speech signals, means for transmitting said speech signals, a band of undesirable frequencies being superposed on said speech signals and emanating from said source, a piezo-electric device, and means co-operating with said piezo-electric device and coupling said piezo-electric device with said transmitting means to render said piezo-electric device of low impedance and consequently absorbent to said band of undersirable frequencies.

6. A system for substantially eliminating a plurality of undesirable frequencies which are superposed upon a band of frequencies corresponding to speech signals, comprising a plurality of piezo-electric bodies upon which are impressed said band of frequencies corresponding to speech signals as well as the superposed undesirable frequencies, one piezo-electric body corresponding to each superposed frequency, and a plurality of reactive elements, one reactive element being coupled to each piezo-electric body and co-operating with each piezo-electric body so as to render the magnitude of the reactance substantially negligible, whereupon the superposed frequencies become substantially suppressed.

7. A system for substantially suppressing a plurality of undesirable frequencies which lie within the limits of a band corresponding to speech signals, comprising a plurality of piezo-electric devices, one piezo-electric device corresponding to each undesirable frequency, and a plurality of reactive elements, one corresponding to each piezo-electric body, each reactive element being coupled to a piezo-electric device so as to render its reactance neglible at a particular undesirable frequency, whereupon the undesirable frequencies become absorbed without any substantial distortion of the band.

8. A system for substantially eliminating the effect of a plurality of interfering frequencies which lie within the limits of a band, comprising a plurality of electro-mechanical vibrating bodies, and a plurality of reactive elements, one corresponding to each electro-mechanical vibrating body, each reactive element being coupled to the corresponding electro-mechanical body and rendering the electro-mechanical body to which it corresponds of low impedance at one of the interfering frequencies.

In testimony whereof, I have signed my name to this specification this 29th day of December, 1926.

WILLIAM H. T. HOLDEN.