Aug. 30, 1932. C. W. HANSELL 1,874,982

FREQUENCY CHANGER

Filed June 20, 1929

Fig. 1

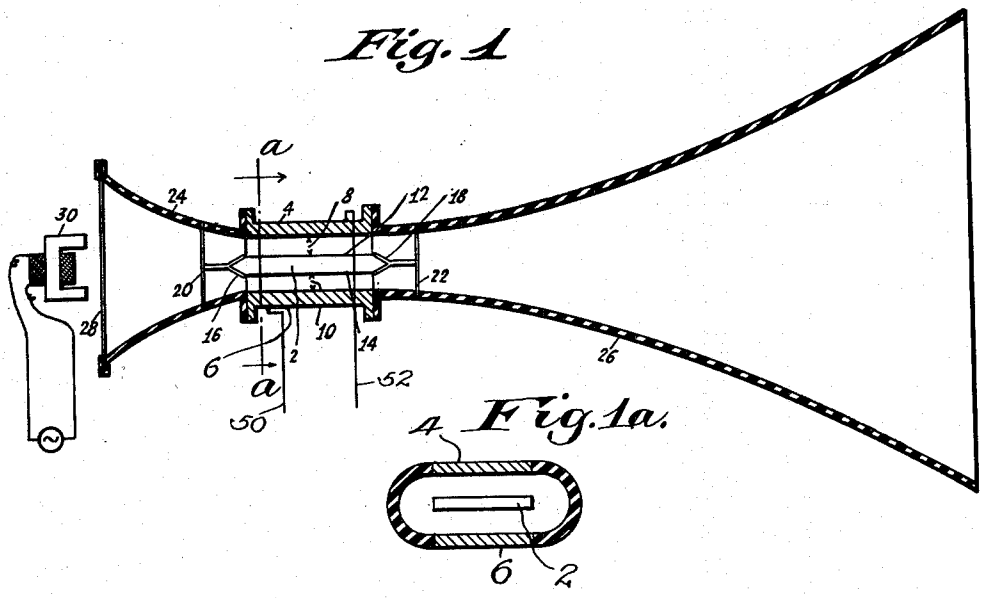


Fig. 1a.

Fig. 2

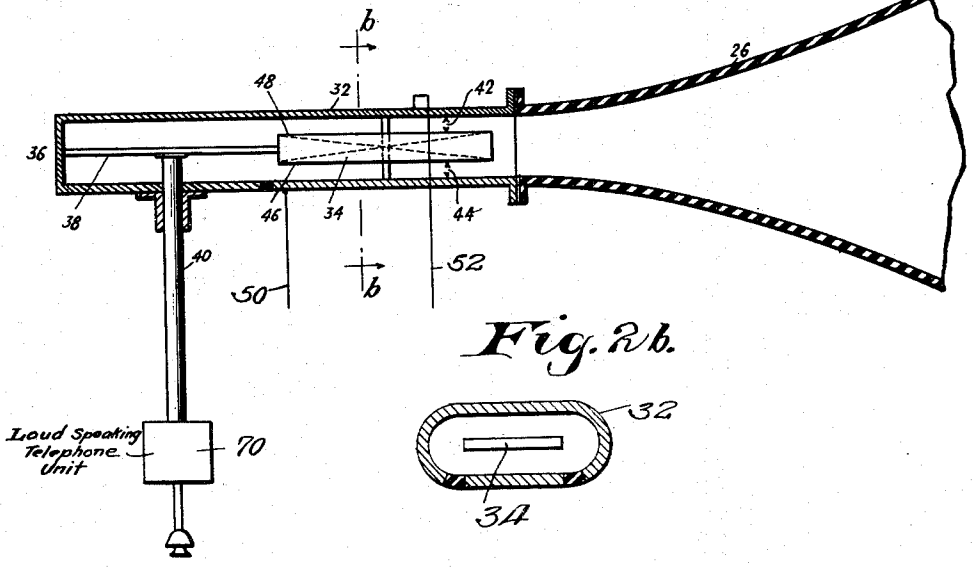


Fig. 2b.

INVENTOR
CLARENCE W. HANSELL
BY H. G. Grover
ATTORNEY

Patented Aug. 30, 1932 1,874,982

UNITED STATES PATENT OFFICE

CLARENCE W. HANSELL, OF PORT JEFFERSON, NEW YORK, ASSIGNOR TO RADIO CORPORATION OF AMERICA, A CORPORATION OF DELAWARE

FREQUENCY CHANGER

Application filed June 20, 1929. Serial No. 372,237.

This invention relates to a frequency changer and especially to new and useful methods and means for varying the frequency at which a piezo-electric crystal vibrates.

Heretofore, frequency variation in a crystal was accomplished by varying the tuning of the circuits with which the crystal was associated, or by varying the air gaps about one or more faces of the crystal. In the latter case variation of the gap causes a variation in the natural period of the column of medium in contact with a face of the crystal, thereby varying the crystal frequency.

According to this invention the dimensions of the media in contact with one or more faces of the crystal are kept constant; but, by varying the pressure or stiffness of the media, the crystal frequency is changed in any desired fashion. The resulting electrical vibrations are utilized in any desired manner such as, for example, wobbling the frequency of a transmitter in order to reduce fading effects at a receiver, or for frequency modulation.

In one embodiment of my invention a crystal has in contact with one or more of its faces a column of air of a length such that its natural period differs slightly from that of the crystal. Because of this, the crystal will tend to vibrate at some frequency intermediate is own and that of the column of air. By varying the pressure of the air column the reaction on the crystal is varied and hence the frequency of vibration of the crystal is also changed.

The changes in pressure in the air column I cause, in any suitable fashion, for example, by means of a vibrating diaphragm, vibrating in a predetermined fashion. However, if the crystal is not suitably mounted reflections in the pressure waves produced in the column of air may affect in any undesirable manner, the frequency of vibration of the crystal; and, in order to avoid these undesirable reflections I provide, according to my invention, means, in connection with the means for causing the pressure waves, for preventing these reflections and for conducting the pressure waves unidirectionally across a surface or surfaces of the crystal.

Further in accordance with this invention I provide means whereby pressure waves may be applied to crystal faces either in phase or in opposite phase relationship in order to assist and emphasize frequency change in the crystal.

In accordance with the practice of the United States Patent Office, the novel features of my invention are defined in the appended claims; however, my invention may best be understood, both as to its structure and method of operation, by referring to the accompanying drawing in which

Figure 1 is a diagrammatic cross-sectional showing of apparatus illustrating a new and improved method for varying the oscillation frequency of a piezo-electric crystal, and

Figure 1*a* is a cross-section view extending through the crystal and both electrodes of Figure 1 along the line *a*—*a*.

Figure 2 is another embodiment thereof wherein pressure waves of differing phase relationship are applied to surfaces of a crystal for varying its period of vibration.

Figure 2*b* is a cross-section view extending through the crystal and both electrodes of Figure 2 along the line *b*—*b*.

Turning to Figure 1, I have shown a crystal 2 mounted between two spaced members 4, 6 in a manner such that there are air gaps 8, 10 facing surfaces 12, 14 of the crystal. Air gaps or columns 8, 10 may be made equal for this particular arrangement and should be adjusted so as to have a frequency differing slightly from that of crystal 2. Preferably the resonance frequencies of the crystal and the air gaps should be different but their resonance curves should overlap when it is desired to make the crystal oscillation frequency most sensitive to air pressure.

The crystal may be supported in any suitable fashion; thus, it may be bevelled at its ends and supported by elements 16, 18 attached to rods 20, 22 which in turn are fixed to conduits 24, 26 attached in any suitable way to members 4, 6.

A diaphragm 28 is attached at one end in any suitable fashion to conduit 24 and is

vibrated by electromagnet 30 which may be excited, for example, by speech frequency currents for frequency modulation of the crystal, or by some constant frequency current for varying or wobbling within predetermined limits the frequency of crystal 2.

It will be seen that vibration of the diaphragm 28 causes pressure vibrations in the media in contact with the surfaces 12, 14 of the crystal. In order to prevent reflection of these vibrations the conduit 26 is made in the form of an exponential horn so that the vibrations will be conducted over the surface of the crystal unidirectionally thereby preventing reflection and its concomitant ill effects.

In the absence of exciting currents for vibrating diaphragm 28 the crystal will vibrate at some frequency intermediate its own natural frequency and that of the columns of air. The amount with which the frequency of the crystal will be modified by the use of the air gaps will depend upon the reaction of the air in the gap upon the crystal. Hence, it will be seen, by varying the pressure of the air in the gaps the reaction can be varied and hence the crystal frequency will be varied in a predetermined fashion, according to the vibration of diaphragm 28. In this manner a crystal disposed so as to have constant dimensional media contacting with at least one of its faces, is made to have its period of vibration varied according to the stiffness or pressure of the media.

The electrical connections between the faces 12, 14 of the crystal, and the electrical circuits with which the crystal is used, are made through the dielectric capacity of the air gaps. Thus the air gaps form series condensers which readily pass electrical currents of the frequencies corresponding to the oscillating frequencies of the crystal. If desired, the crystal may, by means of electrodes 4 and 6 and conductors 50 and 52, be connected to a suitable source of high frequency for modulating purposes.

In Figure 2 I have shown apparatus for unidirectionally passing over a crystal, pressure waves differing in phase. Within a conduit 32 I mount a crystal 34 supported in a similar manner to that shown in Figure 1, at its front and rear faces. Conduit 32 is closed off by a member 36 and between 36 and the crystal 34 there is placed, as shown, a piston 38 vibratable or oscillatable in any desired fashion by means of rod 40. Conduit 26 in Figure 2 is also exponential in form in order to carry pressure waves unidirectionally over the surfaces of crystal 34 thereby preventing reflection.

In this case, however, the columns 42, 44 of media contacting with faces 46, 48 of crystal 34, have different dimensions. Column 42 is made to have a natural period of oscillation a little longer than the natural period of oscillation of crystal 34; whereas, column 44 is given a natural period of oscillation a little less than that of crystal 34.

The differences in dimensions of the columns or gaps of air contacting with the crystal, are necessary because of the phase relationship of the pressure waves applied thereto. Thus, for a given movement of piston 38 the pressure waves on faces 48, 46 will be opposite in phase, for example, if there is a compression wave on 48 there is a rarefaction wave on 46.

By the choice of columns having natural tunings on opposite sides of the natural crystal tuning, the effect of pressure waves for changing the frequency of the crystal by the movement of 38 is emphasized; whereas, if the natural frequencies of the gaps were taken on one side of the crystal frequency, say, both less than the crystal frequency, then the effect of the compression and rarefaction waves would be to neutralize each other and have little or no effect on the crystal frequency.

The rod 40 may, for example, be moved by means of an electromagnet or by suitably attaching it to a loud speaking telephone unit 70. It is to be distinctly understood, of course, that this invention is not limited to the apparatus 70 as shown in the drawing since any suitable equipment for moving rod 40 may be utilized.

The apparatus shown in Figure 2 is as well adapted for use as the apparatus in Figure 1 for either frequency wobbling or for frequency modulation. In Figure 2 also it is clear that, as in Figure 1, the dimensions of the columns of media contacting with surfaces of the crystal are not varied to cause changes in the crystal frequency; but, the stiffness or pressure of the media is varied to cause the desired frequency change.

Many changes may obviously be made from the apparatus as shown in the drawings; and hence, I do not intend to be limited thereby, but solely by the width of the appended claims.

Having thus described my invention, what I claim is:

1. The method of varying the natural frequency at which a piezo-electric crystal vibrates in order to obtain frequency modulated energy which includes continuously varying the pressure of the medium surrounding the crystal in accordance with signal modulated energy.

2. The method of varying the natural frequency at which a piezo-electric crystal vibrates in order to obtain frequency modulated energy which includes continuously varying the pressure of the air surrounding the crystal in accordance with signal modulated energy.

3. The method of varying the natural frequency at which a piezo-electric crystal vi-

brates in order to obtain frequency modulated energy which includes continuously varying the pressure of an air column on one side of the crystal in accordance with signal modulated energy.

4. The method of varying the natural frequency at which a piezo-electric crystal vibrates in order to obtain frequency modulated energy which includes continuously varying the pressure applied to a gaseous medium contacting with the crystal in accordance with signal modulated energy.

5. In combination, a crystal disposed so as to have a gap over one of its faces and means for varying the pressure of the media within the gap without altering the dimensions of the gap.

6. A crystal having an air gap over one of its faces, and means for varying the pressure of the air in the gap without changing the dimensions of the gap.

7. The method of varying the natural frequency at which a crystal vibrates in apparatus wherein the crystal is mounted between gaps of constant dimensions, which includes subjecting the media in the gaps to pressure waves.

8. The method of varying the natural frequency at which a crystal vibrates in order to obtain frequency modulated energy which includes continuously passing pressure waves unidirectionally over the crystal in accordance with signal modulated energy.

9. In combination, a crystal, means for generating pressure waves and means for causing the generated waves to pass unidirectionally over the crystal in order to vary the natural frequency at which the crystal vibrates.

10. In combination, a crystal, means for producing pressure waves in the media around the crystal and means for conducting the waves through the media and over the crystal without reflection.

11. Apparatus for varying in a predetermined fashion the frequency of vibration of an oscillator comprising a crystal, means for mounting the crystal so that the crystal has air columns over a plurality of its faces, the air columns having natural frequencies differing slightly from the natural frequency of the crystal, and means for varying the pressure of the air columns without changing their dimensions, thereby altering the frequency of vibration of the crystal.

CLARENCE W. HANSELL.