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D. GRIMES

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SELECTIVE RADIORECEIVER

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Fig. 1

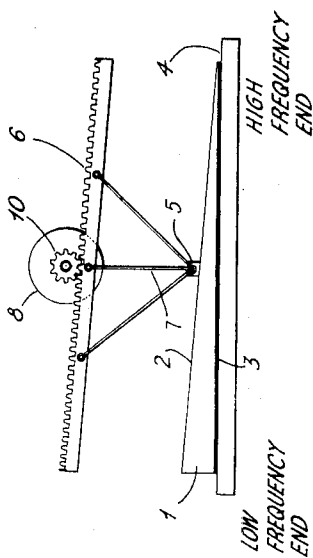


Fig. 2

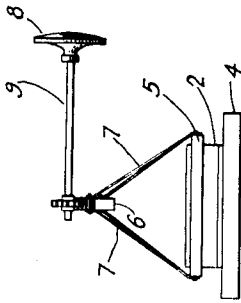
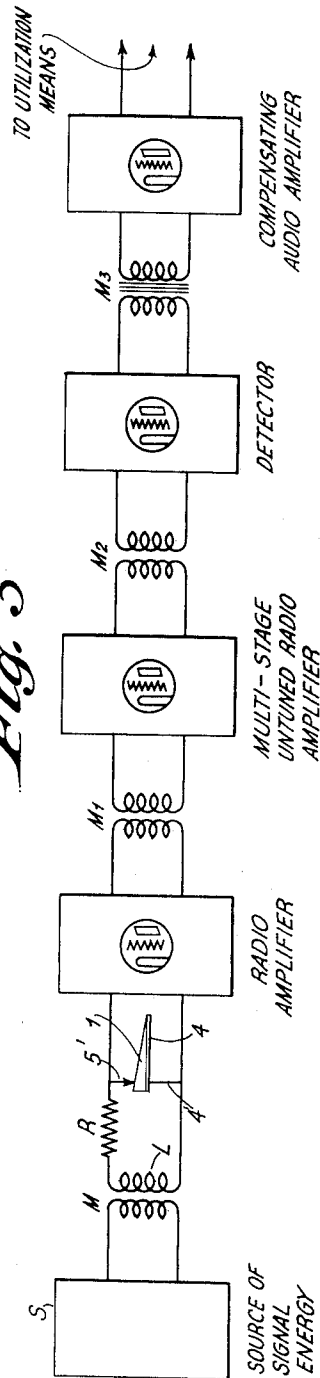


Fig. 3



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## UNITED STATES PATENT OFFICE

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## SELECTIVE RADIORECEIVER

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7 Claims. (Cl. 250—40)

My present invention relates to radio receivers, and more particularly to a method of, and means for, securing a high degree of selectivity in a radio receiver.

5 Various devices are resorted to at the present time in order to secure maximum selectivity in a radio receiver. For example, in a receiver employing multi-stage tuned radio frequency amplification it is customary to employ several tunable  
10 circuits in cascade prior to the detector stage. The variable condensers of these stages are arranged for uni-control by usually employing a gang condenser. As is well known to those skilled in the art, the use of a gang condenser requires  
15 careful matching of the condenser units of the gang, as well as matching of the cascaded radio frequency circuits. The prior art contains many examples of different arrangements which have been resorted to for accomplishing such match-  
20 ing.

However, the use of a plurality of cascaded tuned radio frequency circuits, which circuits are carefully matched as to tuning devices, does not necessarily result in a receiver of a high degree  
25 of selectivity. It is a well known fact that there is a practical limit beyond which further cascading of tuned circuits will result in additional selectivity only at excessive cost. Accordingly, the superheterodyne type of radio receiver is often  
30 employed in place of the tuned radio frequency receiver. It is well known that the superheterodyne receiver is inherently selective to a high degree.

Nevertheless, when it is desired to achieve uni-  
35 control tuning of the local oscillator, radio frequency and frequency changing circuits, it is a well known fact that recourse must be had to devices which are often troublesome in use and embodiment in the receiver. In any case,  
40 whether the receiver be of the superheterodyne or tuned radio frequency type, it is necessary to employ a gang condenser and careful matching of a plurality of high frequency stages.

Now, I have discovered a novel method of, and  
45 devised simple means for, operating a radio receiver so that it possesses a relatively high degree of selectivity. Simultaneously, my present method of reception utilizes but a single tunable stage, readily adjustable through a range of frequencies, which gives all the selectivity necessary  
50 in a radio receiver, and avoids matching of any tuning devices and cascaded circuits. Briefly, advantage is taken of the well known frequency selective characteristic of a piezo-electric crystal  
55 in securing the aforementioned results. Further-

more, my present receiver tuning device utilizes a phenomenon peculiar to an especially designed piezo-electric crystal. That is to say, I have observed that a piezo-electric crystal of variable  
5 thickness has a variable frequency selection characteristic.

Accordingly, it may be stated that it is one of the main objects of my present invention to provide a high frequency receiving system comprising a plurality of high frequency amplifier  
10 circuits, a single variable tuning device being utilized in advance of the amplifier device for imparting to the receiver sufficient selectivity necessary to receive signals transmitted through a predetermined range of frequencies.  
15

Another important object of the present invention is to provide in a radio receiver, embodying a plurality of radio frequency amplifier stages, a variable tuning device which avoids the  
20 necessity for the utilization of gang condensers and matching of cascaded circuits, the tuning device essentially comprising a piezo-electric element designed in such a manner that it may be adjusted to resonate at a plurality of different  
25 frequencies in a desired range of frequencies.

Another object of the present invention is to provide a piezo-electric device, particularly adapted for tuning resonant high frequency circuits to different frequencies in a desired range of  
30 high frequencies, the device comprising a crystal having at least one face thereof disposed at a predetermined pitch with respect to its other face, and an adjustable electrode movably associated with said first face.

And still another object of the present invention is to provide a tuning means for a radio receiver comprising a piezo-electric crystal of constantly varying thickness, and an electrode so  
35 designed and arranged with respect to one of the faces of the crystal that displacement of said electrode produces a corresponding, and predetermined, frequency change in the tuning means.  
40

Still other objects of the invention are to improve generally the simplicity and efficiency of high frequency signalling systems, and to particularly provide a tuning means for a radio receiver which is not only selective and reliable in operation, but economically manufactured and assembled in the receiver.  
50

The novel features which I believe to be characteristic of my invention are set forth in particularity in the appended claims, the invention itself, however, as to both its organization and method of operation will best be understood by  
55

reference to the following description taken in connection with the drawing in which I have indicated diagrammatically one circuit arrangement whereby my invention may be carried into effect.

In the drawing,

Fig. 1 is a schematic side elevation of the tuning means embodying the present invention,

Fig. 2 is a front elevation of the device shown in Fig. 1,

Fig. 3 diagrammatically shows a radio receiver embodying the present invention.

Referring now to the accompanying drawing wherein like reference characters designate the same elements in the different figures, there is shown in Figs. 1 and 2 a tuning device constructed according to the principles of the present invention. The piezo-electric element 1 varies from the design of a normal crystal of uniform thickness in that one of its faces 2 is inclined with respect to a lower face 3. That is to say, the crystal 1, which for example, may be a quartz crystal, is produced by treating the face 2 of a normal crystal of uniform thickness in such a manner that a crystal of constantly varying thickness is produced. Thus, the face 2 may be designed to have the desired pitch with respect to the face 3 by a grinding operation. Obviously, the means employed for securing the tapered crystal is of no consequence as far as the characteristic of the crystal is concerned. It is sufficient that a crystal of constantly varying thickness is produced. Those skilled in the prior art are, of course, well acquainted with the method of producing a normal crystal of uniform thickness.

The face 3 of the crystal is allowed to rest on a bottom plate 4, the latter functioning as the fixed electrode of the crystal. For the upper electrode of the crystal there is utilized a mobile contactor 5, the latter preferably consisting of the same metallic material as the plate 4. It will be noted that the contactor 5 is disposed in sliding contact with the inclined crystal face 2, and that it comprises in fact a thin strip of metal having a length greater than the breadth of the crystal 2.

The contactor 5 may be arranged for sliding movement over the crystal face 2 by securing it to a moving rack 6. The securing means between the electrode 5 and the rack 6 may comprise any means well known to those skilled in the art, as for example three metallic, rigid members 7. A manipulating knob 8 provided with a shaft 9 and pinion 10 may be employed for driving the rack 6. It is to be understood, however, that any other desired driving means may be employed for adjusting the position of the mobile electrode 5 with respect to the crystal face 2.

When the device shown in Fig. 1 is employed as a tuning means for a resonant circuit, the end of the crystal 1 which has the minimum thickness comprises the high frequency end of the tuning device, while the opposite end, that of maximum thickness, constitutes the low frequency end of the tuner.

In Fig. 3 there is schematically shown a signalling system, such as a radio receiver, which is arranged for utilizing the device shown in Figs. 1 and 2 as a frequency selector. Thus, the receiver comprises a source of signal energy S which is coupled, as at M, to the resonant input circuit of a stage of radio frequency amplification conventionally represented. The signal energy source is preferably the usual antenna circuit for collecting signal energy of all frequencies,

or it may even comprise a preceding stage of untuned radio frequency amplification coupled to a prior antenna system for amplifying the collected signal energy prior to frequency selection in the tuned stage. The tuned stage comprises the inductance coil L and the piezo-electric tuning device arranged in shunt therewith.

There is inserted a high ohmic resistance R (preferably around 500,000 ohms) between coil L and the crystal in Fig. 3. This is necessary to enable the crystal to tune in the desired signal and reject the undesired ones. In such a circuit the crystal itself is acting as a complete tuned anti-resonance circuit such as we have when using a coil and condenser. The resistance R has a negligible effect at the resonance frequency of the crystal so that the entire voltage of coil L is available to the input grid of the succeeding amplifier. However, off resonance, the impedance of the crystal drops and the voltage of the coil L is greatly reduced by the resistance R so that the off-resonance signals have no appreciable magnitude when they reach the grid of the amplifier.

The tuning device is shown in a simplified manner, the tapered crystal 1 being shown mounted upon the bottom electrode 4, the arrow 5' corresponding to the adjustable contactor 5. A lead 4' connects the bottom electrode 4 to the low potential side of the coil L. The piezo-electric tuner is arranged in the input circuit of a radio amplification stage, as pointed out above, and it is to be understood that the amplifier may comprise any type of electron discharge tube well known to those skilled in the art, the amplified output of the amplifier being impressed as at M<sub>1</sub>, upon the input circuit of a multi-stage untuned radio frequency amplifier. Of course, a single untuned radio stage can follow the tuned radio amplifier if desired.

Any well known type of detector circuit may have its input coupled, as at M<sub>2</sub> to the output of the untuned radio amplifier, the detected output being impressed upon the input, as at M<sub>3</sub>, of an audio frequency amplifier. The latter may comprise one or more stages of amplification. Any well known type of utilization means may be coupled to the output of the audio amplifier, and such utilization means may comprise a loud speaker, head phones or any other desired type of reproducing means for electrically transmitted intelligence. For a reason to be described in further detail at a later point, the audio amplifier is preferably given a rising frequency characteristic. That is to say, a compensating audio amplifier is employed, the amplifier transmitting the higher audio frequencies to a greater extent than the lower audio frequencies.

Considering, now, the operation of the signalling system shown in Fig. 3, and particularly the functioning of the tuning device disclosed therein, it is pointed out that it is merely necessary to move the electrode 5' of the inclined face 2 of the piezo-electric crystal in order to vary the frequency setting of the receiver. As stated above, the present tuning device applies a phenomenon observed in piezo-electric devices. The phenomenon, without entering into detailed theoretical discussion, involves the fact that a tapered piezo-electric crystal having its inclined face free and accessible, and its other face mounted on an extended electrode, is capable of resonating at a plurality of different frequencies throughout a predetermined range of frequencies, as an electrode, comprising a narrow

strip compared to the bottom electrode, is moved along the inclined face of the crystal, and in sliding contact therewith.

In other words, after calibration of the tuning device, a definite position of the electrode 5 along the face 2 corresponds to a predetermined frequency. It is sufficient to point out at this time that the frequency at which a piezo-electric crystal resonates is inversely related to the thickness of the crystal, it being understood of course that the crystal portion whose thickness is under consideration is disposed between a pair of electrodes. Thus, it will be seen that moving the electrode 5 towards the thicker end of the crystal 1 results in resonating the crystal to a relatively low frequency compared with the frequency to which the less thicker portions of the crystal are resonant.

It will now be realized that adjustment of the electrode 5' in Fig. 3 results in frequency selection, since only electrical energy of a frequency corresponding to the frequency setting of the member 5' will be transmitted between the source S and the first stage of radio frequency amplification. It is well known to those skilled in the art that a piezo-electric crystal coupling circuit between a source of signal energy of a group of frequencies and a radio amplifier will transmit only such energy which has a frequency substantially equal to the frequency of the coupling circuit. That is to say, the single tuned stage in Fig. 3 is sharply selective, and as a matter of fact would be so selective as to give all the selectivity necessary in a radio receiver.

Furthermore, the tuned stage is a variable one, and hence avoids matching of any tuning devices and cascaded circuits, since the succeeding amplifier stage, or stages, are untuned. It is obvious that the crystal 1, and its electrodes 4 and 5, as well as the motion of the manipulating knob 8 may be so designed that frequency selection through any predetermined range of frequencies may be effected.

To compensate for the sharp cut-off characteristic of the piezo-electric crystal 1 at the higher side band frequencies, a compensating audio frequency amplifier may be employed. The latter may be employed in order to preserve fidelity since the crystal tuning device is sharply selective and tends to produce a sharp, peaked resonance curve. That is to say, the upper side band frequencies on each side of the accepted carrier are transmitted through the crystal with less efficiency than the lower side band frequencies. Hence, by employing an audio amplifier which has a rising frequency characteristic, that is one which amplifies the higher audio frequencies to a greater extent than the lower audio frequencies, the sharp cut-off characteristic of the piezo-electric tuner is compensated for.

While I have indicated and described one arrangement for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organizations shown and described, but that many modifications may be made without departing from the scope of my invention as set forth in the appended claims.

What I claim is:

1. A tuning device comprising a piezo-electric crystal of varying thickness, an electrode affixed to a face thereof, and a second electrode in contact with another face of the crystal, and means for adjusting the position of the second electrode with respect to said second face by displacing the second electrode along different elemental areas of the face of the crystal.

2. A tuning device comprising a piezo-electric crystal of constantly varying thickness, an electrode affixed to a face thereof, and a second electrode in contact with another face of the crystal, and means for adjusting the position of the second electrode with respect to said second face by displacing the second electrode along different elemental areas of the face of the crystal.

3. A tuning device comprising a tapered piezo-electric crystal, an electrode affixed to a face thereof, and a second electrode in contact with another face of the crystal, and means for adjusting the position of the second electrode with respect to said second face by displacing the second electrode along different elemental areas of the face of the crystal.

4. In combination, a piezo-electric crystal having one face thereof disposed at an incline with respect to another face, a metallic electrode adjacent to the non-inclined face, and an adjustable electrode, comprising a narrow metallic strip, in sliding contact with said inclined face.

5. In a signalling system including an electronic tube provided with output terminals and input terminals, an input circuit for said tube including a piezo-electric crystal connected across the input electrodes of the tube and a high impedance element, said crystal having one face thereof inclined with respect to another face, a metallic electrode adjacent to the non-inclined face and an adjustable electrode comprising a narrow metallic strip in sliding contact with the inclined face, said two electrodes being arranged so as to connect the crystal across said input terminals.

6. In combination a piezo-electric crystal having one face thereof disposed at an incline with respect to another face thereof, an electrode adjacent to one of said faces and an adjustable electrode in the form of a narrow strip as compared with the crystal in sliding contact with said inclined face and means for varying the position of the adjustable electrode along the inclined face of the crystal.

7. In a signalling system including an electronic tube provided with output and input electrodes, an input circuit for said tube including a piezo-electric crystal connected across the input electrodes of the tube said crystal having one face thereof ground at an angle with respect to the opposite face thereof, electrodes for each of the said two crystal faces for connecting the crystal in said input circuit, means for adjusting one of said electrodes with respect to its associated crystal face by displacing the last named electrode along different elemental areas of the associated face of the crystal to thereby tune the input circuit of the tube.

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