April 29, 1941. DE WITT R. GODDARD 2,240,293

PIEZOELECTRIC FILTER

Filed March 23, 1938

Fig. 1

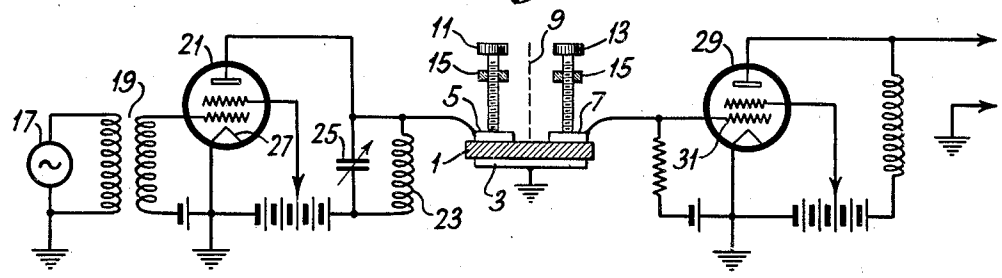


Fig. 2

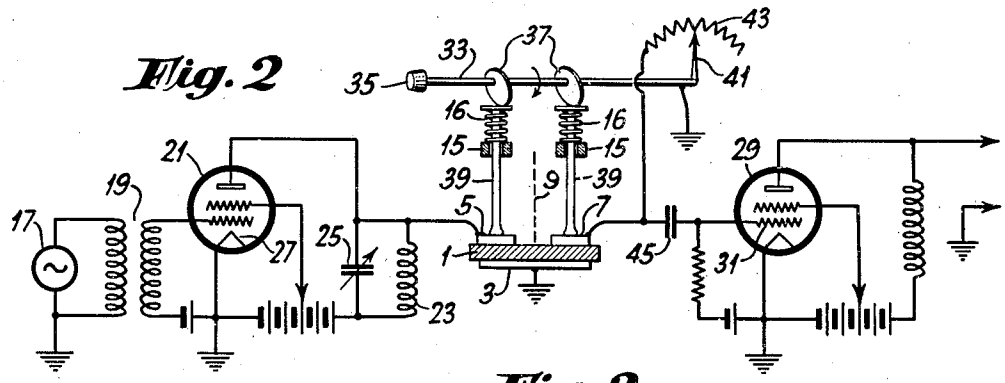
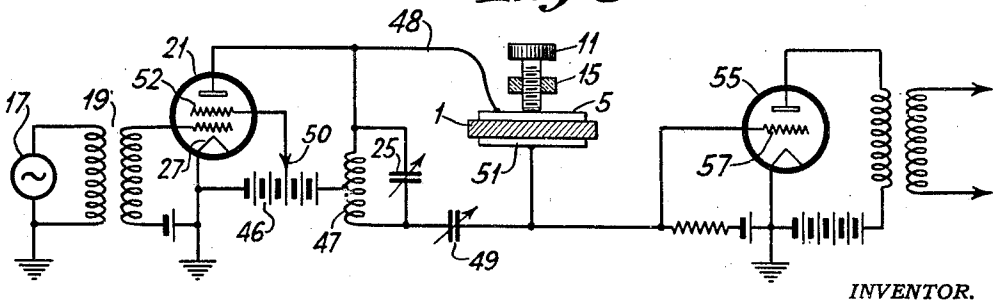


Fig. 3



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PIEZOELECTRIC FILTER

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11 Claims. (Cl. 178—44)

This invention relates to piezoelectric filters and has particular utility in filter systems as used generally in radio apparatus.

Piezoelectric filters as used in the past have been so designed that their resonance curves are very sharp giving an extremely narrow band filter. For some purposes the band thus obtained is too narrow. Accordingly, it is one of the objects of my invention to broaden this resonance curve, thereby making the filter available for more extended use.

Another object of my invention is to provide a piezoelectric filter system of adjustable band width.

My invention will now be described in more detail, reference being made to the accompanying drawing, in which

Figure 1 shows a circuit diagram which will be referred to in explanation of the basic principles of my novel filter system;

Fig. 2 illustrates an embodiment in which a common control is provided both for the electrodes of a piezoelectric device and for the adjustment of a rheostat for grounding one of the circuits through a suitable impedance; and

Fig. 3 illustrates an alternative embodiment of the invention.

Referring first to Fig. 1, I show a conventional type of piezoelectric crystal filter in which neutralization is unnecessary due to the shielded construction of the three-electrode crystal holder. The crystal itself is shown at 1 having a single grounded electrode 3 which may comprise a metallic part of the crystal holder, and two opposed electrodes 5 and 7 which are separated by an electrostatic shield 9, this shield being a part of the crystal holder (not otherwise shown). In order to obtain optimum sharpness of resonance, the crystal and the circuit feeding it should have approximately the same impedance. Now, I have found that by pressing the electrodes down upon the crystal, either with weights or springs or in any other suitable manner, the resonance curve of the crystal is broadened, and if the crystal is fed from a high impedance source, that is, say, from a tuned circuit, the width of the resonance curve may be varied over a range of width wherein the maximum width may be as much as twenty times the minimum width.

The adjustment of electrode pressure on the crystal 1 may be made independently with respect to the electrodes 5 and 7, if desired, by manipulating the two screws 11 and 13 which may be mounted in insulated portions of the crystal holder shown at 15. The input circuit to the crystal electrodes 3 and 5 may, if desired, include a source of alternating current energy or signals 17 feeding through a transformer 19 to an electron discharge tube 21, the output circuit of which comprises a resonant section consisting of an inductance 23 in parallel with a capacitor 25. The cathode 27 of the tube 21 is grounded, as is the crystal electrode 3. On the output side of the crystal filter there is shown an amplifier or detector stage comprising an electron discharge tube 29 whose input circuit includes a control grid 31 directly connected to the crystal electrode 7. The other details of the circuit shown in Fig. 1 may be considered conventional and need not, therefore, be described.

In the prior art difficulties have been encountered when the electrode pressure is varied due to the fact that a resulting variation in the voltage available from the crystal also occurs. In order to overcome this difficulty I have provided a unit control device as shown in Fig. 2 comprising a shaft 33 having a control knob 35. On the shaft 33 two cams 37 are mounted in position to be engaged with the heads of certain plunger rods 39 which are respectively employed for supporting and adjusting the electrodes 5 and 7. In order to maintain the plunger rods 39 in engagement with the peripheries of the cams 37 coiled springs 16 may be placed under the plunger heads and over the support of the insulation members 15. The control shaft 33 also has mounted thereon a contactor arm 41 which is part of a rheostat having a resistor 43.

The circuit details of Fig. 2 are substantially identical to those of Fig. 1 and hence need not be further described at this point, except that I have shown in Fig. 2 the addition of the rheostat 43 as a connection to the electrode 7 for grounding the same through a suitable impedance. There is also added a capacitor 45 between the crystal electrode 7 and the grid 31 of the tube 29.

In the operation of the embodiment as shown in Fig. 2 the potentiometer or rheostat 43 is adapted to maintain approximately constant voltage on the grid of the tube 29 despite the adjustment of the pressure on the electrodes 5 and 7. In other words, a voltage compensating device is provided by this construction which includes the unit control element 33—35.

The alternative circuit arrangement shown in Fig. 3 is one wherein I make use of a two-electrode piezoelectric element. The crystal 1 is here mounted in a crystal holder (not shown) where the opposing electrodes 5 and 51 are in contact with the crystal. Means are also provided in-

cluding a thumb screw 11 threaded through an insulation member 15 in the crystal holder for causing the electrodes to exert pressure on the crystal, this pressure being adjustable to vary the band width of the filter. A source 17 of radio frequency alternating current is fed through the transformer 19 to the input side of an electron discharge tube 21 constituting an amplifier. The output circuit of this amplifier includes an anode potential source 46 in circuit between the cathode 27 and a center tap on an inductance coil 47. The inductance coil 47 is in a parallel tuned circuit which also includes the adjustable capacitor 25. The adjustable tap 50 which may be connected at any suitable point intermediate the extreme terminals of the source 46 leads to the screen grid 52. From the plate circuit of this tube 21 a conductor 48 is connected to the electrode 5 of the piezoelectric element. The other electrode 51 is connected to the control grid 57 of an electron discharge tube 55 which may be either an amplifier or a detector stage. A capacitor 49 is made adjustable in order to provide suitable neutralization of the inter-electrode and crystal holder capacitance of the piezoelectric element. The capacitor 49 also isolates the grid 57 from the plate potential source 46.

The parallel tuned circuit 25—47 is tuned to the resonant frequency of the crystal. The leakage due to the electrostatic capacitance between the electrodes of the crystal holder is effectively neutralized by the means herein shown, particularly at the capacitor 49. In order to maintain a constant overall response of the system shown in Fig. 3 for various adjustments of the crystal electrode pressure, it is, of course, to be understood that a suitable compensating voltage will be applied to the screen grid 52 in the tube 21.

I have found that one or another of the various embodiments of my invention is particularly useful in broadcast receivers for selecting a desired side band and for suppressing the other side band. The filter system may also be used for improving the response at the low frequency end of the audio scale of a single side band receiver.

Another use which has been found for my invention relates to side band selectivity in phase modulation receivers. A similar use is to be found in single side band transmission for enabling the transmitter to more completely isolate one set of side bands.

Various other uses of my invention will suggest themselves to those skilled in the art as, for example, where it is desired to provide automatic tuning control for narrow band telegraph channels and radiophone receivers. My invention is, therefore, to be considered as having all the breadth which the scope of the claims will permit.

I claim:

1. A filter system comprising a piezoelectric crystal mounted in a holder and compressed between its electrodes, a variably tuned input amplifier stage connected to one of said electrodes, a connection from a different one of said electrodes, namely, the output electrode, to a control grid in a subsequent electron discharge tube stage, means for varying the degree of compression of the electrodes against the crystal thereby to adjust the band width of the filter, and a device providing compensation for voltage variations in the output energy delivered by said crystal when subjected to different pressures, said device being mechanically coupled to said compression varying means.

2. A system in accordance with claim 1 in which said voltage compensating device comprises a rheotat connected between the second mentioned crystal electrode and ground.

3. A system in accordance with claim 1 and having an electrostatic shield interposed between the input and output crystal electrodes.

4. A filter system comprising a three-electrode piezoelectric device, having an electrostatic shield interposed between two of the electrodes which are presented to one crystal face and a single opposing electrode which is grounded, input and output circuit connections associated respectively with one and the other of the two electrodes first mentioned, a rheostat forming a leakage path to ground from said output circuit connection, and unit control means for simultaneously varying the degree of pressure of said electrodes against the crystal, and the impedance of said rheostat.

5. A system in accordance with claim 4 and comprising excentric cams mounted on a rotatable shaft of said unit control means and electrode pressure rods the heads of which are resiliently held in contact with the peripheries of said cams.

6. A filter system comprising a piezoelectric device mounted in a crystal holder and having input and output electrodes, means for impressing on said input electrode alternating currents of different frequencies extending over a wider band than that which said filter system is adapted to pass, electrode - pressure - exerting means for varying the band width of said filter system, compensating means for limiting the output voltage delivered by said piezoelectric device, and means for neutralizing the crystal holder capacitance.

7. In a piezoelectric filter system having adjustable input and output crystal electrodes, the method of varying the band pass width which comprises the steps of varying the pressure applied by said electrodes against the faces of the crystal, and simultaneously providing voltage compensation in respect to the output energy delivered by the piezoelectric element of said system.

8. A piezoelectric filter system having means for variably adjusting its band pass width, said means including mechanical devices for varying the pressure of the crystal electrodes upon the crystal element means connected to the output side of said filter for variably adjusting the voltage of the output energy, and manipulatable control means common to said electrode pressure varying means and to said voltage varying means.

9. A piezoelectric filter system comprising an input circuit, an output circuit, circuit means comprising a piezoelectric device having one electrode disposed against one face of the crystal element and two electrodes disposed against the opposite face of said element, the two electrodes last mentioned being individually connected to the input and output circuits respectively, an electrostatic shield interposed between the two electrodes last mentioned, and means for adjusting the band width of said system, said means comprising manually adjustable devices for varying the pressures of said electrodes against the crystal element.

10. A piezoelectric filter comprising an input circuit, an output circuit, a three-electrode piezoelectric device having one grounded electrode, a

second electrode connected to the input circuit, and a third electrode connected to the output circuit, and adjustable means for varying the pressures of the second and third electrodes upon the crystal, said adjustable means being operable to vary the band pass width of said filter.

11. A filter in accordance with claim 10 and having means including a potentiometer connected to said output circuit for introducing voltage compensation into the output energy derived from said filter.

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