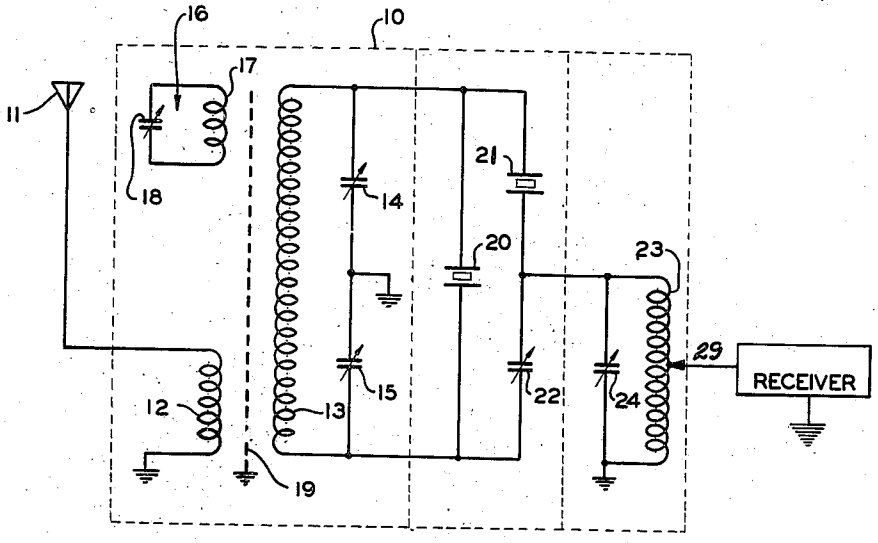
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CRYSTAL FILTER CIRCUIT

Filed March 14, 1945

FIG. 1



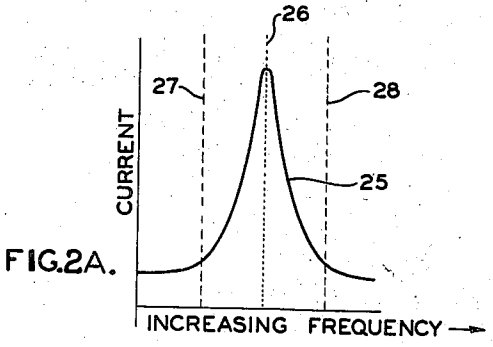




FIG.2A.

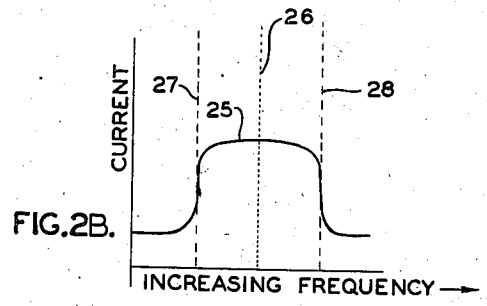



FIG.2B.

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## CRYSTAL FILTER CIRCUIT

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3 Claims. (Cl. 250—20)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment to us of any royalty thereon.

The present invention relates generally to electromagnetic-wave filter circuits, and more particularly to filter circuits, incorporating piezoelectric crystals, adapted to suppress strong interfering signals and reduce noise level when installed in conjunction with a radio receiver.

It is well known that interference due to atmospheric conditions or man made static is caused by waves of highly damped form which, therefore, are not restricted to any definite or particular frequency. The elimination of such disturbances in a receiver by the utilization of a simple filter tuned to a particular frequency is difficult, if not impossible, to effect. Such means, while eliminating a certain definite frequency from the incoming signal energy, are not capable of effectively handling the band of frequencies which is present incident to the damped nature of the interfering energy. Moreover, standard filter means are unable to suppress a closely adjacent, stray or disturbing frequency, especially where the value of interfering frequency is such that it lies within the band width of the resonance curve of the receiver selector circuit.

Where a high Q, narrow-pass, crystal filter circuit is employed as a solution to the above-described difficulty a new problem arises. By reason of the steep selectivity characteristic of these circuits, there results a cutting off of a portion of the side bands of the desired signal as well as discrimination against unwanted and interfering signals. Thus, while interference is thereby reduced, the intelligibility of the desired signal is impaired.

Accordingly, it is the principal object of this invention to provide a crystal filter arrangement to be used in combination with a radio receiver having a resonant input circuit tuned to a desired signal whereby a strong interfering signal is suppressed, noise level is reduced, and the desired incoming signal is passed without cutting off a portion of the side bands thereof.

It is another object of this invention to provide a crystal filter arrangement of the above-mentioned type wherein the width of the band accommodating the side bands of the desired signal may be adjustably shaped.

Briefly stated, the objects of the invention are attained by the use of a circuit entailing a first crystal arranged to reject a strong interfering

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signal, a wave trap for absorbing noise energy, and a second crystal adapted to pass the desired frequency in association with a band spreading network for controlling the Q of said second crystal and thereby the band-pass width thereof.

For a better understanding of the present invention, as well as further objects and features thereof, reference is made to the ensuing description to be read in connection with the annexed drawing. The scope of the invention will be pointed out in the accompanying claims.

In the drawing: Figure 1 schematically illustrates a preferred embodiment of a crystal filter arrangement in accordance with the invention; and Figure 2*a* shows the band-pass curve secured with a high Q crystal filter circuit, while Figure 2*b* shows the curve then obtained by the use of a band spreading network in combination with said high Q crystal circuit.

Referring now to the drawing, and more particularly to Figure 1, there is shown a crystal filter arrangement completely enclosed in a metallic shield box 10 having three compartments. The receiving antenna 11 is connected to one side of the primary winding 12 of a radio frequency transformer, the other side thereof being grounded. Inductively coupled to the primary winding 12 of the transformer is a secondary winding 13 which is balanced to ground through a pair of condensers 14 and 15. Also inductively coupled to the primary winding 12 is a wave trap 16 consisting of an inductor 17 and a variable condenser 18. Electrostatically shielding primary winding 12 and inductor 17 from secondary winding 13 is a Faraday screen 19 serving to prevent stray capacitative coupling between these elements and thereby tending to eliminate high frequency disturbances, said screen however having no effect on the inductive coupling therebetween.

Shunted across secondary winding 13 is a first quartz crystal 20. Also provided is a second quartz crystal 21 connected in series with a variable condenser 22, the series combination being shunted across the secondary winding 13. The juncture of crystal 21 and condenser 22 is connected to one side of a band spreading network consisting of an inductor 23 in parallel with a variable capacitor 24, the other side of said network being grounded. The antenna terminal of the receiver is connected to an adjustable tap 29 on inductor 23, so that the input impedance of the receiver, which is principally resistance, is connected across a portion of inductor 23.

The dimensions of crystal 21 are such that it is

resonant to the desired incoming frequency. That portion of the circuit comprising secondary winding 13, variable condensers 14 and 15, crystal 21 and variable condenser 22 behaves as a bridge arrangement. Variable condenser 22 serves as a phasing condenser which has a maximum capacity somewhat higher than the capacity of the crystal 21 in its holder. In operation, secondary winding 13 is tuned by condensers 14 and 15 so that resonance with the desired incoming signal is obtained. When phasing condenser 22 is set to balance the crystal-holder capacity, the resonance curve of the crystal circuit is substantially symmetrical; the crystal 21 acts as a series resonant circuit of very high Q and thus introduces a low impedance path to signals of the desired frequency. Without phasing condenser 22, the capacity of the crystal-holder (with the crystal 21 acting as the dielectric) would by-pass signals of undesired frequency to the output circuit.

Crystal 20 is dimensioned so that it is resonant to a strong interfering frequency which may be closely adjacent to the desired frequency, and it functions to cancel out or absorb the undesired signal.

Wave trap 16 is tuned so that it is resonant to a frequency about 10 or more kilocycles removed from the desired signal, the wave trap serving to absorb noise energy and interfering signals.

Because of the high Q of the crystal filter circuit, its selectivity characteristic is extremely sharp as shown in Figure 2*a* wherein curve 25 is obtained by plotting the current against frequency in the series-resonant circuit presented by crystal 21. Dotted line 26 represents the point of resonance and the carrier frequency of the desired signal while dashed lines 27 and 28 indicate the side band limits of the incoming signal. It will be seen that the side bands of the incoming signal are largely cut off, hence a circuit of this characteristic would be unsuitable for reception.

The band spreading network when tuned to parallel resonance presents an extremely high impedance path in series with the crystal circuit and the receiver with a consequent reduction in Q of the filter circuit and a broadening of the selectivity curve. The connection to tap 29 introduces in a varying degree the input impedance of the receiver into the band spreading network. This impedance is principally resistive. Any reactive component of this impedance combines with the reactances of the band spreading network. It may be desirable to detune the band spreading network slightly from resonance. Condenser 24 and adjustable tap 29 are adjusted so that the selectivity curve is spread to a width just sufficient to accommodate the desired incoming signal, as shown roughly in Figure 2*b*. In this manner the desired incoming signal is received without distortion while all other signals and noise are greatly attenuated.

In practice, windings 12 and 13 and inductors 17 and 23 may be multi-tapped and a number of different plug-in crystals 20 and 21 may be provided, thereby permitting the crystal filter circuit to be used effectively at any one of a plurality of desired incoming frequencies.

While there has been described what is at present considered a preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims, to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. In combination with an antenna and a radio receiver having an input circuit, a filter comprising a first crystal circuit, resonant to an undesired signal frequency, interconnected between the antenna and receiver in a manner whereby said interfering signal is absorbed, a second crystal circuit resonant to a desired incoming frequency and interconnected between the antenna and receiver in a manner presenting a low impedance path solely to the desired signal, and an inductance-capacitance parallel resonant network across the output of said second crystal circuit, and means connecting the input circuit of said receiver across a portion of said resonant network whereby the selectivity of said second crystal circuit is adjusted to pass to the receiver the desired signal carrier and side bands only.

2. In combination with an antenna and a radio receiver having an input circuit, a filter comprising an inductor, capacitative means for balancing said inductor to ground and tuning same to a desired incoming frequency, means for applying energy from the antenna to said inductor, a first crystal resonant to an undesired signal frequency shunted across said inductor, a second crystal resonant to the desired incoming frequency, a capacitor in series with said second crystal, the series combination being shunted across said inductor, said capacitor having a value such as to neutralize the off resonance capacitance of said second crystal, an inductance-capacitance parallel resonant network connected between the juncture of said series combination and ground, and means connecting the input circuit of said receiver across a portion of said resonant network whereby the effective Q of said second crystal is lowered and there is provided a path passing only the incoming carrier and the side bands thereof.

3. In combination with an antenna and a radio receiver having an input circuit, a filter comprising a radio frequency transformer having its primary winding connected to the antenna, capacitative means for balancing the secondary winding of said transformer to ground and tuning same to the desired incoming frequency, a first inductance-capacitance parallel network inductively coupled to said transformer and resonant to a frequency adjacent to the desired incoming frequency, a Faraday screen shielding said secondary winding from said primary winding and said first inductance-capacitance network, a first crystal resonant to an undesired signal frequency shunted across said secondary winding, a second crystal resonant to the desired incoming frequency, a capacitor in series with said second crystal, the series combination being shunted across said secondary winding, said capacitor having a value such as to neutralize the off-resonance capacitance of said second crystal, and a second inductance-capacitance parallel resonant network connected between the juncture of said series combination and ground, and means connecting the input circuit of said receiver across a portion of said resonant network whereby the effective Q of said second crystal is lowered and there is provided a path passing only the incoming carrier and the side bands thereof.

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