

June 2, 1931.

I. F. BYRNES

1,808,524

ELECTRICAL APPARATUS

Filed July 19, 1927

Fig. 1

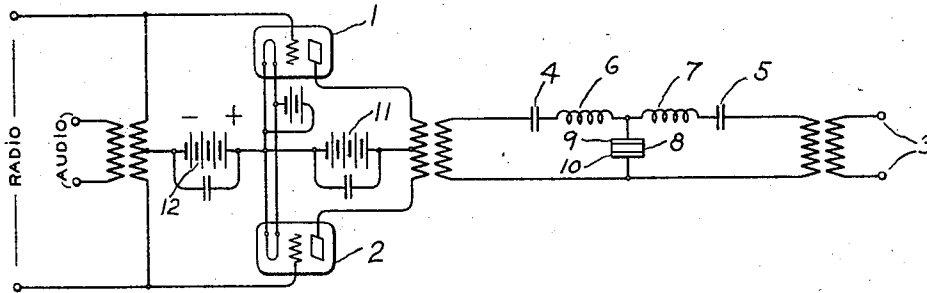


Fig. 2

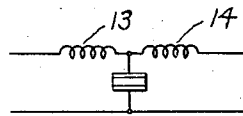


Fig. 3

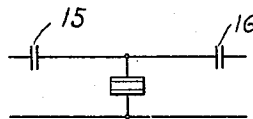
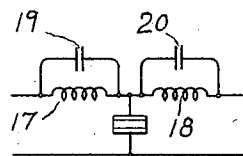


Fig. 4



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## UNITED STATES PATENT OFFICE

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## ELECTRICAL APPARATUS

Application filed July 19, 1927. Serial No. 206,968.

My invention relates to electrical apparatus comprising means for eliminating currents of undesired frequencies, and has for its principal object the provision of an improved wave filter which offers a high attenuation to currents of undesired frequencies, possesses sharp cutoff and operates with a high degree of efficiency.

Various types of wave filters comprising capacities and inductances interconnected with one another have been provided in the past. The operation of many of these filters involves considerable power losses and is unsatisfactory in other respects, such as the sharpness of the cutoff and the attenuation offered to the currents of the undesired frequencies. In accordance with my invention, these difficulties are avoided by the provision of a filter which comprises a piezo electric element such as a crystal of quartz or the like.

My invention will be better understood from the following description when considered in connection with the accompanying drawings and its scope will be pointed out in the appended claims.

Referring to the drawings, Fig. 1 shows a modulating system wherein my invention has been embodied; Fig. 2 shows a filter of the low frequency pass type; Fig. 3 shows a filter of the high frequency pass type; and Fig. 4 shows the application of my invention to a frequency band eliminator.

The system illustrated by Fig. 1 comprises a pair of balanced modulation devices which are connected between an audio frequency input circuit and an output circuit 3 through a frequency band pass filter which comprises series-connected capacities 4 and 5, series-connected inductances 6 and 7, and a shunt-connected piezo electric element including a crystal 8 and electrodes 9 and 10. Current is supplied to the plate circuits of the devices 1 and 2 from a source 11; and the negative grid bias potential required for proper operation of the devices 1 and 2 is applied to the input-circuit by a source 12.

The crystal 8 is a small block of quartz, or other suitable piezo electric material, pro-

vided with surfaces that are located in known relation to its optical and electrical axes. The free vibration of this crystal is determined for the most part by its mechanical dimensions. When subjected to an electrostatic field of a frequency corresponding to its free vibration period, the crystal exhibits the properties of a resonant circuit having extremely low losses. With the crystal 8 connected as illustrated in Fig. 1, currents of frequencies which correspond substantially to its free vibration period are excluded from the output circuit 3 and a sharp line of demarcation is readily maintained between the transmitted and excluded frequencies.

Figs. 2 to 4 illustrate the use of a piezo electric element in various types of filters. Thus Fig. 2 shows the use of the piezo electric element in a low frequency pass type of filter comprising series-connected inductances 13 and 14; Fig. 3 shows the use of the element in a high frequency pass type of filter comprising series-connected capacities 15 and 16; and Fig. 4 shows the use of the element in a frequency band eliminator type of filter comprising series-connected inductances 17 and 18 and capacities 19 and 20 which are connected in parallel with the inductances 17 and 18 respectively. In each embodiment of the invention, the piezo electric element is connected in shunt to the various other elements of the filter. Numerous tests have shown that a filter comprising a piezo electric element connected in this manner possesses the advantages of low loss, sharp cutoff and high attenuation for the frequencies which come within the range determined by the mechanical dimensions of the crystal.

The embodiment of the invention illustrated and described herein has been selected for the purpose of clearly setting forth the principles involved. It will be apparent, however, that the invention is susceptible of being modified to meet the different conditions encountered in its use and I therefore aim to cover by the appended claims all modifications within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. The combination of a circuit, means for energizing said circuit, and a filter comprising a pair of impedance devices connected in series with said circuit, and a piezo electric element which is connected in shunt to said circuit at a point intermediate said devices, said element having a free vibration period corresponding to the frequencies of the currents to be excluded from said circuit.

2. The combination of a circuit, a pair of inductances connected in series with said circuit and a piezo electric element connected in shunt to said circuit at a point intermediate said inductances, said element having a free vibration period corresponding to the frequencies of the currents which are to be excluded from said circuit.

3. The combination of a circuit, a pair of inductances and a pair of capacities connected in series with said circuit, and a piezo electric element connected in shunt to said circuit at a point intermediate said inductances, said element having a free vibration period corresponding to the frequencies of the currents which are to be excluded from said circuit.

In witness whereof, I have hereunto set my hand this 18th day of July, 1927.

IRVING F. BYRNES.

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