

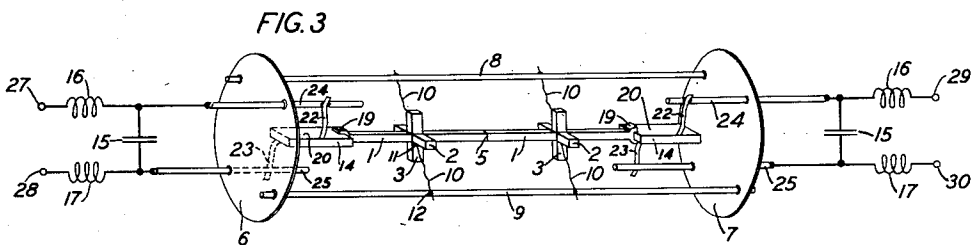
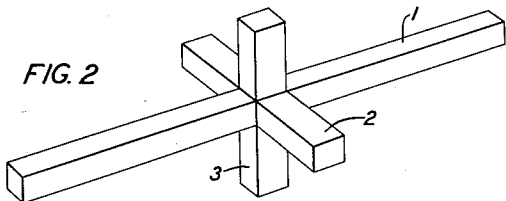
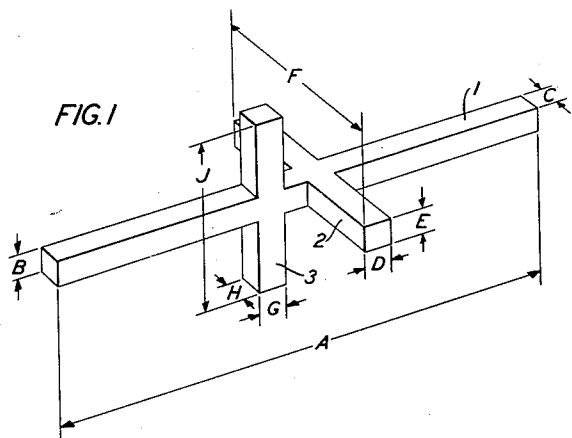
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WAVE FILTER

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WAVE FILTER

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This invention relates to wave filters and more particularly to those of the electromechanical type.

The object of the invention is to improve the attenuation characteristic of electromechanical wave filters.

The mechanical portion of one type of electromechanical wave filter comprises a central rod and two crossbars which may be proportioned to provide two peaks of attenuation. To save material and space the crossbars may be located close together near the center of the rod. Heretofore the practice has been to arrange the crossbars parallel to each other. With such a construction there is a tendency, under some circumstances, for the two crossbars to act as a tuning fork and introduce an extraneous mode of vibration which causes a serious dip in the attenuation characteristic. In accordance with the present invention this loss of attenuation is substantially prevented by swinging one of the crossbars about the central rod through an angle of approximately 90 degrees. The crossbars may be further rearranged so that their longitudinal axes intersect. The filter may be supported by means of wires attached to the central rod at or near a nodal point.

The nature of the invention will be more fully understood from the following detailed description and by reference to the accompanying drawing in which like reference characters refer to similar or corresponding parts and in which:

Fig. 1 is a perspective view of a mechanical wave filter in accordance with the invention;

Fig. 2 is a perspective view of a modified form of the filter of Fig. 1; and

Fig. 3 shows partly in perspective and partly diagrammatically two sections of the filter of Fig. 2, with associated electromechanical converters at the end, in a suitable mounting.

Taking up the figures in more detail, Fig. 1 shows one embodiment of the filter comprising a central rod 1 and two crossbars 2 and 3, all made of some suitable acoustic material. The rod 1 has a length A which is long compared to either of its rectangular cross-sectional dimensions B and C. The crossbars 2 and 3, also of rectangular cross section, are located close together on opposite sides of the center of the rod 1. The longitudinal axis of each crossbar is perpendicular to the plane defined by the longitudinal axis of the rod 1 and the longitudinal axis of the other crossbar. The crossbar 2 has a width D, a thickness E and a length F, and extends for equal distances on each side of the rod 1. The corresponding dimensions of the crossbar 3 are G, H

and J. As shown, the dimensions B and E are equal and the dimensions C and H are equal, but these are not necessary limitations as E may be either larger or smaller than B and H may be either larger or smaller than C. The structure shown offers some advantages, however, in the way of ease of construction.

It is to be understood that the rod 1 will have longitudinal vibrations impressed upon one end by means of some suitable driving device such, for example, as the electromechanical converter shown in Fig. 3 and described more fully below. These vibrations will set up flexural vibrations in the crossbars 2 and 3. Peaks of attenuation will occur at the frequencies of antiresonance in the crossbars. In its preferred embodiment the filter will have an attenuation peak below the transmission band and another peak above the band. One of the crossbars, say 2, will therefore have its width D and its length F so proportioned that a flexural antiresonance, preferably its first, occurs at a frequency below the band and the other crossbar, 3, will have its width G and its length J so proportioned that a flexural antiresonance occurs at a frequency above the band. For sharp cut-offs, these antiresonances should be placed near the band limits. For this case the rod 1 will have a length A approximately equal to a half wave-length at the mid-band frequency. The width of the transmission band is determined by the ratio of the sum of the masses of the crossbars 2 and 3 to the mass of the rod 1. A narrow band calls for comparatively massive crossbars.

Fig. 2 shows a modified form of the filter of Fig. 1 in which both of the crossbars 2 and 3 are moved to the center of the rod 1, so that their longitudinal axes now intersect. This results in a structure which is simpler and easier to construct.

Fig. 3 shows a composite structure comprising two mechanical filter sections of the type shown in Fig. 2 connected in tandem. The two central rods 1 are arranged in line and their adjacent ends are cemented or otherwise fastened together at the point 5. The mounting for the filter comprises two end plates 6 and 7 of insulating material connected by two metallic rods 8 and 9 which pass through holes in the end plates. Each of the filter sections is supported by means of a pair of mounting wires 10, 10 each of which extends from a point 11 on the rod 1, which is at or near a node of motion, to a point 12 on one of the rods 8 or 9. Since the crossbars 2 and 3 are also located at a nodal point on the rod 1, the inner end of the wire 10 may conveniently be

attached to a point 11 where the crossbars intersect. The wires 10 may be secured at their ends by soldering or otherwise. If the crossbars 2 and 3 are made of ceramic material, soldering to the point 11 will be facilitated by applying a small amount of silver paste and baking. The wires 10 preferably have small kinks therein, as shown, to make them more elastic. Care must be taken that the central rods 1 are in axial alignment. Care must also be taken that the wires 10 are substantially perpendicular to the longitudinal axis of the rods 1 so that the adjacent halves of the two rods 1 will not be subjected to axial tension or compression by the wires 10.

If the composite mechanical filter is to be used in an electrical system means must be provided at one end for converting the electrical vibrations to longitudinal mechanical vibrations and at the other end for reconvertng to electrical vibrations. As shown in Fig. 3 each of these electromechanical converters may comprise a piezoelectric crystal 14, a shunt capacitor 15 and two equal series inductors 16 and 17. The crystal 14 is preferably a parallelepiped of Rochelle salt with its thickness dimension parallel to the Y axis and its other two dimensions at an angle of approximately 45 degrees to the X and Z axes. The crystal 14 and the rod 1 are attached together at their ends by glue or otherwise. Small flanges, such as 19, may be provided at the end of the rod 1 to give added support to the crystal 14. However, if flanges are used, their effect must be taken into consideration in calculating the frequency at which the rod 1 will resonate. Each major face of the crystal 14 has associated therewith an electrode 20 which may, for example, be tinfoil attached with cement. The electrodes of each of the crystals 14 are connected by means of the flexible leads 22 and 23, respectively, to the short wires 24 and 25 which pass through the plate 6 or 7 and are, in turn, connected through the series inductors 16 and 17 to the terminals 27 and 28 or the terminals 29 and 30, one pair of which is used as the input and the other as the output. The length of the crystal 14 is approximately equal to a half wave-length at the mid-band frequency of the filter. The capacitance of the capacitor 15 and the inductance of the inductors 16 and 17 are proportioned to provide the desired electrical image impedance and band width for the electromechanical converter. The band of the converter is preferably made somewhat wider than that of the mechanical filter sections to allow for a narrowing of the band of the converter, due to the effects upon its component elements of temperature changes, without cutting into the band of the mechanical sections.

What is claimed is:

1. A mechanical wave filter for transmitting a band of frequencies comprising a central rod and two crossbars all made of acoustic material, the longitudinal axis of each of said crossbars being perpendicular to the plane defined by the longitudinal axis of said rod and the longitudinal axis of the other of said crossbars.

2. A filter in accordance with claim 1 in which said crossbars are located close together.

3. A filter in accordance with claim 1 in which said crossbars are on opposite sides of the center of said rod.

4. A filter in accordance with claim 1 in which said crossbars are located close together and on opposite sides of the center of said rod.

5. A filter in accordance with claim 1 in which the longitudinal axes of said crossbars intersect.

6. A filter in accordance with claim 1 in which the longitudinal axes of said crossbars intersect at the center of said rod.

7. A filter in accordance with claim 1 in which said rod has a length equal to a half wave-length at a frequency within said band.

8. A filter in accordance with claim 1 in which the length of said rod is long compared to its cross-sectional dimensions.

9. A filter in accordance with claim 1 in which one of said crossbars has a flexural antiresonance at a frequency on the lower side of said band and the other of said crossbars has a flexural antiresonance at a frequency on the upper side of said band.

10. A filter in accordance with claim 1 in which one of said crossbars has its first flexural antiresonance at a frequency on the lower side of said band and the other of said crossbars has its first flexural antiresonance at a frequency on the upper side of said band.

11. A filter in accordance with claim 1 in which one of said crossbars has a flexural antiresonance at a frequency on the lower side of said band and near the lower cut-off and the other of said crossbars has a flexural antiresonance at a frequency on the upper side of said band and near the upper cut-off.

12. A filter in accordance with claim 1 in which one of said crossbars has its first flexural antiresonance at a frequency on the lower side of said band and near the lower cut-off and the other of said crossbars has its first flexural antiresonance at a frequency on the upper side of said band and near the upper cut-off.

13. In combination, a filter in accordance with claim 1 and mounting means therefor comprising a pair of oppositely extending wires attached at their inner ends to a point on said central rod is a node of motion.

14. In combination, a filter in accordance with claim 1 and mounting means therefor, said crossbars having intersecting longitudinal axes and said mounting means including a pair of oppositely extending wires having their inner ends attached at intersections of said crossbars.

15. A mechanical wave filter for transmitting a band of frequencies comprising a central rod and two crossbars all made of acoustic material, said crossbars being located close together near the center of said rod and the longitudinal axis of each of said crossbars being perpendicular to the plane defined by the longitudinal axis of said rod and the longitudinal axis of the other of said crossbars.

16. A filter in accordance with claim 15 in which said crossbars are on opposite sides of the center of said rod.

17. A filter in accordance with claim 15 in which the longitudinal axes of said crossbars intersect.

18. A filter in accordance with claim 15 in which said rod has a length equal to a half wave-length at a frequency within said band.

19. A filter in accordance with claim 15 in which one of said crossbars has its first flexural antiresonance at a frequency on the lower side of said band and the other of said crossbars has its first flexural antiresonance at a frequency on the upper side of said band.

20. A filter in accordance with claim 15 in which said rod has a length equal to a half wave-length at a frequency within said band and said crossbars are on opposite sides of the center of said rod.

21. A filter in accordance with claim 15 in which said crossbars are on opposite sides of the center of said rod, one of said crossbars has its first flexural antiresonance at a frequency on the lower side of said band and the other of said crossbars has its first flexural antiresonance at a frequency on the upper side of said band.

22. A filter in accordance with claim 15 in which said rod has a length equal to a half wavelength at a frequency within said band, one of said crossbars has its first flexural antiresonance at a frequency on the lower side of said band and the other of said crossbars has its first flexural antiresonance at a frequency on the upper side of said band.

23. A filter in accordance with claim 15 in which said rod has a length equal to a half wavelength at a frequency within said band, said crossbars are on opposite sides of the center of said rod, one of said crossbars has its first flexural antiresonance at a frequency on the lower side of said band and the other of said crossbars has its first flexural antiresonance at a frequency on the upper side of said band.

24. In combination, a filter in accordance with claim 15 and mounting means therefor comprising a pair of oppositely extending wires attached at their inner ends to a point on said central rod which is a node of motion.

25. In combination, a mechanical wave filter and mounting means therefor, said filter comprising a central rod and a transverse member, said transverse member being located near a

nodal point on said rod and said mounting means including a pair of oppositely extending wires attached at their inner ends to said nodal point.

26. The combination in accordance with claim 25 in which said wires have small kinks therein.

27. In combination, a mechanical wave filter comprising two sections and mounting means for each of said sections, each of said sections comprising a central rod and a transverse member, said transverse member being located near a nodal point on said rod, said rods being connected together in axial alignment and said mounting means including a pair of oppositely extending wires attached at their inner ends to said nodal point.

28. The combination in accordance with claim 27 in which said wires have small kinks therein.

29. The combination in accordance with claim 27 in which said wires are perpendicular to the longitudinal axis of said rod.

30. The combination in accordance with claim 27 in which said wires have small kinks therein and are perpendicular to the longitudinal axis of said rod.

31. A mechanical filter for transmitting wave energy lying within a band of frequencies while highly attenuating energy of frequencies lying outside of said band comprising a plurality of mechanical vibrators connected in tandem, each of said vibrators having a nodal point and a support fixedly engaging said vibrator at its nodal point.

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