This invention relates in general to mechanical filters and in particular to a mechanical filter that has a very narrow bandwidth.

The applications of M. L. Doelz entitled "Mechanical Filter," Serial No. 248,011, filed September 24, 1951, and "Longitudinal Support of Mechanical Filter," Serial No. 283,340, filed April 21, 1952, disclose electromechanical filters wherein a plurality of discs are coupled together by longitudinal wires connected to their peripheries. A magnetostrictive driving wire is connected to a first disc and driven by a signal source and an output wire is connected to the last disc and is coupled to a magnetostrictive wire. Applicant has found that this type of electromechanical filter has very desirable performance and gives a fine frequency response.

The present invention relates to a filter of the type described in the above applications wherein the disc resonators are tuned so that they function as impedance matching elements.

It is an object of this invention therefore to provide a mechanical filter which has a very narrow passband.

Another object of this invention is to provide a mechanical filter wherein the disc resonators function as impedance matching elements.

A feature of this invention is found in the provision for an electromechanical filter wherein alternate discs are tuned so that they resonate at the center frequency of the filter and the intermediate discs are tuned to resonate at a frequency outside the passband of the filter.

Since the intermediate discs have a high reactive impedance at the center frequency, they reduce the coupling between the passband sections and therefore function as impedance matching elements.

Further objects, features and advantages of this invention will become apparent from the following description and claims when read in view of the drawings, in which:

Figure 1 is a sectional view of an electromechanical filter.

Figure 2 illustrates the electrical analogue for the mechanical filter shown in Figure 1.

Figure 3 illustrates the pi equivalent of one section of the filter.

Figure 4 illustrates a T-section which is the equivalent of the pi section shown in Figure 3, and

Figure 5 illustrates the simplified electromechanical analogue of the filter.

Figure 1 illustrates an electromechanical filter with a portion of the cover removed. A base plate 10 has mounted thereon a pair of standoffs 11 and 12 respectively. The standoffs are each formed in two parts and the lower parts are attached to the base plate 10 by set screws and the top parts are attached by set screws 13 to the lower parts.

At the junction between the upper and lower parts of the standoffs 11 and 12 are formed circular openings lined with a suitable gasketing material through which cylinders 21 and 22 extend. These cylinders are clamped by the stand-offs 11 and 12. The cylinders are hollow as shown in cutaway and contain a magnetic driving coil 23 which has output leads 24 and 26 which are attached, respectively, to output contacts 27. The contacts extend through the base plate 10.

Polarizing magnets 29 and 31, respectively, are supported by the stand-offs 11 and 12 immediately above the cylinders 21 and 22. The cylinders 21 and 22 may be made of a non-magnetic material, as for example, brass.

Mounted between the cylinders 21 and 22 is the vibrating filter assembly comprising a plurality of active discs and a pair of end discs 25 and 30, respectively. The discs are connected together by longitudinal coupling wires 39 which are attached to the peripheries of the discs. The discs are spaced equidistant apart.

As pointed out in the Doelz application, Serial Number 248,011, the thickness and diameter of the discs determine the resonant frequency of the filter.

The end discs 25 and 30 are attached to the cylinders 21 and 22 by welding.

Thus, the end discs 25 and 30, respectively, are firmly supported by the cylinders 21 and 22 and do not comprise a part of the vibrating system. The spacing between the disc 25 and the adjacent active disc is substantially the same as that between a pair of active discs.

The short lengths of coupling wire joining the active filter structure and the inactive end discs act as springs interspaced between the vibrating filter structure and the fixed mounting structure. As best shown in cutaway, the lower edge of the discs 25 and 30 do not extend within the confines of the cylinders 21 and 22. A driving rod 40 extends through the driving coil 23 and is attached to the periphery of the first active disc 32.

The last active disc 38 at the opposite end of the filter also has a driving wire 41 that extends within the confines of the cylinder 22 and through a second driving coil contained therein. The output leads of the driving coil within the cylinder 22 are designated as 42 and 43, respectively, and are connected to terminals 44, respectively, which extend through the base plate 10.

A cover member 47 is generally rectangular in shape and has downwardly extending sides 48. It may be placed over the filter assembly and firmly attached to the base plate 10, as for example, by crimping or soldering. The filter unit may be hermetically sealed if desired.

Attached to the base plate are a pair of mounting pins 49 and 51 which may be used to attach the filter assembly to a chassis.

In prior mechanical filters, the bandwidth has been decreased by reducing the diameter of coupling wires between the discs; however, the minimum wire diameter is limited by the requirement for a mechanical structure capable of withstanding shock and vibration. This invention makes it possible to construct a narrow band filter without reducing the coupling wire size below the minimum value necessary for strength and rigidity.

The main difference between my filter and the prior ones is in the tuning of the active discs. Four of the discs 32, 34, 36 and 38 are tuned to resonate at the center frequency of the filter (f0) which might be 455 kilocycles, for example. The alternate discs, 33, 35 and 37 are tuned to resonate at a frequency (f1 or f2) outside the bandwidth of the filter. Since they have a high reactive impedance at the center frequency (f0), they reduce the coupling between the bandpass sections, and, thereby, function as impedance matching elements.

The impedance matching discs may be tuned to a frequency (f1) above the center frequency or they may be tuned to a frequency (f2) below the center frequency. In a particular mechanical filter, they may all be tuned to the same frequency, or they may be tuned to alter-
nate frequencies. In all cases, the bandwidth of the mechanical filter will be determined by the difference between the center frequency \( f_0 \) and the offset resonant frequencies \( f_1 \) or \( f_2 \) of the impedance matching sections.

The electrical analogue for the mechanical filter is shown in Figure 2. The series resonant elements, \( X_b \), are tuned to the center frequency, \( f_0 \). The resonant elements, \( X_t \), may be tuned either above or below the center frequency. To illustrate the operation of this filter, we may assume that they are tuned to a frequency, \( f_1 \), above the passband. In this case, we will have a large capacitive reactance at \( f_1 \). We assume that the capacitive reactance, \( X_t \), is large compared with reactance of the coupling element, \( X_m \).

To simplify the circuit, we may transform the impedance matching delta sections to their equivalent T sections as shown in Figures 3 and 4. The T sections may be substituted for the delta sections in Figure 2 and the capacitors, \( X_m \), combined with the capacitors in the series resonant elements, \( X_b \), to obtain the filter shown in Figure 5.

In this circuit, \( X \) is the total reactance of each loop and \( X_b \) is the coupling reactance. Since \( X_b \) is much smaller than the coupling reactance in a standard design, it is possible to obtain a narrow bandwidth, without sacrificing the strength of the filter structure.

Thus, by merely offsetting the frequency of alternate discs, the passband of the filter may be controlled.

By way of example, the frequency \( f_0 \) might be 455 kilocycles. If the filter is designed to have a passband of 300 cycles, \( f_1 \) might be 458 kilocycles and \( f_2 \) might be 452 kilocycles.

Although this invention has been described with respect to a particular embodiment thereof, it is not to be so limited as changes and modifications may be made therein which are within the full intended scope of the invention, as defined by the appended claims.

I claim:

1. An electromechanical filter comprising a resonating assembly having a plurality of discs and a predetermined resonant frequency, a plurality of longitudinal supporting wires attached to the peripheries of said discs, a base member, a pair of stand-offs attached to said base member, the end discs of said assembly attached to said stand-offs, and alternate discs of said filter assembly tuned to the resonant frequency and the remaining discs tuned off of the resonant frequency.

2. A passband mechanical filter having a predetermined center frequency comprising a plurality of discs supported longitudinally, wires attached to the peripheries of said discs and supporting said discs in a parallel spaced arrangement, alternate discs tuned to the center frequency of said filter and the remaining discs tuned off of the center frequency of said filter.

3. The mechanical filter of claim 2 wherein the said remaining discs are tuned to alternate frequencies above and below the predetermined center frequency of said filter.

4. A passband electromechanical filter comprising a base member, a pair of stand-offs mounted on said base member, a driving coil supported by one of said stand-offs, a pick-up coil supported by the other of said stand-offs, a resonating assembly having a predetermined resonant frequency comprising a plurality of discs and a plurality of longitudinal wires attached to the peripheries of said discs, said resonating assembly supported by said stand-offs, a driving wire attached to the periphery of the second of said discs and extending through the pick-up coil, alternate discs tuned to said predetermined resonant frequency, and the remaining discs each tuned to a frequency different from said resonant frequency.

5. The electromechanical filter of claim 4 wherein some discs of the said remaining discs are tuned above the predetermined resonant frequency and the remainder of the said remaining discs are tuned below the predetermined resonant frequency.

6. A resonating assembly having a predetermined resonant frequency comprising a plurality of discs mounted in a parallel-spaced relationship, a plurality of longitudinal supporting wires attached to the peripheries of said discs, an odd number of said discs, the end discs and alternate discs therewith being tuned to said resonant frequency, and the remaining discs being tuned to a frequency different from said resonant frequency.

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