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M. BÖRNER

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MECHANICAL FILTER COUPLING

Filed Dec. 3, 1958

Fig. 1

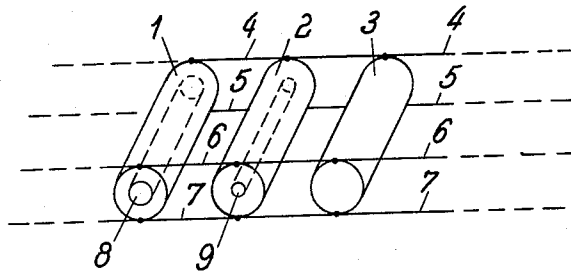


Fig. 3

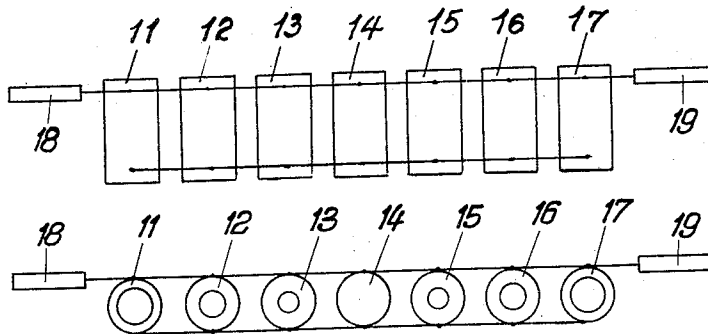
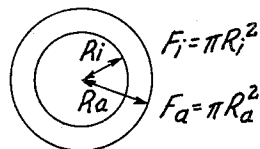


Fig. 4

Fig. 2



Inventor:

MANFRED BÖRNER

BY *Ed. D. Frankel*

PATENT AGENT

1

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MECHANICAL FILTER COUPLING
Manfred Börner, Ulm (Danube), Germany, assignor to
Telefunken G.m.b.H., Berlin, Germany
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The present invention relates to mechanical frequency filters and, especially, to means for varying the coupling between individual elements of the filters.

The copending application, Serial No. 693,681, filed Oct. 31, 1957, relates to a mechanical frequency filter comprising a plurality of mechanically coupled resonant bodies to be energized in torsional oscillation, said resonant bodies being coupled with each other by means of longitudinally oscillating coupling lines or wires. For this purpose, cylindrical resonant bodies are suitably used which are arranged adjacent one another with their axes mutually parallel. These bodies are interconnected to form a ladder-like structure by means of wires serving as coupling means and running perpendicularly to the axes of the bodies. In the aforementioned application, means are disclosed for making the coupling coefficients between the individual resonant cylinders of different magnitude, i.e., by applying the coupling wires to suitable points of different oscillating amplitude on the individual resonant bodies.

For reasons of manufacture, it is often desirable to use stretched, substantially straight coupling wires with the result, that the adjusting means described in the above-mentioned copending application cannot be used for adjusting the coupling coefficients.

It is an object of the present invention to obtain different coupling coefficients for the individual resonant cylinders by providing at least one, or preferably several, resonant cylinders with a coaxial central bore of suitable diameter. In the following, it will be explained how the coupling coefficient depends upon the diameters of the bores through the resonant bodies to be coupled with one another, so that the coupling can be readily adjusted to the desired value by suitably dimensioning these bores.

Still further objects and the entire scope of applicability of the present invention will become apparent from the detailed description given hereinafter; it should be understood, however, that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

In the drawings:
FIGURE 1 is a perspective view of a part of a system of filters employing different degrees of coupling between individual filter resonators, according to the invention;

FIGURE 2 is an enlarged end view of a resonator according to the present invention;

FIGURE 3 is a plan view of a filter system according to the present invention;

FIGURE 4 is a side view of the system according to FIGURE 3.

According to FIGURE 1, three cylindrical resonators 1, 2 and 3, energized in torsional oscillation, are mutually coupled by means of coupling wires 4, 5, 6 and 7. In this embodiment, the resonators 1 and 2 are provided with cylindrical coaxial bores 8 and 9, respectively, so that the resonators are hollow cylindrical bodies, while the resonator body 3 constitutes a solid cylinder.

The coupling between two adjacent resonators is dependent upon the constants of the material, i.e., the density ρ and the velocity of mechanical propagation v , upon the cross sectional area of the resonators, the area of

2

the bores and the area of the coupling wires. F_a denotes the total cross sectional area of the resonators including bore, while F_i denotes the cross sectional area of the bore, as shown in cross section in FIGURE 2. The coupling coefficient between two adjacent resonators of the same kind can be calculated according to the following equation:

$$K = \frac{4}{\pi} \frac{\rho_k v_k f_k}{\rho v F_a \left(1 - \frac{F_i^2}{F_a^2}\right)}$$

wherein the parameters relating to the material of the resonators have no subscripts, and those of the coupling wires are provided with the subscript k , and wherein f_k denotes the total cross sectional area of the coupling wires.

If the coupled systems have different cross sections F_a , different bores F_i and/or different properties of the material ρ , v , the coupling coefficient can be calculated with the aid of the following equation:

$$K_{1/2} = \frac{4}{\pi} \frac{\rho_k v_k f_k}{\sqrt{\rho_2 v_2 F_{a2} \left(1 - \frac{F_{i2}^2}{F_{a2}^2}\right) \cdot \rho_1 v_1 F_{a1} \left(1 - \frac{F_{i1}^2}{F_{a1}^2}\right)}}$$

wherein the subscripts 1 and 2 relate to the respective parameters of one or the other resonator.

It can be seen that the coupling coefficient between two adjacent resonators is increased when the diameter of the bore is increased in the respective resonators.

FIGURES 3 and 4 show a system of mechanical filters comprising seven resonators, 11, 12, 13, 14, 15, 16 and 17. Longitudinally oscillating magneto-strictive transducers 18 and 19 are provided to energize the filter, said transducers being magnetized in a manner known per se by means of a permanent magnet (not shown) and being coupled to external electric circuits (not shown) by means of a coil (also not shown). The bores of the outermost resonators 11 and 17 have larger diameters than the bores of the inner resonators, whereby the sizes of the diameter are gradually increased starting from the center resonator 14 towards the outer resonators 11 and 17. As a result of this, the coupling increases towards the outside between the individual filter resonators, as required by theoretical considerations.

I claim:

1. In a mechanical tuned filter including a plurality of axially parallel cylindrical resonators to be energized in torsional oscillation and all resonant at the same frequency, and said resonators being coupled with one another by means of longitudinally oscillating coupling wires joined tangentially to said cylinders, the improvement characterized by providing at least one of the resonators with a coaxial bore therein, the diameter of the bore serving to determine the coefficient of coupling between the associated resonator and adjacent resonators.

2. In a mechanical filter according to claim 1, at least three resonators comprising said filter, and at least two of said resonators having bores therein and arranged in such a manner that the diameters of the bores symmetrically increase from the center of the filter towards the outer ends thereof.

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