April 8, 1958 W. T. HARRIS 2,830,204

LINEAR MECHANICAL OSCILLATOR CIRCUIT ELEMENT TRANSDUCER

Filed July 1, 1955

Fig. 1.

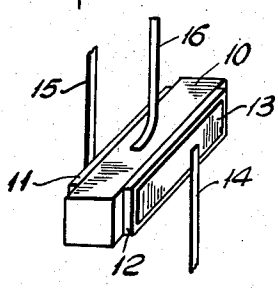


Fig. 2.

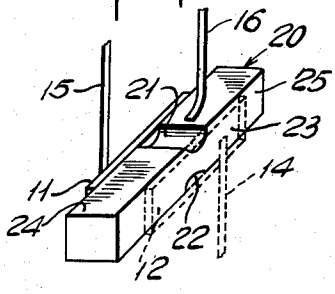


Fig. 3.

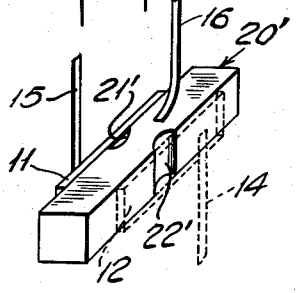


Fig. 4.

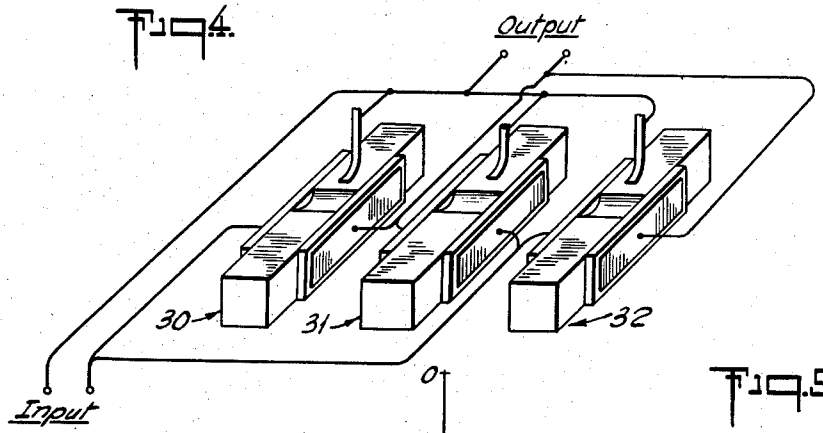


Fig. 5.

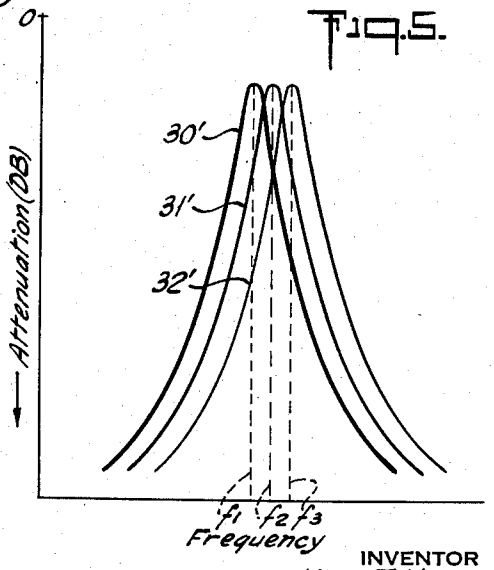
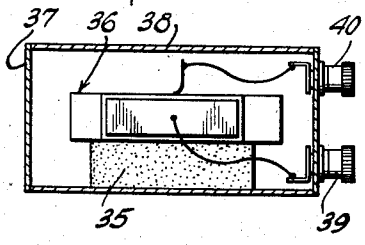


Fig. 6.



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LINEAR MECHANICAL OSCILLATOR CIRCUIT ELEMENT TRANSDUCER

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Application July 1, 1955, Serial No. 519,459

10 Claims. (Cl. 310—9.6)

My invention relates to circuit-element transducers or filters of the variety in which independent electrical input and output circuits may be coupled solely by mechanical means. The invention incorporates certain improvements and modifications over that disclosed in my copending application Serial No. 301,554, filed July 29, 1952, now abandoned.

It is an object of the invention to provide improved means of the character indicated.

It is another object to provide an improved circuit-element transducer lending itself to design for response essentially at any selected frequency, out of a wide range of frequencies.

It is a specific object to provide an improved circuit element transducer which will exhibit essentially only one characteristic resonant frequency, determined by essentially only one mechanical mode of oscillation of the basic mechanically resonant element thereof.

It is another specific object to meet the above objects with a transducer construction lending itself particularly to application to an intermediate-frequency range, extending from the upper audio frequencies to substantially higher frequencies, as of the order of 500 kc./s.

It is a general oject to meet the above objects with a transducer construction which is rugged and reliable and which exhibits low loss when mechanically coupling two electrical circuits.

Other objects and various further features of novelty and invention will be pointed out or will occur to those skilled in the art from a reading of the following specification in conjunction with the accompanying drawings. In said drawings, which show, for illustrative purposes only, preferred forms of the invention:

Fig. 1 is a simplified perspective view of a transducer or filter incorporating features of the invention;

Figs. 2 and 3 are views similar to Fig. 1, but illustrating modifications;

Fig. 4 is a similar view, illustrating a multiple employment of my transducers;

Fig. 5 is a frequency-response characteristic for the device of Fig. 4; and

Fig. 6 is a longitudinal sectional view of a mounted and encased transducer of my invention.

Briefly stated, my invention contemplates utilizing an elongated rod as the stabilizing element to determine coupling between an electrical input circuit and an electrical output circuit. The longitudinally resonant mode of the rod determines the frequency at which coupling is achieved. In the forms to be described, the rod is metal, and I prefer that a central part of the rod be cut away or recessed so as to define a locally weakened or compliant section connecting two like end masses. The input and output electric-circuit connections are made by way of two like electromechanical transducers bonded to opposite sides of the rod in such manner that the transducer-elongation axes are aligned substantially with the longitudinal axis of the rod.

Referring to Fig. 1 of the drawings, my invention is shown in application to a filter or an oscillator-control transducer element, comprising an elongated metal bar or rod **10** of rectangular cross-section. Input and output electrical circuits to the transducer are established by way of piezoelectric elements **11—12**, which may be barium-titanate slabs bonded on opposite sides of the central region of the bar **10**. For purposes of electrical connection, foil electrodes, as at **13** for the slab **12**, may be applied to the outer exposed surfaces of slabs **10—11**, with lead connections **14—15** thereto. The inner surfaces of the slabs may be bonded in intimate contact with the metal rod **10** so that the latter may constitute a common terminal. Thus, I show but a single lead **16** connected to the rod **10**; preferably, this connection is established near the center, inasmuch as longitudinal resonance will involve least displacement at the center.

The terminals **15—16** may constitute an input circuit, and the terminals **14—16** may constitute an output circuit. These circuits will be completely isolated, except for such coupling as is achieved through the mechanically resonant properties of the bar **10**, and for the arrangement shown in which the elongation axes of the slabs **11—12** are oriented substantially parallel to the longitudinal axis of the rod **10**, the longitudinal-resonance frequency of the metal bar **10** substantially completely dominates the response of the transducer.

Fig. 2 shows a modification in which the bar **20** is locally excavated or recessed at **21—22**, the recesses **21—22** being preferably symmetrically formed on opposite longitudinal faces of the rod **20**. The recesses **21—22** provide a locally weakened or compliant section **23** integrally interconnecting end masses **24—25**, and the piezoelectric slabs **11—12** are bonded to the bar **20** as described for the case depicted in Fig. 1, the organization being such that slabs **11—12** are each bonded to both end masses **24—25**.

The arrangement of Fig. 3 resembles that of Fig. 2, except that the recesses **21′—22′** are formed in the same longitudinal faces as those to which the slabs **11—12** are bonded. Performance of the two forms, namely, the forms of Figs. 2 and 3, are generally similar, except that the form of Fig. 2 is inherently more capable of preventing flexural modes of vibration. On the other hand, the form of Fig. 3 combines flexural and longitudinal modes.

Fig. 4 depicts a plural combination of my circuit-element transducers, there being shown three transducers **30—31—32**. All said transducers **30—31—32** may be of the design of Fig. 2, and therefore of the non-flexural variety. Each transducer includes its own input and output circuits, but all input circuits are interconnected and all output circuits are interconnected. The resonant properties of the transducers **30—31—32** are preferably slightly different, exhibiting responses **30′—31′—32′** as shown in Fig. 5. By choosing the resonant frequencies f_1, f_2, f_3, such that the pass bands for the elements **30—31—32** are adjacent (bandwidth being determined, for example, by the spread between points 3*db* down from peak response), it will be seen that a flat-topped band-pass filter is realized by interconnecting the circuits as shown in Fig. 4, the connections of Fig. 4 being such as to establish all input circuits to elements **30—31—32** in parallel, and all output circuits in parallel.

The mounting of any of the described forms of my invention is readily achieved by bonding one face of any element to a block of cellular rubber or the like, as depicted at **35** in Fig. 6, for the case of the transducer element **36**. For protection against dust and damage, the block **35** may, in turn, be bonded to one inner wall of a box or case **37** having a top panel **38**, which may be

bonded to the rest of the box, as by peripheral soldering, to establish a hermetically sealed device. Electrical connections to the transducer elements are made to terminal fittings 39—40, as will be understood.

It will be appreciated that I have described a simple circuit-element transducer construction in which electrical performance is virtually completely dominated by longitudinal mechanically resonant properties of the elongated bar. I prefer that such bars be of metal so as to simplify electrical connection to the inner faces of the piezoelectric slabs. However, for other types of transducer element, it may not be necessary to employ a metal to dominate electrical performance. The mechanical mode of oscillation utilized by my transducers is such as to render the transducers particularly applicable to a range of frequencies extending from the upper audio frequency to frequencies of the order of 500 kc./s.

While I have described the invention in detail for the preferred forms shown, it will be understood that modifications may be made within the scope of the invention as defined in the claims which follow.

I claim:

1. A circuit-element transducer, comprising an elongated metal bar of rectangular cross-section, said bar being centrally cut away to the exclusion of the ends of the bar, thereby defining a compliant central portion connecting said ends, two piezoelectric slabs bonded to opposed longitudinally extending faces of said bar and spanning said compliant central section, the elongation axes of said elements being oriented generally parallel with the longitudinal axis of said bar, and independent electric-circuit connections to said elements, whereby the mechanical properties of said bar are the sole determining factor for coupling circuits including said connections.

2. A transducer according to claim 1, and including a cushioning mounting element bonded to one face of said bar.

3. A transducer according to claim 2, in which said mounting element is of cellular rubber-like material.

4. A transducer according to claim 2, in which said mounting element is bonded to a face between said opposed faces.

5. A transducer according to claim 2, and including a hermetically sealed container for said bar and mounting element, said mounting element being bonded to an inner surface of said container.

6. A circuit-element transducer, comprising an elongated bar centrally cut away to define a compliant section connecting two end masses, two piezoelectric elements bonded to said bar at opposed faces thereof, each piezoelectric element being in part bonded to one mass and in part bonded to the other mass, said masses being of substantially greater mass than said piezoelectric elements and independent electric-circuit connections to said elements.

7. A circuit-element transducer, comprising an integral mechanically resonant structure consisting of two longitudinally opposed similarly elongated end masses connected by a central section of greater longitudinal compliance than longitudinal end portions of said structure, a first electro-mechanical transducer element bonded to both end masses and bridging said compliant section, and a second electromechanical transducer element bonded to both end masses and bridging said compliant section.

8. A circuit-element transducer, comprising an elongated metal rod of rectangular cross-section, two opposed longitudinal faces of said rod being symmetrically cut away at the longitudinal center of said rod to define a central compliant section connecting similar end masses for longitudinal mechanical resonance, and two piezoelectric slabs bonded to opposed longitudinal faces of said rod and spanning said compliant connection, said rod being of substantially greater mass than said piezoelectric slabs, whereby mechanical resonance of said masses through said compliance may dominate electrical response of said piezoelectric slabs.

9. A circuit element transducer, comprising an elongated metal rod of rectangular cross-section, two opposed longitudinal faces of said rod being symmetrically cut away at the longitudinal center of said rod to define a central compliant section connecting similar end masses for longitudinal mechanical resonance, and two piezoelectric slabs bonded to the other two opposed longitudinal faces of said rod and spanning said compliant connection.

10. A circuit-element transducer, comprising an elongated metal rod of rectangular cross-section, two opposed longitudinal faces of said rod being symmetrically cut away substantially only at the longitudinal center of said rod to define a central compliant section connecting similar end masses for longitudinal mechanical resonance, and two piezoelectric slabs bonded to said opposed longitudinal faces of said rod and spanning said compliant connection.

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