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RESONANT CAVITY ELECTRICAL TRANSDUCER

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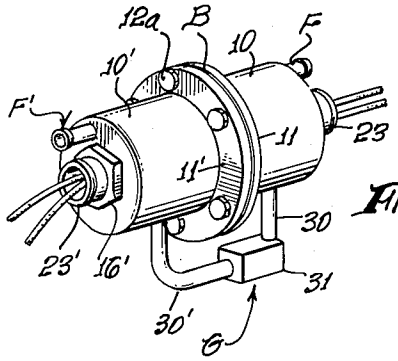


FIG. 1.

FIG. 2.

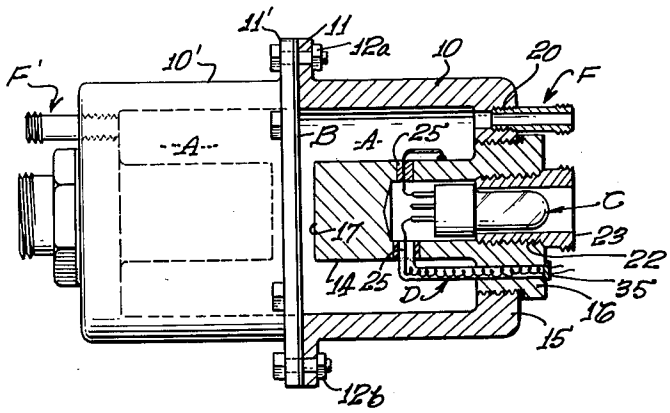
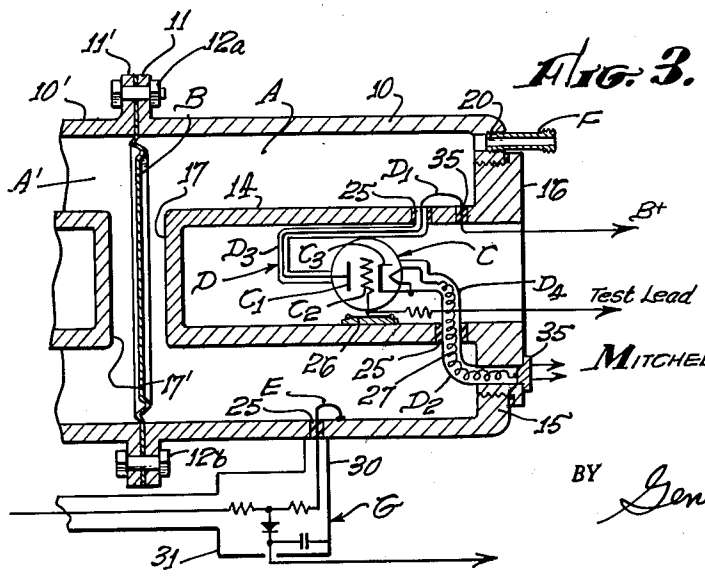


FIG. 3.



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RESONANT CAVITY ELECTRICAL TRANSDUCER

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The present invention relates to an electrical transducer, and more particularly to a transducer utilizing a resonant cavity into whch a minor perturbation is introduced for controlling the frequency of a close-coupled oscillator circuit of which the resonant cavity forms a principal part.

U.S. Patent #2,494,570 to Mezger issued January 17, 1950, discloses the use of a resonant cavity in conjunction with an oscillator circuit to provide a transducer. In the Mezger patent the oscillator circuit is complete without the resonant cavity. In other words, the oscillator includes a "tank circuit" of some type, and the resonant cavity merely receives a small portion of the electromagnetic energy from the oscillator without having any appreciable effect on the frequency or voltage output of said oscillator. More specifically, according to the teaching of Mezger, the resonant frequency of the cavity and the oscillator frequency are intentionally established so as not to coincide, and in fact, if the oscillator frequency does not remain constant the expected potential changes due to small changes in the resonant frequency of the cavity will not occur as predicted.

While the Mezger device and other devices of a similar nature may have some utility, they are also subject to many inherent limitations.

The present invention is based upon an entirely different theory. According to the present invention the resonant cavity is an integral part of the oscillator and provides the tank circuit thereof. The oscillator frequency is therefore controlled by and is substantially identical to the natural resonant frequency of the cavity.

Thus, a basic concept of the present invention is that the principle of the close-coupled oscillator may be advantageously applied to a resonant cavity transducer.

Another feature of the invention is the use of a pair of differentially-connected resonant cavity transducer devices to provide a more accurate measurement than could otherwise be obtained.

One object of the invention is to provide a resonant cavity transducer having minimum expense and maximum utility.

Another object of the invention is to provide a resonant cavity transducer comprising a pair of differentially-connected transducer devices from which a single output signal is derived.

A further object of the invention is to provide a resonant cavity transducer which utilizes minor perturbations in the cavity to produce in the form of frequency changes a precise electrical indication of relatively small mechanical changes, said frequency changes being in the form which is useful in electronic digital computation.

The above and other objects of the invention will be more readily apparent from the following description in conjunction with the accompanying drawing, in which:

FIGURE 1 is a perspective view of the device;

FIGURE 2 is a side elevation view, partially in cross

section, illustrating the principal mechanical construction features; and

FIGURE 3 is a partial cross-sectional view of the device illustrating the complete electrical circuit connections in schematic form.

While the drawing illustrates a pair of transducer devices which are differentially connected to produce only a single output signal, it will nevertheless be understood that this is merely the preferred form of the invention, and that a single transducer device may be utilized if desired. In referring to the drawing, letters and numerals used to identify parts of one of the transducer devices will be primed to identify corresponding parts of the other device.

Before describing the mechanical structure in detail it will be advantageous to briefly outline in general terms the electrical operation of one of the transducer devices in accordance with the invention. An electrical resonant cavity A has a predetermined normal configuration. Means B are provided for introducing a controlled minor perturbation in the cavity, thereby to introduce a minor change in the natural resonant frequency thereof. An electron discharge device C is provided which has at least three electrodes. Coupling means D are utilized to couple the cavity A with the discharge device C in such a manner as to provide an oscillator whose oscillation frequency is controlled by cavity A and is substantially identical to the natural resonant frequency of cavity A. Means E is provided for tapping off a portion of the oscillating energy, in order to transmit same to a frequency indicating means.

For purposes herein a minor perturbation is defined as a change in cavity configuration which is sufficiently small so that the maximum change in impedance relations, energy losses or frequency is of the order of 1%. The changes will in general be much less than 1%, for example, if 1000 megacycles is used as the operating frequency the maximum frequency change may be as little as 10 kilocycles, or $\frac{1}{100}$%.

In the differential form of the invention as illustrated two resonant cavities A and A' have normal configurations which are closely similar, or preferably identical, so that their normal resonance frequencies are identical, or nearly so. Means B for introducing a minor perturbation into both cavities simultaneously may comprise a flexible metallic diaphragm as shown, or it may consist of a vane whose angular position may be varied, or a metallic plunger, or a plunger of dielectric material, or a stream of gas of variable density and hence variable dielectric constant. In conjunction with the flexible diaphragm it is advantageous to use a tube F through which a varying gas pressure may be injected into cavity A for deflecting the diaphragm and correspondingly varying the resonant frequency of the cavity.

The minor perturbation introduced by deflection of the diaphragm B, in this example, serves to increase the natural resonant frequency of cavity A and decrease the natural resonant frequency of cavity A', or vice versa. A difference frequency generating device such as indicated by G is used to suppress the natural resonant frequencies of cavities A and A' and generate only the difference frequency which varies linearly with deflection of diaphragm B and the applied pressure.

The electrical operation of the transducer device hav-

ing been described in general terms, it now becomes convenient to describe more specifically the mechanical structure of the illustrated form of the invention which, as previously mentioned, includes a pair of differentially-connected transducer devices.

Hollow metallic cylinders 10 and 10' are provided on their open ends with outwardly extending circumferential flanges 11 and 11'. A flexible metallic diaphragm B is transversely disposed between members 10 and 10' and has its circumferential edge firmly grasped between flanges 11 and 11'. Bolts 12*a*, 12*b*, etc. hold flanges 11 and 11' in tightly clamped relationship.

In the remaining description the structure associated with cylindrical member 10 will be described in detail, and it will be understood that a corresponding structure is associated with cylindrical member 10'.

A hollow cylindrical metal core member 14 is concentrically disposed within cylindrical member 10. Cylindrical member 10 at its closed end has an inwardly extending flange 15 which is internally threaded to receive a threaded base portion 16 of the core member 14. The annular space between core member 14 and cylindrical member 10 provides cavity A, while flange 15 and base portion 16 together provide a metallic end wall which closes off the space between cylinder and core, and consequently provides a short-circuited end of cavity A. The opposite or outer end of core member 14 is closed off by a metallic wall 17 which is physically spaced a short distance away from diaphragm B (for any permissible degree of deflection of the diaphragm) so as to provide an open-circuited end of the cavity.

Inwardly extending flange 15 has a threaded opening 20 provided therein which receives a threaded tube F, the latter being utilized for injecting a variable gas pressure into cavity A for controlling the deflection of diaphragm B.

Base portion 16 of core member 14 has formed therein a threaded opening 22 which communicates with the hollow interior of core member 14, and a threaded plug 23 upon which discharge device C is mounted is inserted into opening 22 for the purpose of supporting the electron discharge device C within core member 14.

In the drawing, FIGURE 2 does not illustrate the electrical connections. These are shown in FIGURE 3, and it will be readily understood by persons skilled in the art that the electrical details in FIGURE 3 are, for the most part, exaggerated for the purpose of clear illustration.

Electron discharge device C has at least three electrodes including a plate C_1, a grid C_2 and a cathode C_3. Coupling means D includes an electromagnetic coupling loop D_1 for supplying input energy into cavity A as well as a coupling loop D_2 for receiving output energy from the cavity. A first connecting circuit D_3 connects the plate C_1 to loop D_1, while a second connecting circuit D_4 connects loop D_2 with cathode C_3. The characteristics of the coupling elements D_1—D_4 are such that discharge device C and cavity A provide an oscillator whose oscillation frequency is substantially identical to the characteristic resonant frequency of the cavity.

While coupling loops D_1 and D_2 are suitable for magnetic coupling to the cavity it will be understood that electrical probes may be substituted for either or both if so desired. Each of the coupling loops is insulated from the metallic wall of the cavity at the point of entry by means of insulating bushings 25, in conventional fashion, and by-passed to ground by capacitors 35. Grid C_2 is grounded as far as radio frequency is concerned by virtue of its connection to insulated plate 26 supported from the inner wall surface of core member 14.

It is convenient to supply energizing potential to the oscillator by connecting the otherwise free end of loop D_1 to a suitable voltage (B plus). Loop D_2 and connecting circuit D_4 consist of a hollow conductor whose free end is accessible for external circuit connections, and which carries a filament lead 27 in its hollow interior.

The operating frequency is such that cavity A is somewhat less than ¼ wave length long. Connecting circuit D_3 is approximately ¼ wave length long, adjusted for proper phase shift. In D_2 and D_4 the filament lead 27 is approximately ¼ wave length long.

The energy tap E consists of a single conductor passing through a bushing 25 in the wall of cylinder 10 and hence through a rigid coaxial shield 30 to a rigid housing 31 in which the difference frequency generating circuit G is contained. Circuit G preferably operates on the conventional thermionic diode or crystal rectifier principle.

Typical electrical operating characteristics which may be achieved are as follows. Utilizing a tube 6AF4 or 5703 together with a maximum voltage of 300 volts and a grid drive of 20 volts, with a resonant frequency of about 1000 megacycles, a loaded Q of about 8000 may be achieved with a sensitivity of 500 cycles per microinch deflection of the diaphragm, or equivalent end-loading.

While a grounded-grid circuit has been illustrated, it will be understood that a grounded plate or grounded cathode could be used, or any other type of circuit connection which would provide stable oscillation.

Where the transducer is utilized for position indication it is particularly advantageous to use a plunger in lieu of the resilient diaphragm as shown.

Many modifications of the invention will be apparent to those skilled in the art, and it will be understood that I do not intend to be limited to the details shown or described, except in accordance with the following claims.

I claim:

1. A transducer comprising, in combination: first and second rigid hollow metallic cylinders disposed in longitudinal alignment and having abutting ends; a flexible metallic diaphragm disposed transversely between said cylinders and closing off said abutting ends thereof; first and second rigid hollow metallic cylindrical core members concentrically disposed in the outer ends of respective ones of said cylinders; first and second rigid metallic plates closing off the outer ends of the annular spaces between said cylinders and said cores and rigidly supporting the outer ends of said cores relative to the outer ends of said cylinders; third and fourth rigid metal plates closing off the inner ends of said cores, said core inner ends being approximately equally spaced from the normal position of said diaphragm; first and second electron discharge devices housed within corresponding ones of said core members, and each having at least three electrodes; first and second electrical circuit means respectively associated with said first and second electron discharge devices, each of said circuit means coupling the associated discharge device to the cavity between the corresponding cylinder and core for providing an oscillator whose oscillation frequency is at all times substantially identical to the natural resonant frequency of said cavity; mechanical means for deflecting the central portion of said diaphragm along the longitudinal axis of said cylinders so as to vary the resonant frequencies of both of said cavities concurrently but in opposing directions; and means for transmitting oscillating energy from both of said cavities concurrently, to a difference frequency generating device, so as to produce a difference frequency indicative of the magnitude of the deflection of said diaphragm.

2. A transducer as claimed in claim 1 in which each of said first and second plates has an opening therein adapted to admit gas to the associated cavity, whereby deflection of said diaphragm is accomplished by the differential gas pressures existing in said cavities.

3. A transducer as claimed in claim 1 in which each of said cylinders is provided with an outwardly extending circumferential flange on its inner end, the outer circumferential portion of said diaphragm being disposed between said flanges, and which further includes fastening

means pressing said flanges together for securely maintaining the relative positions of said cylinders and the outer circumferential portion of said diaphragm.

4. A transducer as claimed in claim 3 in which said first and second plates are partially provided by circumferential flanges extending inwardly from the outer ends of said cylinders, and partially provided by circumferential flanges extending outwardly from the outer ends of said cores, the mating circumferential surfaces of said flanges being threadedly engaged.

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