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DEVICE FOR QUADRATICALLY CONVERTING A LINEAR DISPLACEMENT INTO AN ELECTRICAL QUANTITY

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FIG. 1

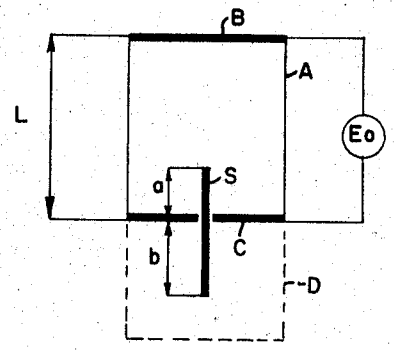


FIG. 2

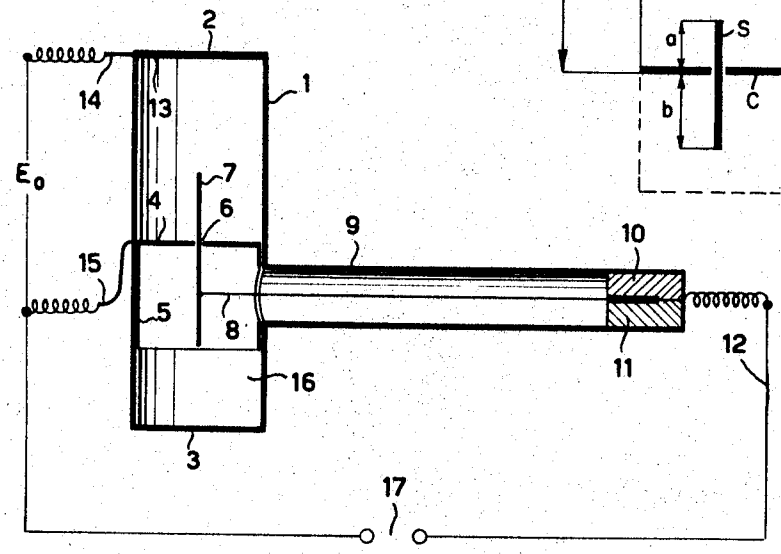
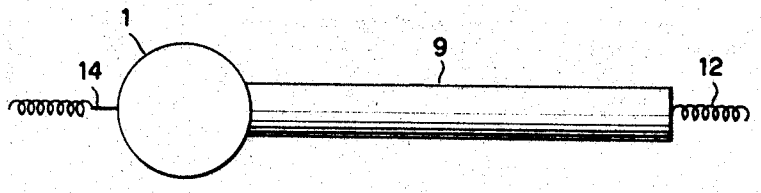


FIG. 3



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DEVICE FOR QUADRATICALLY CONVERTING A LINEAR DISPLACEMENT INTO AN ELECTRICAL QUANTITY

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11 Claims. (Cl. 323—93)

The invention relates to a device for converting a displacement into an electrical quantity that is variable with the square of the displacement.

According to the invention there is provided in a device having an elongate electrode such as an electrode rod passing through a hole provided in a disc shaped electrode, the electrode rod being perpendicular to the main plane of the disc shaped electrode and being able to be moved in its longitudinal direction, a further electrode being mounted at one side of the said disc shaped electrode and spaced therefrom, whereas at the other side of the said disc shaped electrode an equipotential space is provided.

Preferably both disc shaped electrodes are circular shaped and the hole in the one electrode through which the electrode rod is passed is concentric with the said circular disc electrode.

The invention applies as well to a quadratic variable condenser as to a quadratic variable resistance. In the first case the space between the rod electrode and both the disc electrodes should be nonconducting and may be filled with a liquid which has a substantially higher resistivity than that of the electrodes, in one case with a dielectric, and in the second case this space should be electrically conducting and can be filled with, e.g., an electrolyte.

Further details of the invention will be explained with reference to the drawings in which:

FIG. 1 shows a theoretical scheme elucidating the invention;

FIG. 2 shows an embodiment of the invention in further detail and

FIG. 3 shows the embodiment of FIG. 2 in plan view.

In FIG. 1 the rod electrode S is axially movably mounted in a hole in the disc electrode C. The length of the rod electrode that emerges above the disc electrode C equals a and the length of the rod electrode below the disc electrode C equals b. Opposite to the disc electrode C is placed a disc electrode B, both electrodes being mounted to an electrically isolating cylinder A. The electrodes B and C are for clarity's sake drawn with heavy lines, but their actual thickness is only about 5μ. The electrodes B and C are spaced apart at a distance L. At the lower side of electrode C is placed a metallic cage D, electrically connected to electrode C. Across electrodes B and C a voltage E_o is applied. The voltage present over the gap between S and C will then, according to a well-known formula, equal

$$\frac{E_o.a}{2L}$$

Consequently, the loop consisting of electrode C, electrode S and again back to electrode C (partly via cage D) receives an E.M.F. equalling

$$\frac{E_o.a}{2L}$$

The load of this circuit is formed by the shunt between part b of rod electrode S and the electrode C in combination with the equipotential cage D.

Presume the space between the electrodes B and C and

inside cage D is nonconducting. In that instance the load impedance is the capacity between part b of the rod electrode S and the combination of electrode C and cage D. This capacity is proportional to b. It follows:

capacity between C and $a=k_1.a$;
capacity between C and $b=k_2.b$,

in which k_1 and k_2 are constants independent of a and b. In view of the fact that a and b have the same cross section on both sides of C, $k_1 \approx k_2 = k$. Both these capacities will be called C_a and C_b respectively.

Further it should be observed, that if the space between the electrodes B and C and that inside cage D is filled with a liquid dielectric, the capacities C_a and C_b are multiplied by the dielectric constant of said dielectric, so that still the same result is obtained. It is further observed that the equation

$$e_o = \frac{E_o}{2} \cdot \frac{a^2}{L \cdot t}$$

can be written as $e_o = f.a^2$ in which f is independent of a and equals

$$\frac{E_o}{2Lt}$$

where t is a constant, so that f can be adjusted by adjusting L.

If the space between electrodes B and C and inside cage D is filled with a conducting liquid, e.g., an electrolyte, then the same equations remain valid, except that the expression for capacity should be replaced by an expression for conductivity. In that instance the conductivity between S and B equals $k_3.a$ and that between S and C equals $k_4(a+b)$, in which $k_3 \approx k_4$, because electrode portion a has the same cross section as has electrode portion b. The equation for e_o thus becomes:

$$e_o = \frac{E_o}{2} \frac{a}{L} \cdot \frac{k_3 \cdot a}{k_4(a+b)} \approx \frac{E_o}{2} \cdot \frac{a^2}{Lt}$$

where $t=a+b$ is a constant.

In FIG. 2 an embodiment of the invention is shown as applied to an acceleration meter. A plastic cylinder **1** is at its upper side provided with a conducting coating, e.g., of platinum **2**. The bottom **3** is simply of plastic without any conducting coating.

Perpendicular to the axis of the cylinder is placed a disc electrode **4** having a central hole **6** through which a rod electrode **7** emerges. This rod electrode is attached by means of spot welding to a spring blade **8**, e.g., of Phosphor bronze. At the side of the cylinder **1** is attached another cylinder **9** of plastic in which the main part of the spring blade **8** is situated. At its righthand end this spring blade is clamped rigidly between two blocks **10** and **11** which are firmly connected to each other, e.g., by means of bolts (not shown), gluing or welding. Connected with the electrode **4** is a conducting skirt **5**. The space inside cylinders **1** and **9** is filled with an electrolyte. Electrodes **2** and **4** are connected by means of conductors **14** and **15** to a voltage source E_0. Conductor **15** is further connected to an output **17**, the other pole of which is connected through conductor **12** with the spring blade **8**, that electrically conducting is connected to the rod **7**. The spring blade **8** is, as far as it contacts the electrolyte covered with an insulation, e.g., a thin film of lacquer or other insulating material.

The nominal FIG. 2 is on scale 1:1 to a real embodiment. Only the electrodes are thinner than shown whereas the hole **6** is about 1 mm. The electrode rod **7** has a thickness of about 0.15 mm.

When a voltage E_0 is applied to the conductors **14** and **15** a voltage proportional to the square of the distance of the part of electrode **7** emerging above electrode **4** will be taken off between the poles of output **17**. The move-

ments of the electrode rod 7 in this embodiment are obtained by accelerations in the vertical direction.

In the embodiment shown the liquid 16 has a resistivity of 1000 ohm-cm. Such a resistivity easily can be obtained by dissolving a salt in water, as is well known. In order to critically damp the oscillating system 8, 7 the viscosity of the liquid can be influenced and adapted to a critical damping, e.g., by adding sugar to the salt solution.

In order to avoid polarization the electrodes preferably are made of platinum covered with platinum black or a very fine platinum sponge, as is well known in the art.

The skirt 5 needs only to have such a length, that the space below electrode 4 is an equipotential space. Experience has shown that the device as shown in FIGURE 2 gives an exact quadratic relation between displacement of electrode 7 and the voltage between the poles of the output 17. The accuracy is better than 1% with deviations of the rod 7 up to 5 or 6 mm.

I claim:

1. A device for converting a displacement into an electrical quantity so arranged that the electrical quantity varies with the square of the displacement, comprising a first electrode and a second electrode spaced apart and facing each other, a hole provided in said first electrode, and a third electrode having an elongate form and a uniform cross-section perpendicular to its length, said third electrode being positioned within said hole and having a portion thereof extending on either side of said first electrode, mounting means for said third electrode permitting said electrode to be displaced for a limited distance in the direction of its length with respect to said first electrode, electrical connecting means mounted on each of said electrodes, a voltage source connected to said first and second electrodes, and output terminals one connected to said third electrode and another connected to one of said first and second electrodes.

2. Device according to claim 1, characterized in that the first and the second electrode have plane surfaces facing each other.

3. Device according to claim 1, characterized in that the said first electrode is disc shaped.

4. Device according to claim 1, characterized in that the first and the second electrode have a thickness substantially smaller than their remaining dimensions and present planar mutually parallel surfaces to each other.

5. A device according to claim 1, characterized in that electrically conducting means are provided at the side of said first electrode opposite to that facing said second electrode, thereby providing an electrostatically shielded space at said side of said first electrode, said space extending from said first electrode in a direction away from said second electrode over a distance at least equal to the length of the portion of said elongate electrode extending at said side of said first electrode.

6. A device according to claim 5 wherein said electrically conducting means is a metallic cage connected to said first electrode.

7. Device according to claim 1, characterized in that the space between the first and second electrode and that surrounding the third electrode is filled with a liquid having a resistivity substantially greater than that of said electrodes.

8. Device according to claim 7, characterized in that the liquid is electrically insulating.

9. Device according to claim 7, characterized in that the liquid is an electrolytic solution.

10. Device according to claim 1, characterized in that the first and second electrode are connected to the poles of a voltage source and that the output is connected to the first and the third electrode respectively.

11. Device according to claim 1, characterized in that the rod electrode is connected to a resilient mounting means.

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