

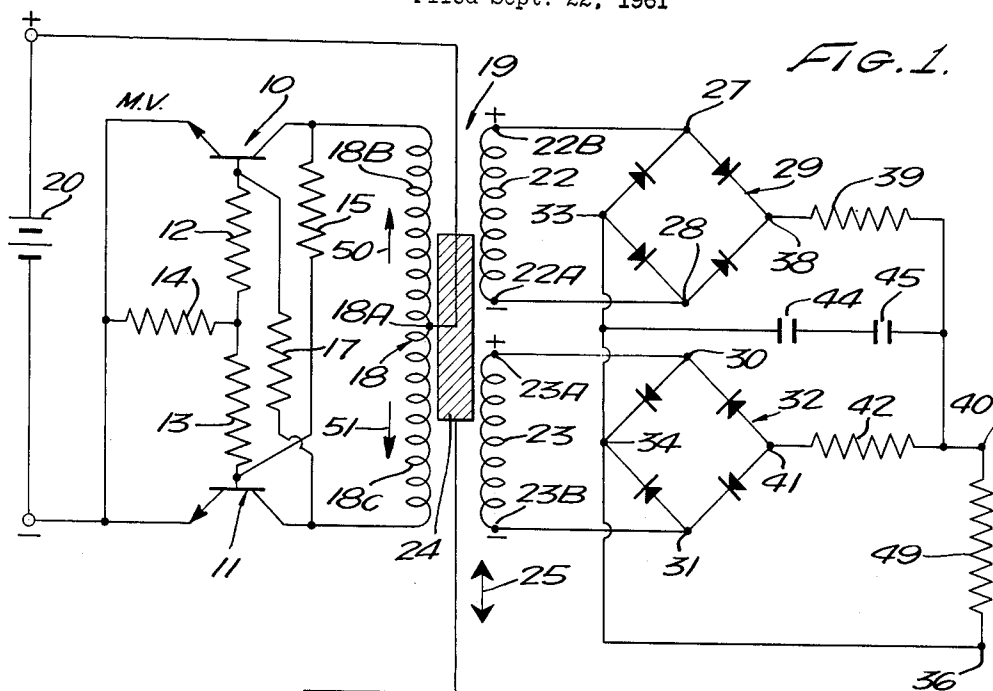
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MOVABLE CORE TRANSDUCER

Filed Sept. 22, 1961



MOVEMENT
PRODUCING
MEANS

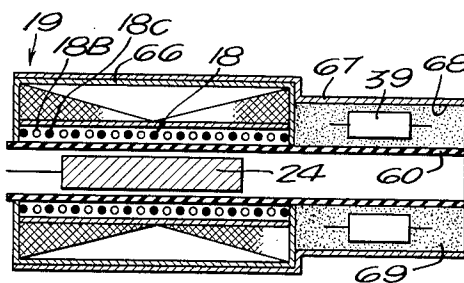
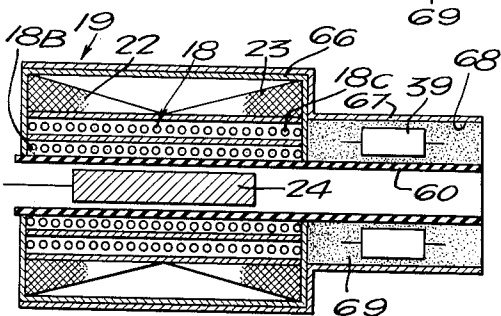
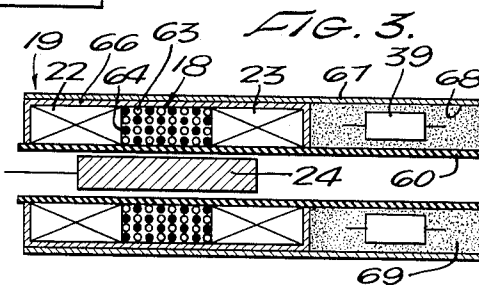
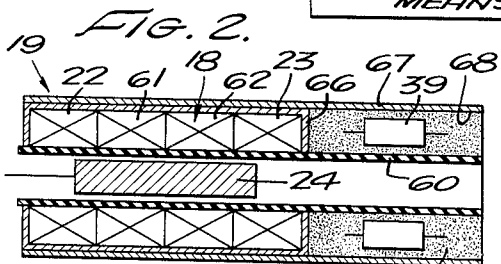


FIG. 4.

FIG. 5.

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MOVABLE CORE TRANSDUCER

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This present invention relates to transducers wherein an electrical signal is developed representative of the position of an element with the relationship between the signal and position being substantially linear and in general involves a D.C.-to-A.C. converter, the converter constituting a variable transformer connected in an oscillator circuit.

In general, a D.C.-to-A.C. conversion circuit is disclosed herein wherein a variable transformer is connected in an oscillation network and the variable transformer has a primary winding, the primary winding having associated therewith a movable, high-permeability core of the position of which is determinative of an output voltage which may be fed to a demodulator circuit for conversion of the A.C. output to a D.C. signal representative of the position of the core.

Using these techniques, a relatively small inexpensive unit is provided for use in many different arrangements wherein it is desired to develop an output voltage representative of the position of a movable element such as, for example, in servo systems.

It is therefore an object of the present invention to provide a new and improved transducer of this character wherein an output voltage either A.C. or D.C. is representative of the position of a movable element.

Another object of the present invention is to provide a system of this character which may be physically incorporated in a relatively small unit.

Another object of the present invention is to provide a unit of this character involving the use of a transistor-type of multivibrator associated with a transformer construction having associated therewith a movable core, with the position of the core determining the output voltage.

Another object of the present invention is to provide an arrangement of this character wherein the primary winding or coil of a differential transformer serves a dual function namely (1) as a source of excitation of the secondary coils or windings of the transformer as well as (2) as a frequently determining element of the oscillator circuit, thus eliminating one relatively large component.

Other objects of the present invention involve practical physical constructions which are compact and which provide a linear relationship between output signal and core movement and particularly where the range of core movement is relatively large.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. This invention itself, both as to its organization and manner of operation, together with further objects and advantages thereof, may be best understood by reference to the following description taken in connection with the accompanying drawing in which:

FIGURE 1 of the drawing illustrates a system and device embodying features of the present invention, the same being illustrated schematically.

FIGURES 2-5 are generally cross-sectional views through different physical structures each being used in the system illustrated in FIGURE 1.

Referring to the drawing, there is provided a multivibrator circuit involving the transistors 10 and 11 connected in a multivibrator-type circuit. The base electrodes of transistors 10 and 11 are interconnected by two series-connected resistors 12 and 13 with the junction point of such resistors 12 and 13 being connected through

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resistor 14 to the emitter electrodes of transistors 10 and 11. The collector electrode of transistor 10 is connected to the base electrode of transistor 11 by resistor 15 and likewise the collector electrode of transistor 11 is connected to the base electrode of transistor 10 by resistor 17. The collector electrodes of transistors 10 and 11 are interconnected by the center-tapped primary winding 18 of transformer 19 with the center tap of winding 18 being connected to the positive terminal of D.C. source 20, the negative terminal of source 20 being connected to interconnected emitter electrodes of transistors 10 and 11.

The transformer 19 comprises the aforesaid center-tapped primary winding 18, the secondary windings 22 and 23 which are interconnected in differential manner, and a movable, high-permeability core member 24, such core member 24 being movable in the direction indicated by the arrows 25 in response to a condition as, for example, in response to the position of an element in a servo system for developing an output voltage representative of the position of such element and hence the position of the core member 24.

As illustrated in the drawing, the secondary winding 22 has its terminals connected to diagonally opposite points 27, 28 of a full-wave bridge-type rectifier circuit 29. In like manner, the secondary winding 23 has its opposite terminals connected to diagonally opposite points 30 and 31 of a full-wave bridge-type rectifier circuit 32. The terminals 33 and 34 of bridge-type rectifiers 29 and 32 are interconnected to a common output terminal 36. The other terminal 38 of rectifying circuit 29 is connected through resistor 39 to the other output terminal 40. Similarly, the other output terminal 41 of the bridge-type rectifier 32 is connected to the same output terminal 40 through resistor 42.

A pair of series-connected capacitors 44 and 45, which indeed may comprise one single capacitor, are connected across the output terminals 36 and 40 and such capacitors 44, 45 operate in conjunction with resistors 39, 42 to provide a filtered D.C. output at the terminals 36, 40. These output terminals are interconnected by a load resistor 49 and it will be seen that the voltage developed across this resistor 49 is dependent upon the position of the movable core member 24. In the central position of the core member 24, the voltages induced in the secondary windings 22 and 23 are equal, with the result that the voltage developed across the resistor 49 under that condition is zero.

It will also be appreciated that the transistors 10 and 11 functioning in a multivibrator circuit are alternately rendered conductive and nonconductive such that when the transistor 10 is conducting, current flows through the upper half of the primary winding 18 in the direction indicated by the arrow 50 and likewise, when the transistor 11 is conducting, the current flows through the bottom half of the primary winding 18 in the direction indicated by the arrow 51. Thus, in the central position of the core member 24, the voltages induced in the secondary windings 22 and 23 are equal and opposite in phase so that when these two secondary windings are connected in series relationship, the A.C. output voltage is substantially equal to zero. This A.C. output voltage developed in the coils 22, 23 may be used as an indication of the position of core 24; alternatively, as shown in the drawing, the A.C. voltages developed in these secondary windings 22, 23 may be rectified and the net D.C. rectified voltage is then used as an indication of the position of core 24.

The coils 22 and 23 are wound with respect to the primary coil 18 so as to have the relative polarities indicated by the plus and minus signs adjacent the terminals 22A,

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22B of winding 22 and terminals 23A, 23B of winding 23. Thus, when transistor 10 is rendered conductive, a current flows through the upper half of primary winding 18 in the direction indicated by the arrow 50, and winding 22 has the polarity indicated in the drawing, i.e. the terminal 22B being positive and the terminal 22A being negative. Likewise, the voltage developed in the other secondary winding 23 has the polarity indicated by the plus and minus signs, the terminal 23A being positive and the terminal 23B being negative. Under this particular instantaneous condition exemplified current may be considered to flow from the terminal 22B to rectifier terminal 38 through resistor 39, load resistor 49, rectifier terminal 33, rectifier terminal 28 and the coil terminal 22A. Likewise, considering the voltage induced in winding 23, current flows from terminal 23A to rectifier terminal 30, rectifier terminal 34, output terminal 36, load resistor 49, output terminal 40, resistor 42, rectifier terminals 41 and 31 and to the coil terminal 23B. It will be seen that these two currents flow in opposite directions through the resistor 49 and since such currents are equal, i.e. the voltages induced in coils 22 and 23 are equal, the net current flow through resistor 49 is zero. It will be seen that the same condition exists when transistor 11 is conducting and transistor 10 is non-conducting.

These conditions, however, are altered when the core 24 is moved from its center position. Thus, assuming that the core 24 is moved upwardly from its central position, a greater voltage is induced in secondary winding 22 than is induced in the other secondary winding 23 so that a residual voltage of a definite polarity is developed across resistor 49 and likewise when the core member 24 is moved downwardly from its central position, a greater voltage is induced in winding 23 than is induced in winding 22 and there is a residual voltage developed across resistor 49.

It is thus seen that the intensity of the voltage developed across resistor 49 and its polarity is indicative or representative of the position of the core member 24.

Referring now to FIGS. 2-5 each of the physical constructions is used in the system illustrated in FIG. 1. In each case a high permeability core member 24 is slidably mounted in a nonmagnetic coil form 60 of for example, plastic, stainless steel, brass or the like upon which windings corresponding to windings 18, 22, 23 in FIG. 1 are wound. In each case the transformer 19 of FIG. 1 comprises windings of different configuration on coil form 60.

In FIG. 2 the primary winding 18 comprises two individual coils 61, 62 of the same number of turns in an abutting relationship with a connection between the two serving as center tap 18A. The secondary windings 22, 23 comprise individual coils abutting coils 61 and 62 respectively.

In FIG. 3 the primary winding 18 is formed by winding two conductors simultaneously on coil form 60 such that the two conductors are uniformly or homogeneously interwound, one of the conductors being illustrated as circles 63 in FIG. 3 and the other conductor being illustrated as darkened circles 64. One end of each of such conductors 63, 64 are interconnected to provide the center tap 18A; and the secondary windings 22, 23 are individual coils wound adjacent opposite ends of the composite primary winding 18.

In FIG. 4 the primary winding 18 is in the form of a double layer winding on coil form 60, that winding closest to coil form 60 being one half 18B of the primary winding and the other winding on such winding 18B being the other half 18C, one end of each winding 18B, 18C being interconnected to provide the center tap 18A in FIG. 1. In this case the secondary windings 22 and 23 are wound on top of winding 18C so as to have a generally tapered or triangular cross-section with the apices of the triangular section being generally coincident and being located longitudinally in the center of primary winding 18 as illustrated.

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In FIG. 5 the primary winding 18 is wound by winding two conductors on the coil form 60 simultaneously as in FIG. 3, one of the conductors so wound constituting primary half 18B and the other conductor constituting primary half 18C which have ends thereof interconnected to provide center tap 18A. The secondary windings 22, 23 in FIG. 5 are wound and have the same configuration as described in FIG. 4.

The arrangements shown in FIGS. 4 and 5 wherein the primary winding 18 extends longitudinally a considerable distance along the coil form are preferred since the core member 24 then moves a greater distance in producing an output voltage which is linearly related to core movement, the general reason being that in such case the impedance remains substantially constant as long as the core remains within the confines of the primary winding.

In each of FIGS. 2-5 all of the components shown in FIG. 1 (with the exception of source 20) are mounted in a unitary manner on the coil form 60. Such components include the transistors 10, 11, rectifying elements comprising the bridge rectifiers 29, 32, and the various resistances and capacitors shown in FIG. 1.

For this latter purpose, in each of FIGS. 2-5 the windings of the transformer 19 is enclosed by a high permeability shield 66 which is in the nature of a sleeve having ring shaped or flanged ends that abut coil form 60 which however is sufficiently prolonged to provide a convenient mounting for the above mentioned components. These components are in turn encased in an outer sleeve member 67 which may be of insulating material and which define an annular space 68 within which such components are disposed. This annular space may be filled with a suitable insulating potting compound 69 which may be applied using conventional techniques to hermetically seal such components against outside influences such as humidity and the like.

While the particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from this invention in its broader aspects and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

I claim:

1. A position-to-voltage transducer including a multi-vibrator network, said network including a pair of transistors, a voltage source supplying said network, a transformer having a two-section center-tapped primary winding and a pair of secondary windings with a movable core member adjustably coupling said primary winding to said secondary windings, one terminal of said source being connected to said center tap on said primary winding, one of the outside terminals of said primary winding being connected to a collector electrode of one of said transistors, the other outside terminal of said primary winding being connected to the collector electrode of said other of said transistors, the other terminal of said source being connected to the emitter electrodes of each of said transistors, first resistor means interconnecting the collector electrode of one of said transistors to the base electrode of the other transistor, second resistor means interconnecting the collector electrode of said other transistor to the base electrode of said one transistor, a pair of series-connected resistors interconnecting the base electrodes of said transistors, a resistor connected between the center tap of the last-mentioned series-connected resistor and the emitter electrodes of said transistors, and means connected to said secondary windings and producing a voltage representative of the voltages developed in said secondary windings.

2. A transducer as set forth in claim 1 in which said network is mounted on a coil form, and said core member being movably mounted in said coil form.

3. A transducer as set forth in claim 2 in which the transformer windings comprising a portion of said net-

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work is partially surrounded by a high permeability shield, the remaining portion of said network being mounted on said coil form, a housing sleeve partially surrounding said shield and said remaining portion of said network, said remaining portion of said network being encased in a potting compound which is retained by said housing sleeve.

4. A position-to-voltage transducer comprising a multivibrator circuit, means for supplying current to said multivibrator circuit, said means including a two-section center-tapped primary winding of a transformer, a voltage source having one of its terminals connected to the center tap on said winding, the other terminal of said source being connected to said multivibrator circuit, a pair of secondary windings of said transformer, said transformer including a movable core member for adjustably coupling said primary winding to said secondary windings, and means developing a voltage representative of the net voltage of said secondary windings, said primary winding being mounted on a coil form, said secondary windings being mounted on said coil form, a magnetic shielding structure partially surrounding said primary and secondary windings, and said core member being movably mounted in said coil form.

5. A transducer as set forth in claim 4 in which said primary winding comprises two coil sections which are interconnected to define a center tap, and said secondary windings being disposed on said coil form on opposite sides of said primary winding.

6. A transducer as set forth in claim 4 in which said primary winding comprises two conductors which are interwoven such that a turn of one conductor is adjacent a turn of the other conductor, said one conductor comprising one half of said primary winding and said other

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conductor comprising the other half of said primary winding.

7. A transducer as set forth in claim 6 in which the turns of said conductors extend radially outwardly of said coil form.

8. A transducer as set forth in claim 6 in which the turns of said conductors are spaced equidistant from the center of the coil form.

9. A transducer as set forth in claim 8 in which said secondary windings are generally triangular in cross section with the apices of the triangles being generally coextensive and being longitudinally at the center of the primary winding.

10. A transducer as set forth in claim 4 in which said primary winding comprises two equal sections, one section being wound on the other section, and said secondary windings being wound on said one section and comprising windings which are each generally triangular in cross section with the apices of the triangles being generally coextensive and being longitudinally at the midpoint of said primary sections.

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