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DIFFERENTIAL TRANSFORMER

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Fig. 1

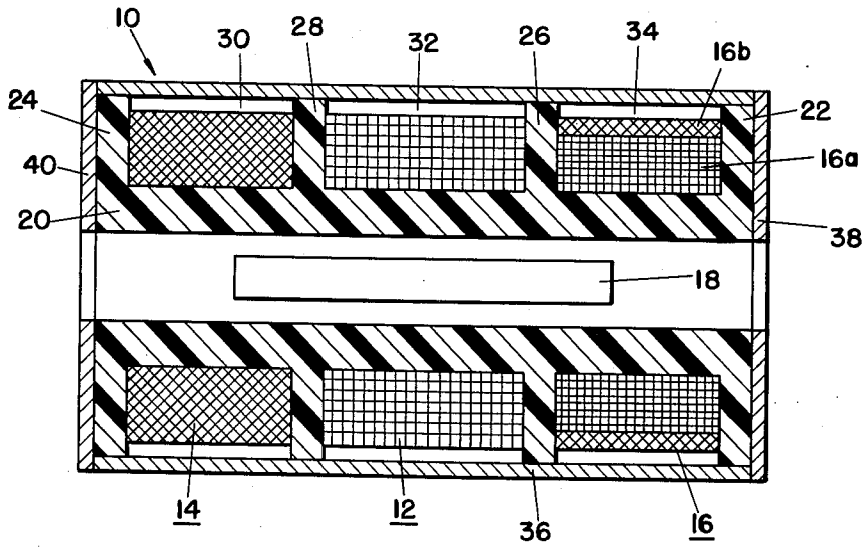
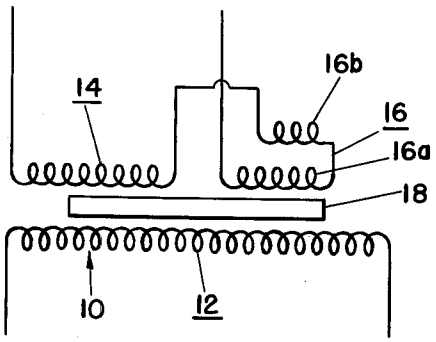


Fig. 2



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DIFFERENTIAL TRANSFORMER

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The present invention relates to a differential transformer, and more particularly to a non-symmetrical differential transformer.

Heretofore, differential transformers were composed of a tubular bobbin of non-conducted, non-magnetic material having three individual coils of conductive wire wound thereon in side-by-side relation, and an armature core of magnetic material movably disposed within the bobbin as shown in United States Letters Patent No. 2,507,344. The center coil of the differential transformer being the primary coil, and the two end coils, each of which is composed of the same number of turns, being the secondary coils, with the secondary coils being connected in bucking series arrangement. By bucking series arrangement, it is meant that the coils are connected so that when an A.C. current input is placed on the primary coils, the output of one of the secondary coils is of an opposite phase to the output of the other secondary coil.

When the armature core of such a differential transformer is in a position where it extends across the entire primary coil and projects beyond each end of the primary coil and across the same number of turns of each of the secondary coils, the armature core is at its null position, i.e., the output of each of the secondary coils are equal and of opposite phase so that the total output of the transformer is zero. If the armature core is moved in either direction from its null position, it will extend across more turns of one of the secondary coils and less turns of the other secondary coil so that the output of the transformer increases.

The type of differential transformer shown in Patent No. 2,507,344 has its null position in the center of the transformer so that the transformer is a symmetrical type transformer, i.e., movement of the armature core in either direction from the null position produces outputs of equal magnitude. The maximum output of such a differential transformer is obtained when the armature core has moved to a position where it still extends across the entire primary coil, but projects only across one of the secondary coils. However, in such differential transformers, the maximum length of travel of the armature core from its null position to the position providing the maximum output of the transformer is small, being a maximum of one-quarter the length of the transformer. However, there are requirements for a differential transformer which has a longer permissible displacement of the armature core and which does not have to be symmetrical.

It is an object of the present invention to provide a novel differential transformer.

It is another object of the present invention to provide to non-symmetrical differential transformer.

It is a further object of the present invention to provide a non-symmetrical differential transformer which is relatively small and of simple design so as to be relatively inexpensive to manufacture, and which is stable electrically and mechanically.

For the purpose of illustrating the invention there is shown in the drawings a form which is presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

FIGURE 1 is a longitudinal sectional view of the differential transformer of the present invention.

FIGURE 2 is a circuit diagram of the differential transformer of the present invention.

Referring initially to FIGURE 2, the differential transformer of the present invention is generally designated as 10.

Differential transformer 10 comprises a primary inductance coil 12, and a pair of secondary inductance coils 14 and 16 which are connected together in bucking series arrangement. Secondary coils 14 and 16 are magnetically coupled to the primary coil 12 through opposite ends of an armature core 18. Armature core 18 is a rod of magnetic material which is movably disposed between the primary coil 12 and the secondary coils 14 and 16. Secondary coil 14 is wound entirely in the same direction. However, secondary coil 16 has a major portion 16*a* which is wound in the same direction as the secondary coil 14, and a minor portion 16*b* which is wound in the direction opposite to the major portion 16*a*. Thus, one portion of the secondary coil 16 is wound in a clockwise direction, and the other portion of the secondary coil 16 is wound in a counterclockwise direction.

It is well known that the direction of the flow of a current induced in an induction coil is dependent on the direction that the coil is wound. Since the portion 16*a* and 16*b* of the secondary coil 16 are wound in opposite directions, a current induced in the major portion 16*a* of the secondary coil 16 will flow through the major portion 16*a* in the direction opposite to the direction of flow of a current induced in the minor portion 16*b* of the secondary coil 16. Thus, a current induced in the major portion 16*a* of the secondary coil 16 will be of opposite polarity to a current induced in the minor portion 16*b* of the secondary coil 16. Since the major portion 16*a* of the secondary coil 16 is wound in the same direction as the secondary coil 14, and the secondary coil 16 is connected in bucking series arrangement to the secondary coil 14, a current induced in the major portion 16*a* of the secondary coil 16 will be of opposite polarity to a current induced in the secondary coil 14. However, since the minor portion 16*b* of the secondary coil 16 is wound in the opposite direction to the major portion 16*a* of the secondary coil 16, a current induced in the minor portion 16*b* will be of the same polarity as a current induced in the secondary coil 14. Thus, although the secondary coil 16 is connected in bucking series arrangement with the secondary coil 14, the minor portion 16*b* of the secondary coil 16 is in aiding series arrangement with the secondary coil 14.

In the operation of the differential transformer 10 of the present invention, when an A.C. input current is placed across the primary coil 12, a current will be induced in each of the secondary coils 14 and 16 of a magnitude dependent on the number of turns of each of the secondary coils 14 and 16 which are crossed by the armature core 18. Since the current induced in the major portion 16*a* of the secondary coil 16 is of opposite polarity to the current induced in the secondary coil 14, and the current induced in the minor portion 16*b* of the secondary coil 16 is of the opposite polarity of the current induced in the major portion 16*a* of the secondary coil 16, the total output from the secondary coils 14 and 16 is equal to the difference between the magnitude of the current induced in the major portion 16*a* of the secondary coil 16 and the sum of the currents induced in the secondary coil 14 and the minor portion 16*b* of the secondary coil 16. Thus, if the armature core 18 extends across the same number of turns of each of the secondary coils 14 and 16, the sum of the currents induced in the secondary coil 14 and the minor portion 16*b* of the secondary coil 16 will be greater than the magnitude of the current induced in the major portion 16*a* of the secondary coil 16 so as to provide an output current from the secondary coils 14 and 16. Therefore, in order to position the armature core 18 at its null position, i.e., where the total output from the sec-

ondary coils 14 and 16 equals zero, the armature core 18 must extend across a larger number of turns of the secondary winding 16 than the secondary winding 14. This places the null position of the armature core 18 adjacent one end of the differential transformer 10. Thus, there is provided a non-symmetrical differential transformer which has its null position adjacent one end of the differential transformer, and in which movement of the armature core 18 from its null position toward the other end of the differential transformer provides an output current from the differential transformer.

Referring to FIGURE 1, there is shown a preferred form of the differential transformer of the present invention.

Differential transformer 10 comprises a tubular bobbin 20 a non-magnetic, non-conducted material, such as a plastic or ceramic. Bobbin 20 has a pair of radially extending end flanges 22 and 24, and a pair of radially extending additional flanges 26 and 28 spaced along the bobbin 20 between the end flanges 22 and 24. The flanges form three compartments 30, 32, and 34 therebetween. Flanges 26 and 28 are positioned so that the end compartments 30 and 34 are of the same width.

The primary inductance coil 12, which is a helically wound coil of insulated electrically conducted wire, is wound around the bobbin 20 within the center compartment 32. Secondary coil 14 is wound around the bobbin 20 within the end compartment 30. Secondary coil 16 is wound around the bobbin 20 within the end compartment 34. Secondary coil 16 is formed by winding an electrically conductive wire around the bobbin 20 in the same direction as the winding of secondary coil 14 until the major portion 16*a* of the secondary coil 16 is completed, and then reversing the direction of the winding of the wire to form the minor portion 16*b* of the secondary coil 16. Although the major portion 16*a* of the secondary winding 16 is shown to be in the bottom compartment 34, the minor portion 16*b* of the secondary coil 16 can be wound over the minor portion 16*b*. The secondary windings 14 and 16 are connected in bucking series arrangement as shown diagrammatically in FIGURE 2. The secondary coils 14 and 16 are preferably each made up of the same number of turns of the same size wire so that they are of the same volume. Thus, the dlifferential transformer 10 is physically symmetrical. Since the secondary coils 14 and 16 are of the same size, they will expand or contract the same amount, and will be stressed the same amount upon changes in temperature. Thus, the differential transformer 10 of the present invention is mechanically stable. Also, the electrical resistance of the secondary windings 14 and 16 will change the same upon changes in temperature so that the differential transformer 10 of the present invention is also electrically stable.

Armature core 18 is movably disposed within the bobbin 20. Armature core 18 comprises a rod of magnetic material which is of a length greater than the width of the primary coil 12, but shorter than the total length of the bobbin 20. If desired, a sleeve 36 of a magnetic material can be placed around the bobbin 20, and discs 38 and 40 of a magnetic material placed against the end flanges 22 and 24 to shield the coils and to reduce the reluctance of the magnetic flux path. Although the bobbin 20 is shown as having a plurality of flanges forming compartments in which the various coils are wound, the differential transformer 10 of the present invention can also be made with a bobbin which does not have the flanges, and with the various coils wound thereon in their proper position. However, a flanged bobbin is preferred since it facilitates the winding of the coils in their proper position.

The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification as indicating the scope of the invention.

I claim:

1. A differential transformer comprising a primary inductance coil, a pair of secondary inductance coils connected together in bucking series arrangement, and an armature core movably disposed between said primary coil and said secondary coils, said armature being of a length to permit the armature to extend across the entire width of the primary coil and at least a portion of the width of each of said secondary coils, said secondary coils being magnetically coupled to said primary coil through opposite ends of said armature core, one of said secondary coils having a major portion which is wound in the same direction as the other secondary coil and a minor portion which is wound in the direction opposite to said major portion.

2. A differential transformer comprising a tubular bobbin of a non-magnetic, non-conductive material, a primary coil of an electrically conductive wire wound around said bobbin, a pair of secondary coils of electrically conductive wire wound around said bobbin on opposite sides of said primary coil, said secondary coils being connected in bucking series arrangement, one of said secondary coils having a major portion which is wound around said bobbin in the same direction as the winding of said other secondary coil and a minor portion which is wound around said bobbin in the direction opposite to the winding of said major portion, and an armature core of a magnetic material movably disposed within said bobbin, said armature core being of a length longer than the width of said primary coil but shorter than the total length of the bobbin.

3. A differential transformer in accordance with claim 2 in which the volume of each of said secondary coils are equal.

4. A differential transformer comprising a tubular bobbin of a non-magnetic, non-conductive material having a radially extending flange at each end thereof and a pair of radially extending flanges between the end flanges, said flanges forming three separate compartments therebetween, a primary coil of electrically conductive wire wound around said bobbin in the center compartment, a separate secondary coil of electrically conductive wire wound around said bobbin in each of said end compartments, said secondary coils being connected in bucking series arrangement, one of said secondary coils having a major portion wound around said bobbin in the same direction as the winding of said other secondary coil and a minor portion wound around said bobbin in the direction opposite to the winding of said major portion, and an armature core of a magnetic material movably disposed within said bobbin said armature core being of a length longer than the width of said primary coil but shorter than the total length of the bobbin.

5. A differential transformer in accordance with claim 4 in which the end compartments of the bobbin are of the same width, and the secondary coils are of the same volume.

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