United States Patent

[11] **3,614,692**

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[21] Appl. No. **42,703**
[22] Filed **June 2, 1970**
[45] Patented **Oct. 19, 1971**
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[54] **VARIABLE INDUCTION DEVICE**
13 Claims, 7 Drawing Figs.

[52] **U.S. Cl.** ..... **336/15,** 339/8 A
[51] **Int. Cl.** **H01f 21/04**
[50] **Field of Search** ..... 336/15; 338/79; 334/38; 339/8 A

[56] **References Cited**

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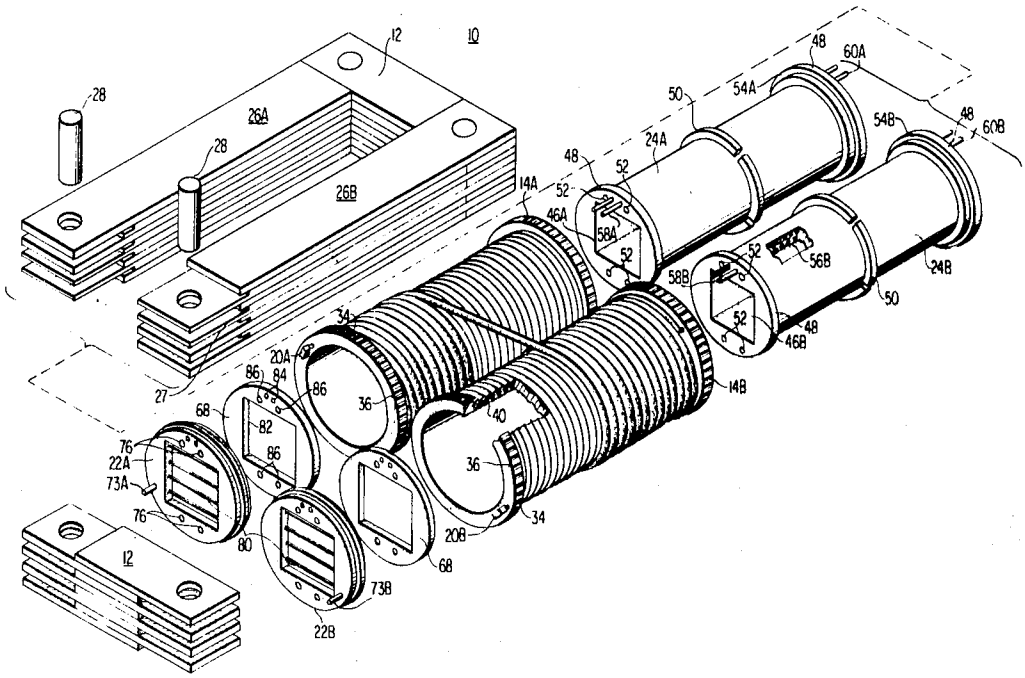
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Primary Examiner—Thomas J. Kozma
Attorney—Burns, Doane, Swecker & Mathis

ABSTRACT: The disclosure relates to a variable induction device or transformer of the type comprising a rectangular magnetic core having two primary transformer windings on opposite core legs and a transferable secondary winding carried by a pair of axially rotatable drums which are each mounted in telescoping relationship over an associated one of the primary transformer windings. Each drum carries a portion of the secondary winding, and the portions are connected in series opposition. The turns of the transferable secondary winding may be transferred from one drum to the other by rotating the drums in synchronism, thereby varying the effective number of transformer secondary turns. A fixed secondary winding or coil having a predetermined number of fixed turns is provided on one of the drums, and electrical connections are made to the windings on the drums by way of an induced current-cancelling commutator. All of the elements comprising the variable induction device are removably mounted and one of the core end members is removable to provide interchangeability of the elements.



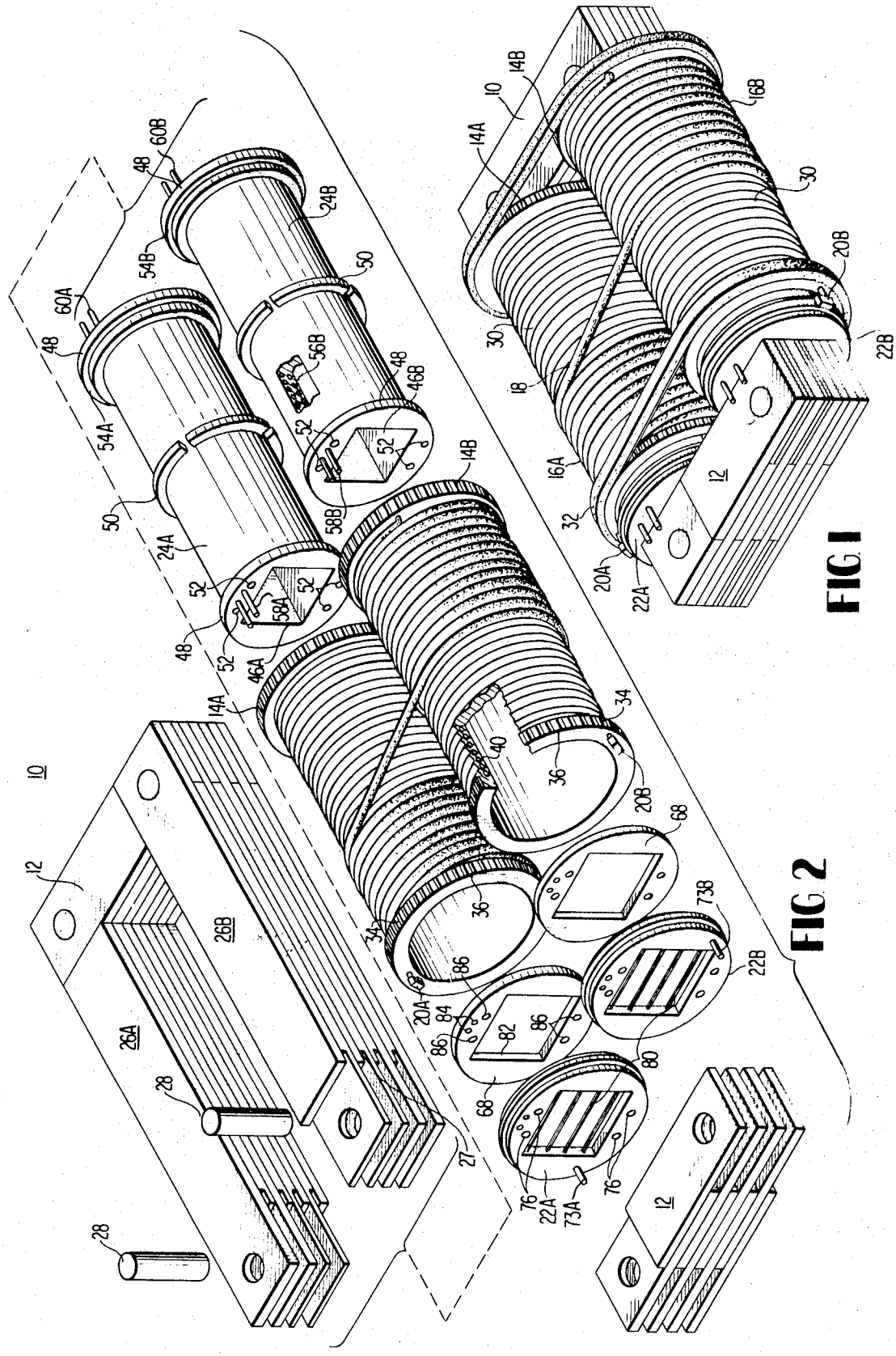


FIG 1

FIG 2

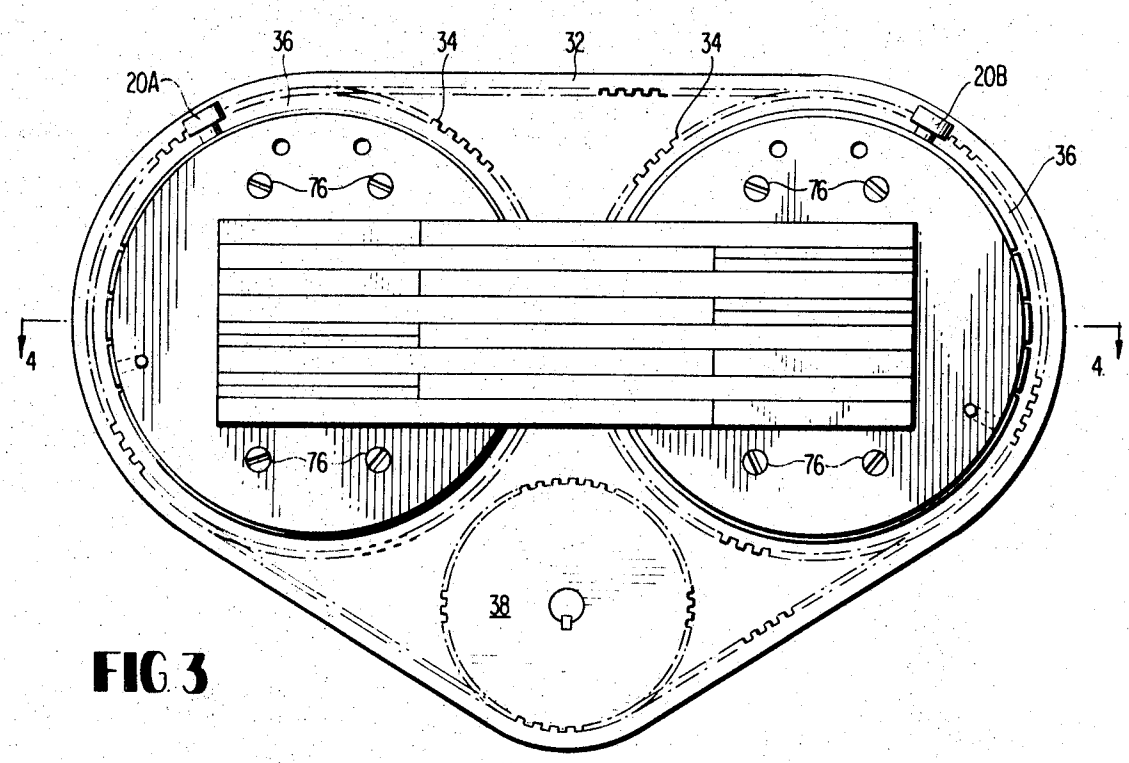


FIG. 3

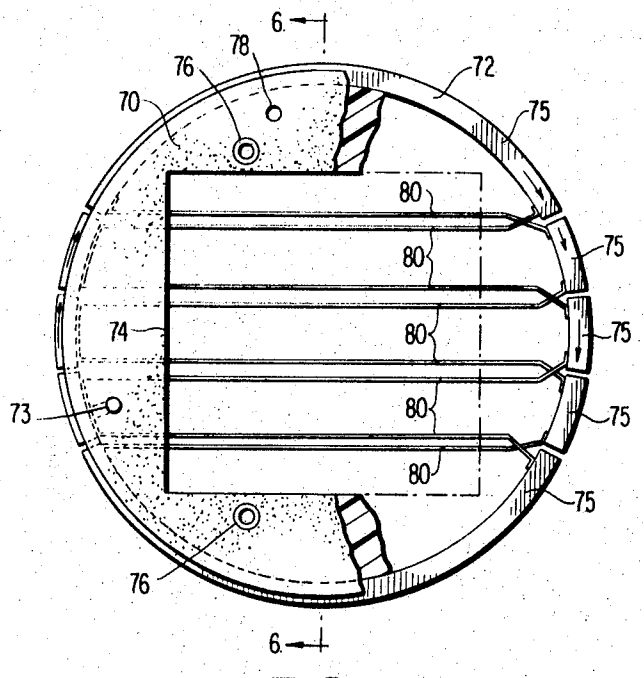


FIG. 5

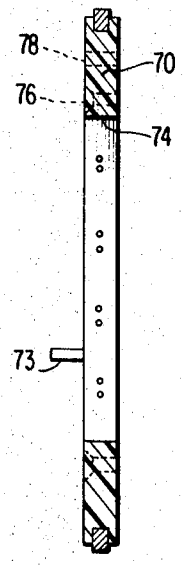


FIG. 6

FIG. 4

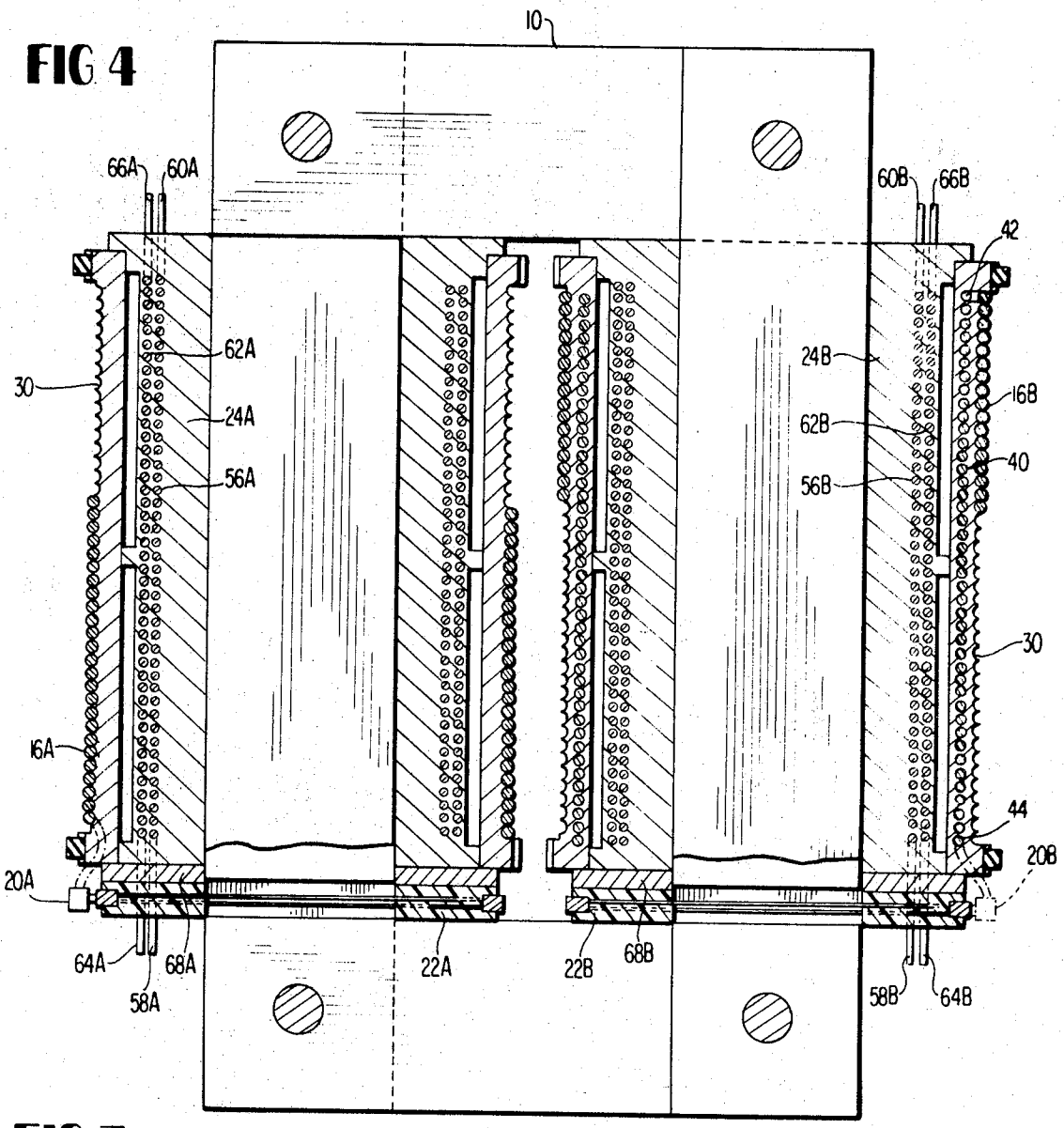
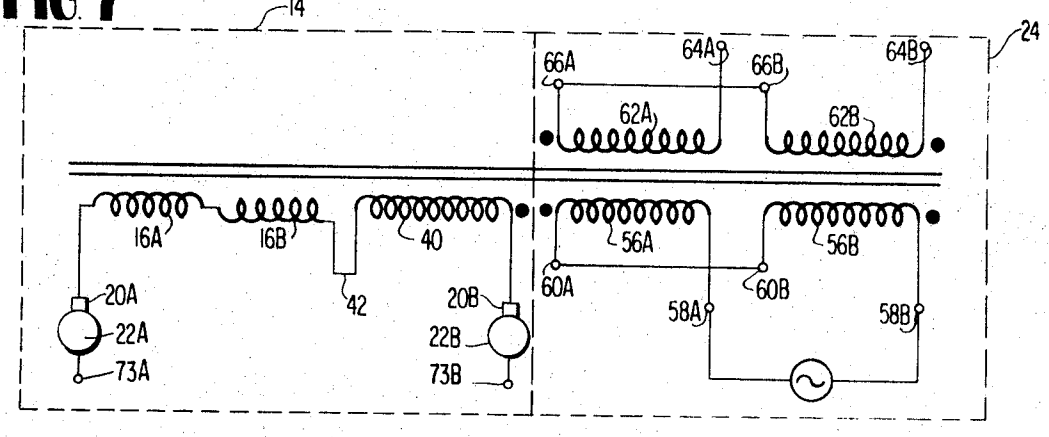

10
66A
60A
60B
66B
42
62A
30
24A
56A
24B
16B
62B
40
56B
30
16A
44
20A
20B
64A
68A
22A
22B
68B
58A
58B
64B

FIG. 7


14
24
66A
64A
66B
64B
62A
62B
16A
16B
40
56A
56B
60A
60B
58A
58B
20A
22A
73A
42
20B
22B
73B

VARIABLE INDUCTION DEVICE

BACKGROUND OF THE INVENTION

The present invention relates to a variable induction device, and more particularly, to a variable induction device providing an output voltage which may be continuously varied between a predetermined minimum and maximum.

Among the more common types of variable transformers are the conventional autotransformer and transformers utilizing tap changing systems. The autotransformer is similar to a potentiometer in that a continuously variable output voltage is "picked off" a transformer winding by a sliding contact. The use of a tap-changing system to provide a variable output voltage requires the selective making and breaking of contacts connected at desired points along a transformer winding. Both types of variable transformers are subject to mechanical wear and do not provide a truly continuous output voltage, i.e. the output voltage varies incrementally with these types of systems.

In another type of variable transformer, as exemplified by U.S. Pat. No. 1,004,102 to Storer, the output voltage is varied by varying the number of secondary winding turns in series aiding and in series opposition with a generator. This is accomplished in the device illustrated in the Storer patent by providing a secondary winding in series with an AC generator which is wound in series opposition on two reels and which is transferred from one reel to the other when the reels are rotated. A primary winding, connected across the generator output terminals, is wound on the core about which the reels rotate and is therefore magnetically coupled to the transferable winding. The output voltage is taken between one end of the secondary winding and one side of the generator, the connections to the secondary winding being made through commutators which cooperate with a great number of brushes to prevent arcing.

Since the transferable secondary windings are connected in series opposition, the voltage induced in the winding on one of the reels adds to the generator voltage and the voltage induced in the winding on the other reel subtracts from the generated voltage. Thus, when the entire secondary transformer winding is transferred to the additive reel, the total output voltage is equal to the generator voltage plus the voltage across the secondary winding. Likewise, when the entire secondary transformer winding is transferred to the subtractive reel, the total output voltage is equal to the generator voltage minus the voltage across the secondary winding.

The device disclosed in the Storer patent is thus, in effect, a device for regulating the output voltage of a generator by varying the impedance between the generator output terminals and the load. Line isolation, i.e. isolation between the generator and the load, is not provided and, in addition, the magnetizing current at the full voltage condition is supplied by only one of the primary transformer windings, causing an unbalance in the primary circuit at full voltage. Furthermore, the Storer device does not provide the versatility required in many applications.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a novel variable induction device having a transferable secondary winding which is electrically isolated from the primary circuit.

It is a further object of the present invention to provide a novel variable induction device which the primary circuit is balanced in the maximum output voltage condition.

It is yet another object of the present invention to provide a novel variable induction device which is versatile and may be easily converted for use in a variety of applications.

It is a yet a further object of the present invention to provide a novel commutator for providing a current path between the rotating and fixed elements in the induction device of the present invention with a minimum of commutator losses and arcing.

Briefly, these and other objects and advantages are accomplished by providing two spaced, axially rotatable drums having a secondary transformer winding comprising a fixed, electrically conductive coil wound on one of the drums and a transferable coil wound on both of the drums, the transferable coil being adapted to be selectively transferred from one of the drums to the other in response to the axial rotation of the drums to thereby modify the effective number of turns of the fixed coil.

DESCRIPTION OF THE DRAWINGS

A preferred embodiment of the present invention is illustrated in the accompanying drawings, in which:

FIG. 1 is a perspective view of the induction device of the present invention;

FIG. 2 is an exploded view of the device of FIG. 1;

FIG. 3 is an elevational view of the device of FIG. 1;

FIG. 4 is a cross-sectional view of the device along the line 4—4 in FIG. 3;

FIG. 5 is a detail view partially in cross section illustrating the commutator of the device of FIG. 1;

FIG. 6 is a cross-sectional view of the commutator taken along the line 6—6 in FIG. 5; and

FIG. 7 is a schematic diagram of the induction device of FIG. 1.

DETAILED DESCRIPTION

Referring to FIG. 1, the induction device of the present invention comprises a rectangular laminated core **10** having a removable end member **12**, two generally cylindrical, substantially hollow drums **14A** and **14B** carried by opposite legs of the core **10** for axial rotation about the longitudinal axes thereof, two electrically conductive coils **16A** and **16B** formed by a flexible conductor **18** wound about each of the drums **14**, and means for simultaneously modifying the number of turns in each of the coils **16**. Electrically conductive contacts or brushes **20A** and **20B** are connected to one end of an associated one of the drums **14A** and **14B**, respectively, in wiping engagement with an associated one of the commutators **22A** and **22B** which are nonrotatably carried by opposite legs of the core **10**. Although not shown in FIG. 1, two cylindrical members **24A** and **24B** are carried by opposite legs of the core **10** within the drums **14A** and **14B**, respectively, to provide a means for inducing a cyclically varying magnetic flux in the coils **16** or alternatively to generate an output voltage in response to a cyclically varying magnetic field induced therein by the coils **16**.

A more detailed understanding of the construction of the device of the present invention may be had by reference to the exploded view of FIG. 2. As shown in FIG. 2, the core **10** preferably comprises a pair of spaced substantially parallel laminated legs **26A** and **26B** of any suitable cross-sectional shape. Illustratively, suitable cross-sectional shapes may include square, rectangular, cruciform, or octagonal shapes.

The adjacent ends of the legs **26A** and **26B** may be interconnected by a pair of transverse laminated end members **12**. Slots **27** are provided to receive the commutators **22** as will hereinafter be described. This may be accomplished, as illustrated, by shortening a selected number of laminations which form the legs **26A** and **26B**.

The end members **12** may be connected to the legs **26A** and **26B** in any conventional manner, such as by means of pins **28**. In this manner, one of the end members **12** may be removed from the legs **26A** and **26B** to facilitate the assembly and the removal of the various elements comprising the induction device. Greater versatility is thereby achieved as will hereinafter be described.

With continued reference to FIG. 2, each of the drums **14A** and **14B** of electrically nonconductive material may be provided with a generally circumferential, helical groove **30**, running from one end of each drum **14** to the other end thereof along the external surface thereof. The electrical con-

ductor 18 generally conforms to the shape of the grooves 30 and is wound about both of the drums 14 in the grooves 30 to provide the two electrically conductive coils 16A and 16B, the turns of which are transferable from one drum 14 to the other by axially rotating the drums 14 in synchronism through a timing belt 32. Any suitable conventional level wind mechanism may be utilized as an alternative to the groove 30 if desired.

As is more clearly illustrated in FIG. 3, the timing belt 32 engages gear teeth 34 provided on a flange 36 at either or both ends of each of the drums 14. The timing belt 32 may also engage a gear 38 which may in turn be driven either manually or by a motor (not shown). The timing belt 32 circumscribes the gear 38 and the flanges 36 at the end of the drums 14, thereby providing synchronous axial rotation of the drums 14 in response to the rotation of the gear 38. Suitable stops (not shown) such as limit switches or mechanical stops may be provided to prevent the motor from driving the drums 14 beyond predetermined limits.

Referring back to Fig. 2, the electrically conductive contacts or brushes 20A and 20B are connected to one end of an associated one of the drums 14A and 14B.

One of the drums 14, for example, the drum 14B, is provided with an electrically conductive fixed coil 40 wound thereabout and preferably embedded beneath the surface thereof as illustrated in FIGS. 2 and 4. In the preferred embodiment of the present invention, the number of turns of the fixed coil 40 is equal to the total number of turns of the coils 16A and 16B formed by the conductor 18 on the respective drums 14A and 14B. One end 42 of the fixed coil 40 is connected to the end of the overlying coil 16B and the other end 44 of the fixed coil 40 is connected to the brush 20B as illustrated in phantom in FIG. 4. The end of the coil 16A on the drum 14A is connected to the brush 20A, also illustrated in phantom in FIG. 4.

Referring again to FIGS. 2 and 4, the cylindrical members 24A and 24B of electrically nonconductive material, are each provided with a longitudinal cavity 46 generally conforming to the shape of the legs 26 of the core 10, thereby allowing the cylindrical members 24A and 24B to be nonrotatably carried by the legs 26A and 26B, respectively, in telescoping relationship thereover. Each of the cylindrical members 24A and 24B may be provided with circumferential flanges 48 at each end thereof, as well as a circumferential flange 50 intermediate the ends thereof. The flanges 48 at one end of each of the cylindrical members 24 may be provided with a plurality of internally threaded apertures 52 to facilitate the assembly of the induction device as will hereinafter be described. Additionally, a shoulder 54 extending radially outwardly beyond the flanges 48 may be provided at the other end of each of the cylindrical members 24A and 24B.

The circumferential surfaces of the flanges 48 and 50 are preferably very smooth to provide substantially friction-free bearing surfaces upon which the drums 14 may be carried for rotation. The shoulder 54 provided on the flanges 48 at one end of each of the cylindrical members 34 is also preferably smooth to provide a relatively friction-free surface against which the drums 12 may abut, as will be more fully described.

As illustrated more clearly in FIG. 4, each of the cylindrical members 24A and 24B is provided with a primary transformer winding 56A and 56B, wound thereabout preferably beneath the surface thereof. The respective ends 58A and 60A of the primary transformer winding 56A and the ends 58B and 60B of the primary transformer winding 56B protrude through suitable lead ports in the respective ends of the cylindrical members 24A and 24B and extend axially therebeyond as illustrated in phantom.

Secondary transformer windings 62A and 62B wound in overlying relationship with the primary transformer windings 56A and 56B respectively may also be provided in the respective cylindrical members 24A and 24B. The ends 64A and 66A of the secondary transformer winding 62A and the ends 64B and 66B of the secondary transformer winding 62B may likewise protrude through and extend axially beyond the ends of the respective cylindrical members 24A and 24B.

The ends 58 and 64 of the primary and secondary transformer windings 56 and 62 respectively also extend through suitable lead ports in both the commutators 22 and bearing plates 68 as will hereinafter be more fully described.

The construction of the commutators 22 utilized with the variable induction device of the present invention are more fully described with reference to FIGS 5 and 6. Referring now to FIGS 5 and 6, the commutators 22 preferably comprise a generally flat, circular plate 70 of an electrically nonconductive material and segmented ring 72 of electrically conductive material. The segments 75 of the ring 72 are shown as being carried by the outer periphery of the plate 70 in electrical isolation from each other. An output terminal 73 may be electrically connected to one or more segments of the ring 72 at a convenient position.

An aperture 74 generally conforming to the shape of the legs 26, a plurality of apertures 76 aligned with the positions of the threaded apertures 52 in the cylindrical members 24, and a plurality of lead ports 78 aligned with the lead ports in the cylindrical members 24, and a plurality of lead ports 78 aligned with the lead ports in the cylindrical members 24 may be provided through the plate 70. The segments 75 of the segmented ring 72 are electrically connected by a plurality of conductors 80, such that a closed, conductive loop is formed by the commutator segments 75 and the conductors 80.

As shown in FIG. 2, the core 10 cross-sectional area is subdivided by the conductor crossover through the slots 27 in such a manner that the current induced by the field in pairs of conductors 80 is equal and opposite. Any grouping of pair conductors, even or odd, that accomplishes this may be utilized.

As illustrated in FIG. 5, the current (as indicated by arrows) induced in immediately adjacent segments 75 of the ring 72 is in the same direction in the segments. However, the segments are connected by the conductors 80 such that the currents oppose and thus cancel. By selecting the segments and the conductors 80 such that the total induced current tending to flow in one direction is equal to the total induced current tending to flow in the opposite direction, e.g. by selecting an even number of segments of substantially the same length and pairs of conductors of substantially the same length, the total induced current flowing through the closed loop formed by the segments 75 and the conductors 80 is zero thereby eliminating commutator losses. Since the segments 75 and the conductors 80 form a continuous closed conductive path, the segments are all at the same potential and arcing does not occur as the brushes 20 bridge the gaps between segments in moving around the ring 72.

The assembling of the variable induction device of the present invention will now be described with reference to FIGS. 1 through 3. As illustrated in FIG. 2, the one of the end members 12 of the core 10 is first removed, and the legs 26A and 26B may be inserted into the cavities 46A and 46B of the cylindrical members 24A and 24B, respectively. The drums 14A and 14B may then be positioned in telescoping relationship with the respective cylindrical members 24A and 24B with the ends thereof abutting the respective shoulders 54A and 54B. A bearing plate 68 having a leg-receiving aperture 82, suitable lead ports 84 and a plurality of apertures 86 aligned with the like apertures in the commutators 22 as previously described, may be positioned on the end of each of the legs 26 in abutting relationship with the drums 14. The commutators 22A and 22B may then be mounted on the respective legs 26A and 26B, the conductors 80 being disposed in the slots 27. The end member 12 may then be inserted between the laminations of the legs 26 and secured against removal by inserting the pins 28 therethrough.

The bearing plate 68 may, of course, be eliminated and the function thereof performed by providing a smooth bearing surface on one side of the commutators 22. In addition, conventional fasteners such as flathead screws may be inserted through the apertures 76 in the commutator and the apertures 86 in the bearing plate 68 into the threaded apertures 52 in the cylindrical member 24 to provide additional strength. The in-

duction device may then be secured to a suitable frame (not shown) adjacent the manually or electrically driven gear **38** and the timing belt **32** may be mounted to circumscribe and engage the gear teeth **34** on the drums **14** and the gear **38** as illustrated in FIG. 3.

The operation of the variable induction device of the present invention may be more fully understood with reference to the schematic diagram of FIG. 7. Referring now to FIG. 7, the coils carried by the drums **14** are shown on the left side of the diagram and the coils carried by the cylindrical members **24** are shown on the right side of the diagram, as illustrated in phantom, to facilitate the description of the operation.

The end **60A** of the primary winding **56A** may be electrically connected to the end **60B** of the primary winding **56B** and an AC input signal applied between the ends **58A** and **58B** of the respective primary windings **56A** and **56B**. Likewise, the ends **66A** and **66B** of the secondary transformer windings **62A** and **62B**, respectively, may be electrically connected, and an output voltage may be taken between the ends **64A** and **64B** of the respective windings **62A** and **62B**. This type of transformer connection may be referred to as a humbucking connection and is a desirable feature in a well-designed transformer.

The fixed coil **40** having one end connected to the brush **20B** and the other end **42** connected to the end of the overlying transferable coil **16B** is preferably wound in a direction opposite from that of the transferable coil **16B**, for example, in a counterclockwise direction looking from the left end of the drawing of FIG. 1. The transferable coil **16A** and **16B** are connected in series opposition, and therefore the transferable coil **16A** is in series aiding with the fixed coil **40**.

In operation, the primary windings **56** are energized and induce an AC current into the secondary winding **62** and the coils **16** and **40**. If the primary windings **56** are energized from a 115 volt AC line and if, as illustrated, the turns ratio between the primary windings **56** and the secondary windings **62** is 1:1, the voltage appearing between the ends **64A** and **64B** of the secondary windings **62A** and **62B**, respectively, will be 115 volts AC.

Furthermore, if the total number of turns of the coils **16** and **40** is equal to the total number of turns of the coils **56** as illustrated, an output voltage which is variable between zero and 115 volts AC appears between the output terminals **73A** and **73B** on the commutators **22A** and **22B**, respectively. The maximum output voltage condition, i.e. 115 volts AC appearing between the output terminals **73A** and **73B** may be obtained by synchronously rotating the drums **14A** and **14B** until all of the turns of the coil **16B** have been transferred from the drum **14B** to the drum **14A**. Since the coil **16A** is connected in series aiding to the fixed coil **40**, the voltages across the coil **16A** and the coil **40** add to produce a maximum or a 115 volt AC output voltage. Additionally, since at the maximum output voltage condition the fixed coil **40** and the coil **16A** are wound on opposite drums, the variable secondary circuit is balanced, i.e. there are an equal number of turns on each drum.

The minimum output voltage condition may be obtained by rotating the drums in the opposite direction to transfer all of the turns of the coil **16A** to the opposite drum. The coil **16B** then has a maximum number of turns, and since the voltage induced thereacross is in series opposition with the voltage across the coil **40**, the output voltage is a minimum or zero volts. It is, of course, apparent that any output voltage between zero and 115 volts AC may be obtained by rotating the drums **14A** and **14B** in the proper direction until the desired output voltage is obtained.

It is thus apparent from the above description that the variable induction device of the present invention provides an output voltage which is continuously variable between a predetermined maximum and minimum while providing isolation between the primary and secondary circuits. Also, the variable winding circuit is balanced at the full output voltage condition.

In addition, the induction device of the present invention is extremely versatile since the elements comprising the device may be easily removed and replaced with elements having various electrical characteristics. The secondary transformer windings **62** provide even further versatility since they may be connected in any number of ways to the variable secondary circuit or to independent loads.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed is:

1. A variable induction device comprising:
   - a core of magnetic material having two substantially parallel legs;
   - a substantially cylindrical member nonrotatably carried by each of said legs in telescoping relationship;
   - a generally cylindrical, substantially hollow drum coaxially mounted on each of said members for axial rotation thereabout;
   - a first electrically conductive coil having a predetermined number of fixed turns wound in a predetermined direction about one of said drums;
   - electrical contact means carried by one end of each of said drums for rotation therewith, one of said contact means being electrically connected to one end of said first coil;
   - an electrically conductive commutator carried by each of said legs in wiping engagement with said contact means;
   - a second electrically conductive coil having a predetermined number of transferable turns wound about said drums, one end of said second coil being electrically connected to the other end of said first coil, the either end of said second coil being electrically connected to the other one of said contact means;
   - transformer winding means carried by said cylindrical members in electrical isolation from said first and second coils and in magnetic flux linking relation to said first and second coils; and
   - means for simultaneously axially rotating said drums about said cylindrical members to selectively modify the effective number of said fixed turns in said first coil by transferring the turns of said second coil from one of said drums to the other of said drums.

2. The variable induction device of claim 1 wherein said core includes end members connected between the adjacent ends of said legs, one of said end members being removable to expose one end of each of said legs, thereby permitting the changing of said drums and said cylindrical members to achieve different electrical characteristics of said inductive device.

3. The variable induction device of claim 1 wherein said commutator comprises an electrically conductive segmented ring, the segments of said ring being electrically connected whereby currents induced in adjacent of said segments by said cyclically varying magnetic flux are substantially self-cancelling.

4. The variable induction device of claim 1 wherein said second coil is adapted to be wound about said first coil radially outward therefrom.

5. The variable induction device of claim 1 wherein said first coil is embedded in said one of said drums and said second coil is adapted to be wound about the surfaces of said drums.

6. The variable induction device of claim 1 wherein said transformer winding means comprises a primary transformer winding carried by said cylindrical members, and further including a secondary transformer winding carried by said cylindrical members in overlying relation to said primary transformer winding.

7. The variable induction device of claim 1 wherein the number of fixed turns of said first coil is equal to or greater than the total number of transferable turns of said second coil.

8. The variable induction device of claim 1 wherein the transferable turns of said second coil on said one drum are connected to the transferable drums of said second coil on the other drum in series opposition and wherein the transferable turns of said second coil on said one drum are connected to said first coil in series opposition.

9. A variable induction device comprising:

a magnetic core;

two spaced drums each mounted for axial rotation about said core;

an electrically conductive coil having a predetermined number of fixed turns wound in a predetermined direction on one of said drums;

transformer winding means carried by said core in electrical isolation from said coil for inducing a cyclically varying magnetic flux in said coil;

means for axially rotating said drums; and

coil means wound on both of said drums and adapted to be selectively transferred from one of said drums to the other in response to the rotation of said drums for modifying the effective number of said fixed turns of said electrically conductive coil.

10. The variable induction device of claim 9 including electrical contact means mounted on each of said drums, and a commutator mounted on said core adjacent each of said contact means and in wiping electrical contact therewith.

11. The variable induction device of claim 9 wherein said transformer winding means is carried by two spaced cylindrical members mounted on said core in telescoping relationship therewith.

12. The variable induction device of claim 11 wherein each of said drums is mounted substantially coaxially with an associated one of said cylindrical members in telescoping relationship therewith.

13. The variable induction device eof claim 11 including a secondary transformer winding of a fixed predetermined number of turns carried by at least one of said cylindrical members.