Feb. 15, 1966 W. KOBER 3,235,824

VARIABLE VOLTAGE TRANSFORMER

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Fig. 1.

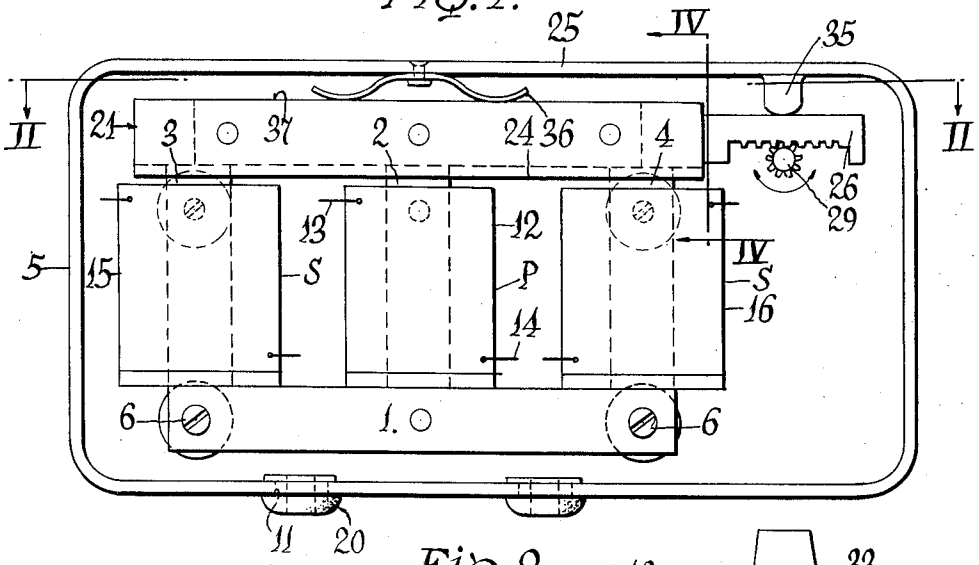
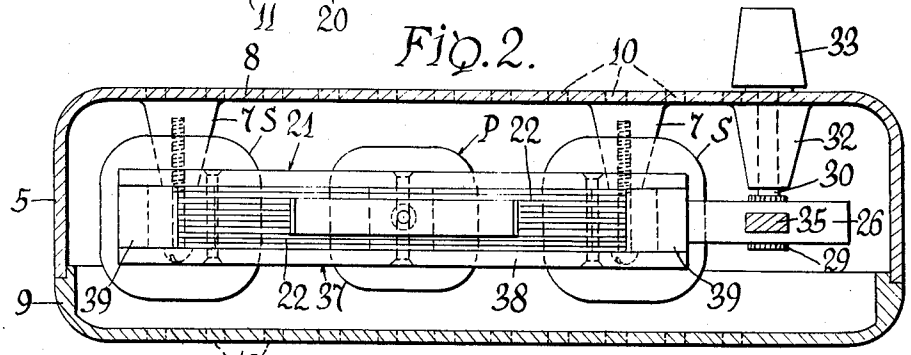


Fig. 2.



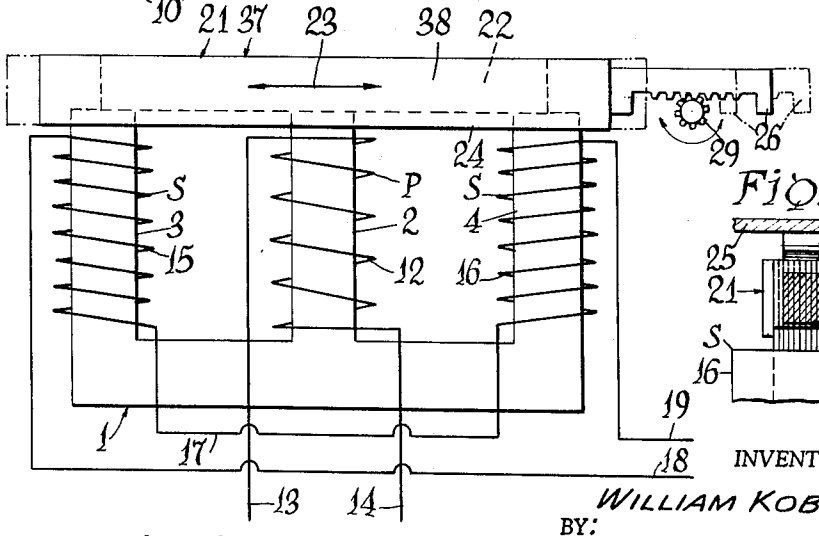


Fig. 3.

Fig. 4.

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Fig. 5.

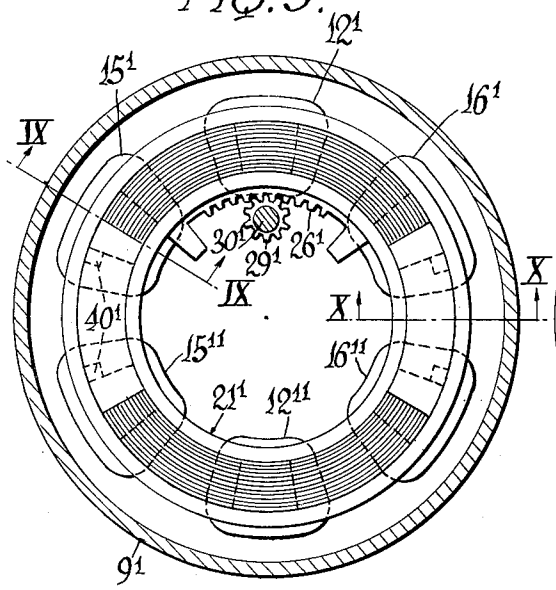


Fig. 6.

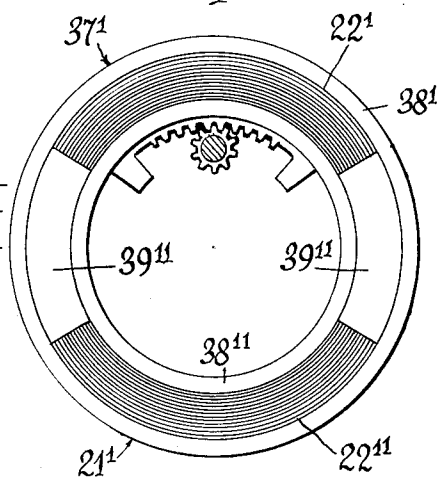


Fig. 7.

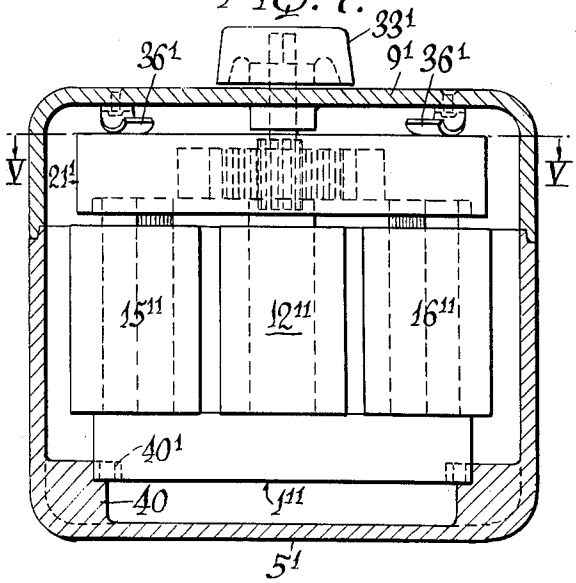


Fig. 8.

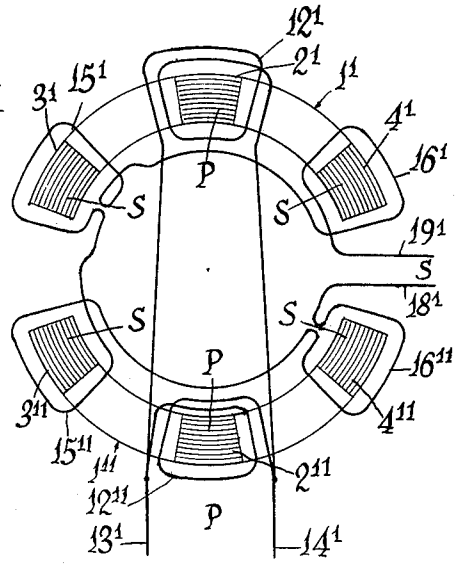


Fig. 9.

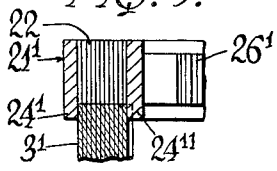
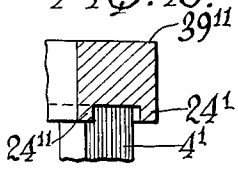


Fig. 10.



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VARIABLE VOLTAGE TRANSFORMER

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Filed May 24, 1961, Ser. No. 112,447
10 Claims. (Cl. 336—133)

This invention relates generally to the electrical control art, and more specifically to a new and useful variable voltage transformer device.

Pending application Serial No. 695,394, filed November 8, 1957, and now abandoned, in the name of Norbet N. Bojarski, discloses a multi-purpose transformer intended to produce an output voltage which is smoothly and continuously variable in infinitesimal increments, and which does not require brushes or other current carrying moving parts. Such a transformer is characterized by the provision of an armature member movable relative to a primary and two secondary legs to divert primary flux from one secondary leg to the other, and thereby vary the division of flux between the secondary legs while maintaining a substantially constant reluctance in the primary magnetic circuit. The variation in secondary or output voltage is theoretically determined by the area of contact between the movable, magnetic armature and the secondary legs.

However, a serious problem is presented by flux leakage in such transformer devices. The magnetic flux passing to the movable magnetic armature portion, from the exposed secondary end faces as well as the primary end face, tends to escape to comprise leakage flux through the air. This is a disturbance because the secondary voltage variations are no longer entirely determined by the area of contact between the armature and the secondary legs, also, leakage inductance or reactance is produced by the flux flowing through each secondary leg and completing its path through the air, escaping through the exposed end of the secondary leg. This leakage flux increases the reactance and decreases the constancy of output voltage with changing load, thereby creating a regulation problem.

Accordingly, the primary object of my invention is to provide a transformer device of this general type with means effectively blocking such leakage flux and thereby precluding such disturbances.

Another object of my invention is to provide the foregoing in an extremely simple, relatively inexpensive, highly effective and durable construction.

A variable voltage transformer constructed in accordance with my invention is characterized in one aspect thereof by the provision of a transformer core having a primary and two secondary legs, a primary winding on the primary leg and a secondary winding on at least one of the secondary legs, and an armature member having a non-magnetic electrically conductive portion and a magnetic portion and the member being movable to divert primary flux from one of the secondary legs to the other thereof, thereby to vary the relative reluctance of the magnetic circuits comprising the secondary legs, the magnetic portion being encircled by the electrically conductive portion to block the air leakage of flux therefrom.

The foregoing and other objects, advantages and characterizing features of a variable voltage transformer constructed in accordance with my invention will become clearly apparent from the ensuing detail description of two, illustrative embodiments thereof, taken together with the accompanying drawings illustrating such embodiments, wherein like reference numerals denote like parts throughout the various views and wherein:

FIG. 1 is a side elevation view of one illustrative form of transformer constructed in accordance with my invention, the cover of the enclosing housing being removed;

FIG. 2 is a sectional view thereof, taken about on line II—II of FIG. 1;

FIG. 3 is a generally diagrammatic view of the transformer of FIGS. 1 and 2, illustrating its mode of operation;

FIG. 4 is a fragmentary, sectional view thereof, taken about on line IV—IV of FIG. 1;

FIG. 5 is a sectional view of another illustrative form of transformer constructed in accordance with my invention, taken about on line V—V of FIG. 7;

FIG. 6 is a view corresponding to that of FIG. 5 but showing only the movable armature member and means for moving the same;

FIG. 7 is a vertical, sectional view thereof;

FIG. 8 is a diagrammatic view thereof;

FIG. 9 is a fragmentary, sectional view thereof, taken about on line IX—IX of FIG. 5; and

FIG. 10 is a fragmentary, sectional view thereof, taken about on line X—X of FIG. 5.

Referring first to the illustrative embodiment shown in FIGS. 1 through 4 of the accompanying drawings, one form of variable voltage transformer constructed in accordance with my invention comprises a core, generally designated **1**, preferably of a laminated construction known in the art. Core **1** is generally E-shaped, having a center, primary leg **2** and two outer secondary legs **3**, **4**.

The laminations comprising core **1** are secured together, as by rivets or the like, and are mounted in a housing **5** as by means of bolts **6** passing through core **1** and threadedly engaging embossments **7** projecting from the rear wall **8** of the housing. The front of housing **5** normally is closed by a removable cover **9**, and ventilating openings **10** are provided through rear wall **8** and cover **9**.

A primary winding **12** is placed on primary leg **2**, and has leads **13** and **14** adapted for connection to a source of exciting voltage, not shown. A pair of secondary windings **15**, **16** are placed on the two outer legs **3**, **4**, respectively, which windings are oppositely wound and series connected through a common lead **17**, to comprise a differential secondary winding **15**, **16** having leads **18** and **19** adapted for connection to the load, also not illustrated.

To vary the net voltage induced in secondary windings **15**, **16**, means are provided for adjusting the position of an armature member **21**, thereby to vary the relative reluctance of the magnetic circuit through secondary windings **15** and **16**. Armature **21** has a portion **22** of laminated, magnetic material, encircled by electrically conductive non-magnetic material portion to be described, and armature **21** is confined for reciprocation in the direction of arrows **23** (FIG. 3) as by the depending extensions **24** on opposite sides of the armature, which extensions bear against the legs **2**, **3**, **4** on opposite sides thereof and confine the armature for reciprocating movement in a lengthwise direction, in the plane of the core legs. For moving armature **21**, I provide means which can comprise a rack **26** projecting from armature **21** and secured thereto in any desired manner. Rack **26** meshes with a pinion **29** mounted on a shaft **30** journalled in a boss **32** carried on the rear wall **8** of housing **5**. Shaft **30** extends through the housing wall for manipulation by a control knob **33**.

Referring now to the schematic diagram of FIG. 3, the neutral position of aramture **21** is shown in full lines, and it will be noted that when armature **21** is in this position the laminated, magnetic portion **22** thereof is in working contact with the inner half of the end face area of each secondary leg **3**, **4**. Therefore, all other factors being equal, the reluctance of each secondary

magnetic circuit is the same, and because the secondary windings 15, 16 are opposed to each other the voltages induced therein cancel out, producing a zero output voltage.

When armature 21 is moved to the extreme left hand position illustrated by the dashed lines in FIG. 3, its magnetic portion 22 is in working contact with the entire end face area of secondary leg 3 as well as the primary leg 2, and out of working contact with the end face area of secondary leg 4. Accordingly, the magnetic path containing leg 3 is of much less reluctance than the path containing leg 4, and the magnetic flux produced by primary winding 2 is diverted from leg 3 to leg 4. In other words, the relative reluctance of the two secondary circuits is varied in a direction producing a much greater voltage induced in winding 15 than in winding 16, whereby there is produced a net maximum output voltage of one polarity.

Conversely, when armature member 21 is moved to its extreme right hand position illustrated by the dashed lines in FIG. 3, the magnetic portion 22 is in working contact with the entire end face area of secondary leg 4 and is out of worikng contact with the end face area of secondary leg 3. This varies the relative secondary reluctance in the opposite direction to produce, in the chosen example, an equal maximum net voltage of opposite polarity. Obviously, armature 21 can be moved to any position between the illustrated extremes, to produce a net output voltage continuously variable between no voltage and a maximum of either polarity.

Thus, not only can the output voltage be readily and continuously varied by infinitesimal increments from one extreme to the other but the two extremes can encompass a reverse polarity, and the primary reluctance is not affected by such variations in output voltage, but is independent thereof. Primary leg 2 preferably has a cross sectional area equal to that of secondary leg 3, and also equal to that of secondary leg 4, all other things being equal, for maximum utilization of transformer capacity. The total end face area of secondary legs 3 and 4 in working contact with the magnetic armature portion 22 remains the same in all positions of armature 21 whereby the primary reluctance is independent of armature position. The primary leg end face has the same area in working contact with the magnetic armature portion 22 at all positions thereof.

A boss 35 depends from top wall 25 of housing 5, and bears against rack 26 to hold it in meshing engagement with pinion 29. A spring 36 also is carried by top wall 25, and bears against the upper surface of armature 21 to hold the magnetic armature portion 22 in working contact with the end faces of the core legs 2, 3 and 4. Openings 11 surrounded by grommets 20 of insulating material, are provided for passage of the primary and secondary leads 13, 14, 18 and 19 out of the housing 5.

In this example, it is seen that the secondary or net output voltage should vary in accordance with the relative areas of contact between armature portion 22 and the respective secondary legs 3 and 4, with the voltage varying as the area of contact with each secondary is varied relative to the area of contact with the other. However, if the aforementioned leakage flux is present, the actual performance of the transformer is caused to depart from the theoretical, and with the further results that regulation is poor.

Such leakage flux occurs when flux escapes from the exposed end face areas of secondary legs 3 and 4, completing its path through the air and back to the secondary leg from which it escapes. Leakage flux also can occur when flux passing to magnetic portion 22 of armature 21 escapes into the air. Such leakage flux presents a very real problem in terms of regulation, increased reactance, and departure from the desired mode of operation, and therefore is desired to be avoided.

In accordance with my invention, such leakage flux is effectively precluded by encircling the magnetic portion 22 of armature 21 with a ring-like body 37 of highly electrically conductive material, such as copper, having sides 38 and ends 39. This material provides a highly electrically conductive loop completely surrounding armature portion 22 on opposite sides and ends thereof, with the end sections 39 being large enough to enclose the total end face area of each secondary leg 3, 4.

The body 37 provides an electrically conductive path completely surrounding magnetic armature portion 22 and effectively blocks the escape of leakage flux from magnetic portion 22 to the air. Any such leakage flux is resisted because it induces a current in the loop provided by body 37, in a direction producing an opposing flux.

The enlarged end sections 39 cover the exposed secondary end face area, and similarly prevent the escape of flux from such exposed areas into the air. Any flux passing into the ends 39 does not escape therefrom, because it induces a current in the ends 39, in a direction producing an opposing flux. From this, it will be appreciated that the ends 39 need not be solid, but could comprise loops or hollow end sections, so long as they provide a closed loop encircling each secondary end face when the armature section has been moved to otherwise expose such end face.

Thus, the above described undesirable leakage flux is avoided in an extremely simple but highly effective manner.

Body 37 can be a one-piece fabrication, but in practice the ends 39 and sides 38 probably would be formed separately, and brazed or otherwise bonded together in a manner providing good electrical continuity.

In addition, it will be observed that the sides 38 of the electrically conductive body 37 can be formed to provide the guide extensions 24. This is particularly advantageous, because such extensions then function as guides confining the movable armature to movement in the desired path, and also as electrically conductive shields preventing the air leakage of flux from the contiguous sides of the core legs 2, 3 and 4.

The embodiment of FIGS. 5–10 shows my invention applied to a circular construction. In this form of the invention there are provided two cores 1′, 1″, each semicircular in plan view and E-shaped in elevation, arranged in opposed spaced-apart relation to form a circle. Thus, there are provided a total of two primary legs 2′, 2″ and four secondary legs 3′, 4′, and 3″, 4″. Primary windings 12′ and 12″ are provided around the primary legs 2′, 2″, respectively, and are connected in parallel, having leads 13′, 14′ for connection to a suitable source. Secondary windings 15′, 16′ are provided around the secondary legs 3′, 4′ respectively, and secondary windings 15″, 16″ are provided around the secondary legs 3″, 4″, respectively. In the illustrated form, windings 12′ and 12″ are wound about their respective core legs 2′, 2″ in the same direction. The secondary windings are series connected, having leads 18′, 19′ for connnection to a load, and are wound with windings 3″ and 4′ in opposition to windings 3′ and 4″.

Armature 21′ is annular in form, and has two magnetic portions 22′, 22″, with portion 22′ being arranged for working contact with primary leg 2′ and secondary legs 3′, 4′, and with portion 22″ being arranged for working contact with primary core leg 2″ and secondary legs 3″, 4″. Both magnetic portions are enclosed within and encircled by a body 37′ of electrically conductive material and comprising outer and inner sides 38′, 38″, and end portions 39″. Sides 38′, 38″ encircle the opposite sides of the magnetic portions 22′, 22″ and the space between the magnetic portions is filled by the end portions 39″. However, the end portions need not be solid, as shown, but could be loops, as previously described with reference to end sections 39 (FIG. 2).

The magnetic armature portions 22′, 22″ are held in working engagement with their respective core leg end

faces by springs 36', carried by the removable top 9', comprising the cover for an enclosing housing 5'. The cores 1', 1'' are supported by a shouldered annular boss 40 adjacent the lower end of housing 5, being held in spaced apart relation by shoulders 40'.

For moving armature member 21', I provide a rack 26', carried by the side 38'' of body 37' and engaging a pinion 29' carried by a shaft 30' extending through top cover 9' for manipulation by knob 33'.

It will be appreciated that the operation of this embodiment is the same as described with reference to the embodiment of FIGS. 1–5, except that double the number of cores are provided.

In the neutral position of armature 21', portion 22' is in working contact with primary leg 2' and one half the end face area of secondary legs 3' and 4', and portion 22'' is in working contact with primary leg 2'' and one half the end face area of secondary legs 3'' and 4''. The relative reluctance of the two secondary circuits of each core 1', 1'' is the same, resulting in zero net output voltage. Turning knob 33' to shift armature 21' in one direction will increase the relative reluctance in the secondary circuits including legs 4' and 3'', thereby varying the output voltage in one direction, and shifting armature 21' in the opposite direction will increase the relative reluctance in the secondary circuits including legs 3' and 4'', thereby varying the output voltage in the opposite direction.

The highly electrically conductive body 37' provides current conducting loops ringing each armature portion 22', 22'', and at the opposite ends thereof, thereby blocking the air leakage of flux from the end face areas of legs 3', 3'', 4' and 4'', and from armature portions 22', 22''. The opposite sides 38', 38'' of body 37' are extended to provide flux blocking guides 24', 24'', respectively, in working contact with opposite sides of the core legs. Although only one such extension would be required for guidance purposes, two of them are provided, as shown, for leakage flux blocking purposes.

The electrically conductive bodies 37, 37' can be secured to the magnetic portions 22 and 22', 22'', respectively, by any desired means. For example, they can be held together by screws or other fastenings, not shown, extending through the sides 38, 38', 38'' and the associated magnetic portions 22, 22' and 22''.

Where reversal of polarity is not desired, the transformer can be connected as an autotransformer, using the primary as a base, by tapping the primary into the secondary. Other winding arrangements also could be used. For example, the secondary windings could be unequal, and additive.

Accordingly, it is seen that my invention fully accomplishes its intended objects and provides a variable transformer which can be used for the control of electric ovens, varying the intensity of incandescent illumination, induction heating control, the control of welding equipment, and a wide variety of other purposes.

While I have disclosed and described in detail only two, illustrative embodiments of my invention, it will be appreciated that this has been done by way of illustration only, without thought of limitation. Variations and modifications will readily occur to those skilled in the art, and I intend to include the same within the scope of the appended claims.

Having fully disclosed and completely described my invention, together with its mode of operation, what I claim as new is:

1. A variable voltage transformer comprising, a transformer core having a primary leg and two secondary legs and each leg having an exposed face, a primary winding on said primary leg and a secondary winding on at least one of said secondary legs, an armature member having a magnetic portion overlying the face of the primary leg and movable to overlie selected areas of the secondary faces to divert primary flux from one of said secondary legs to the other thereof, thereby to vary the relative reluctance of the magnetic paths between the primary and the secondary legs, and said armature member including a non-magnetic electrically conductive portion providing a highly electrically conductive closed loop completely surrounding said magnetic portion on opposite sides and ends thereof, thereby to block the air leakage of flux from said faces and from said magnetic armature portion, said face of each core leg being covered by said armature member in all positions thereof.

2. A variable voltage transformer comprising, a transformer core having a primary leg and two secondary legs and each leg having an exposed face, a primary winding on said primary leg and a secondary winding on at least one of said secondary legs, and an armature having a magnetic portion with a surface disposed to overlie one face of said primary leg and of sufficient length to partially overlie corresponding faces of said secondary legs, thereby to complete magnet circuits therethrough, and the armature having a portion of electrically conductive non-magnetic material completely surrounding said magnetic portion on opposite sides and ends thereof adjacent to said surface and of sufficient length so that the faces of the secondary legs are covered at all times by the armature, thereby to block the air leakage of flux from said magnetic portion, said armature being movable to divert primary flux from one of said secondary legs to the other thereof.

3. A variable voltage transformer as set forth in claim 2, together with guide means constraining said armature for movement in a predetermined path relative to said faces, said guide means comprising extensions of said electrically conductive portion and said extension being in working contact with said primary and secondary legs on opposite sides of said faces thereof and thereby simultaneously blocking the air leakage of flux therefrom.

4. A variable voltage transformer as set forth in claim 3, wherein said primary and secondary faces are alined with each other, and said guide means constrain said armature for substantially straight line reciprocation thereagainst.

5. A variable voltage transformer as set forth in claim 2, wherein the total secondary face area and the primary face area in working contact with said magnetic portion remain constant in all operating positions of the latter.

6. A variable voltage transformer as set forth in claim 2, wherein said magnetic portion is of a size to have, in one position of said portion, simultaneous working contact with the face of said primary leg and with substantially one-half of the face of each of said secondary legs, and the opposite ends of said electrically conductive portion being substantially co-extensive with the remainder of said faces of said secondary legs.

7. A variable voltage transformer as set forth in claim 2, wherein said magnetic portion is movable to an operating position out of working contact with at least a portion of the face of at least one of said secondary legs, and said electrically conductive portion being, in that position, so located as to block the air leakage of flux from the exposed secondary face portion.

8. A variable voltage transformer comprising, two transformer cores and associated armature members, each core having a primary leg and two secondary legs and each leg having an exposed face and all of the faces of the cores being arranged substantially in a circle, a primary winding on each primary leg and a secondary winding on at least one secondary leg of each core, each armature member having a magnetic portion overlying the face of the primary leg and movable to overlie selected areas of the secondary faces to divert primary flux from one of said secondary legs to the other thereof, the magnetic portions being curved to overlie the core faces and being mutually spaced apart at their ends, thereby to vary the relative reluctance of the magnetic paths between the primary and the secondary legs, and said armature members

including non-magnetic electrically conductive portions providing highly electrically conductive closed loops completey encompassing said magnetic portions inside and outside thereof and filling the space between their ends, thereby to block the air leakage of flux from said faces and from said magnetic armature portions, said face of each core leg being covered by said armature member in all positions thereof.

9. A variable voltage transformer as set forth in claim 8, together with guide means constraining said armature member for movement in a predetermined path, said guide means comprising extensions of said electrically conductive portions, said extensions being in working contact with opposite sides of said primary and secondary legs adjacent said faces, thereby to block the air leakage of flux therefrom.

10. A variable voltage transformer as set forth in claim 8, wherein said magnetic portions are of a size to expose face portions of said secondary legs, and said electrically conductive portion being at least co-extensive with and overlying such exposed end face portions.

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