July 24, 1956 A. E. FEINBERG 2,756,398

TRANSFORMER

Filed May 3, 1949 2 Sheets-Sheet 1

FIG. 1

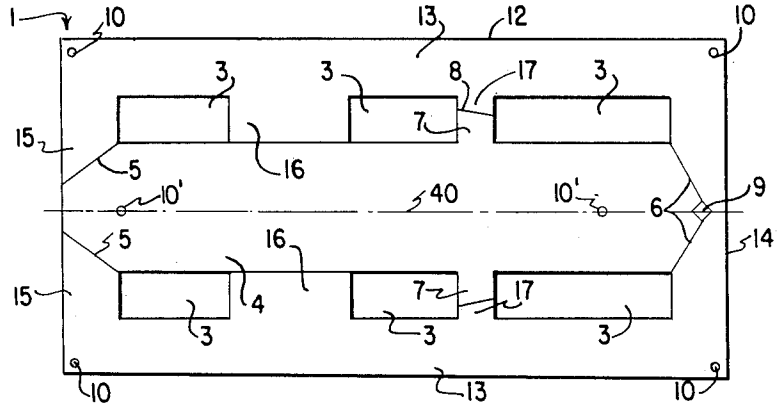



FIG. 2

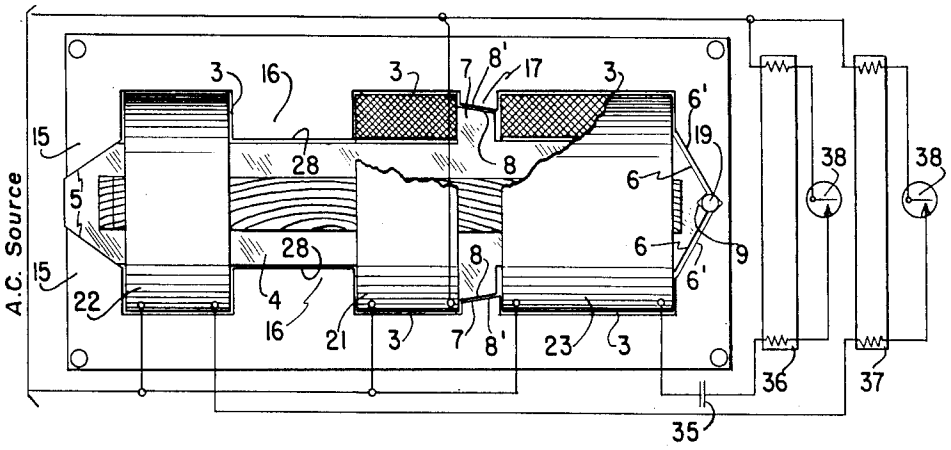



FIG. 4

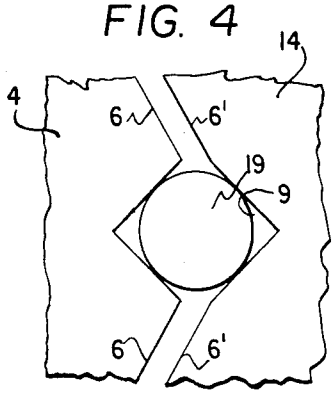



FIG. 3

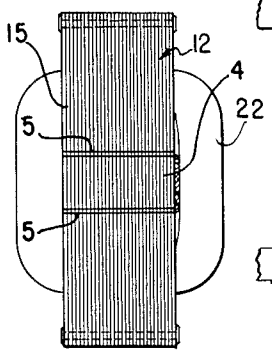
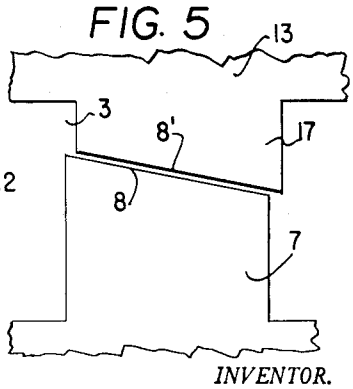



FIG. 5




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TRANSFORMER

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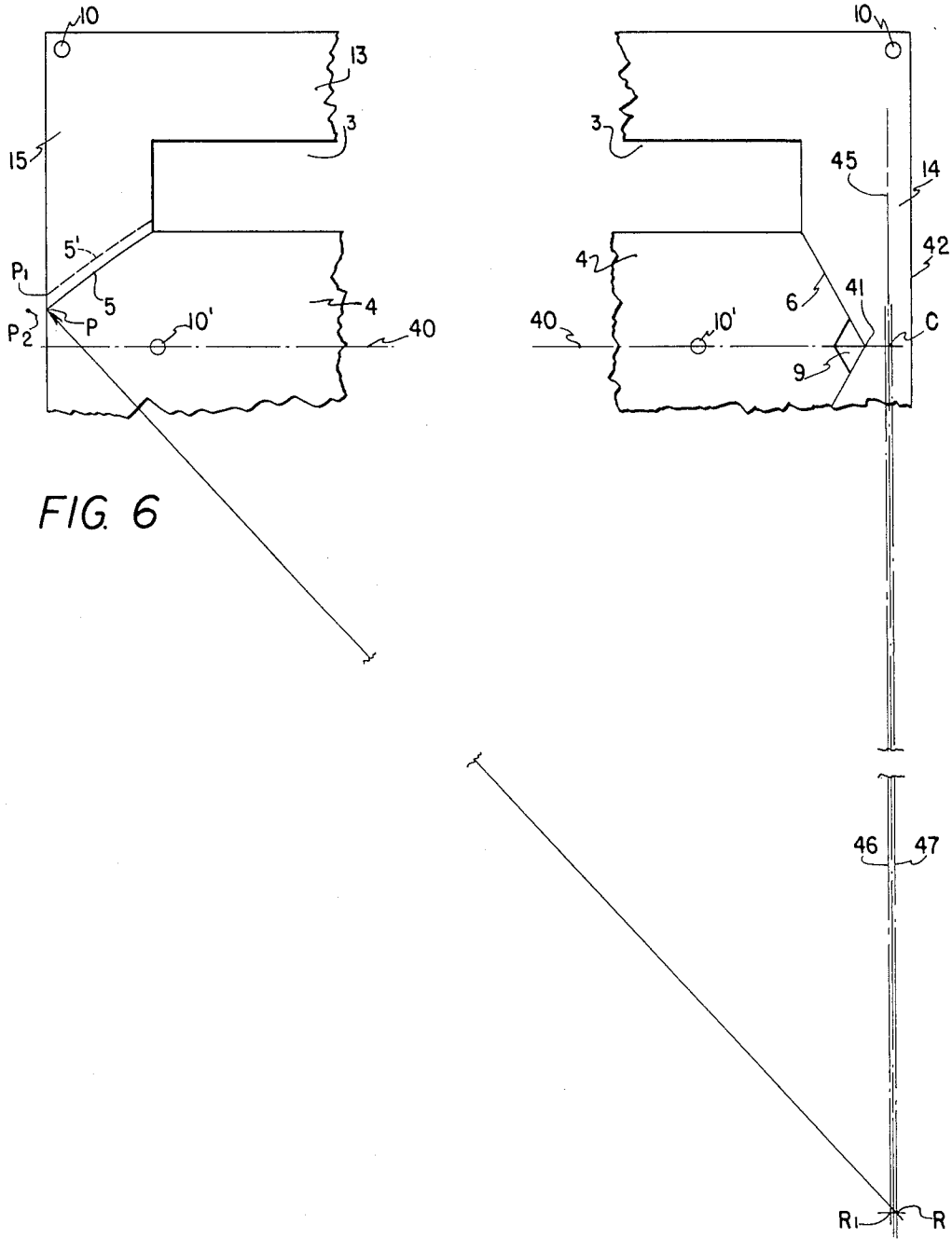



FIG. 6

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United States Patent Office 2,756,398 Patented July 24, 1956



2,756,398

# TRANSFORMER

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Application May 3, 1949, Serial No. 91,167

22 Claims. (Cl. 336—165)

This invention relates to electric transformers of the type that are particularly useful for providing leading and lagging currents for operating a pair of hot cathode gaseous discharge tubes such as fluorescent lights, ultraviolet tubes, or the like. In its more particular aspects the invention is concerned with the construction of the core of the transformer.

Shell type transformers have heretofore been provided for supplying leading and lagging currents to two independently operable glow discharge lamps of the fluorescent type. In such an arrangement it has been found desirable to introduce an air gap in the magnetic circuit of the leakage flux path of the transformer secondary coil that supplies the leading current. This air gap must be in the circuit of the main magnetizing flux and must be outside of the circuit of the leakage flux path of the coil that supplies the lagging current. In shell type transformers of the above character it is customary to provide magnetic shunts between adjacent coils, these shunts having a non-magnetic gap to provide the necessary reluctance. In such arrangements it is quite important that the gap be of precisely the desired length, which length may be of the order of .01 of an inch to .04 of an inch. It is very difficult to punch openings in transformer laminations if the openings are to be of such exceedingly small size. It is one of the objects of the present invention to provide a transformer core the laminations of which are so constructed as to facilitate the formation of an air gap of precisely the desired size without requiring punching of holes of widths of the smallness of the dimensions above mentioned.

In accordance with the principles of the present invention each lamination of a shell type transformer core consists of two parts formed from a single blank. One of the parts is of a generally rectangular shape split at one of its shorter sides and the other part is in the form of a long leaf or tongue adapted to be placed between the longitudinal sides of the first mentioned part and extend lengthwise thereof from one transverse edge towards the other. The arrangement is such that by shifting the central lamination portion in a direction lengthwise of the core there is a resulting short spreading of the longitudinal sides of the core. This spreading can be very accurately controlled and it is this spreading that is relied upon to produce the air gap in the shunts around the coils.

In accordance with the preferred embodiment of the present invention the laminations that are to constitute the shell of the transformer are stacked together and secured in their stacked position. The laminations that are to constitute the central portion of the core are also stacked together. The coils are then slipped into position as the central portion and the central portion with the coils thereon is then slipped into position in the shell. Thereafter a spacer pin is driven between one end of the central portion and the shell to shift the central portion lengthwise and produce the desired air gap between one end of the central portion and the shell. This shifting



action of the central portion then causes spreading of the longitudinal arms of the shell.

The attainment of the above and further objects of the present invention will be apparent from the following specification taken in conjunction with the accompanying drawing forming a part thereof.

In the drawing:

Figure 1 is a top view of a lamination blank cut in accordance with the present invention;

Figure 2 is a diagrammatic view of a transformer embodying the present invention, with the circuit connections thereto;

Figure 3 is an end view of the transformer of Figure 2;

Figures 4 and 5 are enlarged fragmentary views of portions of the transformer of Figure 2; and

Figure 6 is a diagrammatic view to illustrate the manner of construction.

Reference may now be had more particularly to the drawings wherein like reference numerals designate like parts throughout.

In Figure 1 there is shown at 1 a sheet of silicon steel, blanked to constitute one of the transformer core laminations. The sheet 1 is of a thickness of the order of 0.025 inch, as is customary for transformers for fluorescent lights. The core is die stamped along the full lines shown in Figure 1 to provide six rectangular windows, indicated at 3, the metal at 3 being stamped out and constituting waste material which may or may not be utilized in other connections. The metal is also stamped out to form a central winding-receiving core 4 which, by reason of the cut, is mechanically separate from the rest of the lamination sheet. The core 4 has slightly curved inclined edges 5—5 at one end and tapered edges 6—6 at the opposite end. Between the two edges the core 4 has projections 7—7 at opposite ends thereof, each of which projections terminates at an inclined or tapered edge 8. A small square or diamond shaped hole is punched in the lamination at 9 for a purpose to be more fully described as this specification proceeds. In addition, the lamination may have a number of rivet-receiving holes 10—10'.

The above mentioned stamping operation divides the laminations into two separate useful pieces, namely, a central core section 4 and an outer rectangular shell section 12. The shell 12 has two longitudinal sides 13—13 joined by a transverse end 14 and having opposite the end 14 a transverse end that is split into two parts 15—15 by the lines of cut 5—5. In addition, the shell 12 has a pair of projections 16—16 comprising magnetic shunts extending up to the core 4 and a pair of magnetic shunts 17—17 extending up to the projections 7—7 of the core.

In one preferred construction the angle of inclination of the tapered edges 6—6 was made 60° to the horizontal. The angle of inclination of the line of cut 8 was made 10° to the horizontal and the angle of inclination of each line of cut 5—5 was made 40.6° to the horizontal. This is for a definite purpose which is discussed more fully as the specification proceeds.

An explanation will now be given of the construction of the transformer of Figure 2 embodying the laminations of Figure 1. To construct this transformer the cut lamination stampings are separated. Thereafter a number of laminations 12 are stacked together, one upon the other, and are then secured together in stacked formation in any desired manner. One way of securing them together is by using rivets at the aligned rivet holes 10—10. Thereafter a similar number of central core laminations 4 are stacked together in juxtaposed position and are locked together as by rivets through the holes 10'. Thereafter a prewound primary transformer coil 21 is positioned on the assembled core sections 4 to a position abutting the projection 7 on one side thereof. A prewound lagging secondary coil 22 is also positioned on the core 4, and a

prewound leading secondary coil 23 is also positioned on the core on the side thereof opposite the projection 7. The coils may be locked to the central core in any desired manner as, for instance, by driving a wood wedge lengthwise between the coils and the core. Thereafter the core 4 with the coils 21, 22 and 23 thereon is positioned in the shell 12 with the coils thereof lying in the windows 3. The core 4 is then shifted a small amount to the left from the position illustrated in Figure 1 to that of Figure 2. The core 4 is shifted by driving a slightly oversized pin 19 into the rectangular hole 9. The net effect of the shifting of the core 4 is that the transverse ends 15—15 are spread a short distance from their original normal positions, the amount of spread depending upon the amount of shifting of the core 4. This spread produces a short air gap between the core 4 and the edge 28 of the shunt 16 and also produces a short air gap between each projection 7 and the shunt portion 17 of the shell lamination.

A lateral displacement of the core 4 will result in an air gap between the lines 6—6 and the corresponding lines 6'—6' equal to the sine of the angle of the edges 6—6 multiplied by the lateral displacement of the core. If it is desired to produce an air gap of 0.015 inch between the edges 6—6 and the corresponding edges 6'—6' it is necessary to have a lateral displacement of the core 4 in the amount of 0.0173 inch. The pin 19 that is inserted into the hole 9 is therefore of a diameter sufficiently greater than the width of the hole 9 to produce that displacement.

Assume that the lamination sheet 1 is 5.125 inches long. When the core 4 is displaced laterally 0.0173 inch from the position illustrated in Figure 1 to the position illustrated in Figure 2 such displacement at an angle 40.5° for the inclined edges 5 will result in a spread of the shell laminations at the transverse ends 15—15 of approximately 0.0147 inch. A spread of the arms 15—15, of .0147 inch, will result in a spread of approximately .01 inch of the edge 28 of each shunt 16 from the core. This produces an air gap of an average width of .010 inch between the shunt 16 and the core 4. This is a sufficient air gap at this point. This displacement of the transverse edges 15—15 produces a displacement of approximately .0056 inch at the projections 17. An air gap of that thickness at the point 17 would not be sufficient if the line 8 were parallel with the longitudinal axis of the core. It is for this reason that the line of cut 8 is made at an angle. The angle is set at 10° to the horizontal because at this angle a lateral displacement of .0173 inch of the core 4 will add to the gap between the lines 8 and 8' about .003 inch, giving a total gap between 8—8' approximately .0086 inch, which is sufficient for the purposes.

The above figures are all approximate and are intended only as a means of illustrating the manner of calculating the angles 5, 6 and 8 and the manner of calculating the required amount of lateral displacement of the central core 4.

The lines of cut 5—5 appear to be straight lines but actually they have a slight curvature, each of the lines of cut 5 being a curve having a comparatively large radius. The positions of the centers of curvature are such that the cut edges 5—5 on the core section 4 are slightly convex and therefore the corresponding edges on the transverse shell ends 15—15 are slightly concave. This is provided so that upon shifting of the core section 4 to the left from the position illustrated in Figure 1, and the corresponding flexing of the ends 15—15 apart, there will still be a substantial area of contact between the cut edges of the core and the corresponding edges of the transverse ends 15—15.

A transformer of the above mentioned type is intended particularly for a high reactance type of unit supplying leading and lagging currents to two hot cathode type fluorescent units. In Figure 2 I have shown the coils connected in a circuit with a condenser 35 in series with the coil 23 to cause it to furnish a leading current to a leading lamp 36. The secondary coil 22 supplies a lagging current to a lagging lamp 37. Each lamp is provided with the usual cathode heating filaments and with an automatic starter 38. Each coil 22 and 23 is connected in step-up autotransformer relationship to the primary coil 21. The leading coil 22 may be a single coil or it may be a two winding coil one of which windings is a compensating winding connected in circuits known in the art.

The air gap at 6—6' is in the primary flux circuit and is in the circuit of the leakage flux of the leading current coil 23 but is entirely outside of the leakage flux path of the lagging coil 22.

In one preferred construction the primary winding 21 had 530 turns of #27½ wire and the lagging coil 22 at the split end of the core shell had 528 turns of #27½ wire. The leading coil 23 had 778 turns of #28 wire and, in addition, it had a compensator coil of 213 turns of #28 wire. The compensator coil could, optionally, be omitted entirely. The condenser 35 was four microfarads capacity at 285 volts. This transformer was suitable for two fluorescent tubes 36—37 each of forty watts in a 120 volt 60 cycle system. The above details are given merely to illustrate one preferred construction, it being understood that the invention is not limited to the constants mentioned.

Reference may now be had to Figure 6 for an explanation of one manner of calculating the curvature of the line of cut 5. This figure shows, in fragmentary and enlarged form, the upper half of a lamination 1. The overall length of this lamination is assumed to be 5.125 inches and the overall width is 2.594 inches. The longitudinal center line of the laminations is indicated at 40. The line of cut 6 is at 60° to the center line 40 and extends clear to the center line. The core 4 is of a width of .937 inch, and the arm 14 of a width of .453 inch. The point 41 which is the intersection of the lines 6 and 40 is .183 inch from the edge 42. It was assumed that the core 4 is to be displaced laterally .0173 inch. The line of cut 5 must therefore be such that when the core 4 is displaced laterally .0173 inch the arm 15 will rise the desired amount, namely, each arm shall rise .0147 inch. Thus the point P on the core 4 will be displaced laterally to a point $P_2$ a distance of .173 inch and the corresponding point on the arm 15 will be displaced to a point $P_1$, a distance .0147 inch above its previous position. The point $P_1$ will move in an arc of a circle centered at a theoretical center C which is on the center line 40 midway between the point 41 and the right hand end of the lamination. With known dimensions of the core it is possible to calculate the angle $PCP_1$ which will produce a rise $P—P_1$ of .0147 inch. Assume that this angle is an angle "A." With the point C as a center draw a line 45 at right angles to the line 40. Then draw two additional lines 46 and 47 parallel to and on opposite sides of the line 45 and spaced equidistant from the point C and a distance apart equal to $P—P_2$ or .0173 inch. Then locate a point R on the line 47 at such a distance below the line 40 that is equal to cot $A/2$ multiplied by half the distance $P—P_2$. With R as a center and RP as a radius then strike an arc. This arc is the line of cut 5. With a line of cut 5 which is an arc of the radius indicated and of the center indicated we have a condition such that if the core 4 is moved laterally a distance $P—P_2$ resulting in a corresponding parallel movement of the center R to a point $R_1$, the angle $RCR_1$ is equal to the angle $PCP_1$. As a result the curve 5', which is the curve 5 turned about C as a center through an angle $PCP_1$, is then centered at $R_1$. The radius RP is so great in relation to the length of the arc 5 that the arc 5 appears like a straight line.

The above discussion points out a method of ascertaining the center and radius of the curve 5 for one given construction. The same method may be used for other specific dimensions and other specific air gap distances. When the curve 5 is thus located then a lateral shifting

of the core 4 from P to $P_2$ will result in the desired angular displacement of the arms 15 and will bring the curve 5 of the core 4 into coincidence with the curve 5' of the arm 15 so that the two curves are again centered on the same center.

The separating of the transverse ends 15—15 results from the exertion of a force by the cut ends 5—5 of the core against the corresponding ends 5'—5' of the split parts 15—15 of the shell. The edges 5—5 of the core are therefore in pressure engagement with the edges of the parts 15—15 due to the natural resiliency of the material. This pressure has a beneficial effect towards keeping the reluctance of the interface surfaces 5 and 5' between the core and the parts 15 at a constant value and at a low value. Also, it tends to inhibit vibration of the end laminations under the magnetic action.

In compliance with the requirements of the patent statutes I have here shown and described a preferred embodiment of my invention. It is, however, to be understood that the invention is not limited to the precise construction here shown, the same being merely illustrative of the principles of the invention. What I consider new and desire to secure by Letters Patent is:

1. A transformer comprising a rectangular shell having a slot across one transverse end thereof dividing that transverse end into two parts, and means spreading the two longitudinal sides apart by spreading the two parts of the transverse end at the slot, said means comprising a central longitudinally extending transformer core one end of which is wedged in said slot in a position forcing the two parts of the transverse end apart, said core extending substantially to the other transverse end of the shell.

2. A transformer comprising a rectangular shell having a slot across one transverse end thereof dividing that transverse end into two parts and tapered with its maximum width along the inner edge of the transverse end and its minimum width along the outer edge of the transverse end, means spreading the two longitudinal sides apart by spreading the two parts of the transverse end at the slot, said means comprising a longitudinally extending transformer core one end of which makes a snug fit in said slot, said core being of a length to extend substantially to the other transverse end of the shell, and means spacing the other end of the core from the shell to produce a gap in the magnetic circuit between the shell and said other end of the core, and to force said one end into the tapered slot to expand the same and thus spread the longitudinal sides apart.

3. A transformer comprising a rectangular shell having a tapered slot across one transverse end thereof dividing that transverse end into two parts, a core extending lengthwise of the shell and having a tapered end which is a counterpart of the taper of said slot, transformer coils on said core, said tapered end of the core fitting in said tapered slot, said core being of a length sufficient to extend from said tapered slot to the opposite transverse end of the shell, and means forcing said tapered end of the core toward said slot for spreading apart the two parts of said one transverse end of the shell.

4. A transformer comprising a rectangular shell having a tapered slot across one transverse end thereof dividing that transverse end into two parts, a core extending lengthwise of the shell and having a tapered end which is a counterpart of the taper of said slot, transformer coils on said core, said tapered end of the core fitting in said tapered slot, said core being of a length sufficient to extend from said tapered slot to the opposite transverse end of the shell, and means forcing said tapered end of the core toward said slot for spreading apart the two parts of said one transverse end of the shell, and means spacing said core from the opposite transverse end of the shell to produce a gap between said core and said opposite transverse end of the shell.

5. A transformer comprising a rectangular shell having a tapered slot across one transverse end thereof dividing



that transverse end into two parts, a core extending lengthwise of the shell and having a tapered end which is a counterpart of the taper of said slot, transformer coils on said core, said tapered end of the core fitting in said tapered slot, said core being of a length sufficient to extend from said tapered slot to the opposite transverse end of the shell, and means forcing said tapered end of the core toward said slot for spreading apart the two parts of said one transverse end of the shell, and means spacing said core from the opposite transverse end of the shell to produce a gap between said core and said opposite transverse end of the shell, said spacing means compressing said core towards the tapered slot to hold the tapered end of the core in spreading position in said slot.

6. A transformer comprising a rectangular shell having a slot across one transverse end thereof dividing that end into two separable parts, the sides of the slot being inclined with respect to one another, a longitudinally extending core between the longitudinal sides of the shell, one end of the core extending into and fitting closely in said slot and being of a length sufficient to extend up to the other transverse end of the shell, and a spacer separating said other end of the core from the shell thereby forcing said one end of the core toward the slot and wedging the inclined sides of the slot apart.

7. A transformer comprising a rectangular shell having a slot across one transverse end thereof, a longitudinally extending core between the longitudinal sides of the shell, one end of the core extending into and fitting closely in said slot and being of a length sufficient to extend up to the other transverse end of the shell, and a spacer separating said other end of the core from the shell thereby shifting said one end of the core toward the slot, said slot and said one end of the core being correspondingly tapered so that longitudinal shifting of the core in one direction in the slot will cause spreading of the slot and accompanying spreading of the longitudinal sides of the shell.

8. A transformer comprising a rectangular shell having a slot across one transverse end thereof, a longitudinally extending core between the longitudinal sides of the shell, said shell having magnetic shunts extending from the longitudinal sides thereof towards the core, one end of the core extending into and fitting closely in said slot, said slot and said one end of the core being correspondingly tapered so that longitudinal shifting of the core in one direction in the slot will cause spreading of the slot and accompanying spreading of the longitudinal sides of the shell, the core being of a length sufficient to reach between the two transverse ends of the shell when the tapered end of the core is in the slot, and a spacer separating said other end of the core from the shell whereby the core is shifted toward the slotted end of the shell to spread the longitudinal sides of the shell.

9. A transformer comprising a rectangular shell having a slot across one transverse end thereof, a longitudinally extending core between the longitudinal sides of the shell, said shell having magnetic shunts extending from the longitudinal sides thereof towards the core, one end of the core extending into and fitting closely in said slot, said slot and said one end of the core being correspondingly tapered so that longitudinal shifting of the core in one direction in the slot will cause spreading of the slot and accompanying spreading of the longitudinal sides of the shell, the core being of a length sufficient to reach between the two transverse ends of the shell when the tapered end of the core is in the slot, and a non-magnetic spacer separating said other end of the core from the shell and shifting the core in the slot to spread the longitudinal sides thereof also moving the ends of the shunts away from the core.

10. A transformer comprising a rectangular shell having longitudinal sides and transverse ends a slot across one transverse end thereof, the sides of the slot being inclined with respect to one another, a longitudinally ex-

tending core between the longitudinal sides of the shell, one end of the core extending into and fitting closely in said slot and slidable therein in a direction at an angle to at least one of the inclined sides of the slot, the other end of the core extending up to the other transverse end of the shell, transformer coils on said core, and means between adjacent coils establishing a magnetic shunt from the shell to the core there being a line of cleavage in the path of the flux through the shunt forming an air gap in the magnetic shunt, and means including said core for spreading the longitudinal sides thereby increasing the air gap in said magnetic shunt.

11. A transformer comprising a rectangular shell member having longitudinal sides and transverse ends and having a slot completely across one transverse end thereof, the sides of the slot being inclined with respect to one another, a longitudinally extending core member between the longitudinal sides of the shell, one end of the core member extending into and fitting closely in said slot and slidable therein in a direction at an angle to at least one of the inclined sides of the slot to facilitate spreading of the slot, the core member being of a length sufficient to extend up to the other transverse end of the shell, transformer coils on said core member, and means between adjacent coils establishing a magnetic shunt from the shell member to the core member, said last means being integral with at least one of the members, and there being a line of cleavage in the path of the flux through the shunt at the juncture between the portion thereof that is part of the shell member and the portion that is part of the core member forming an air gap in the magnetic shunt, and means including said core member for spreading the longitudinal side members to increase the air gap in the magnetic shunt.

12. Apparatus for supplying electrically displaced operating currents for a pair of gaseous discharge tubes, said apparatus comprising a transformer having two secondaries and a primary, a condenser in circuit with only one of the secondaries to cause it to furnish a leading current, the other secondary furnishing lagging current, the transformer having a magnetic structure, a portion of the primary magnetic flux path being of substantially greater reluctance than the reluctance of the rest of the primary flux path to prevent saturation of the magnetic circuit by flux resulting from a leading secondary current, said portion being adjacent the leading secondary and being in the leakage flux path thereof and outside of the leakage flux path of the lagging secondary, the magnetic structure having means forming a part of the leakage flux path of the leading secondary and providing an air gap in the leakage flux path of the leading secondary which air gap is outside of the primary magnetic flux path and outside of the lagging secondary leakage flux path, said air gap being at an inclination to the longitudinal axis of the magnetic structure.

13. A transformer comprising a rectangular shell having a slot across one transverse end thereof dividing that transverse end into two parts, and means spreading the two longitudinal sides apart by spreading the two parts of the transverse end side at the slot, said means comprising a central longitudinally extending transformer core one end of which is in said slot, and said first means including cooperating engaging camming surfaces on the core and on the shell respectively, at the slot for increasing the spread of the slot upon longitudinal movement of the core in one direction.

14. A transformer comprising a rectangular shell having longitudinal sides and transverse ends and a slot across one transverse end thereof dividing that transverse end into two parts, the opposite transverse end joining the two longitudinal sides, a core between the two transverse ends, means between the transverse ends establishing a magnetic shunt from the core to the longitudinal sides and with an air gap in said shunt, and means for spreading the longitudinal sides apart to increase the air gap, said last means including said core.

15. A transformer comprising a rectangular shell having longitudinal sides and transverse ends and a slot across one transverse end thereof dividing that transverse end into two parts, the opposite transverse end joining the two longitudinal sides, a core between the two transverse ends, means between the transverse ends establishing a magnetic shunt from the core to the longitudinal sides and with an air gap in said shunt, and means for spreading the longitudinal sides apart to increase the air gap, said last means including said core and including a spacer at an end of the core and forcing the core into the slot at said one transverse end and forming a gap in the magnetic circuit from the core to the other transverse end.

16. An electrical apparatus such as a transformer which comprises, a longitudinally-extending core part having a pair of coils mounted in a spaced relationship therealong, a pair of wedge portions and a pair of planar portions on opposite sides of said core part, a pair of pole pieces adapted to be positioned on opposite sides of said core part, said pole pieces having offset portions providing windows to receive projecting portions of said coils, each of said pole pieces having a wedge portion engaging one of the opposed wedge portions of said core part, each of said pole pieces having a planar portion constructed and arranged to be positioned by its own wedge portion and the engaging wedge portion of said core part in a spaced relationship with respect to one of the planar portions of said core part to define an air gap therewith, and adjustable means operably connected between said pole pieces and core part and constructed and arranged to move said core part with respect to said pole pieces along the opposed wedge portions of said core part.

17. An improved electrical apparatus which comprises, a pair of magnetic parts providing a magnetic circuit, each of said parts having an abutment surface in an opposed relationship with the abutment surface of the other of said parts, the opposed abutment surfaces of said parts being sloped and having a sliding-wedge operative relationship with respect to each other, said parts having a pair of air-gap-providing surfaces, means of rigidly-flexible construction holding said parts together in an assembled relationship with their opposed abutment surfaces in an operative relationship with respect to each other and their opposed air-gap-providing surfaces in a spaced relationship with respect to each other, means operatively positioned to move one of said parts transversely outwardly and inwardly with respect to the other of said parts on its opposed abutment surface, and said parts being constructed and arranged to vary the spacing between their opposed air-gap-providing surfaces when said one part is moved transversely outwardly and inwardly by said last-mentioned means.

18. An improved electrical apparatus which comprises, a pair of magnetic parts providing a magnetic circuit, each of said parts having a sloped abutment surface in an opposed and sliding-wedge operating relationship with the abutment surface of the other of said parts, said parts also having a pair of opposed air-gap-providing surfaces, means having yieldable portions holding said parts together in an assembled relationship with their opposed abutment surfaces in an operating relationship with each other and their opposed air-gap-providing surfaces in a transversely spaced relationship with each other, and means operatively positioned to move one of said parts longitudinally with respect to the other of said parts on their opposed abutment surfaces to adjust the transversely spaced relationship of the opposed air-gap-providing surfaces in conjunction with the yieldable portions of said first-mentioned means.

19. An improved electrical apparatus such as a transformer which comprises, a longitudinally-extending core part having at least one coil mounted thereon, at least one wedge portion and at least one planar air-gap pro-

viding portion on said core part; a longitudinally-extending pole part positioned along said core part, said pole part having an offset portion defining a window to receive a projecting portion of said coil, having at least one planar air-gap providing portion thereon positioned in an opposed air-gap defining relationship with the planar air-gap portion of said core part, and having at least one wedge portion thereon in an opposed and operatively-slidable abutment with the wedge portion of said core part; said opposed and abutting wedge portions supporting said opposed planar air-gap portions in a spaced relation with each other; and an adjustable mounting means for said core or pole parts having means operatively engaging one of said parts to move its wedge portion in slidable abutment along the wedge portion of the other of said parts and vary the planar air-gap spacing between said opposed air-gap portions.

20. An electrical apparatus comprising: an elongated magnetic core part having a pair of coils mounted in longitudinally spaced relationship therealong, a pair of wedge-forming portions inclined with respect to the longitudinal axis of said core part and a pair of air-gap-forming portions both pairs of which are on opposite lateral sides of said core part; magnetic shell means including a pair of opposed magnetic portions positioned on opposite sides of said core part and coils, each of said magnetic portions having inclined portions complementary to said wedge-forming portions of said core part and engagaing the same and also having air-gap-forming portions adjacent to said air-gap-forming portions of said core part; and means between said magnetic shell means and said core part for moving said core part longitudinally of said shell means, thereby varying the relative positions of engagement of the engaging wedge-forming portions of said core part and said magnetic shell means to spread apart said air-gap-forming portions thereof.

21. An improved electrical apparatus which comprises; a pair of magnetic parts providing a magnetic circuit, each of said parts having a sloped abutment surface in opposed and sliding-wedge relationship with the sloped abutment surface of the other of said parts, the sloped abutment surface of one of said parts being resiliently urged into engagement with the sloped abutment surface



of the other part, and means for forcing one of said parts relative to the other in a direction making an angle with said sloped abutment surfaces so that movement of said one part imparts lateral movement to the other part as said sloped abutment surfaces slide relative to one another, said magnetic parts having laterally-spaced, air-gap-forming portions adjacent to but spaced from one another, the spacing between said air-gap-forming portions varying as determined by the positions of the sloped abutment surfaces relative to one another.

22. Electrical apparatus comprising a first elongated magnetic part having at least one coil mounted thereon, at least one wedge portion and at least one air-gap-forming portion; a second longitudinally-extending magnetic part positioned opposite said first part; said first part and magnetic part together defining a window which receives the projecting portion of said coil; said second part having at least one air-gap-forming portion positioned in an opposed air-gap-defining relationship with said air-gap-forming portion of said first part, and having at least one wedge portion thereon in operatively slidable abutting relation with said wedge portion of said first part; said abutting wedge portions supporting said opposed air-gap-forming portions in spaced realtionship with each other, and means for moving one of said parts in a direction making an angle with said abutting wedge portions of said parts to move the other of said parts laterally thereof to vary the air-gap-spacing between said opposed air-gap-forming portions.

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