

July 21, 1953

G. M. SHINGLEDECKER ET AL

2,646,552

VARIABLE TRANSFORMER

Filed Jan. 27, 1950

2 Sheets-Sheet 1

Fig. 1

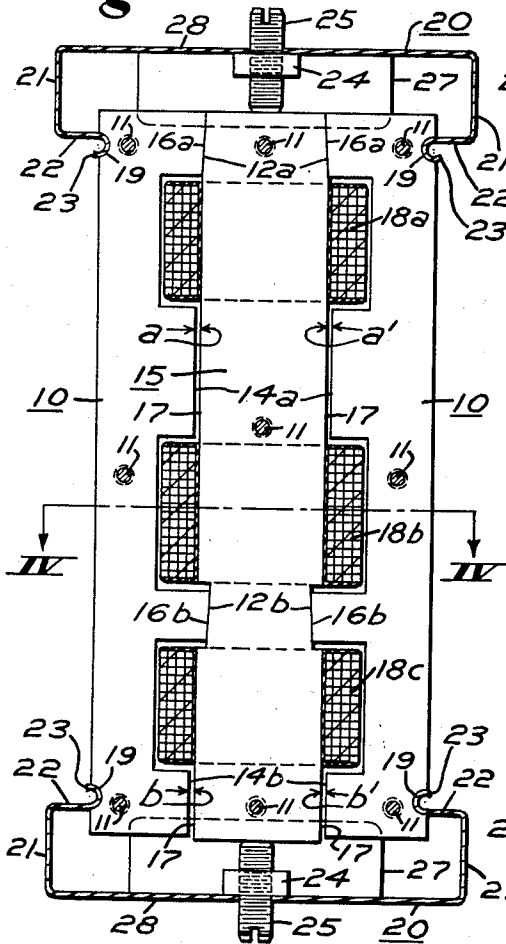


Fig. 2

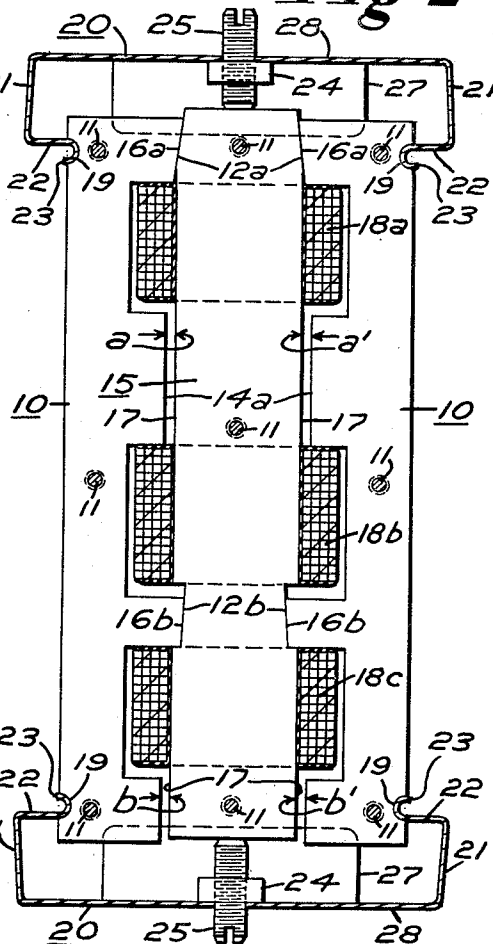


Fig. 4

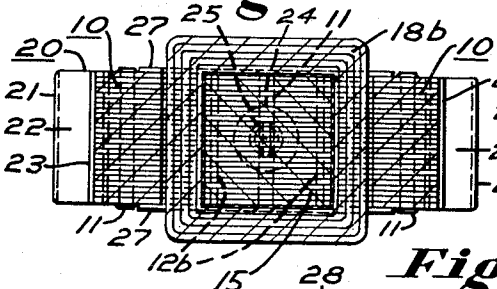


Fig. 11

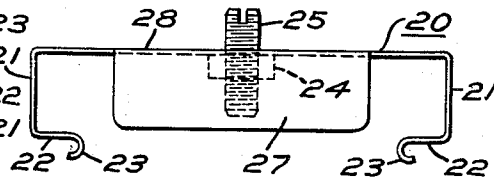
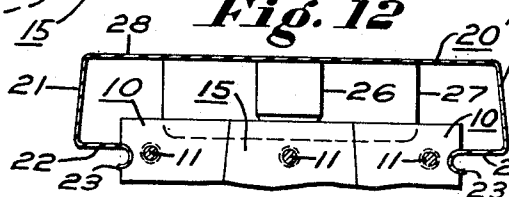


Fig. 12



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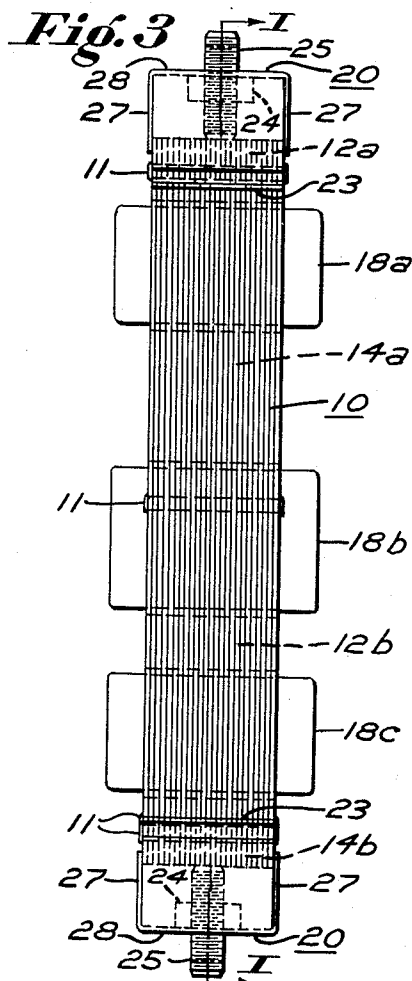
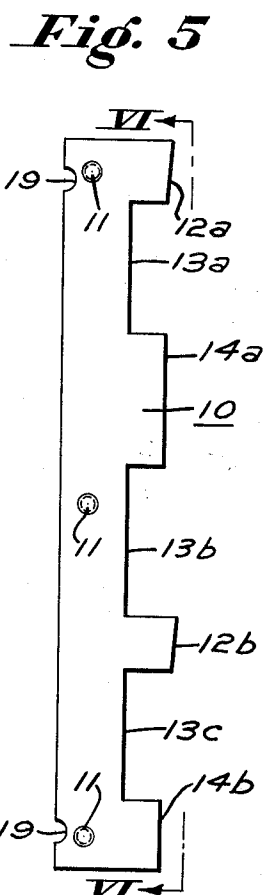
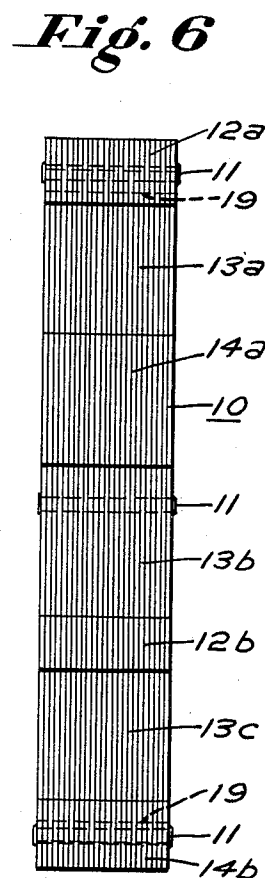
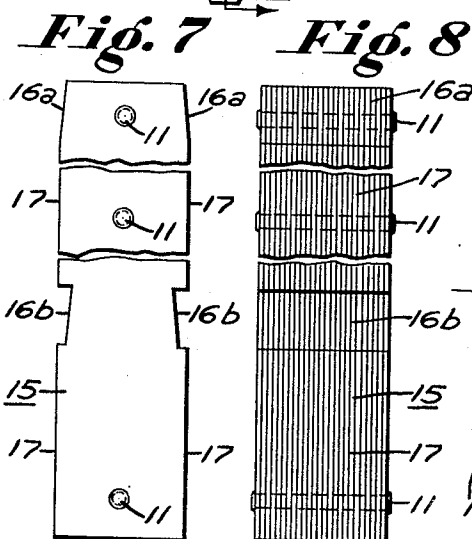
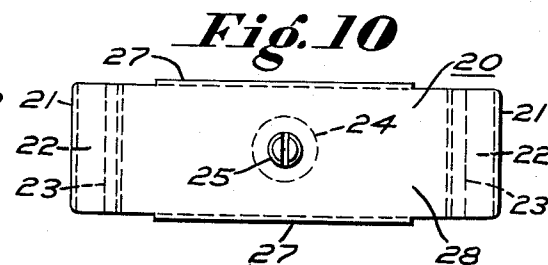
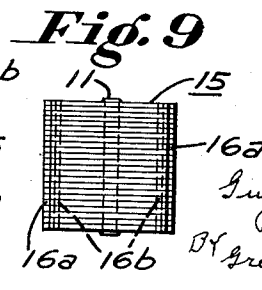
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VARIABLE TRANSFORMER

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2 Sheets-Sheet 2



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2,646,552

VARIABLE TRANSFORMER

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12 Claims. (Cl. 336—133)

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This invention relates to air gap control of electrical apparatus and particularly to means for obtaining an extremely accurate air gap setting for an electric apparatus such as a transformer. A more important phase of my invention pertains to an improved electrical transformer that may be accurately adjusted after it is assembled.

In the manufacture of ballast transformers for fluorescent lamps, it is customary to fabricate laminations for an I or center core piece and a pair of outer or surrounding E pole pieces from electric strip steel. This may be accomplished by punching holes, blanking out the I-piece laminations, blanking out an opposed pair of E-pieces, stacking the pieces, and annealing. Punches and dies for this purpose have to be made with close tolerances to produce stampings with a minimum burr to thus reduce rejections. That is, requirements for a minimum burr height as well as maximum accuracy as to dimensions necessitate great care in producing the pieces.

Although fairly close accuracy can be insured by care in die and punch design and setting, this does not solve the problem as to air gap requirements for the electrical apparatus or transformer when assembled. The extremely close tolerance required for air gap spacing, about 0.005" for a transformer of the above type, is an important factor in obtaining a suitable product. In a transformer of the above type, it is necessary to provide an extremely accurate air gap setting or spacing between the part which makes up the center or I-piece and the surrounding part which is made up of a pair of opposed E-pieces. It is customary to make the core or I-piece upon which coils or windings are to be mounted of a plurality of laminations suitably held or secured together as by welding or riveting. It is also customary to make the surrounding field pieces, such as a pair of opposed E-pieces, of a plurality of laminations suitably held or secured together in a similar manner. This further complicates the problem of obtaining a desired setting or spacing between adjacent air gap portions of the field and core parts.

In view of the above problem, we have worked out an entirely new approach in accordance with which the air gap setting of an electric device such as a transformer may be adjusted with extreme accuracy after the parts thereof have been assembled.

It has thus been an object of our invention to solve the problem herein presented by an entirely new approach thereto.

Another object has been to devise a new and improved form of transformer construction.

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A further object has been to make possible a maximum efficiency of air gap setting in an electrical apparatus such as a transformer by providing means for accurately adjusting previously assembled parts to a desired air gap setting as indicated by an ordinary characteristic-testing apparatus.

These and many other objects of our invention will appear to those skilled in the art from the illustrated structure and the description thereof.

In the drawings:

Figure 1 is a front vertical sectional view in elevation of a transformer constructed in accordance with our invention and is taken on line I—I of Fig. 3;

Fig. 2 is a sectional view similar to Fig. 1, but shows the core adjusted with respect to the field or pole construction in accordance with the principles of my invention; this view illustrates a maximum air gap setting that may be effected;

Fig. 3 is a side view in elevation of the transformer of Fig. 1;

Fig. 4 is a horizontal section taken along the line IV—IV of Fig. 1;

Fig. 5 is a front view in elevation of a pole or field piece of the transformer shown in Figs. 1, 2 and 3;

Fig. 6 is a side view of the pole piece of Fig. 5, taken at 90° to Fig. 5 and along the line VI—VI thereof;

Fig. 7 is a broken front view in elevation of a core piece or part of the construction of Figs. 1-3;

Fig. 8 is a side view of the core piece of Fig. 7 taken at 90° with respect thereto;

Fig. 9 is a top end view of the core piece of Fig. 7;

Fig. 10 is a top plan of a cap construction as employed in the apparatus shown in Figs. 1-2 of the drawings;

Fig. 11 is a side view in elevation of the cap of Fig. 10; and

Fig. 12 is a side fragmental sectional view of a modified form of cap assembly that may be employed for enclosing one end of the transformer of Figs. 1 and 3.

As previously implied, heretofore the air gap setting of an electric transformer had to depend for its accuracy upon the fabricating operations of the individual parts thereof and upon the accuracy of assembling its parts into a complete apparatus. In accordance with our invention, the setting can now be effected with highest accuracy to obtain an exact desired spacing after the parts have been assembled and in accordance with a continuous reading made by an ordi-

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nary electrical testing instrument. That is, the parts may be assembled into a magnetic circuit arrangement and the transformer windings then connected electrically to testing equipment to determine if the air gap setting is too great or too small. The setting can then be adjusted inwardly or outwardly until it is exactly correct. This is accomplished by providing means for adjusting the core piece or part upon which the coil or coils are mounted with respect to the opposed pole pieces that prove an enclosing pole part. Co-operating sloped-abutment or wedge faces or surfaces are employed to expand or move the surrounding pole pieces toward and away from the core part.

Thus in accordance with our invention, the parts of the electrical apparatus are assembled and are somewhat rigidly-flexibly or yieldably held in place by end caps or members. At least one adjusting means extends through one of the caps and is adapted to engage the core part to move it with respect to the field or pole pieces. The adjusting means preferably has a relatively fine pitch to provide extremely close graduations until the desired setting is obtained. We prefer to assemble the parts, as indicated in Fig. 2, so that they preliminarily have a full maximum or minimum setting and then to make a one-way adjustment away from the maximum or minimum setting until the desired air gap relationship is attained. However, if a two-way adjustment is desired, this can be readily effected where, as illustrated in Fig. 1, each end cap is provided with an adjusting means.

Referring particularly to Figs. 1-3 of the drawings, we have disclosed an electrical transformer constructed in accordance with our invention having an opposed pair of E or pole pieces 10 and a center core or I piece 15. Since each of the pole pieces 10 is of similar construction, we have used similar designating numerals for both of them.

Referring particularly to Figs. 1 and 5, each pole piece 10 may be made up, as shown in Fig. 6, of a plurality of electrical (magnetic) steel laminations secured together by some suitable means such as rivets 11. Each complete longitudinal pole piece 10 is provided as shown with transversely-offset windows 13a, 13b and 13c which are adapted to receive coils or windings 18a, 18b and 18c of the core part 15. As shown particularly in Figs. 7 and 8, the core part 15 may also be made up of electrical steel laminations secured together by rivets 11. I have shown two longitudinally spaced-apart transverse or inwardly-extending leg portions on each pole piece 10 having sloped or tapered wedge faces or surfaces 12a and 12b that are adapted to co-operatively engage wedge faces or surfaces 16a and 16b, respectively, of the core piece 15. It will be noted that the core piece 15 has longitudinally spaced-apart, transversely-extending abutment portion pairs along its opposite sides. As seen, relative movement between the wedge surfaces 12a and 16a and 12b and 16b (see Figs. 1 and 2) will cause the pole or field pieces 10 to move transversely inwardly or outwardly and change the setting of the air gap spacings *a* and *b*. The air gaps are provided between planar faces or transversely-offset surfaces 14a and 14b of the other two legs of each pole piece 10 and opposite or adjacent planar side faces or surfaces 17 of the core piece 15.

Cap members or elements 20 of somewhat rigidly flexible spring-like metal construction are

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provided with depending skirt-portions 21 on opposite sides thereof. Each skirt-portion 21 is connected by an inwardly-projecting, integral, shelf-like portion 22 to an integral, outwardly turned-up flange portion 23. It will be noted that the flange portion 23 has spaced-apart walls connected by a shoulder that is adapted to engage or snap into side grooves or slots 19 in end portions of the pole or field pieces 10. It will be noted that a cap 20 is provided for the upper and lower ends of the assembly and that each cap can be forced into a locking position over the ends of the assembly by reason of its spring-like construction. This rigidly flexibly holds the parts in an assembled relation by tension force.

To effect the adjustment between the inner core part 15 and the outer or surrounding pair of pole parts 10, the cap member 20 is shown provided with a threaded adjustment or set screws 25. The screw 25 is mounted within a bearing button 24 that is secured on the inside of the cap 20 and has a threaded bore corresponding to the threads of the screw. The pitch or lead of the threads is preferably slight, so that extremely accurate adjustments can be effected.

As shown particularly in Figs. 1, 2, and 3, a desired adjustment between the pole pieces 10 and the core piece 15 may be obtained by adjusting one of the pair of set screws 25 shown within its bearing button 24. The other set screw 25 can be slightly eased off if desired, although the flexible construction of the opposing cap will permit some adjustment being made by one set screw without an offsetting adjustment by the other set screw. As shown in Fig. 12, only one set screw 25 may be used in one of the caps and the other cap 20' may have an inwardly-extending abutment or boss 26 that will take the place of an additional set screw. In this arrangement, the top of cap 20' is made up of more flexible construction or has a lesser thickness than the opposing cap 20 which carries the set screw 25.

Since the air gap settings *a* and *b* are extremely critical in apparatus of this type, we have determined that adjustments permitted on either side of the neutral setting of Fig. 1 will be sufficient for ordinary requirements, although a greater slope or taper of the wedge faces may be provided to increase the maximum and minimum settings, if required. It will be apparent that the pole pieces 10 are expanded outwardly to the position in Fig. 2 against the spring action of the enclosing end cap members 20 or 20 and 20' and that they will move inwardly under the spring tension of these members when the gap is to be decreased rather than increased. Since the cap members are normally snapped into the grooves 19 under tension, it will be apparent that they always exert a force tending to move the enclosed field or pole pieces 10 inwardly towards the core piece 15. Thus, for any setting of the air gaps, the pole pieces 10 will be positively held at such setting by the clamping-like tension forces exerted by the cap members 20 through the pieces 10 and 15, upon their co-operating wedge faces 12a and 16a as well as 12b and 16b. It will also be apparent that the air gap adjustments effected will be the same on opposite sides of the center or core piece 10, compare *a* and *a'* and *b* and *b'*.

As shown in the figures, the caps 20 and 20' have opposite pairs of inwardly-projecting, flexible, front and back skirt or flange portions 27 that are constructed to tightly engage front and back sides of the pole pieces 10 and the core piece

15 at their opposite end portions to clamp or hold them in position with respect to each other and with respect to the caps. It will be noted that the flange portions 27 are spaced from the side skirt portions 21 at their ends, but that they are all preferably an integral part of the top or cover portion 28 of the caps 20 and 20'. The flexible projecting portions 21 and 27 thus constrain the pieces 18 and 15 transversely or horizontally and the portion 28 constrains them endwise or longitudinally, or in other words, hold the transformer parts in an assembled relationship.

The caps 20 and 20' are preferably of non-magnetic, somewhat flexible or spring-like metal and the adjustment screws 25 and the abutment or boss 26 may be of non-magnetic metal or of a non-conducting material such as hard rubber or plastic.

It will be noted that the E pieces 10 are moved transversely inwardly and outwardly with respect to the I piece 15 by the action of their adjacent abutting wedge surfaces when the I piece is moved longitudinally inwardly and outwardly with respect to the E pieces. The transverse outward movement (a spreading movement) is effected against the tension of the cap member or members 20, while the transverse inward movement is, at least in part, effected by the release of at least a portion of the tension, or in other words, in the direction of or with the tension force. Since the air gap portions *a*, *b*, etc. between an E piece and the I piece are planar or are parallel to a plane representing their major axes, as well as to a longitudinal plane representing their plane of movement, it will be apparent that the air gap flow will always be at right angles to such longitudinal planes or fully transversely of the transformer. This is a highly important feature of our invention and provides a transformer of maximum efficiency from an electrical standpoint. The extremely accurate and minute air gap adjustment made possible by our construction is also highly important, as previously indicated.

What we claim is:

1. 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.

2. An electrical apparatus as defined in claim 1 wherein, cap means flexibly holds said pole pieces in an assembled relation with said core part.

3. An electrical apparatus as defined in claim 1 wherein, a cap member is clamped over an end portion of said pole pieces, said adjustable

means is operably mounted on said cap member and is constructed to engage said core part.

4. An electrical apparatus as defined in claim 3 wherein, a rigidly-flexible cap is clamped over an opposite end portion of said pole pieces.

5. Improved electrical apparatus such as a transformer which comprises, a longitudinally-extending electrical core part having longitudinally spaced-apart pairs of transversely-oppositely extending wedge surfaces, said core part also having longitudinally spaced-apart pairs of transversely-inwardly offset air gap surfaces, a pair of longitudinally-extending opposed pole pieces adapted to be positioned on transversely-opposite sides of said core part, each of said pole pieces having longitudinally spaced-apart and transversely-inwardly extending wedge surfaces therealong adapted to slidably engage wedge surfaces of each pair of said core parts, said pole pieces having longitudinally spaced-apart transversely-inwardly offset air gap surfaces therealong adapted to co-operate with air gap surfaces of each pair of said core parts, grooves about opposite end portions of said pole pieces, a pair of cap members, each of said cap members being adapted to be mounted over one end portion of said pole pieces and to engage the grooves therein, at least one of said cap members being of flexible construction, a set screw operably positioned in the other of said cap members and extending inwardly thereof into engagement with one end portion of said core part to adjust the relative relationship of said core part with respect to said field pieces.

6. Electrical apparatus as defined in claim 5 wherein, a set screw is operably mounted on said first-mentioned cap member and extends inwardly therefrom into engagement with an opposite end portion of said core part.

7. Electrical apparatus as defined in claim 5 wherein, said first-mentioned cap member is provided with an inward projection extending into abutment with said core part, and said cap members are of flexible metal construction and are constructed and arranged to flexibly clamp said pole pieces in an assembled relationship with respect to said core part.

8. 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.

9. An improved electrical apparatus such as a transformer which comprises, a core part having an electric winding thereon, said core part being provided with a wedge surface, a pole part hav-

ing a window portion for receiving an extending portion of said winding, said pole part having a wedge surface constructed and arranged to co-operatively engage the wedge surface of said core part, said core and pole parts being provided with a pair of co-operating adjacent surfaces having a spaced-apart relationship with respect to each other, means operatively connected between said core part and said pole part and constructed and arranged to move said core part with respect to said pole part along the co-operating wedge surfaces of said parts, said means comprising a cap member mounted on said pole part and a stud element adjustably mounted on said cap member, and said stud element being constructed and arranged to engage said core part.

10. 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-gaps-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.

11. An improved electrical apparatus as defined in claim 10 wherein, said last-mentioned means is adjustably carried by said first-mentioned means, and said first-mentioned means is a cap member.

12. 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 providing 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.

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