May 12, 1959 B. A. BARENGOLTZ 2,886,791

TRANSFORMER CORE AND COIL CLAMPING MEANS

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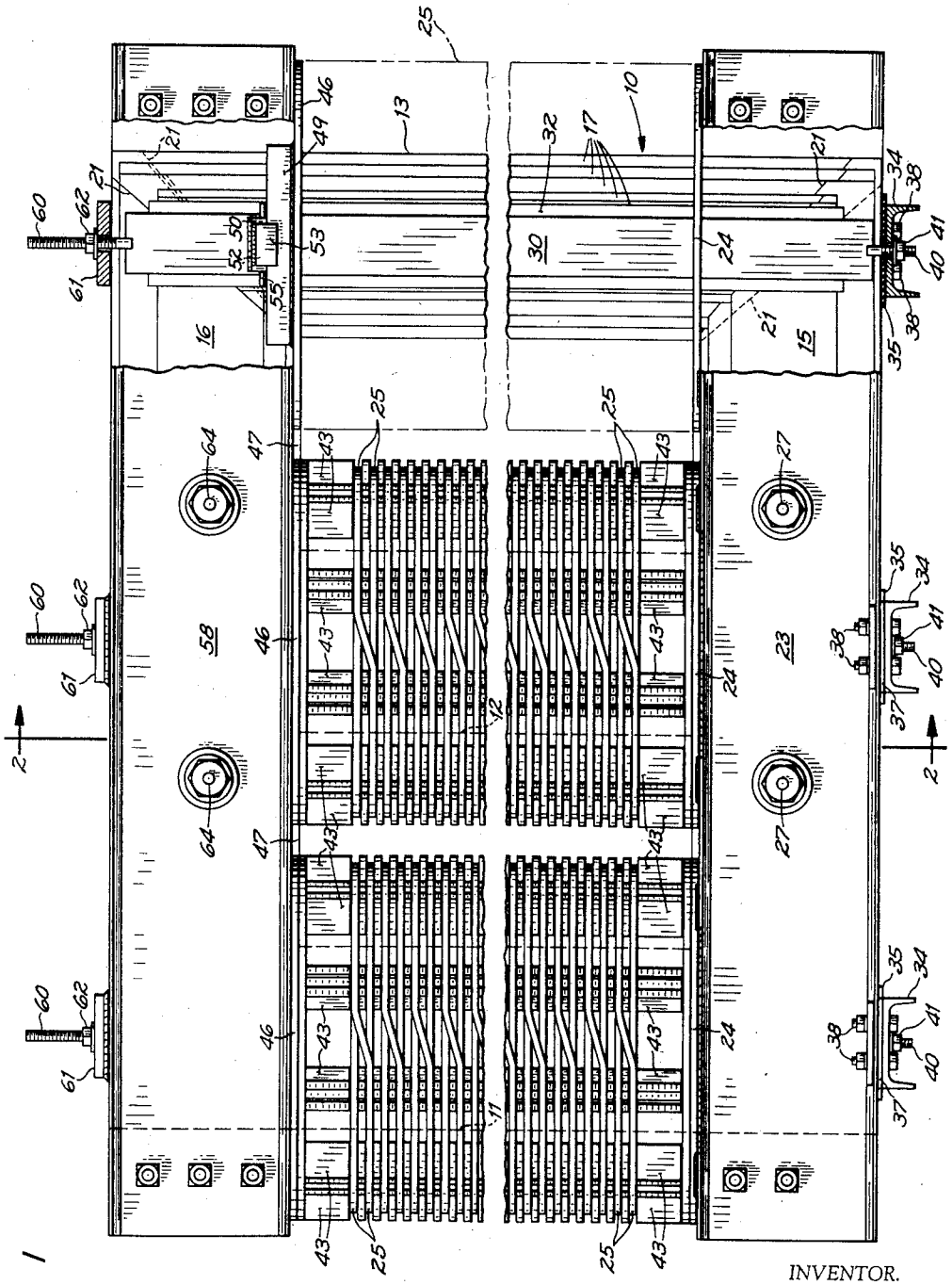


Fig. 1

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Fig. 3

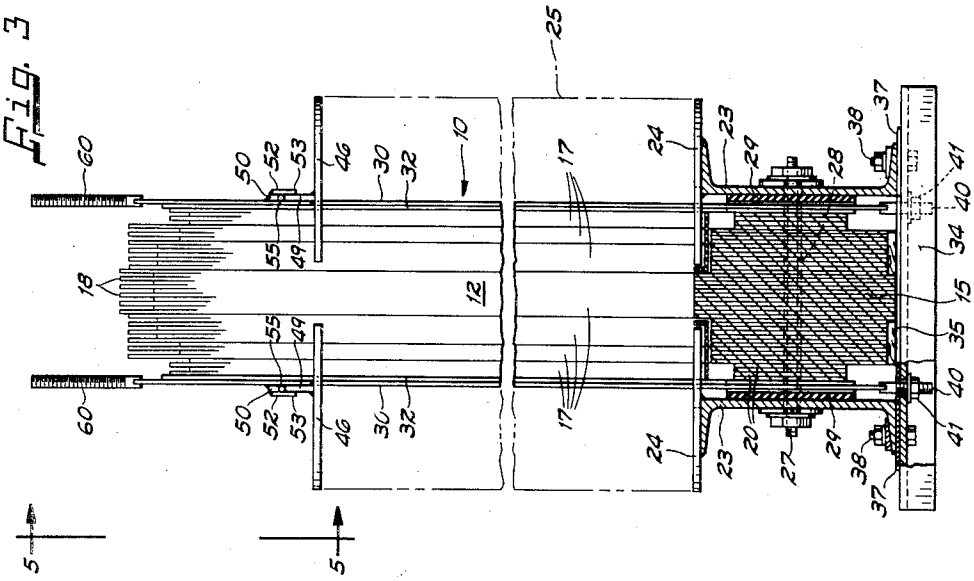
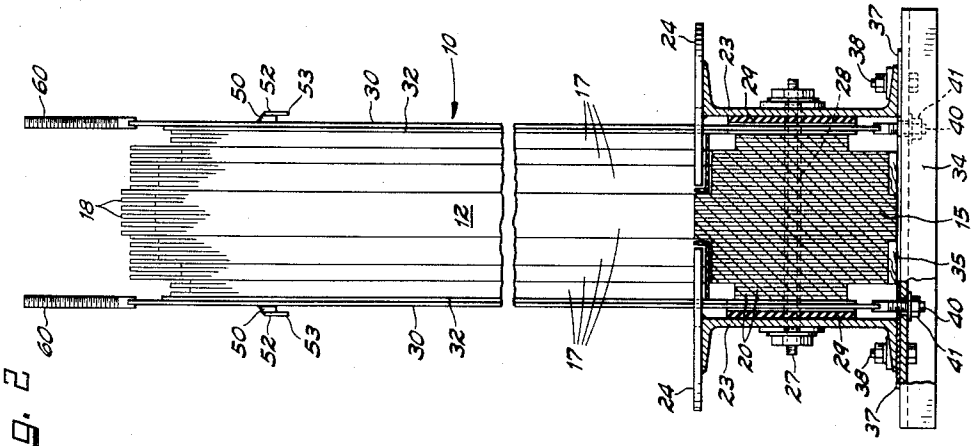


Fig. 2



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Fig. 4

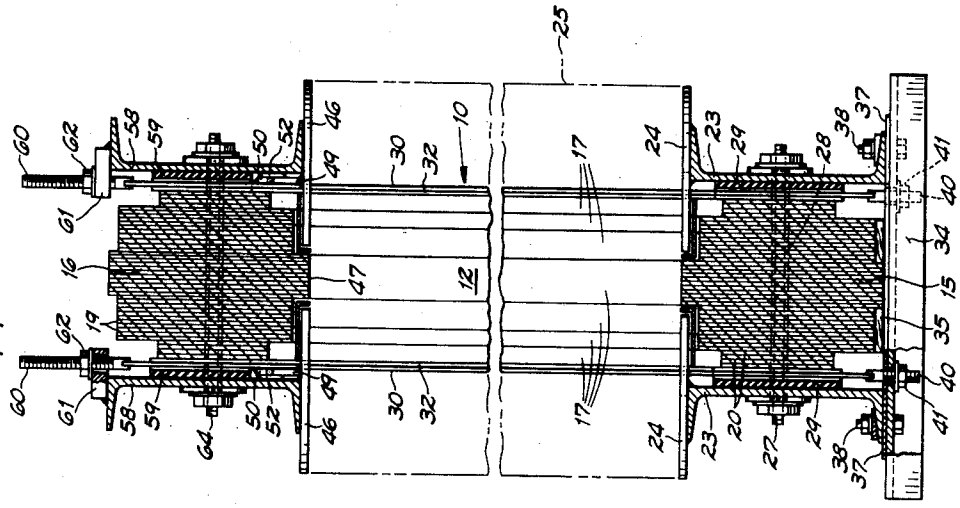
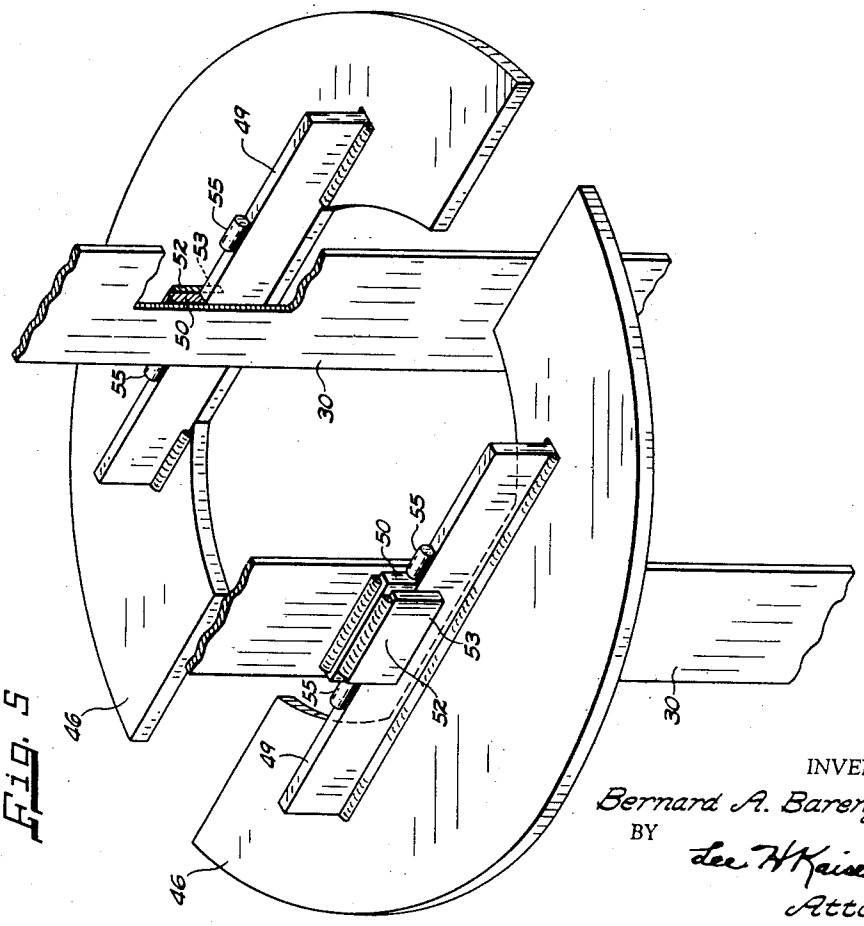


Fig. 5



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TRANSFORMER CORE AND COIL CLAMPING MEANS

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Application March 11, 1957, Serial No. 645,285

7 Claims. (Cl. 336—197)

This invention relates to stationary induction apparatus and more particularly to means for clamping the core and coils of stationary induction apparatus of the power type.

In the conventional construction of electrical power transformers having laminated magnetic cores, channel iron lower side frame members are disposed on opposite sides of, and bolted to, the lower yoke of the core, and lock strips disposed on opposite sides of, and bolted to, the legs of the core are secured to the lower side frame members and extend through the window of the electrical coils. Among the last assembly operations for magnetic cores having conventional clamping means, laminations of the upper yoke are individually assembled in interleaved relation with the leg laminations, and channel iron, upper side frame members are positioned on opposite sides of the upper yoke, bolted to the upper yoke laminations, and secured to the lock strips. Subsequently a plurality of means such as set screws threadably engaging the side frame members are tightened to clamp the electrical coils in an axial direction and prevent movement thereof under the stresses incident to short circuit conditions.

This conventional means for clamping the core and coils has several disadvantages. Often the electrical coils, particularly those of the pancake type, swell to such an extent in an axial direction that it is impossible to interleave the top yoke laminations with the leg laminations without first drying out the coils. This swelling of the coils sufficiently in an axial direction to prevent assembly of the upper yoke laminations occurs most frequently when a transformer is not completely finished during a working day and the coils stand overnight. At times it is necessary to dry out the coils three or four times to shrink them sufficiently to permit assembly of the upper yoke laminations to the leg laminations. Such prior art core and coil clamping means resulted in unnecessary delay in manufacture as well as waste of time and labor.

Alignment between the lock strips and upper side frame members was extremely critical with such prior art clamping means, and it was virtually impossible to interchange lock strips or side frame members between transformers. This criticality of alignment between lock strips and upper side frame members required marking, drilling, and machining of the upper side frame members of each transformer separately to assure that they mated with the lock strips. Consequently, construction of side frame members by production means such as a jig was not feasible, and the loading of the lock strips interconnecting the upper and lower side frame members was seldom uniform.

A still further disadvantage of this prior art core and coil clamping means was that tightening of a plurality of set screws, many of which were in inaccessible positions behind lead supports, to clamp the electrical coils in an axial direction was tedious and difficult and seldom resulted in uniform clamping of the electrical coils.

It is an object of the invention to provide an improved means for clamping the core and coils of an electrical

transformer which permits holding the electrical coils to a predetermined axial height independent of the upper yoke and upper side frame members, whereby the transformer may stand for days without swelling of the coils even though the upper yoke and upper side frames are not assembled. It is a further object of the invention to provide such an improved clamping means which avoids the delays in manufacture inherent when the above described prior art clamping means were utilized and permits saving of more than fifty percent in the time and labor required to assemble transformers. A still further object of the invention is to provide such an improved clamping means which obviates the necessity of drying out the coils as was frequently required when prior art clamping means were utilized.

Another object of the invention is to provide an improved means for clamping the core and coils of an electrical transformer wherein the side frame members and lock strips are fully interchangeable between transformers, wherein the lock strips are easily secured to the side frame members, and wherein loading of the lock strips is substantially uniform.

Still another object of the invention is to provide improved clamping means for the core and coil of an electrical transformer wherein it is only necessary to tighten at a few places to clamp each coil in an axial direction in contrast to the tightening of a multiplicity of relatively inaccessible set screws as required with prior art clamping means. A further object of the invention is to provide such improved clamping means which results in a more rigid frame structure for resisting short circuit forces in the electrical coils and more uniform clamping of the electrical coils.

Another object of the invention is to provide an improved clamping means for the core and coil of an electrical transformer which permits a material reduction in the height of the magnetic core and in the amount of steel required in the core.

A still further object of the invention is to provide an improved clamping means for the core and coil of an electrical transformer which results in an appreciable reduction in the noise level of the transformer.

These and other objects and advantages of the invention will be apparent from the following detailed description when taken in conjunction with the accompanying drawing wherein:

Fig. 1 is an elevation view of an electrical transformer core and coil assembly having improved clamping means in accordance with a preferred embodiment of the invention, a portion being broken away to better illustrate the construction;

Fig. 2 is a vertical sectional view taken through the center core leg along line 2—2 of Fig. 1 but before the electrical coils, the upper yoke, and the upper side frame members are assembled.

Fig. 3 is a view similar to Fig. 2 after electrical windings are inserted over the core legs, upper clamping plates are secured to the lock strips, and the lock strips are tightened to clamp the coils in an axial direction independent of the upper yoke and upper side frame members;

Fig. 4 is a view similar to Figs. 2 and 3 after the upper yoke and upper side frame members are assembled; and,

Fig. 5 is a perspective view showing details of the interengaging means between the upper clamping plates and the lock strips, a portion being broken away to better illustrate the construction.

Referring to the drawing, a three phase electrical transformer is illustrated having a laminated magnetic core 10 of the stacked type, although it will be apparent that the invention is also applicable to transformers hav-

ing wound type cores. Magnetic core 10 has three laminated leg members 11, 12 and 13 connected at their lower ends by a lower yoke member 15 and at their upper ends by an upper yoke member 16. The illustrated magnetic core 10 is of approximately cruciform cross section, being built up of packs 17 of laminations which are wider and longer at the middle of the core than at the outer faces of the core. However, it will be understood that the cruciform cross section is by way of example only and that the invention is equally applicable to cores having legs and yokes which are of rectangular or of any other desired cross section. In each laminar layer the leg laminations 18 in the core legs 11, 12 and 13 are joined at their upper and lower ends to yoke laminations 19 and 20 in the upper and lower yokes respectively by miter butt joints 21, and the core joint is of the overlap-butt type wherein the ends of the interleaved leg and yoke laminations have a tapered overlap with respect to each other.

In transformers having prior art core and coil clamping means, lock strips bolted to the core leg members extended through and were secured to upper and lower side frame members. In such prior art construction the alignment of the lock strips and side frame members was critical, and it was necessary to match each of the lock strips so the upper side frame members before the side frames were drilled and machined. Further, no means were provided to clamp the electrical coils in an axial direction until the upper yoke laminations were interleaved with the leg laminations and the upper side frame members bolted thereto, and the swelling of the electrical coils in an axial direction often required three or four drying operations to shrink the electrical coils sufficiently to permit interleaving the upper yoke laminations with the leg laminations.

In the improved clamping means of the invention the coils are clamped independently of the upper yoke and also independently of the upper side frame members, thus preventing swelling of the coils when the partially assembled transformer stands overnight and obviating the necessity of coil drying operations. Further, the mating of the lock strips and upper side frame members is not critical, the lock strips and side frame members can be drilled and machined by production methods, if desired, prior to assembly, and these members are fully interchangeable between transformers.

Lower support means for the core and coil assembly includes a pair of lower side frame members 23, preferably of channel iron, disposed on opposite sides of the lower yoke 15 and having a plurality of semiannular, horizontally extending, lower clamping plates 24 rigidly affixed to the upper surface thereof. Pairs of semiannular plates 24 form generally annular supports surrounding the core legs 11, 12 and 13 for the lower end of electrical coils 25 encircling the core legs 11, 12 and 13. The lower side frame members 23 are secured to the lower yoke laminations 20 by bolts 27 extending through the clearance holes in the laminations 20 at points between the legs 11, 12 and 13, and insulating sleeves 28 surrounding bolts 27 insulate them from the lower yoke lamination 20. Insulating fillers 29 are positioned between the lower yoke 15 and the lower side frame members 23. The leg laminations 18 of outer legs 11 and 13 and the leg laminations 18 of center leg 12 are preferably interleaved with the lower yoke laminations 20 in conventional manner while the magnetic core is in a horizontal position flat on the floor and without any windings on the core legs 11, 12 and 13. Steel plate lock strips 30 are disposed on opposite sides of each core leg member 11, 12 and 13 after the building up of the lower yoke 15 and the core leg members but before the lower side frame members 23 are positioned against and bolted to the lower yoke 15. Strips of core frame insulation 32 are disposed between the lock strips 30 and the leg laminations 18 along the entire length of each leg 11, 12 and 13. If desired, elongated wooden filler strips (not shown) of generally U-shaped cross section and adapted to freely receive the lock strips 30 may be placed over the lock strips, and the core legs 11, 12 and 13 may then be wrapped with suitable tape without preventing longitudinal movement of lock strips 30 relative to leg members 11, 12 and 13. The entire assembly of lower yoke 15, lower side frame member 23, and leg members 11, 12 and 13 may then be uprighted and supported on transverse channel base members 34 positioned beneath lower side frame members 23 and in alignment with core leg members 11, 12 and 13. A sheet of insulation 35 is disposed between the lower yoke 15 and the channel base members 34, steel spacers 37 are disposed between the lower side frame members 23 and the channel base members 34, and the lower side frame members 23 are secured to the channel base members 34 by bolts 38. The lower support means for the core and coil assembly thus includes the channel base members 34, the lower frame members 23 secured to the base members 34, and the lower clamping plates 24 carried by the lower side frame members 23.

Fig. 3 illustrates succeeding steps in assembling core and coil clamping means in accordance with the invention. Electrical windings 25 of either the pancake or helically wound type may be inserted over core legs 11, 12 and 13, and the lock strips 30 disposed on opposite sides of each core leg 11, 12 and 13 extend through the window in the barrel type windings 25. Interengaging means between lock strips 30 and the lower support means include a threaded stud 40 secured by suitable means such as welding to the lower end of each lock strip 30 extending through a clearance hole in a channel base member 34 and a nut 41 threaded on the stud 40 beneath the channel base member 34.

Radially extending insulating spacers 43 arranged at circumferentially spaced apart locations are positioned between the lower end of windings 25 and the semiannular lower clamping plates 24, and upper clamping plates 46 disposed above the coils 25 are insulated therefrom by similar radially extending insulating spacers 43 also arranged at circumferentially spaced apart locations. Each upper clamping plate 46 is of approximately semiannular shape, and opposed upper clamping plates 46 are spaced apart to permit the pack 47 of widest upper yoke laminations 19 to extend therebetween, as illustrated in Fig. 4, and to be interleaved with the leg laminations 18. However, it will be appreciated that the two clamping plates 46 above the coil 25 surrounding each of the outer core legs 11 and 13 may, if desired, be integral to provide rigidity, in which event only one radially extending opening is required in the resulting upper clamping plate to permit interleaving of the widest upper yoke laminations 19 in pack 47 with the leg laminations 18 of the outer core legs 11 and 13. Further, the invention also comprehends a construction wherein all of the upper clamping plates 46 are integral.

Releasable interengaging means between lock strips 30 and upper clamping plates 46 may comprise a clamping bar 49 rigidly secured, preferably by welding, to the top surface of each upper clamping plate 46 near the inner margin thereof and a yoke-like arrangement on each lock strip 30 adapted to fit over and latch the clamping bair 49 and including a clamping pad 50 rigidly secured, preferably by welding, to the lock strip 30 and a locking bar 52 rigidly secured, preferably by welding, to the clamping pad 50 and having a depending portion 53 spaced from the lock strip 30 and adapted to fit over the clamping bar 49. A pair of locating studs 55 are rigidly secured, preferably by welding, to the top surface of each clamping bar 49 at sufficiently spaced apart positions to permit entrance of the clamping pad 50 therebetween, and the locating studs 55 prevent relative movement between lock strip 30 and upper clamping plate 46 in a lateral direction.

After lock strips 30 are secured to the upper clamping

plates 46, the nuts 41 may be tightened on studs 40 beneath base channel members 34 to pull the upper clamping plates 46 downward relative to horizontally extending lower clamping plates 24 and thus clamp the coils 25 in an axial direction therebetween. It will be appreciated that at this stage of construction, the upper yoke 16 and upper side frame members are not assembled to the magnetic core. The coils 25 are thus clamped independent of the upper yoke 16 and the upper side frame members. Swelling of the coils 25 in an axial direction is thus prevented, and the operation of drying out the coils, which was frequently required when prior art clamping means were utilized, is obviated by the improved clamping means of the invention.

As best shown in Fig. 4, the upper yoke laminations 19 may then be assembled in interleaved relation with the leg laminations 18 of core leg members 11, 12 and 13 at any desired future time to provide the desired joint construction without the necessity of coil drying operations as was frequently required with prior art clamping means. Upper side frame members 58, preferably of channel iron, may then be positioned on opposite sides of upper yoke 16 with insulating fillers 59 disposed between upper yoke 16 and frame members 58. Each lock strip 30 has rigidly affixed to the upper end thereof, preferably by welding, an upwardly extending, threaded, upper side frame positioning stud 60, and horizontally disposed positioning bars 61 rigidly secured, preferably by welding, at spaced apart positions to the top surface of the upper side frame members 58 have clearance holes for receiving the threaded studs 60. The mating of lock strips 30 and upper side frame members 58 is not critical and no difficulty is encountered in inserting upper side frame positioning studs 60 through the clearance apertures in positioning bars 61. Tightening of nuts 62 threaded on studs 60 above positioning bars 61 urges upper side frame members 58 against upper clamping plates 46 to reinforce the clamping of the coils 25 in an axial direction. Upper support means in the final transformer thus includes the upper clamping plates 46 and upper side frame members 58 secured to the lock strips 30, and the upper frame members 58 held by lock strips 30 in direct contact with the upper clamping plates 46 helps provide a rigid and mechanically strong assembly for resisting short circuit forces in the coils 25. The upper side frame members 58 may be secured by bolts 64 to the upper yoke laminations 19 at points between core legs 11, 12 and 13, and vertically elongated clearance slots (not shown) provided in the upper side frame members 58 for the bolts 64 permit vertical movement of upper side frame members 58 relative to the upper yoke laminations 19 when nuts 62 are tightened on studs 60.

Prior art coil clamping means conventionally included a plurality of set screws threaded to the upper and lower side frame members for exerting pressure axially against the coils. Often these set screws were in inaccessible positions behind lead supports where it was difficult to tighten them, and the resulting clamping of the coils was seldom uniform. The improved coil clamping means of the invention requires the tightening of threaded means at only two places, i.e., nuts 41 on studs 40 below channel base members 34 in contrast to the many set screws which had to be tightened when prior art clamping means were utilized, and the direct contact between the upper side frame members 58 and the upper clamping plates 46 provides a much more rigid frame structure and results in greater uniformity in clamping of the coils 25. Further, the lock strips of the invention are fully interchangeable between transformers, and it is no longer necessary to drill and machine the upper side frame members to fit the lock strips after the upper yoke is assembled as was required with prior art clamping means. It will be appreciated that the invention also comprehends an arrangement wherein the interengaging means between the lock strips and the lower support means is not adjustable but the interengaging means between the lock strips and the upper clamping plates are made adjustable in order to permit tightening of the clamping means from a position above the electrical coils rather than from below the coils as in the disclosed embodiment. Further, it will be apparent that it is within the scope of the invention to utilize adjustable interengaging means between the lock strips and both the upper and the lower supports to permit tightening of the coil clamping means from both the top and the bottom of the transformer.

Transformers constructed in accordance with the improved core and coil clamping means of the invention exhibit a material reduction in noise level in comparison to transformers having prior art clamping means. This reduction in noise may be theoretically explained on the basis that the lock strips which clamp the coils are not rigidly secured to either upper or lower side frame members or to the leg members and thus do not transmit vibrations generated by magnetostriction as readily as when prior art clamping means are utilized.

In the first transformer on which it was utilized, the improved core and coil clamping means of the invention permitted a reduction of more than 1½ inches in core height and a reduction of more than three percent in the amount of steel. Further, the improved clamping means resulted in a reduction of more than fifty percent in the number of man-hours required to assemble the transformer.

It will also be appreciated that the improved core and coil clamping means of the invention permits preassembly, as a unitary construction, of the upper side frame members 58 and such accessories as a tap changer and terminal board, with subsequent assembly of this unitary structure to the magnetic core and coils.

While only a preferred embodiment of the invention has been illustrated and described, many modifications and variations thereof will be apparent to those skilled in the art, and consequently it is intended in the appended claims to cover all such modifications and variations as fall within the true spirit and scope of the invention.

It is claimed:

1. Electrical stationary induction apparatus comprising, in combination, a laminated magnetic core having a plurality of vertical legs connected by upper and lower yokes, a lower support including a pair of lower frame members disposed on opposite sides of said lower yoke, horizontally extending support portions on said lower frame members, electrical windings surrounding said legs and resting on said horizontally extending portions, a pair of lock strips on opposite sides of each of said legs disposed between said leg and the winding surrounding it and being movable longitudinally relative to said leg, a plurality of upper clamping members engaging the upper end of said windings and being movable relative to said magnetic core, a plurality of interengaging means, each being between said lower support and one of said lock strips, and a plurality of interengaging means, each being between one of said lock strips and one of said upper clamping members, each of one of said plurality of interengaging means being adjustable to vary the spacing between said upper clamping members and said lower support, said lower frame members being immovable in at least one direction relative to the surface on which said magnetic core is supported.

2. Stationary induction apparatus comprising, in combination, a laminated magnetic core having a plurality of vertical legs connected by upper and lower yokes, a lower support including a pair of lower frame members disposed on opposite sides of and clamped to said lower yoke, horizontally extending support portions on said lower frame members, electrical windings surrounding said legs and resting on said horizontally extending portions, a pair of lock strips on opposite sides of each of said legs disposed between said leg and the winding surrounding it and being movable longitudinally relative to

said leg, a plurality of horizontally extending upper clamping plates engaging the upper end of said windings and being movable relative to said magnetic core, a plurality of interengaging means, each being between said lower support and one of said lock strips, a plurality of interengaging means, each being between one of said lock strips and one of said upper clamping plates, each of one of said plurality of interengaging means being adjustable to vary the spacing between said horizontally extending portions and said upper clamping plates, a pair of upper side frame members positioned on opposite sides of said upper yoke and disposed above said upper clamping plates, and a plurality of interengaging means, each being between one of said upper side frame members and one of said lock strips and being adjustable to move said upper side frame members toward said upper clamping plates.

3. Electrical stationary induction apparatus comprising, in combination, a laminated magnetic core having a plurality of vertical legs connected by upper and lower yokes, a lower support including a pair of lower frame members disposed on opposite sides of said lower yoke and having horizontally extending portions, said lower frame members being immovable in at least one direction relative to the member on which said magnetic core is supported, electrical windings surrounding said legs and resting on said horizontally extending portions, a pair of lock strips on opposite sides of each of said legs disposed between said leg and the winding surrounding it, each lock strip being movable longitudinally relative to said leg and engaging said lower support, a plurality of upper clamping plates engaging the upper end of said windings and being movable relative to said magnetic core, a pair of upper frame members disposed on opposite sides of said upper yoke and being positioned above and movable relative to said upper clamping plates, interengaging means between said lock strips and said upper clamping plates and being adjustable to vary the spacing between said horizontally extending portions and said upper clamping plates, and interengaging means between said lock strips and said upper frame members and being adjustable to move said upper frame members into engagement with said upper clamping plates.

4. Electrical stationary induction apparatus comprising, in combination, lower support means, a laminated magnetic core supported on said lower support means and having a plurality of aligned vertical legs connected by upper and lower yokes, said lower support means having a pair of members disposed on opposite sides of said lower yoke, each of said members having a plurality of horizontally extending portions and being immovable in at least one direction relative to said lower support means, electrical windings surrounding said legs and resting on said horizontally extending portions, upper support means including a plurality of horizontally extending members engaging the upper end of said electrical windings and being movable relative to said magnetic core and a pair of members disposed on opposite sides of and bolted to said upper yoke, a pair of lock strips on opposite sides of each of said legs disposed between said leg and the winding surrounding it, a plurality of interengaging means, each being between said lower support means and one of said lock strips, a plurality of interengaging means, each being between said upper support means and one of said lock strips, each of one of said plurality of interengaging means including threaded means operatively connected to said lock strip and extending through the corresponding support means and affording relative movement between said upper and lower support means when said threaded means is actuated.

5. Electrical stationary induction apparatus comprising, in combination, lower support means having a plurality of horizontally extending portions, a laminated magnetic core supported on said lower support means and having a plurality of aligned vertical legs connected by upper and lower yokes, said lower support means including a pair of members disposed on opposite sides of and clamped to said lower yoke, electrical windings surrounding said legs and resting on said horizontally extending portions, upper support means including a plurality of horizontally extending members engaging the upper end of said electrical windings and being movable relative to said magnetic core, a pair of lock strips on opposite sides of each of said legs disposed between said leg and the winding surrounding it, each of said lock strips being movable lengthwise relative to said leg and engaging one of said support means, interengaging means between each lock strip and the other support means including threaded means operatively connected to said lock strip and extending through said other support means and affording relative movement between said lower and upper support means when said threaded means is actuated.

6. Electrical stationary induction apparatus comprising in combination, lower support means, a laminated magnetic core supported on said lower support means and having a plurality of aligned vertical legs connected by upper and lower yokes, said lower support means including a pair of members disposed on opposite sides of said lower yoke, each of said members having a plurality of horizontally extending portions and being immovable in at least one direction relative to said lower support means, electrical windings surrounding said legs and resting on said horizontally extending portions, upper support means including a plurality of horizontally extending members engaging the upper end of said electrical windings and being movable relative to said magnetic core, a pair of lock strips on opposite sides of each of said legs disposed between said leg and the winding surrounding it, each of said lock strips being movable lengthwise relative to said leg and engaging one of said support means, interengaging means between each lock strip and the other support means, said interengaging means being adjustable to vary the spacing between said lower and upper support means.

7. Electrical stationary induction apparatus comprising in combination, lower support means having a plurality of horizontally extending portions, a laminated magnetic core supported on said lower support means and having a plurality of aligned vertical legs connected by upper and lower yokes, said lower support means including a pair of lower side frame members disposed on opposite sides of and clamped to said lower yoke, electrical windings surrounding said legs resting on said horizontally extending portions, upper support means including a plurality of horizontally extending plates engaging the upper end of said electrical windings and being movable relative to said magnetic core and a pair of upper side frame members disposed above and movable relative to said horizontally extending plates and disposed on opposite sides of and bolted to said upper yoke, a pair of lock strips on opposite sides of each of said legs disposed between said leg and the winding surrounding it, each of said lock strips being movable relative to said leg and engaging one of said support means, interengaging means between each lock strip and the other support means adjustable to vary the spacing between said lower and upper support means, and interengaging means between said lock strips and said upper side frame members adjustable to move said upper side frame members in a direction toward said lower support means and into engagement with said horizontally extending plates.

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