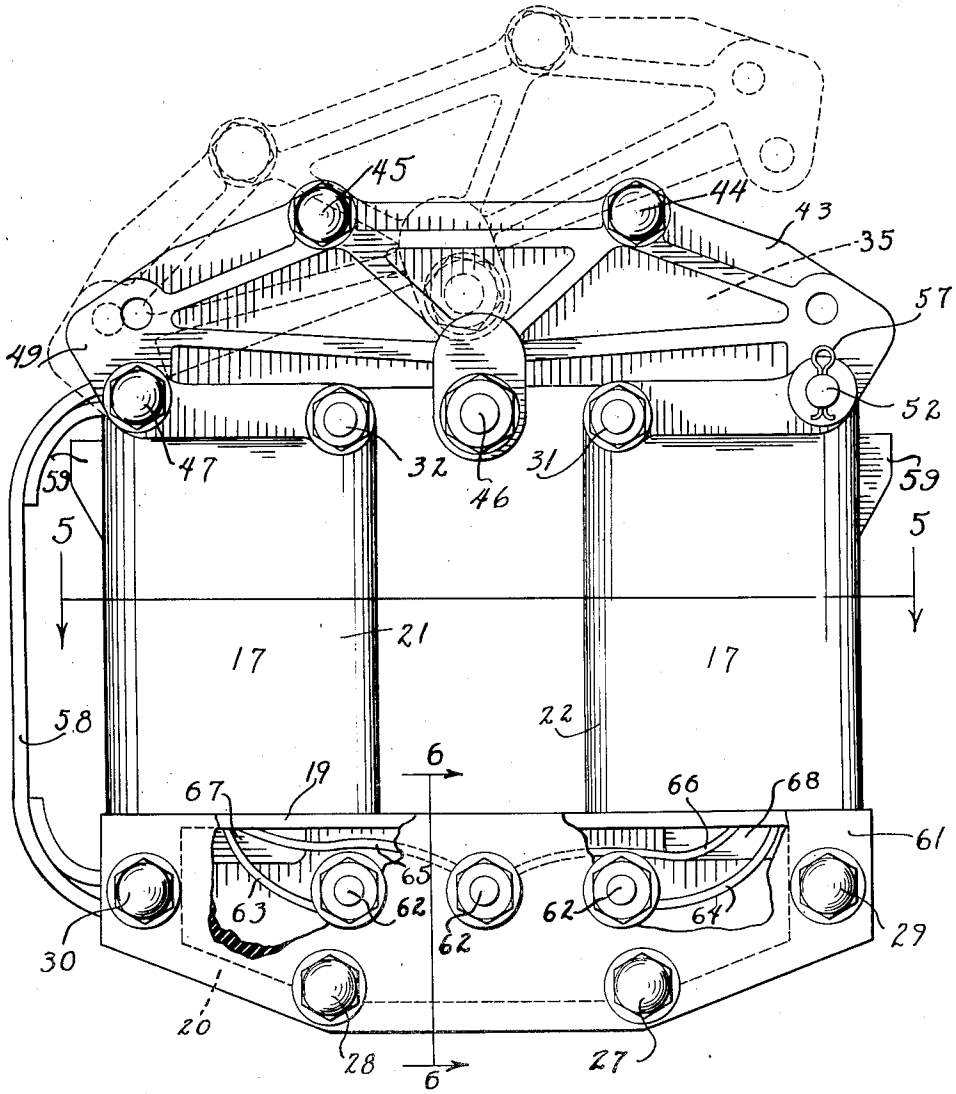
Oct. 19, 1943. R. B. ANNIS 2,332,127

SPLIT CURRENT TRANSFORMER

Filed Feb. 11, 1942 4 Sheets-Sheet 1

Fig. 1.



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SPLIT CURRENT TRANSFORMER

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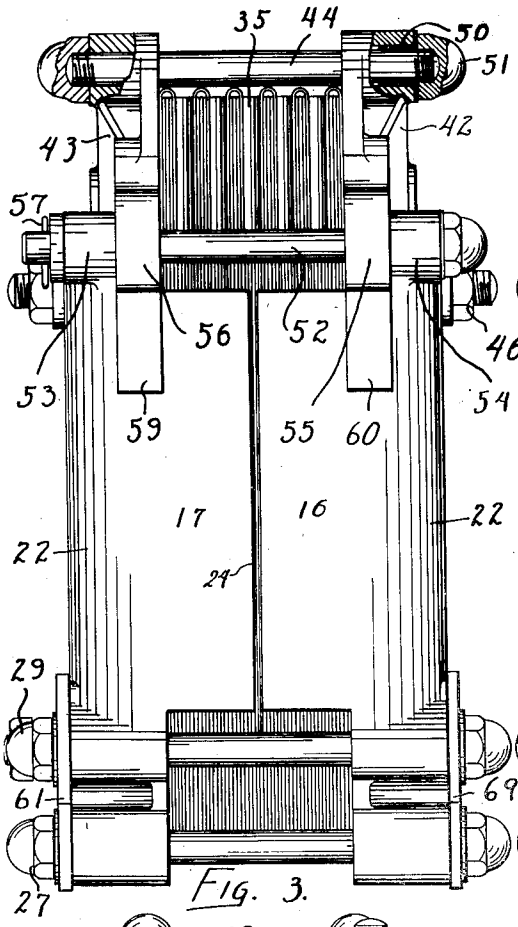


Fig. 3.

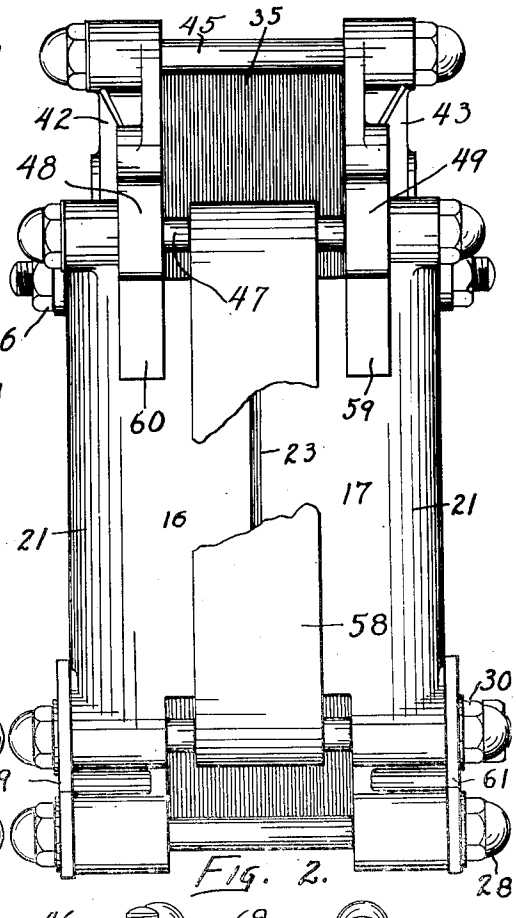


Fig. 2.

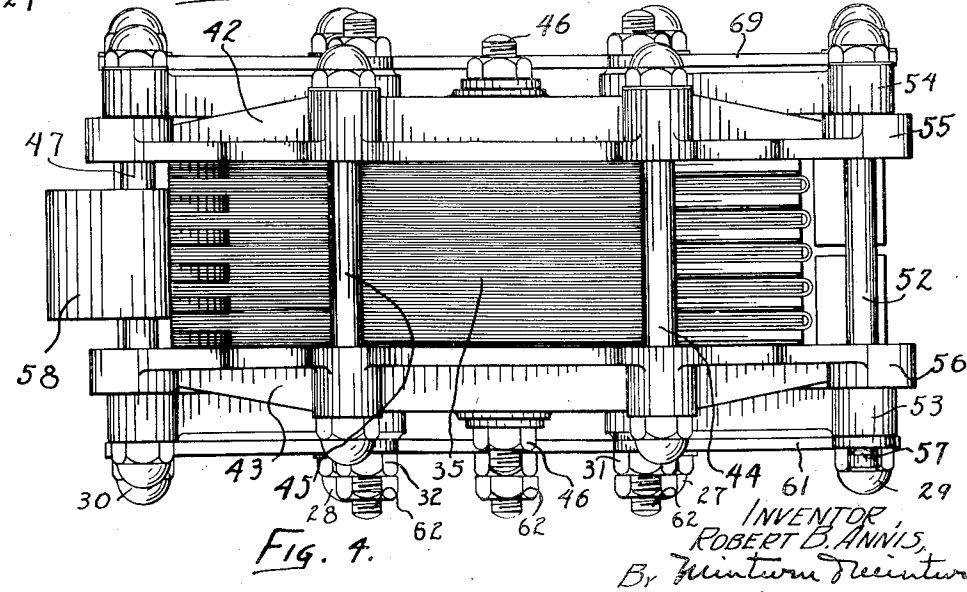


Fig. 4.

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Oct. 19, 1943. R. B. ANNIS 2,332,127

SPLIT CURRENT TRANSFORMER

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Fig. 5.

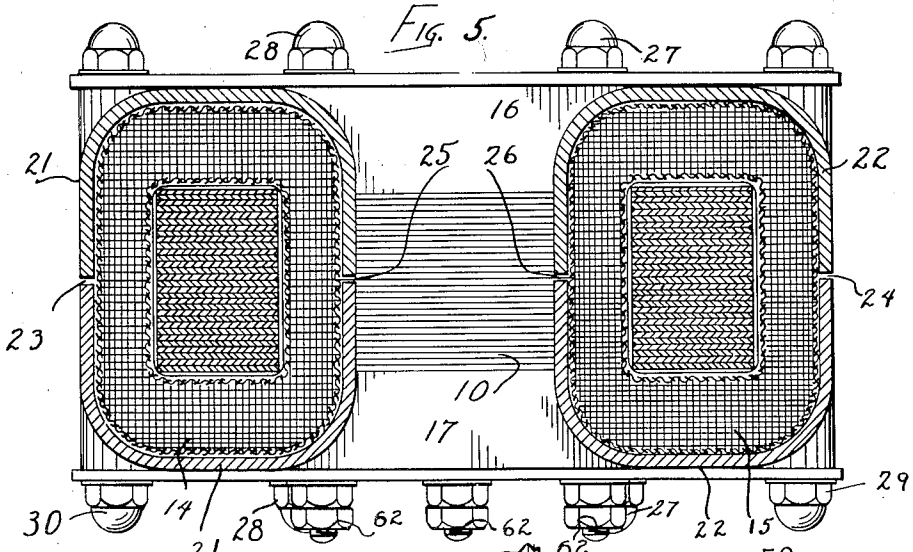


Fig. 6.

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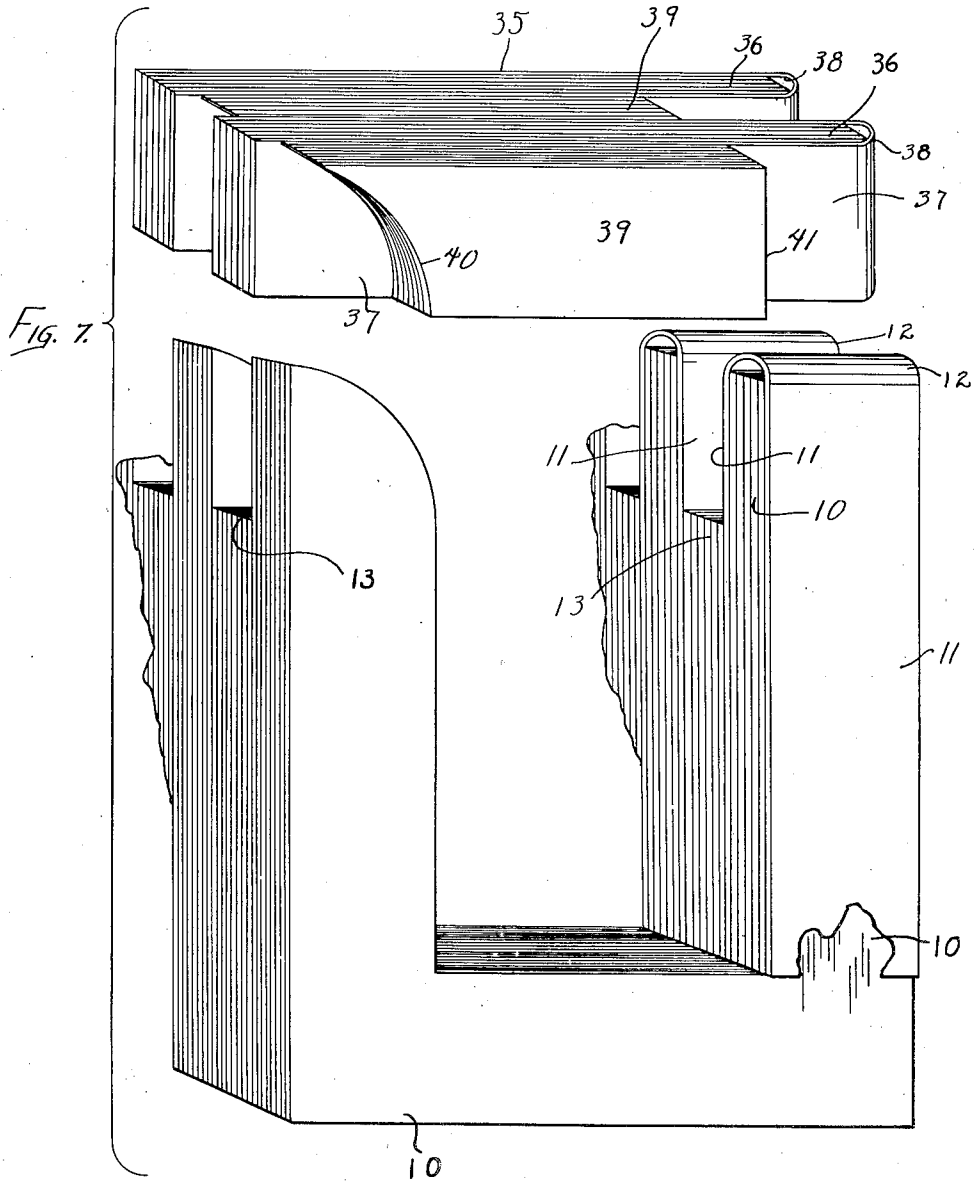


FIG. 7.

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UNITED STATES PATENT OFFICE

2,332,127

SPLIT CURRENT TRANSFORMER

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Application February 11, 1942, Serial No. 430,336

4 Claims. (Cl. 175—358)

This invention relates to a split core current transformer of that type which may be employed for rapid and accurate checking of alternating current flows in circuits particularly for large motors, electric furnaces, or any circuit of that nature which may be difficult or impractical to open in order to connect directly therein ordinary current indicating means. The split core type transformer eliminates the necessity of opening the circuit under load or carrying load by reason of the fact that a part of the transformer core may be opened to permit the core to be carried around the cable or bus bar to have a current induced in the secondary winding that is provided about the core.

A primary purpose of the present invention is to provide a transformer structure which will have one part of the core shiftable from closed to open positions in such manner that the joints between the ends of the shiftable core and the major part of the core provide actual abutting relation between respective laminations of the core parts, thereby forming a low magnetic reluctance joint. A still further important object of the invention is to permit easy and ready opening of the transformer core by hinging the shiftable section to the relatively stationary section in such manner that the hinged portion may be shifted or opened up with a minimum frictional resistance.

The primary object, of course, above all other objects is to provide a current transformer that is extremely accurate throughout a range of primary conductor flows, and it is with this particular object in view that the combinations of elements as set forth by the appended claims have been brought together into their novel associations. Included among other objects and advantages of the invention are the combinations of elements contributing to the mechanical stability, compactness, relatively light weight, and general over-all durability.

Reference is made to the accompanying drawings, in which

Fig. 1 is a view in side elevation of a structure embodying the invention;

Fig. 2, a view in end elevation from the hinged side thereof;

Fig. 3, a view in end elevation from the opposite side;

Fig. 4, a top plan view;

Fig. 5, a view in transverse horizontal section on the line 5—5 in Fig. 1;

Fig. 6, a view in transverse vertical section on the line 6—6 in Fig. 1; and

Fig. 7, a view in perspective in disassociated relation of the core laminations.

Like characters of reference indicate like parts throughout the several views in the drawings.

A plurality of core laminations 10 are each like formed to be generally U-shape, Fig. 7, the upper ends of the vertical legs on one side terminating in square ends parallel with the lower straight under edges. The top ends of the other vertically extending legs of these laminations 10 are rounded off on their inner corners substantially as indicated in Fig. 7. A number of these laminations are laid one against the other in intimate contact to form a group, over the square end legs of which is positioned an inverted U-shape metallic shield 11 having an upper curved end 12 above those square ends and having a downturned leg extending well down on either side of that group of laminations, preferably at least to the lower cross bar of the laminations 10. The legs of this shield member 11 are preferably of the same width as that of each of the legs of the laminations 10 therebetween, and likewise the thickness of each leg of the shield 11 corresponds to that of each of the laminations 10. The terminal upper surface of the bend 12 of the shield 11 is substantially at the same elevation as the uppermost parts of the curved end legs of the laminations 10.

A second group of laminations 13 is provided wherein each of the laminations 13 is of the same general configuration as the laminations 10 with the exception that the upper ends of the legs thereof terminate in both instances by square ends, both of which are at substantially the same elevation spaced below the top curved ends of the laminations 10 a distance approximately the same as the width of the laminations 10 and 13. These groups of laminations 10 and 13 are alternately placed one against the other as shown in Fig. 7 and zones with open end slots or grooves are thereby formed across the upper ends of the laminations 13 between the respective spaced apart adjacent groups of laminations 10.

In this manner an open end transformer core is built and the various laminations in the arrangement above indicated may be temporarily tied together in that alignment in order to permit secondary windings 14 and 15, Fig. 5, to be placed about each of the upturned legs of that core. No winding is provided about the interconnecting lower bars of the laminations of the core.

To protect these two secondary windings 14 and 15 and to maintain the laminations 10 and

13 in intimate compressive contact one laterally against the other, face to face, a pair of symmetrical housing members 16 and 17 are formed, a description being made in detail of the member 17 with the understanding that the member 16 is an exact duplicate thereof.

The member 17, in the present instance, is referred to as a casting made out of preferably a light metal, such as aluminum, in order to reduce the over-all weight of the entire transformer. This member has primarily a longitudinal plate 18 arranged to extend along in intimate contact with the outer face of the uppermost laminations 10. From this plate 18, which is vertically disposed, extend outwardly horizontally therefrom respectively the top and lower flanges 19 and 20. The under flange 20 is carried around and upwardly across the ends of the plate 18 to join with the top flange 19. From the top edge of the plate 18 and extending over onto and from the top face of the flange 19 are housing sections 21 and 22, one toward each end thereof. These sections 21 and 22 are substantially U-shape in horizontal cross-section to open inwardly and have their sides extend across in close proximity to the upper portions of the respective laminations 10 and 13. The inner vertical edges of these housing sections 21 and 22 terminate, either or both short of the center of the combined thickness of the laminations 10 and 13 forming the transformer core so as to leave gaps 23, 24 between the outermost edges of the opposing legs of the housing sections presented by the member 17 and the other housing member 16, Fig. 5. Likewise air gaps 25, 26 may be left between the inner edges of the opposing legs of the housing sections of the members 16 and 17, Fig. 5, the essential requirement being that the two members 16 and 17 do not form a complete metallic or electrical conducting medium entirely around the transformer core and the secondary windings inclosed by the respective housing sections of the two housing members 16 and 17.

It is to be understood, as above indicated, that the housing member 16, being a duplicate of the member 17, is brought up against the back side of the core of the transformer. The housing sections extending upwardly have sufficient cross-sectional open area therewithin to permit the walls of those sections to be brought up into close proximity with the outer surface of the windings 14 and 15. The two members 16 and 17 are compressively urged one toward the other to grip the lower end of the transformer core below the windings 14 and 15 between the plates 18 by means of through bolts 27 and 28 passing through the members 16 and 17 immediately under the laminations, and by another pair of through bolts 29 and 30 through the same members 16 and 17, one each at the respective lower side portions of the core. By tightening nuts on these bolts snugly, the lower ends of the core laminations may be drawn tightly one against the other to hold them in fixed positions. The upper ends of the core laminations are compressively urged together by means of the through bolts 31 and 32, respectively passing through upper inner side portions of the opposing housing sections of the members 16 and 17, the upper ends of those housing sections being inturned by horizontally disposed flanges 33 and 34 respectively above the windings 14 and 15, as indicated in Fig. 6, to bear by the inner flange ends directly against the respective outer faces of the transformer core legs.

Thus by means of the lower bolts 27, 28, 29, 30 and the upper bolts 31, 32, the transformer core thus far described is firmly gripped between the housing members 16 and 17 and the housing sections thereof encircle and inclose the respective windings 14 and 15 to leave the narrow gaps 23, 24 and/or 25, 26 as the case may be. Thus far the transformer core is left with an air gap between the upper ends thereof. To complete the core to form a continuous metal magnetic circuit therearound, the following described built-up bar, generally designated by the numeral 35, is provided.

This bar 35 consists essentially of a plurality of groups of metal laminations, one group embodying like dimensioned laminations 36, square ended, with lengths equal to the distance from outside to outside of the upturned legs of the laminations 10 and 13. Each group of laminations 36 has like outer ends thereof compressibly urged one against the other by means of a U-shape member 37 extending from one leg along one side of the group and curving around the end of the laminations 36 by an outwardly bowed portion 38 and thence around by another leg along the opposite face of the laminations of that group, Fig. 7. Preferably the legs of the member in each instance extend throughout the lengths of the laminations 36 therebetween. A plurality of groups of these laminations 36 thus engaged in each instance by the members 37 are employed and are spaced one group from the other by an intervening group of shorter laminations 39.

These laminations 39 are identical in dimensions, each lamination being formed to have an arcuate end 40 and a square end 41 whereby a group of those laminations 39 may be positioned to have the arcuate ends 40 fit snugly against the upper arcuate ends of the legs of the laminations 10 on the one side and to abut the opposite upturned legs of those laminations 10 on the other side when the top edges of the laminations 39 are substantially horizontally disposed at the same elevation as that of the top ends of the respective legs of the laminations 10. These groups of laminations 39 are positioned longitudinally along the groups of laminations 36 in positions as indicated in Fig. 7, whereby the groups of laminations 39 may be positioned between the legs of the laminations 10 as just indicated when the groups of laminations 36 are inserted and pushed downwardly between the upturned ends of the laminations 10 to abut by their under edges the top ends of the laminations 13.

The various laminations 36 and 39 positioned as above described are maintained by pulling snugly up against the opposing outer sides of the entire stack of laminations clamp members 42 and 43 by means of top bolts 44, 45 and an under bolt 46, the top bolts passing over the top edges of the laminations and the under bolt 46 passing under the lower edges thereof. Nuts on these three bolts are tightened up sufficiently to clamp the pile of laminations securely against displacement between the two clamp members 42 and 43. These clamp members 42 and 43, as indicated in the drawings, are sufficiently well ribbed to prevent distortion so that there is no danger of accidental loosening of the laminations held between those members once the bolts are snugly pulled up.

These two clamp members 42, 43 thus assembled about the intervening bar laminations are hinged by a bolt 47 passing through ears provided at the upper outer corners of the housing sections 21 of the respective housing members 16, 17 and rearwardly and downwardly extending ears 48 and 49 projecting respectively from the clamp members 42, 43. It is pertinent to note that the axis of this bolt 47 is located in reference to the curvature of the ends of the legs of the laminations 10 to be slightly back of that center of curvature and within the plane of the underside of the laminations 36 and 39, and further so located that when the bar 35 is rocked to the closed operating position to have its respective tongue-like end projections interleaved between the upturned tongue-like projections of the core laminations 10, the curved ends 40 of the laminations 39 will snugly abut the curved upper ends of the laminations 10; the straight ends 41 of those laminations snugly abut the inner vertical edges of the upper ends of the laminations 10; and the under edges of the laminations 36 will be in abutment with the top ends of the laminations 13. Then upon lifting the bar 35 to swing it around into an open position, as suggested by the dash lines in Fig. 1, this swinging motion being conducted about the hinged bolt 47, the difference in locations of the hinged bolt center and the center of curvature of the legs of the laminations 10 cause the laminations in the bar 35 to lift from their respective abutting positions, as above indicated, without dragging over the abutting surfaces. In other words, those surfaces gradually separate so that the bar 35 may be readily swung to the open position and back to the closed position. The frictional resistance then is only that arising between the sides of the interleaving groups of laminations.

It is necessary to prevent completing a metallic or an electrical conducting circuit around the core through the various housing, clamp and bolt members. This is done by insulating the interconnecting bolts in such manner as to avoid the completion of this circuit. For example, all of the interconnecting bolts may have an insulating thimble 50, Fig. 3, surrounding one end of each bolt to insulatingly separate it from the engaged member, such as the clamp 42, the thimble further being provided with a flange against which the bolt engaging nut 51 may bear. Such means for interrupting the circuit through the interengaging bolts may be employed in conjunction with all of the bolts, or only those bolts appearing on one side of the core, that is, on the inside or outside. The essential thing is to prevent the completion of an electrical circuit around the core which would in effect form a single turn winding.

As a means for securing the hinged core bar 35 in closed position, a pin 52 may be inserted through upturned ears 53 and 54 provided on the upper outer corners of the respective housing sections 22 of the housing members 16, 17, Fig. 3, and through downturned ears 55 and 56 extending respectively from the clamp members 42 and 43. The pin 52 may be secured in this interengaging position by any suitable means, such as by a cotter pin 57, Fig. 1. For convenience in handling, a carry strap 58 is attached by looping ends over the bolts 30 and 47.

In order to prevent accidental shifting of the various laminations grouped to form the bar 35, when the bar is swung into the open position, stops 59 and 60 are provided on the respective outer upper end faces of the housing members 16 and 17 to form abutments against which ends of the clamp members 42 and 43 will strike upon a predetermined degree of opening of the bar. Since the members 16 and 17 are symmetrical (to avoid having to form right and left hand castings), these stops 59, 60 will appear on both ends although they are only used on that end at which the bar 35 is hinged. In this regard the hinge bolt 47 and the locking pin 52 may be interchanged so that the stops would be used on either end, depending upon the location of the hinge axis. It is to be noted that in conjunction with the use of non-magnetic material in the members 16 and 17, the clamp members 42 and 43 are also preferably made out of a non-magnetic material, such as aluminum.

Preferably an insulating terminal board or plate 61 is mounted in the nature of a cover over the chamber appearing within the boundaries of the flanges 19 and 20 above described as extending outwardly from the plate 18 across the lower portion of the transformer core. This board 61 in the present instance is held in position by means of the bolts 27, 28, 29 and 30 passing therethrough with their heads or nuts, as the case may be, bearing thereagainst from the outer face. Terminals 62 of any suitable number, herein shown as three, are carried in spaced apart relation by this board 61. The number of terminals to be carried by this board will depend upon the number of circuits to be taken from the windings 14 and 15 on the transformer core. In the present showing, Fig. 1, one lead 63 and 64 from the respective windings 14 and 15 is carried in each instance to the outer terminal 62 while the other two leads 65 and 66 are carried to the central terminal 62. These leads 63, 65 and 64, 66 are brought down from their respective windings 14 and 15 through windows 67 and 68 respectively provided through the flange 18 and extending upwardly to open within the housing sections 21 and 22. These terminals 62 are provided for suitable connection with any type of current indicating or recording device as may be desired to be employed to determine thereby the amount of current that may be flowing in a primary conductor (not shown) about which the transformer core may be closed. As a finishing means, for the sake of appearance, a board 69 similar to the board 61 is mounted across the lower chamber provided in the housing member 16, Fig. 6. Obviously the terminals 62 may be mounted on either one of these boards 61 or 69 as may be desired, or both boards may be employed as terminal panels. The board 69 is held in place by the bolts 27, 28, 29 and 30 passing therethrough the same as in the case of the board 61.

In this regard, as above indicated, the transformer is intended to be opened by swinging the bar 35 outwardly to permit bringing the transformer around the conductor, the current flow in which is to be checked, so that the bar 35 may then be closed to have the current carrying conductor extending through the opening between the legs of the transformer core and the upper bar 35 and the lower integrally connecting part of the core. It is then only necessary to connect the indicating or recording instrument to the terminals 62 to obtain a reading. The transformer may be constructed for any number of primary current ranges such, for example (without any limitation thereto), as 150–300–600 amperes. If the primary conductor is looped to

pass through the opening in the transformer twice, then the ratio of the turns of the secondary winding to those of the primary conductor or winding would be, for example, 100 to 2 instead of 100 to 1 when the primary conductor is carried straight through the transformer opening one time only. In other words, considerable range may be had with the one particular size of transformer and one particular set of secondary windings.

By reason of the employment of the housing 16 and 17, not only are the core laminations securely fixed one relative to the other, but the secondary windings and interconnecting leads are thoroughly protected from mechanical injury. Most important, however, is the arrangement of the ninety degree interleaving of groups of the core laminations in respect to the shiftable bar. By this ninety degree interconnecting arrangement, the magnetic core is tightly closed without leaving any appreciable air gaps between the groups of laminations. The rounded end U-shape laminations which confine the ends of the laminations in the various groups aid greatly in permitting the easy insertion of the corresponding ends of the tongues formed in the shiftable bar 35 between the groups of laminations 10. All of the laminations are made out of high permeability, low loss, silicon steel. The tongue-like extensions from the ends of the bar 35 and from the upper ends of the main part of the transformer core are spring-like in nature so that when the tongues, particularly at the free end of the bar, are entered between the upturned ends of the transformer core leg below, there is exerted a lateral spring tension to further aid in forming a very tight fit between those interengaging tongues. At the same time this fit while snug permits opening of the bar 35 without exerting any undue strength on the part of the operator.

Thus it is to be seen that the protection by the use of the looped, U-shape laminations 11 and 37, the various laminations 10, 13, 36 and 39 may be brought through the ninety degree joint into respective abutment without the bowed ends of those protective laminations spacing the other laminations one from the other. While the U-shape laminations 10 and 13 have been described and referred to as each being an integral member, obviously it is possible to build these elements up into the desired U-shape by stacking straight pieces or L-shapes one over the other into the resultant U-form, the important feature being that the core for one side open for closure by the laminated bar 35. Therefore it is to be understood that in employing the term "U-shape laminations" in the claims, that term is intended to include either integral laminations or laminations built up into the resultant U-shape according to practice well known to those versed in the art.

While I have herein shown and described my invention in the one precise form, it is obvious that structural changes may be employed without departing from the spirit of the invention and I therefore do not desire to be limited to that precise form beyond the limitations as may be imposed by the following claims.

I claim:

1. A split core current transformer comprising a laminated open end core built up from a plurality of alternating group of U-shape stacked laminations, both legs in one group being shorter than those of the other group, whereby tongues and grooves are presented across the ends of the core; a laminated core closure bar built up of a plurality of alternating groups of long and short laminations to form grooves across the bar ends between tongues; means for hinging said bar relative to said core to open and close the core through said bar across the ends of said core legs to have the bar at substantially ninety degrees to the core legs in the closed position and the under edges of the tongues of the bar across through the grooves interleaved between the tongues of the legs of the core, and to have the ends of the shorter bar laminations substantially in abutment with the inner edges of the tongues of said legs adjacent their ends; a winding about at least one of said core legs; core lamination position securing means comprising a pair of plates interconnected by bolts to grip lower portions of the core laminations therebetween and each having upwardly extending members to pass over said winding and around against the laminations adjacent their upper leg ends; bolts interconnecting said members; a clamp plate on each side of said core closure bar; bolts interconnecting the bar clamp plates; said hinge means interengaging with one set of said members and said bar clamp plates; said members consisting of non-magnetic, metallic housings encircling said winding, edges of housing sections about each leg being separated to leave an electrical non-conducting gap therebetween; flanges out-turned from said core lamination engaging plates forming floors across the lower ends of said housing sections and also defining a chamber; a terminal board mounted across said flanges to inclose said chamber; and terminals on said board interconnected with said winding.

2. A split core transformer comprising a laminated open end core built up from a plurality of alternating groups of U-shape stacked laminations, both legs in one group being shorter than those in the other group, whereby alternating tongues and grooves are presented across the ends of the core at its open end; a secondary winding about at least one of said legs; a laminated core closure bar built up of a plurality of alternating groups of long and short laminations to form at each end alternating tongues and grooves to match those of said core legs; hinge means forming a bar pivot axis located outside one of said legs rockably supporting said bar to permit it to swing to have both its ends interleave with the ends of said core legs; the inner upper portions of the tongues of said one core leg being curved around from the outer side of the leg and downwardly on the inner side; the ends of the shorter laminations of said bar at its hinge end being curved to fit the curvature of said leg tongues upon bar closure therewith; and the center of curvature of said leg tongue curvature being removed from said bar hinge axis; whereby said bar may be swung about its said axis to bring the respective laminations into interleaving, end to side abutting relations to complete a magnetic circuit of low reluctance.

3. A split core transformer comprising a laminated open end core built up from a plurality of alternating groups of U-shape stacked laminations, both legs in one group being shorter than those in the other group, whereby alternating tongues and grooves are presented across the ends of the core at its open end; a secondary winding about at least one of said legs; a laminated core closure bar built up of a plurality of alternating

groups of long and short laminations to form at each end alternating tongues and grooves to match those of said core legs; hinge means forming a bar pivot axis located outside one of said legs rockably supporting said bar to permit it to swing to have both its ends interleave with the ends of said core legs; the inner upper portions of the tongues of said one core leg being curved around from the outer side of the leg and downwardly on the inner side; the ends of the shorter laminations of said bar at its hinge end being curved to fit the curvature of said leg tongues upon bar closure therewith; and the center of curvature of said leg tongue curvature being removed from said bar hinge axis; whereby said bar may be swung about its said axis to bring the respective laminations into interleaving, end to side abutting relations to complete a magnetic circuit of low reluctance, the other of said core legs at the free end of said bar having the outer ends of both its short and long laminations terminating in lines at ninety degrees to the edges of the laminations.

4. A split core transformer comprising a laminated open end core built up from a plurality of alternating groups of U-shape stacked laminations, both legs in one group being shorter than those in the other group, whereby alternating tongues and grooves are presented across the ends of the core at its open end; a secondary winding about at least one of said legs; a laminated core closure bar built up of a plurality of alternating groups of long and short laminations to form at each end alternating tongues and grooves to match those of said core legs; hinge means forming a bar pivot axis located outside one of said legs rockably supporting said bar to permit it to swing to have both its ends interleave with the ends of said core legs; the inner upper portions of the tongues of said one core leg being curved around from the outer side of the leg and downwardly on the inner side; the ends of the shorter laminations of said bar at its hinge end being curved to fit the curvature of said leg tongues upon bar closure therewith; and the center of curvature of said leg tongue curvature being removed from said bar hinge axis; whereby said bar may be swung about its said axis to bring the respective laminations into interleaving, end to side abutting relations to complete a magnetic circuit of low reluctance; the laminations in each of said bar tongues at the outer free end of the bar being compressively held together by a U-shape clip having legs extending along the sides of the outer laminations of the groups forming said tongues, the clip legs being joined by an outwardly bowed section; and a corresponding clip likewise engaging the laminations of the tongues of the corresponding end of the core.

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