Dec. 7, 1943. C. P. BOUCHER 2,335,910

TRANSFORMER APPARATUS

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FIG. 1.

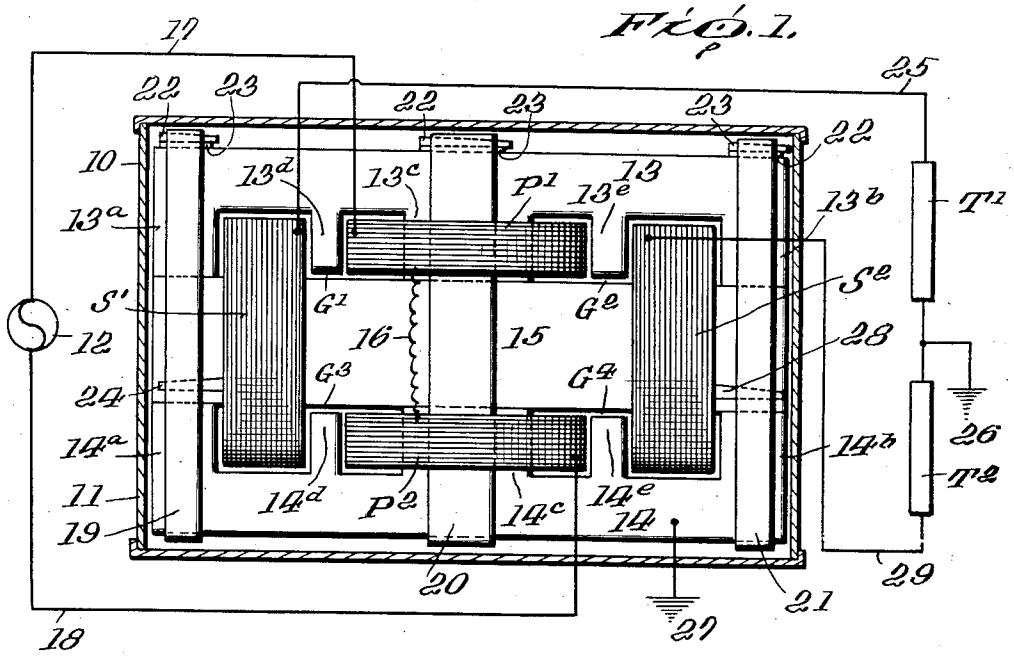
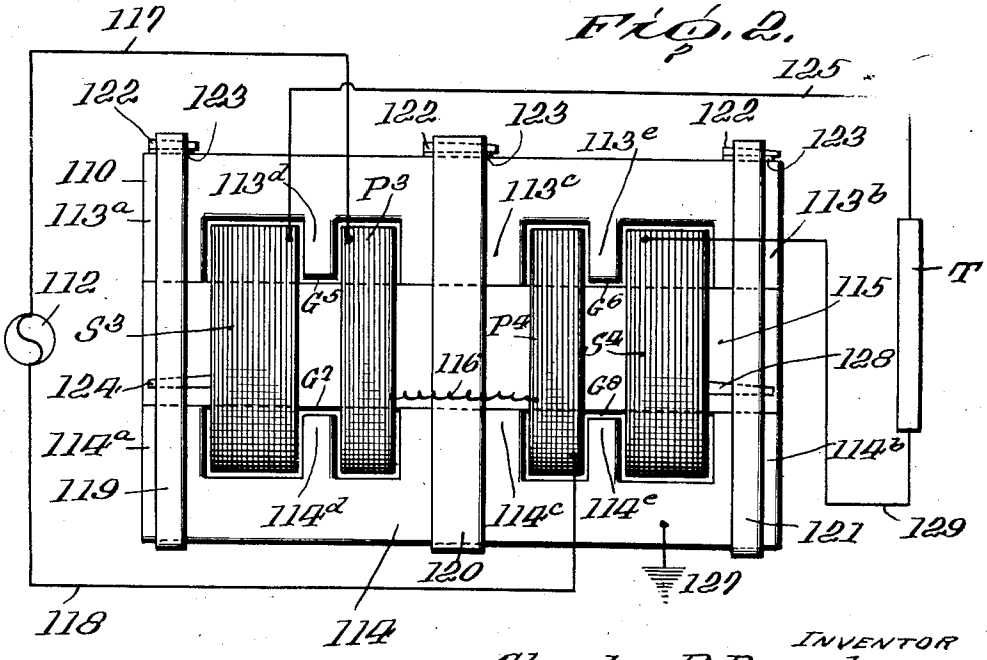


FIG. 2.



INVENTOR
Charles P. Boucher

By John Howard Joynt
HIS ATTORNEY

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TRANSFORMER APPARATUS

Charles Philippe Boucher, Paterson, N. J., assignor to Boucher Inventions, Ltd., Washington, D. C., a corporation of Delaware

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11 Claims. (Cl. 171—119)

This invention relates to electrical transformer apparatus, and more particularly to electrical transformer apparatus for supplying one or more negative loads, as, for example, in the operation of a luminescent tube system.

One of the objects of my invention is to provide simple, practical and thoroughly reliable transformer apparatus which is exceedingly compact, inexpensive and highly efficient in operation.

Another object is to provide a transformer apparatus which is adapted to withstand the varying conditions encountered in actual use, including short-circuiting and grounding of the whole or parts of the apparatus, without damage to the apparatus and the consequent necessity for shutdown and replacement or repairs.

A further object is the provision of a transformer apparatus in which there is a minimum of flux leakage to the casing, resulting in efficient operation and substantially no objectionable vibration of the casing.

Other objects will be obvious in part and in part pointed out hereinafter.

The invention accordingly consists in the combination of elements, features of construction, and arrangement of parts, and in the several operational steps, and in the relation of each of the same to one or more of the others, all as described herein, the scope of the application of which is indicated in the appended claims.

In the accompanying drawing:

Figure 1 is a diagrammatic representation of a transformer embodying the various features of my invention, the transformer being enclosed in a casing and energizing two luminescent tubes.

Figure 2 represents a similar transformer in which the primary coil sections are in different positions from those shown in Figure 1 and in which the load is a single luminescent tube.

Like reference characters denote like parts in the two views of the drawing.

As conducive to a clearer understanding of certain features of my invention, it may be noted at this point that in the operation of a luminescent sign or display employing one or more luminescent gas filled tubes of desired size and configuration, high potential electrical energy is required. The Fire Underwriters do not approve a circuit in which the maximum voltage to ground substantially exceeds seven thousand five hundred volts. Where it is desired to use a tube requiring a higher operating potential, for example fifteen thousand volts, the energy has in some instances been supplied by two separate transformers for each tube, the transformers being connected in series and each having an output voltage of about seven thousand five hundred volts. Such an installation is expensive both because of the amount of equipment involved and because a separate labor charge is made for each unit installed. Moreover, a large space is required to accommodate such equipment.

In the manufacture of heretofore-known transformers having core parts of various sizes and configurations, a corresponding number of dies of different sizes have been required for the manufacture of the various core members. These dies are very expensive and add considerably to the cost of manufacture of the transformers, particularly because a separate set of dies is required for each transformer of different capacity.

In certain heretofore known and used transformers, an excess of weight and space has been made necessary by core designs in which the iron has not been distributed with maximum efficiency, that is, with the proper cross-sectional area in each portion of the core to accommodate the flux coursing through that portion, and with no greater area than that. Thus, in some transformers, the core has been shaped so that in some portions the core area is so small that the flux density has been too great and in other portions the flux density is less than that which the iron will accommodate. Such designs require the whole core to be enlarged to make large enough the portions where the flux density is greatest, thereby increasing the weight of the core and the space it occupies. The only alternative in those designs is to have a core which is inefficient because certain portions are too small to accommodate the flux which should normally course through them and which therefore seeks other paths.

Where a core type of transformer is used the coils are mounted so that parts of them extend beyond the confines of the core. This structure has the disadvantage that a substantial portion of the magnetic flux flows into the casing instead of confining itself to the core, with a consequent loss in efficiency. Moreover, there is much waste space in the casing so that a large amount of insulating compound is required to fill the casing. This insulating compound is expensive and adds to the cost of the transformer.

The shell type of transformer, on the other hand, has some or all of its coil sections mounted entirely within the confines of the core so that there is less waste space than in the core type.

In the ordinary shell type of transformer, however, there is danger that one of the coils will become short-circuited or grounded and will be destroyed by the excess current which results. Such short-circuiting may be caused by moist atmospheric conditions or by shock and vibration to which the transformer may be subjected. The excess current which flows under short-circuit conditions causes heating of the coils and their insulation to such a degree that the insulation becomes charred and burned, rendering them useless so that the transformer must be shut down for replacement or repair. While some heretofore known and used transformers have provided magnetic shunts to limit the current in a whole circuit, these designs do not provide individual protection for each coil section. Accordingly, the coil sections must be designed to carry a heavy current and therefore must be larger, heavier and more expensive.

Another object of my invention, therefore, is to provide a transformer apparatus which is inexpensive in construction, employing windings of minimum necessary current-carrying capacity and of minimum cost, and yet which is of such construction as to reliably withstand the many varying conditions encountered in actual practical use by virtue of the individual protection provided for each secondary winding coil section.

Referring now more particularly to the practice of my invention, attention is invited to Figure 1 of the drawing in which I have shown a transformer, generally indicated by the numeral 10, enclosed in a casing 11, a source of single phase alternating-current electrical energy 12, and two luminescent tubes T1 and T2 energized by the transformer. The transformer 10 comprises a core, a primary winding and a secondary winding. The core is preferably made of laminated magnetic steel and comprises two outer longitudinal bars 13 and 14 and an inner longitudinal member 15. The member 13 has lateral extensions 13a and 13b at its ends and an extension 13c at its center which extend into abutting relationship with opposite end and center portions of the member 15. Likewise the member 14 has lateral extensions 14a, 14b and 14c which abut the ends and center of member 15. Member 13 also has lateral arms 13d and 13e which extend closely toward but do not abut the bar 15 at points intermediate its ends, forming therewith air-gaps G1 and G2 of high magnetic reluctance. Similarly, member 14 has lateral arms 14d and 14e which form air-gaps G3 and G4 with portions of the bar 15 intermediate its ends. The arms 13d, 13e, 14d and 14e are all preferably of the same cross-sectional area and therefore of the same reluctance. Also, the air-gaps G1, G2, G3 and G4 are preferably of the same width and reluctance. The member 15 and the extensions 13c and 14c of the member 13 and 14 preferably have the same cross-sectional area, which is double that of the main portions of the members 13 and 14 and of their extensions 13a, 13b, 14a and 14b. The cross-sectional areas are so proportioned because the number of lines of force normally coursing through the member 15 and extensions 13c and 14c is twice as great as the number of lines normally coursing through the main portions of members 13 and 14 and through their extensions 13a, 13b, 14a and 14b. The cross-sectional area of the shunt arms 13d, 13e, 14d and 14e may be less than that of the extensions 13a, 13b, 14a and 14b in order that the reluctances of the shunt magnetic paths may be considerably higher than the reluctances of the main magnetic paths.

One primary winding coil section P1 is mounted on the extension 13c and another coil P2 is mounted on the extension 14c. These coil sections are connected in series by the lead 16 or in parallel. Where the coils are of fine wire and high resistance they are connected in parallel. Where they are of heavy wire and low resistance they are connected in series. The connections are made in such a manner that both coils generate magnetic flux flowing from the bar 15 into the members 13 and 14, or in the reverse direction, at the same instant. The primary winding is energized through the leads 17 and 18 from the source 12, which may be the standard single-phase, 60-cycle commercial mains or any other suitable source of alternating current energy.

One secondary winding coil section S1 is mounted on the member 15 near its left end in the space between the members 13 and 14 and between the extensions 13a and 14a and the shunt arms 13d and 14d, respectively. Similarly, another secondary coil section S2 is mounted on the member 15 near its right end in the space between the members 13 and 14 and between the extensions 13b and 14b and the shunt arms 13e and 14e, respectively.

After the primary and secondary winding coil sections have been mounted in their proper positions on the core, steel core bands 19, 20 and 21 are put into the positions indicated for holding the core parts in close contact. The core members 13, 14 and 15 are then forced together under heavy pressure, as by an arbor press, and wedges 22 are inserted under the bands to hold them taut, the wedges 22 being insulated from the core members by pads 23.

The coil S1 is grounded to the core by a metal strip 24 connected to one terminal of the coil and held in contact with the core under the band 19. The other terminal of the coil S1 is connected by a lead 25 to one terminal of the tube T1, whose other terminal is grounded at 26 to complete the circuit. The core itself is grounded as at 27. Similarly, the coil S2 is grounded to the core by a metal strip 28 held under the band 21 and is connected from its other terminal to one terminal of the tube T2 by a lead 29. The tube T2 is also grounded at 26. Because of the ground connections two complete circuits are formed. One circuit includes the coil S1 and tube T1. The other circuit includes coil S2 and tube T2. The coils S1 and S2 can therefore be connected in their circuits either in a series or an opposition arrangement. In other words, it is feasible to have the ungrounded terminals of the coils S1 and S2, to which the leads 25 and 29, respectively, are connected, either at opposite potentials or at the same potential at any given instant. The arrangement in which the two terminals are always at approximately the same potential is preferable where the tubes T1 and T2 are mounted in parallel relationship with their sides close together. Adjacent portions of the respective tubes with such a connection will always be at substantially the same potential and therefore there will be no tube-puncturing dielectric discharge.

In the operation of this transformer, as the voltage impressed across the primary winding coil sections by the source 12 rises in one direction from a zero value, a current begins to flow through the primary winding. This current generates a magnetomotive force which causes a

magnetic flux to flow through the core as indicated by the arrows for one half cycle of the applied electromotive force. The path for the flux interlinking the secondary winding coil S1 and the primary winding is in two parts. One part is from the extension 13c through the left half of the member 15, extension 13a and the left half of the member 13, then back to the extension 13c. This part includes and interlinks the primary coil section P1 with the secondary coil S1. The other part is from the extension 14c through the left half of member 15, extension 14a, and the left half of member 14 back into extension 14c, including and interlinking the primary coil P2 with the coil S1. Similarly, the flux linking the coil S2 is in two parts. One part passes from extension 13c into the right half of member 15, then through extension 13b and the right half of member 13 back into extension 13c. This part interlinks the coil S2 with the primary coil P1. The other part courses from extension 14c into the right half of member 15, then through extension 14b and the right half of member 14 back into extension 14c, interlinking the coil S2 with the primary coil P2. It will be understood that during the other half cycle the flux will course in a direction opposite to that outlined above and shown by the arrows.

The magnetic flux links the secondary winding coil sections S1 and S2 and as it changes in magnitude induces an electromotive force in those coils. When the potential across the terminals of one coil, say the coil S1, and also across the terminals of the luminescent tube T1 through the lead 25 and the ground connections, reaches a value sufficiently high to ionize and render conductive the gas in the tube T1, a current flows in the circuit comprising that tube and its coil section. This current renders the tube T1 luminous. When the gas in the tube strikes or becomes ionized the resistance of the tube becomes very low. The current flowing through the circuit would therefore reach a high value were it not for the peculiar magnetic shunt construction provided. The current flowing through the coil S1 creates a back magnetomotive force which opposes the coursing of the main flux through that part of the core on which the coil is mounted. When the back magnetomotive force reaches such a value that the reluctance of the path through the left-hand end of the member 15 is greater than than of the right-hand end of the member 15 or of the magnetic shunt paths, the greater portion of the main flux seeks a path of less reluctance through one of those paths. Thus if the tube T1 has struck before the tube T2, the path of least reluctance for the flux which would ordinarily pass through the left-hand end of the member 15 is through the right-hand end of that member, augmenting the flux normally coursing therethrough and linking the coil S2. Since the flux linking the coil S2 is greater in amount at this time, the potential induced in coil S2 will be increased and therefore the tube T2 will in normal operation become lighted very soon after the tube T1. A similar condition of operation is met when it is the tube T2 which strikes first. In that case, however, the main portion of the flux normally linking the coil S2 will be diverted to link the coil S1 until tube T1 strikes. Where the tubes become ionized and conductive at substantially the same instant, as is the case in this condition of operation, there is little potential difference between adjacent portions of the respective tubes when they are mounted closely together. As a result, no dielectric discharge will take place between the tubes.

When both tubes have become operative, the coil S2 as well as the coil S1 generates a countermagnetomotive force which opposes the coursing of the main flux. That flux which links the coil S1 until it becomes ionized will thereafter seek a path of less reluctance. Thus the major portion of the flux courses in two parts through the air-gaps and shunt arms. One part is from the extension 13c into the member 15, then across air-gap G1 into shunt arm 13d and through the member 13 back to extension 13c. The other part of the shunt path is from member 14c into member 15 and across air-gap G2 into shunt arm 14d, then through member 14 back into extension 14c. It will, of course, be understood that the major portion of the main flux will traverse the same path as that outlined above but in the opposite direction when the electromotive force applied across the terminals of the primary winding is in the other half cycle. By virtue of the magnetic shunt construction, the current in the coil S1 is limited to a safe value, so that there is no danger of the coil's becoming overheated and its insulation becoming charred. Enough current continues to flow through the coil S1 and its load, tube T1, to maintain the tube in a luminous condition until the electromotive force applied across the primary winding decreases almost to zero in following through the cycle of alternation. The tube T1 then becomes extinguished and remains so until the electromotive force across the primary winding reaches a value in the opposite direction such that a voltage is again induced in the coil S1 which is sufficient to ionize the gas in the tube T1 and again render it conductive and luminous.

Similarly, when the voltage induced in the coil S2 is high enough to render ionized and conductive the gas in the tube T2, current flows through the circuit including the coil S2 and tube T2. That current will not exceed a safe value because the countermagnetomotive force developed by the coil S2 will cause the major portion of the flux to pass either through the left-hand end of the bar 15 when the tube T1 has not yet become operative or, when it has, through the shunt paths which include the air-gap G2 and shunt arm 13e, on the one hand, and air-gap G4 and shunt arm 14e, on the other hand. Enough flux continues to link the coil S2 to maintain a flow of current through the tube T2 until the potential applied across the terminals of the primary winding approaches a zero value in following through the cycle of alternation. Where a 60-cycle source of electromotive force is used, the tubes become luminous 120 times per second. Due to persistence of vision, they appear to emit a steady glow.

Should the tube T1 become grounded in operation, as by the formation of a conductive film of moisture, dirt and the like between its electrodes or between the high potential electrode and the ground, the flow of current in the circuit will not substantially exceed that which flows during normal operation of the tube. This is due to the peculiar magnetic shunt construction which provides protection from the flow of excessive current to each individual coil in the same manner as the coil is protected during normal operation. The same protection will be afforded where it is the coil S1 itself, instead of the tube T1, which becomes grounded. As current begins to flow in

the coil S1, a countermagnetomotive force is developed by that coil which causes the major portion of the main flux to seek a path of less reluctance. That path will be through the right-hand end of bar 15 linking the coil S2 when that coil has no current flowing through it. When current is flowing through coil S2, as, for example, when tube T2 is operating, the flux follows two shunt paths. One shunt path is from extension 13c through member 15, air-gap G1, shunt arm 13d and member 13 back to extension 13c. The other shunt path is from extension 14c through member 15, air-gap G3, shunt arm 14d and member 14 back to extension 14c. Due to diversion of the major portion of the magnetic flux from the coil S1 the current flowing through that coil under short circuit conditions will be limited to a safe value so that the coil will not become overheated with consequent charring of its insulation. Similarly, where the coil S2 or its tube T2 becomes grounded, the current flowing through coil S2 will be limited to a safe value by virtue of the diversion of the major portion of the magnetic flux from the coil S2 through the part of the core linking the coil S1 or through two magnetic shunt paths. The shunt paths in this instance are those through the air-gap G2 and shunt arm 13e and through air-gap G4 and shunt arm 14e. Where such individual protection is not provided for the secondary coils, as in the ordinary transformer, those coils must be made of large diameter wire to withstand the heavy short circuit current. Due to the magnetic shunt construction in my transformer the coils can be made of fine wire, which has the advantages of being cheaper and lighter in weight.

Where one coil, say the coil S1, becomes open-circuited, as by breaking of the tube T1 or of one of the leads, no current will flow in that coil. Hence no countermagnetomotive force will be generated by coil S1 and the core path linking it will be of very low reluctance. Therefore, the flux linking coil S2 will be diminished in amount since it will follow the path of least reluctance through the left-hand end of bar 15. The voltage generated in coil S2 will not be sufficient to ionize the gas in tube T2 and no current will flow in the coil S2. It will thus be apparent that both coils are fully protected. Similarly, when the coil S2 is open-circuited, neither it nor the coil S1 will be damaged.

It will be understood that, where desired, the tubes T1 and T2 may be of different resistances. For example, the tube T1 may be of higher resistance than tube T2. In that event the shunt paths through air gap G1 and shunt arm 13d and through air-gap G3 and shunt arm 14d must be designed so as to have comparatively high reluctances. At the same time, the shunt paths through air-gap G2 and shunt arm 13e and through air-gap G4 and shunt arm 14e should be of somewhat lower reluctances.

Considering now another embodiment of my invention, attention is invited to Figure 2, in which I have shown a transformer 110 energizing a single tube T and comprising a core, a primary winding and a secondary winding. The transformer may be enclosed in a casing similar to the one shown in Figure 1. The core comprises three members 113, 114 and 115, which are preferably made of laminated magnetic steel. The members 113 and 114 have lateral extensions 113a, 113b, 114a and 114b at their ends and extensions 113c and 114c at their centers, all of which extensions are turned toward the inner member 115 against which they are forced under pressure and held in firmly abutting relationship by core bands 119, 120, and 121 which are slipped over the parts. Wedges 122, insulated from the core by pads 123, are placed under the core bands to hold them tight. The member 113 has shunt arms 113d and 113e which form air-gaps G5 and G6 with the member 115. Member 114 also has shunt arms 114d and 114e which form air-gaps G7 and G8 with the member 115. Since the amount of flux normally coursing through member 115 and extensions 113c and 114c is twice as great as that normally coursing through the main portions of members 113 and 114 and the extensions 113a, 114a, 113b and 114b, the former parts have cross-sectional areas twice as great as the areas of the latter parts. The shunt arms 113d, 113e, 114d and 114e preferably have smaller cross-sectional areas than any other parts.

The primary winding comprises two coil sections P3 and P4 which are mounted on the member 115 on opposite sides of the extensions 113c and 114c in the spaces between those extensions and the shunt arms 113d and 114d for the coil P3 and the shunt arms 113e and 114e for the coil P4. The coils P3 and P4 are connected in series by the lead 116 or they may be connected in parallel. They are energized through the leads 117 and 118 from the source 112 of alternating current electrical energy. It is not necessary in this transformer that the primary coils be connected in any particular manner. The transformer will operate satisfactorily whether the coils P3 and P4 generate flux which courses in the same direction through the member 115 at any given instant or which courses in opposite directions.

The secondary winding comprises coil sections S3 and S4 which are mounted on the central member 115 and occupy respectively the spaces between shunt arms 113d, 114d and extensions 113a, 114a and 113b, 114b. The coil S3 is grounded to the core at 124 and its other terminal is connected by lead 125 to one terminal of the tube T. Coil S4 is likewise grounded to the core at 128 and its other terminal is connected to the other terminal of tube T by a lead 129. The grounding connections must be such as to place the coils S3 and S4 in series. That is, when the potential of the lead 125 is at a maximum value in a positive direction, the lead 129 must be at a maximum negative potential. The voltage across the tube T then is the sum of the voltages of the two coils and yet the maximum voltage to ground at no point exceeds the voltage across any one coil section. The core may be grounded as at 127.

In the operation of this transformer, as the electromotive force impressed by the source 112 across the terminals of the primary winding rises from a zero value a current flows through the primary winding and generates a magnetomotive force which causes flux to flow in the core. The flux generated by each primary coil follows two parallel paths. With the connections shown, the flux generated by coil P3 during one half cycle of the applied electromotive force courses to the right in the left-hand end of member 115, then in two paths through extensions 113c and 114c into the left-hand ends of members 113 and 114, returning to member 115 through extensions 113a and 114a. Similarly the flux generated by coil P4 during the same half cycle courses to the left in the right-hand end of member 115, then in two paths through extensions 113c and 114c, the

right-hand ends of members 113 and 114 and through extensions 113b and 114b back into member 115. These paths are indicated in the figure by arrows. The flux links the secondary winding coils S3 and S4 and induces in them an electromotive force. When the electromotive force across the outer terminals of the secondary coils and across the terminals of the tube T reaches a value high enough to render the gas in the tube ionized and conductive, a current flows through the tube and through the secondary winding coil sections. As in the transformer of Figure 1, this current does not reach an unsafe value because of the magnetic shunt construction provided. The current flowing through the secondary coils creates a back magnetomotive force which opposes the coursing of the main flux and causes it to seek a path of less reluctance through the magnetic shunt paths provided, thereby reducing the amount of flux which interlinks the primary and secondary windings and thus reducing the voltage and current in the secondary circuit. Thus the major portion of the flux normally linking the coil S3 is diverted around that coil, following two paths from member 115 into extensions 113c and 114c, members 113 and 114, shunt arms 113d and 114d, across air-gaps G5 and G7 and back to member 115. Similarly the major portion of the flux normally linking the coil S4 is diverted around that coil, following two paths from member 115 into extensions 113c and 114c, members 113 and 114, shunt arms 113e and 114e, across air-gap G6 and G8, and back to member 115. Enough flux continues to link the coils S3 and S4, however, to maintain a steady flow of current through the tube T. By this shunting of the major portion of the magnetic flux, the current in the secondary winding is limited to a safe value. Moreover, should either one of the coils become grounded in use, the flux is diverted around that coil through the shunt paths indicated above for normal operation and damage to the coil is prevented. The full main flux continues to link the other coil but since the voltage across that coil is insufficient to ionize the gas in the tube, no current flows in that coil. It will be understood that for the other half cycle of electromotive force applied across the terminals of the primary winding the flux will follow the paths outlined above but will be coursing in the opposite direction.

It will be seen that I have provided a transformer which is economical in construction and installation and which is highly efficient and safe in operation. In both the embodiments I have shown there are only two different shapes of core members. The outer core members have exactly the same configuration. Therefore, only two dies are needed for the manufacture of the core parts. This results in a saving in manufacturing cost. Moreover, the cores are efficiently designed so that the flux is distributed symmetrically and with more or less uniform density. Accordingly, there is no waste iron in the core and it is of minimum weight. Moreover, the heat developed in the transformer is distributed evenly and dissipated efficiently.

My transformer is compact in construction. All the coil sections are contained wholly within the core so that a minimum of flux is lost by fringing to the casing. Moreover, the shunt paths are all within the outer confines of the core. The casing in which the transformer is enclosed therefore does not affcet the reluctances of these shunt paths and is made to fit my transformer closely. Thus there is no waste space in the casing. A minimum of insulating compound is required to fill the interstices in the transformer and the space between it and the casing. The casing itself, being of minimum size, is cheap and light in weight and occupies a minimum of space in installation.

The embodiment of my invention shown in Figure 1 does the work of two transformers and therefore effects further savings in first cost and in operation. Less space is required for installation of this transformer than is required for the installation of two transformers to do the same work. Negative loads of either equal or unequal resistances may be energized from that transformer. Due to the fact that one side of the circuit is through the ground, expensive high potential cables and bushings need be used only on the other side. Where the connections are such that the high potential sides are always at the same potential, a single multi-conductor cable can be used to accommodate both high potential leads and thus effect a further economy.

As many possible embodiments may be made of my invention and as many changes may be made in the embodiments hereinbefore set forth, it will be understood that all matter described herein, or shown in the accompanying drawing, is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In electrical transformer apparatus of the character described, in combination, a central linear core member, two parallel core members disposed on opposite sides of said central member, each of said parallel members having one central and two end extensions abutting said central member and also having two shunt arms intermediate said central and end extensions forming air-gaps with said central member; a primary winding comprising two coil sections mounted on said central extensions of said parallel members and connected in bucking relationship; and a secondary winding comprising two coil sections each mounted on said central member near one of its ends.

2. In electrical transformer apparatus of the character described, in combination, a central linear core member, two parallel core members disposed on opposite sides of said central member, each of said parallel members having one central and two end extensions abutting said central member and also having two shunt arms intermediate said central and end extensions forming air-gaps with said central member; a primary winding comprising two coil sections mounted on said central extensions and connected in bucking relationship; and two secondary windings mounted on said central member near its opposite ends.

3. In electrical transformer apparatus of the character described, in combination, a central linear core member, two parallel core members disposed on opposite sides of said central member, said parallel members having a central and two end extensions abutting said central member and also having two shunt arms intermediate said central and end extensions, forming air-gaps with said central member; a primary winding comprising two coil sections mounted on the central part of the core and connected in bucking relationship; and a secondary winding comprising two coil sections mounted on said central member near its respective ends but inside the end extensions of said parallel members.

4. In electrical transformer apparatus of the character described, in combination, a central linear core member, two parallel core members disposed on opposite sides of said central member, said parallel members having long transverse arms at their centers and ends extending into abutting relationship with said central member and also having short transverse arms intermediate said long arms separated from said central member by air-gaps and forming shunt paths; a primary winding comprising two coil sections mounted on said long central arms and connected in bucking relationship; and a secondary winding comprising two coil sections mounted on said central member between said long end arms and said short arms of said parallel members.

5. In electrical transformer apparatus of the character described, in combination, a central linear core member, two parallel core members disposed on opposite sides of said central member, said parallel members having long transverse arms at their centers and ends extending into abutting relationship with said central member and also having short transverse arms intermediate said long arms separated from said central member by air-gaps and forming shunt paths; a primary winding comprising two coil sections mounted on said long central arms and connected in bucking relationship; and two secondary windings mounted on said central member between said long end arms and said short arms of said parallel members.

6. In electrical transformer apparatus of the character described, in combination, a central linear core member, two parallel core members disposed on opposite sides of said central member, each of said parallel members having one central and two end extensions abutting said central member and also having two shunt arms intermediate said central and end extensions forming air-gaps with said central member; a primary winding comprising two coil sections mounted on said central extensions of said parallel members and connected in parallel-bucking relationship; and a secondary winding comprising two coil sections each mounted on said central member near one of its ends.

7. In electrical transformer apparatus of the character described, in combination, a central linear core member, two parallel core members disposed on opposite sides of said central member, each of said parallel members having one central and two end extensions abutting said central member and also having two shunt arms intermediate said central and end extensions forming air-gaps with said central member; a primary winding comprising two coil sections mounted on said central extensions of said parallel members and connected in series-bucking relationship; and a secondary winding comprising two coil sections each mounted on said central member near one of its ends.

8. In electrical transformer apparatus of the character described, in combination, a central linear core member, two parallel core members disposed on opposite sides of said central member, said parallel members having long transverse arms at their centers and ends extending into abutting relationship with said central member and also having short transverse arms intermediate said long arms separated from said central member by air-gaps and forming shunt paths; a primary winding comprising two coil sections mounted on said long central arms and connected in parallel-bucking relationship; and a secondary winding comprising two coil sections mounted on said central member between said long end arms and said short arms of said parallel members.

9. In electrical transformer apparatus of the character described, in combination, a central linear core member, two parallel core members disposed on opposite sides of said central member, said parallel members having long transverse arms at their centers and ends extending into abutting relationship with said central member and also having short transverse arms intermediate said long arms separated from said central member by air-gaps and forming shunt paths; a primary winding comprising two coil sections mounted on said long central arms and connected in series-bucking relationship; and a secondary winding comprising two coil sections mounted on said central member between said long end arms and said short arms of said parallel members.

10. In electrical transformer apparatus of the character described, in combination, a central linear core member, two parallel core members disposed on opposite sides of said central member, said parallel members having a central and two end extensions abutting said central member and also having two shunt arms intermediate said central and end extensions, forming air-gaps with said central member, a primary winding comprising two coil sections mounted on the core near the center of said central member and connected in bucking relationship; and a secondary winding comprising two coil sections mounted on opposite ends of said central member but inside the end extensions of said parallel members.

11. In electrical transformer apparatus of the character described, in combination, a central linear core member, two parallel core members disposed on opposite sides of said central member, said parallel members having a central and two end extensions abutting said central member and also two shunt arms intermediate said central and end extensions, forming air-gaps with said central member, a primary winding comprising two coil sections mounted on the core between said shunt arms and connected in bucking relationship; and a secondary winding comprising two coil sections mounted on opposite ends of said central member but inside the end extensions of said parallel members.

CHARLES PHILIPPE BOUCHER.