July 6, 1943. C. P. BOUCHER 2,323,703

TRANSFORMER

Filed Jan. 2, 1941

FIG. 1.

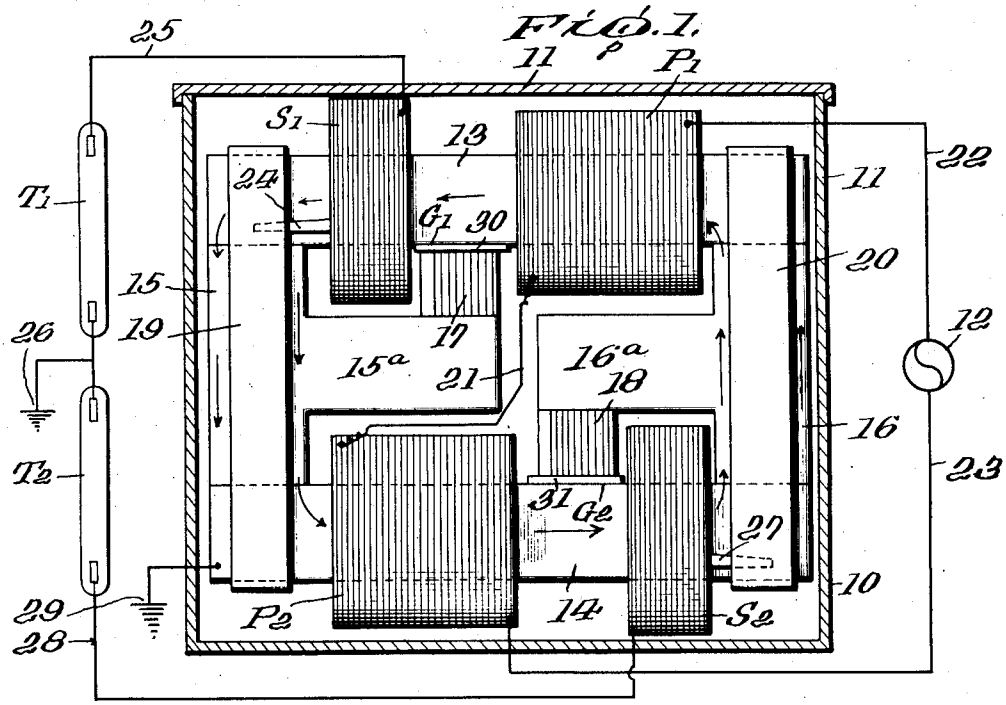
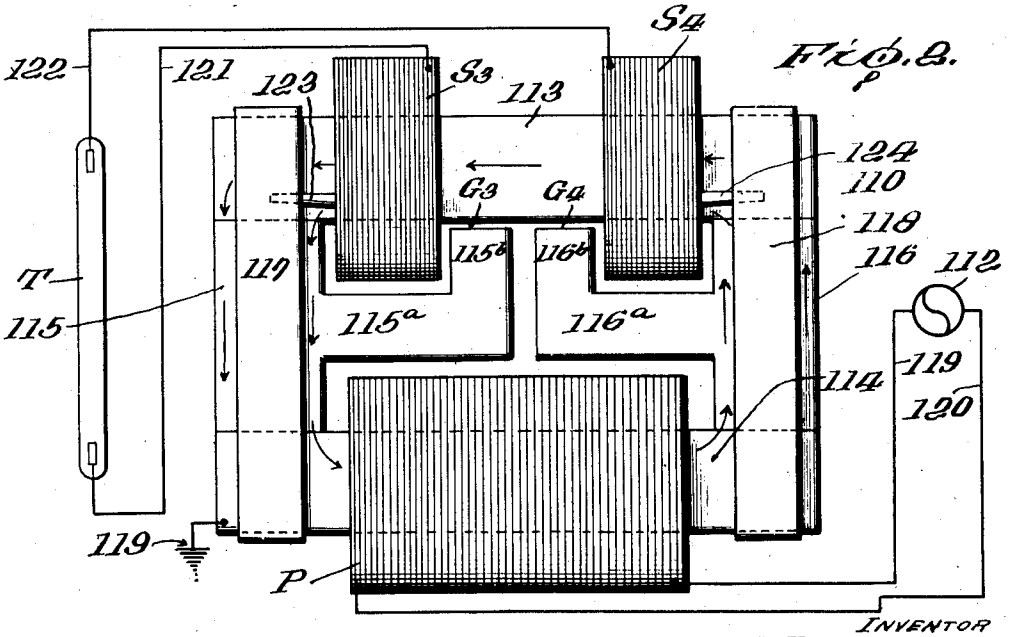


FIG. 2.



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TRANSFORMER

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6 Claims. (Cl. 171—119)

This invention relates to electrical transformer apparatus, and more particularly to transformer apparatus for energizing a negative load, such as one or more luminescent tubes.

One of the objects of my invention is to provide simple, practical and thoroughly reliable transformer apparatus for the operation of a maximum length of luminescent tubing with a minimum expense of transformer investment and installation charge.

Another object is the provision of compact, inexpensive and highly efficient transformer apparatus of the character indicated which is peculiarly adapted to withstand the varying conditions encountered in actual practical use, including short-circuiting and grounding of the whole or the parts of the apparatus, without damage to the apparatus and the consequent necessity for shut-down and replacement or repairs.

A further object is the provision of a transformer apparatus of the character described which lends itself to rapid, efficient and economical production employing a minimum of different parts and requiring a minimum of skill in construction, intallation and repair.

Another object is to provide a transformer system in which negative loads of either equal or unequal resistances may be operated from the same transformer.

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, the useful application of which is indicated in the following claims.

In the accompanying drawing,

Figure 1 is a diagrammatic representation of my transformer apparatus as employed in the operation of two luminescent tubes, and

Figure 2 is a diagrammatic representation of a modified form of my transformer apparatus as employed in the operation of a single luminescent tube.

As conducive to a clearer understanding of certain features of my invetion, 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 an installation in which the maximum voltage to ground at any point substantially exceeds 7,500 volts.

Ordinarily, the desired high potential electrical energy is supplied by alternating-current transformer apparatus connected to a standard single phase, 60 cycle source at either 110 volts or 220 volts. The high potential electrical energy has ordinarily been supplied to the tubes by two separate transformers for each tube, the transformers being connected in series and each having an output voltage of about 7,500 volts. In the operation of a single sign or luminous display, it frequently is necessary to use a plurality of luminescent tubes and energize these tubes by a way of plurality of transformers, two transformers for each tube, in order that the energizing potentials may not reach values to ground in excess of that specified by the Underwriters. Such an installation is expensive, both because of the amount of equipment involved and of the separate labor charge which is made for each unit installed. Moreover, a large space is required to accommodate such equipment.

In certain heretofore known and used transformers, these objects are alleviated somewhat by constructing the secondary winding of the transformer in two coil sections connected together, each wound to give a maximum potential of about 7,500 volts and grounding the inner connection between coil sections. In this manner, the potential across the terminals of a tube may amount to 15,000 volts, for example, while the potential to ground never substantially exceeds 7,500 volts.

In the ordinary type of transformer, 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 insects packing themselves in around a tube terminal and becoming charred by the heat, or by breakage due to high winds or the shock and vibrations 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, rendering the coils 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 ordinarily do not provide individual protection for each coil section unless at sacrifice of simplicity, compactness, efficiency and cost. Accordingly, the coil sections frequently are designed to carry a heavy current, and, therefore, are larger, heavier and more expensive.

An object of my invention, therefore, is to pro-

vide 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 such as the individually short-circuiting of a secondary winding coil section.

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.

Another object of my invention, therefore, is the provision of a single, compact and efficient transformer, employing a minimum number of different parts and requiring a minimum investment of tools and equipment for its production, and affording speed and simplicity in assembly and construction.

Referring now more particularly to the practice of my invention, attention is directed to Figure 1 of the drawing, in which I have shown a transformer generally indicated by the numeral 10, enclosed in a casing 11, and supplied by a source of single phase alternating-current electrical energy 12. Two luminescent tubes T_1 and T_2 are 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 longitudinal linear members 13 and 14 between which are interposed the F-shaped members 15 and 16 with their stems extending inwardly, and shunt pieces 17 and 18. It will be seen that these core members and associated shunt pieces form C-shaped magnetic paths around the secondary coils.

The core members after assembly are pressed together in an arbor press or other suitable equipment to secure a firm magnetic joint of low reluctance between the members. The core members then are held in that relationship by steel core bands 19 and 20. It is to be noted that shunt pieces 17 and 18 are wedged in between the respective stem portions 15*a* and 16*a* of the T-shaped members and the adjacent linear bar members 13 and 14. The desired spacing for the respective air-gaps G_1 and G_2 is had through suitable insulation, such as fibre generally indicated at 30 and 31.

The shunt pieces may be composed of several laminations placed perpendicularly to the laminations of the main core members. This construction conveniently permits accurate adjustment of the shunt path reluctance by adding or taking away laminations as may be necessary to achieve the desired reluctance of the shunt path. Where desired, it will be understood, the shunt pieces may be formed of laminations which are parallel to the laminations of the main core members.

The primary winding of my transformer comprises two coil sections P_1 and P_2 which are mounted respectively on the members 13 and 14 at opposite ends thereof. The coils P_1 and P_2 are connected, preferably in series, by the lead 21 and are energized from source 12 through the leads 22 and 23. The primary winding coil sections may be connected in parallel, rather than in series, if desired.

The secondary winding comprises coil sections S_1 and S_2 which are mounted respectively on the core members 13 and 14 at ends opposite from those on which the primary coil sections are mounted. One terminal of the coil S_1 is grounded to the core through a metal strip 24 which is held in firm contact with the core by the core band 19. The other terminal of the coil S_1 is connected by a lead 25 to one terminal of the luminescent tube T_1. The other terminal of the tube T_1 is grounded as at 26. One terminal of the coil S_2 is likewise grounded to the core through a metal strip 27 which is held in firm contact with the core by the core band 20. The other terminal of the coil S_2 is connected by a lead 28 to one terminal of the tube T_2 whose other terminal is grounded as at 26. The core itself is grounded as at the ground 29. Two complete secondary circuits are formed through the leads and ground connections, one circuit including the coil S_1 and tube T_1 and the other circuit including coil S_2 and T_2. The current and voltage ratings of the coil sections S_1 and S_2 are dependent upon those of luminescent tubes T_1 and T_2 which they are designed to operate. There is no necessary relation between the ratings of the two secondary winding coil sections although ordinarily they are of approximately the same ratings.

Because the two secondary circuits are entirely separate, the coils S_1 and S_2 may be connected either in series or in opposition. In other words, it is possible to have the ungrounded terminals of the coils S_1 and S_2 to which the leads 25 and 28 respectively are connected, either at opposite potentials or at the same potential at any given instant. The arrangement in which the two ungrounded terminals are always approximately at the same potential is preferable where the tubes T_1 and T_2 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 tendency for a tube-puncturing dielectric discharge.

In the operation of my transformer, as the electromotive force impressed across the terminals of the primary coil sections P_1 and P_2 by source 12 rises 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 in the drawing, for example, by the arrows during one half cycle of the applied electromotive force. This flux interlinks the secondary winding coil sections S_1 and S_2 with the primary winding. The path of the flux until one of the tubes strikes is in a counter-clockwise direction along the main core path, coursing from right to left in the member 13, through member 15, from left to right in member 14, and through member 16 back to member 13 during the half cycle under consideration. It will be understood that during the other half cycle of applied electro-motive force, the flux generated in the core will follow the same path but in a direction opposite to that indicated by the arrows.

The flux linking the coil S_1 generates an electromotive force in that coil, this electromotive force being impressed across the terminals of tube T_1 through the lead 25 and the ground connections. When it reaches a value sufficiently

high to render the gas in the tube T_1 ionized and conductive, a current begins to flow through the tube T_1 and its coil S_1. The resistance of the tube T_1 to flow of current being very low when the gas in the tube is ionized, a heavy current would flow through the circuit were it not for the peculiar magnetic shunt construction provided.

After current begins to flow in the coil S_1, it generates a magnetomotive force which opposes the coursing of the main flux and causes it to seek a path of lower reluctance through the air gap G_1, shunt piece **17** and core piece stem **15***a*. Thus, when current is flowing through coil S_1 and tube T_2 is inoperative, during the half cycle under consideration, the major portion of the main flux courses from the right hand end of linear member **13**, as seen in the drawing, across air gap G_1 through shunt piece **17**, stem **15***a*, the lower main part of member **15**, linear member **14** and member **16** back to member **13**. A minor portion of the magnetic flux then links the primary winding and coil S_1. With this decrease in flux there is an accompanying decrease in induced potential so that the secondary current flow is limited to a desired operating value.

Similarly, the flux linking the coil S_2 generates a voltage in that coil which is impressed across the terminals of the tube T_2 through the lead **28** and the ground connections. When the voltage across the terminals of tube T_2 is sufficiently high to ionize the gas in that tube and render it conductive, a current flows through tube T_2 and its coil S_2. This current likewise is limited to a desired value through the action of the shunt core path in diverting the magnetomotive force which bucks the main flux and causes it to seek a path of lower reluctance. Thus, when the tube T_2 is operative and tube T_1 is inoperative, during the half cycle under consideration the flux courses in the counter-clockwise direction from left to right in member **14** across air gap G_2 and through shunt piece **18**, stem or arm **16***a*, the upper part of member **16**, member **13** and member **15**, back to member **14**.

Continuing in the cycle of operation, it will be understood that a point will be reached where T_2 will strike, if T_1 has struck first, or T_1, in the event T_2 struck first and both tubes then are operating. At this point the major portion of the main flux courses in a path from right to left in member **13**, across air gap G_1 through shunt piece **17**, arm **15***a*, the lower part of member **15**, member **14**, air gap G_2, shunt piece **18**, arm **16***a* and the upper part of member **16** back to member **13**. Enough flux continues to link the coils S_1 and S_2 to maintain a steady flow of current through those coils and through the tubes T_1 and T_2 until the electromotive force impressed across the terminals of the primary winding approaches a zero value in continuing through the cycle of alternations.

When the flux linking the coils S_1 and S_2 diminishes to such a value that the voltage induced in those coils is insufficient to maintain the gas in the tubes T_1 and T_2 in an ionized condition, the tubes become extinguished and flow of current through the tubes and their secondary coils ceases. The tubes remain extinguished until the voltage impressed across the terminals of the primary winding by the source **12** rises to a value in the opposite direction which is sufficient to again produce sufficient potential in the coils S_1 and S_2 to ionize the gas in the tubes T_1 and T_2. At this point, the tubes T_1 and T_2 again become conductive and luminous. The current flow in tubes and their coil sections is limited to the desired operating value by the peculiar magnetic core shunt construction described above. Where a 60-cycle source is used to energize the primary winding the tubes become luminous 120 times per second. Due to persistence of vision, they appear to emit a continuous glow of light.

While, as a matter of convenience in describing the operation of my transformer apparatus, the various stages in the operation of the two luminescent tubes T_1 and T_2 and the possibilities attending this operation are treated separately, each without special regard to the operating of the other, it will be understood that under actual operating conditions both luminescent tubes are rendered conductive and luminous at about the same instant and at about the same instant become non-conductive and non-luminous. During those brief periods when the tubes are in their non-conductive states, the complete path of the total magnetic flux is along the entire lengths of linear core members **13** and **14** and the main portions of members **15** and **16** effecting the closure of the magnetic circuit. During those periods when tubes T_1 and T_2 are in their conductive conditions, the major portion of the magnetic flux courses along the magnetic path which includes the arms **15***a* and **16***a*, of the members **15** and **16**, shunt pieces **17** and **18** and the included air gaps G_1 and G_2, the remaining portion of the magnetic flux continuing along the path of low reluctance and interlinking the primary and secondary windings.

Should the tube T_1, for example, become grounded in operation, as by the formation of a conductive film of dirt, salt particles, matted insect bodies, snow, rain or the like, between its electrodes or between the high potential electrode and the ground, the flow of current in the circuit will reach about the same value as 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 from excessive current during normal operation. The same protection will be afforded where it is the coil S_1 itself instead of the tube T_1 which becomes grounded. As current begins to flow in the coil S_1, 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 from the right hand end of member **13** through air gap G_1, shunt piece **17**, arm **15***a*, the lower part of member **15**, member **14**, and member **16** back to member **13**. Due to the diversion of the major portion of the magnetic flux from the coil S_1, the current flowing through that coil under short-circuit conditions will be limited to a safe value. Overheating of the coil and consequent charring of its insulation, therefore, is avoided.

Similarly, where the coil S_2 or its tube T_2 becomes grounded the current flowing through coil S_2 will be limited to a safe value by virtue of the diversion of the major portion of the magnetic flux from the coil S_2 through the magnetic shunt path. The shunt path in this instance is that which includes the air gap G_2, shunt piece **18** and arm **16***a* and the upper part of member **16** back to the member **13**.

Due to the magnetic shunt construction provided in my transformer, the coils need be de-

signed only for the maximum load current, since the short-circuit current under all possibilities does not substantially exceed that value. As a result the transformer employs a finer wire than ordinarily used, the transformer is more compact. The magnetic flux paths are short and on the whole, the transformer is lighter in weight than those heretofore known and used. Furthermore, the relative placement of primary and secondary coils within the housing gives a symmetrical distribution of extraneous flux, thereby assuring a balanced operation under the various conditions encountered in use.

Where one coil, say the coil S_1, becomes open-circuited as by breaking the tube T_1 or of one of the leads, no current will flow in that coil. Hence, no countermagnetomotive force will be generated by coil S_1 and the core path linking it will be of a very low reluctance. The operation of coil S_2 and tube T_2 will not be impaired because the main flux will continue to link coil S_2 and to operate the tube T_2 in the same manner as it does when the circuit comprising coil S_1 and tube T_1 is operating normally. It will be understood that a like effect is had when the coil S_2 is open-circuited. The coil S_1 and its tube T_1 will continue to operate normally.

Ordinarily, in the design of a luminescent sign and display, the complete display is made up of a number of individual luminescent tubes or series of tubes of various configurations which are as near the same length as is conveniently practicable. In energizing two tubes comprising a part of such a display, secondary windings of my transformer apparatus are preferably of about the same voltage ratings as a matter of convenience in production of the apparatus. Better results in operation are achieved where the ratings of the secondary windings conform exactly to the ratings of the individual luminescent tubes they are intended to operate.

Where the tube loads are of substantially the same electrical characteristics, as where tubes of the same length and cross-sectional area, and same gas pressure, the shunt path comprising core piece 17 and air gap G_1 is of approximately the same reluctance as the shunt path formed by shunt piece 18 and air gap G_2. This identity of reluctance of the shunt paths is achieved by inserting the proper number of laminations in the shunt pieces 17 and 18. It will be understood that where desired, the tubes T_1 and T_2 may be of different ratings. For example, the tube T_1 may be of higher resistance than the tube T_2. In that event, the coil S_1 should have a greater number of turns of wire than the coil S_2. Also, the shunt path formed by shunt piece 17 and air gap G_1 should be of higher reluctance than the shunt path formed by shunt piece 18 and air gap G_2. This adjustment of the shunt path reluctances may conveniently be made by inserting the proper number of laminations in the shunt pieces 17 and 18.

It is to be noted at this point that in my electrical transformer apparatus only a single primary winding and a single core structure are employed. The total magnetic flux is created by the one primary winding and, by way of the single core structure, serves to link and energize both secondary windings. This construction, as mentioned above, effects a direct saving in construction over heretofore known transformer apparatus. It is to be particularly noted, however, that these savings in iron, for the core, and wire and copper, for the primary winding, do not result in a loss in operating efficiency nor, of greatest importance, in a risk of damage to any secondary winding coil section as a result of accidental grounding of such a coil section. These savings and economies in the construction of a single piece of apparatus requiring but a single connection to a source of supply energy are of the greatest practical importance in the operation of a maximum length of luminescent tubing by a single piece of apparatus.

Moreover, it should be noted that my transformer apparatus is exceedingly compact and rugged in construction. The primary and secondary winding coil sections snugly fit within the spaces provided for them between the core members. With this construction a minimum amount of iron is required in the core, thus effecting a very real and direct economy. Furthermore, with this construction, the overall dimensions of the transformer apparatus are reduced to a minimum, the length of the magnetic path is minimized, operating efficiency is improved and heat elimination is facilitated. The cost of an enclosure for the transformer apparatus and the packing and shipping costs incident to the transportation of a large number of the units is thus effectively minimized.

Where desired, the highly beneficial operating characteristics of my transformer apparatus are achieved by modifying the construction of the apparatus as by forming core member 15, 15*a* and shunt 17 as an integral piece and likewise making 16, 16*a* and 18 of integral construction. This construction of core members is shown in Fig. 2. Also my transformer may be modified by mounting the secondary winding coil sections on the same linear core member and by employing only a single primary coil section which is mounted on the other linear core member. Such a form of construction is shown in Fig. 2 of the drawing.

In Fig. 2, is shown a transformer 110 which energizes a single tube T and in turn is energized from a source 112 of single phase alternating current electrical energy. The transformer is preferably enclosed in a casing similar to the casing 11 in Figure 1, but not shown in Figure 2 for the sake of clarity in the drawing.

The core of my transformer is formed by two parallel linear members 113 and 114 and the roughly C-shaped members 115 and 116. The parts are held together by steel core bands 117 and 118 which are put in place while the parts are held together under heavy pressure. Member 115 has a central arm 115*a* which extends parallel to the members 113 and 114 toward the center of the transformer and terminates in a shunt portion 115 set at right angles to the arm. Shunt portion 115*b* extends toward member 113, forming therewith an air gap G_3 of high magnetic reluctance. Similarly, member 116 has a central arm 116*a* which extends parallel to the members 113 and 114 toward the center of the transformer and terminates in a shunt portion 116*b*, set at right angles to the arm. Shunt portion 116*b* extends toward member 113, forming therewith an air gap G_4 of high magnetic reluctance. It will be noted that in this modification I have made the shunt portions 115*b* and 116*b* integral with the members 115 and 116 rather than as parts separate therefrom. Thus the number of joints in the shunt paths is reduced and the paths have high permeance except for the reluctance introduced by the air gaps G_3 and G_4. Moreover the integral form of construction lends strength and rigidity to the core, shunt

construction and minimizes hammering or chattering in operation.

The primary winding coil section P of my transformer is mounted on linear member 114. It is energized through the leads 119 and 120 from source 112. The latter may be the ordinary single phase 110 or 220 volt, 60-cycle commercial mains, or may be any other suitable source.

In my transformer there are two secondary winding coil sections S_3 and S_4 which are connected in series to form a single secondary winding. This winding energizes the tube T through leads 121 and 122 from one terminal of each of the coils S_3 and S_4 respectively. The other terminals of the coils are grounded to the core through metal strips 123 and 124 which are held in firm contact with the core under the bands 117 and 118. The core itself is grounded as at 119. Because of the grounding of their one terminals to the grounded core the output terminals of the high potential secondary winding coil sections are limited to a safe value of potential to ground. This is equal to the output potential of the one coil section to which the terminal is connected. In no case may the potential to ground amount to that of the complete secondary winding. This construction gives a direct saving in insulation costs and maintains the possible value of potential to ground within safe limits and yet permits a desired high value across the output terminals of the transformer apparatus.

In the operation of this transformer, as the electromotive force impressed across the terminals of the primary winding P by the source 112 rises from a zero value, current begins to flow through the primary winding. This current generates a magnetomotive force which causes magnetic flux to course through the core in the counter-clockwise direction, as indicated by the arrows in Fig. 2 of the drawing, during a given half cycle of the applied E. M. F. This path is from member 114 through member 116, from right to left throughout the length of member 113, and back through member 115 into member 114. The flux links the secondary coil sections S_3 and S_4 and induces in them an E. M. F. whose value depends on the density of the flux and the number of turns of wire in the coil sections. Since the two coil sections are connected in series, their voltages are added so that the voltage across the terminals of the tube T is twice that developed by any one coil section and yet the maximum voltage to ground in any part of the circuit is no more than that developed by one coil section.

When the voltage applied across the terminals of tube T reaches a value sufficiently high to ionize the gas therein, the tube suddenly becomes conductive and luminous, current beginning to flow as soon as the gas is ionized. This current does not reach an excessive value because of the magnetic shunt construction provided. As current flows through the coils S_3 and S_4 it generates a magnetomotive force which opposes the coursing of the main flux and causes the major portion of it to follow the paths of high reluctance including the shunt members and their included air gaps. Thus, during the half cycle under consideration, while current is flowing through coils S_3 and S_4, the major portion of the main flux courses from member 114 into the lower part of member 116, through arm 116*a*, shunt portion 116*b*, air gap G_4, the central part of member 113, air gap G_3, shunt portion 115*b*, arm 115*a*, and the lower part of member 115 back into member 114. This path excludes the coils S_3 and S_4 a minor portion of the flux continues to course through the bar 113 and energizes these coils. This latter flux, although a minor portion, is sufficient to maintain a steady flow of current through the coils S_3 and S_4 and through the tube T until the primary E. M. F. approaches a zero value in following through the cycle of alternations. At that time, the secondary voltage becomes too low to maintain the gas in the tube T in an ionized condition and the tube becomes non-conductive and non-luminous. It remains in this condition until the secondary voltage again, during the next half cycle of primary E. M. F., reaches a value sufficient to ionize the gas in the tube. The tube thus becomes luminous 120 times per second where a 60 cycle source of primary E. M. F. is used, and as before mentioned, due to persistence of vision it appears to emit a steady glow of light.

Should the tube T become short-circuited, as by the formation of a conductive film of moisture between its terminals, the current then flowing through the secondary coils will not reach an excessive value because of the peculiar magnetic shunt construction provided. As current begins to flow between the terminals of the tube and through the secondary coils, a counter magnetomotive force is developed by those coils which causes the major portion of the main flux to follow a path of high reluctance around and excluding the secondary coils as in normal operation when the tube is ionized. This path is from member 114 into the lower part of member 116 and through arm 116*a*, shunt portion 116*b*, air gap G_4, the central portion of member 113, air gap G_3, shunt portion 115*b*, arm 115*a*, and the lower part of member 115 back into member 114. The current flowing when the tube is short-circuited, will be about the same as that which courses through the tube when it is operating normally, since the short-circuit impedance is about the same as the impedance when the tube is in its conductive condition. In neither case will the current exceed a safe value.

Where a single coil section, say the coil S_3, becomes grounded, as by the grounding of one terminal of the tube T, the current flowing through that coil will not reach an unsafe value. As current begins to flow through the grounded coil S_3, it causes a magnetomotive force to be developed by that coil opposing the coursing of the main flux and causing the major portion of it to seek a path of high reluctance around and excluding the coil S_3. The path includes and links the coil S_4 since no current flows in that coil, due to the potential applied to tube T being sufficient to strike the tube, to give rise to an opposing magnetomotive force. This path, for the half cycle under consideration is from member 114 through member 116, the right half of member 113, air gap G_3, shunt portion 115*b*, arm 115*a* and the lower part of member 115 back into member 114. The voltage generated in the coil S_4 will not be sufficient to ionize the gas in the tube T. Accordingly, no current will flow either in the tube or in the coil S_4. A similar condition of operation exists when it is the coil S_4, rather than coil S_3, which is grounded.

Where the whole secondary winding becomes open-circuited, as by the breaking of the tube T, no current will flow in the secondary circuit, since the construction of my transfer is such as to fully protect the secondary windings under all conditions damage to insulation is precluded, the

transformer withstanding the open-circuited voltage without rupture of insulation.

Where desired, the primary winding can be made in two coil sections mounted on the lower parts of the members 115 and 116 between arms 115a and 116a and the bar 114.

It will be understood that the coil sections S_3 and S_4 may be connected to two separate loads, instead of the single tube T. The coils S_3 and S_4 may then be connected either in series, or, if the load mid-point is grounded, in opposition. In that case the operation of the transformer will be similar to that of the transformer illustrated in Figure 1.

The transformer illustrated in Figure 2 is particularly economical in construction. The single primary coil section P is cheaper in construction than are two separate primary coil sections. Moreover, the core members 115 and 116 are identical in shape as are also the bar members 113 and 114. Accordingly, only two dies are needed for the stamping of the core members. This effects a considerable saving because dies are very expensive.

A saving is also effected in installation where my transformer is used. Only one transformer is needed to energize two short tubes or one long tube, whereas to meet the Underwriter's requirements of maximum voltage to ground two transformers have heretofore been required. A fixed labor charge is made for each unit installed and, accordingly, by reducing the number of units, the cost of installation is reduced.

Thus it will be seen that there has been provided in this invention transformer apparatus in which the various objects hereinbefore noted, together with many practical advantages thereof, are successfully achieved. It will be seen that my transformer apparatus is exceedingly compact and rugged in construction and that it lends itself to inexpensive and efficient commercial production and installation, employing a minimum of different shaped core members and requiring a minimum of expensive dies, tools and equipment in its construction. It will be seen, further, that my transformer apparatus permits the energization of a greater length of luminescent tubes than heretofore known transformer apparatus without at the same time encountering excessively high output potentials from terminals or conductors to ground, or risking damage to the secondary windings in the event of accidental grounding of either one or both coil sections of these windings.

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 core comprising two separate parallel linear core members and two separate end core members interposed between said linear members, including substantially C-shaped portions, a primary winding comprising two coil sections one mounted on each of said linear members and two secondary winding coil sections, also one mounted on each of said linear members, said two end core members forming with said linear members a closed main magnetic path interlinking said primary winding and said secondary winding coil sections and with said C-shaped portions also forming individual magnetic shunt paths around said secondary winding coil sections internally of said main magnetic path.

2. In electrical transformer apparatus of the character described, in combination, a core comprising two separate parallel linear core members and two separate end core members interposed between said linear members, each consisting of a C-shaped portion with a back extension, a primary winding and two secondary winding coil sections mounted on said core, the toes and back extensions of said two end core members forming with said linear members a closed main magnetic path interlinking said primary winding and said secondary winding coil sections and with said C-shaped portions also forming magnetic shunt paths around said secondary winding coil sections internally of said main magnetic path, with an air-gap from C-shaped portion to linear member in each shunt path at a central portion of said linear member.

3. In electrical transformer apparatus of the character described, in combination, a core comprising two separate parallel linear members and two separate end core members interposed between said linear members, each consisting of a C-shaped portion with a back extension, a primary winding mounted on one of said linear members, and two secondary winding coil sections mounted on the other of said linear members, the toes and back extensions of said end core members forming with said linear members a closed main magnetic path interlinging said primary winding and said secondary winding coil sections and with said C-shaped portions facing each other and almost abutting the linear member on which said secondary coil sections are mounted at a point between the same and forming individual magnetic shunt paths around said secondary winding coil sections internally of said magnetic path with included air-gaps.

4. In electrical transformer apparatus of the character described, in combination, two separate linear core members spaced in parallel relationship, two separate core members, each having a portion so positioned as to abut the near ends of said linear core members to effect a closed magnetic circuit and each having a C-shaped portion so positioned as to form a shunt path including air-gaps to at least one of said linear members near the central portion thereof; a primary winding mounted on said linear core members; two secondary winding coil sections mounted on said linear core members linking said core members through the space provided between said members and the nearby C-shaped members; and separate binding means about the one near ends of the linear members and each abutting core member for maintaining said core members in said abutting relationship with minimum effect on said air-gaps.

5. In electrical transformer apparatus of the character described, in combination, two separate parallel linear core members, two separate core members spaced apart and including C-shaped portions cooperatively associated with said linear members effecting a closed magnetic circuit therewith by way of their one portions and establishing shunt core paths including air-gaps by way of their C-shaped portions at points centrally of said linear members, iron or steel clamping means at opposite ends of said parallel members for holding together said linear core members and said members including C-shaped

portions with minimum effect on said air-gaps, a primary winding mounted on said linear core members, and two secondary windings mounted on said linear core members and lying within the space provided by the C-shaped portions, said secondary windings being connected in series with their common connecting terminals held grounded to the core members by said clamping means.

6. In electrical transformer apparatus of the character described, in combination, two separate linear core members spaced in parallel relationship, two separate core members interposed between said linear members and each consisting of a C-shaped portion with an extended heel portion positioned so that the toes and extended heel portions abut the near ends of said linear core members to effect a closed magnetic circuit and with the C-shaped portions forming shunt paths including air-gaps with one of said linear members near the central portion thereof; two secondary winding coil sections mounted on said one linear core member and linking said core member through the space provided between said member and the nearby C-shaped core members; a primary winding mounted on the other of said linear core members; separate core bands about the one near ends of the linear members and each abutting core member for maintaining the whole in abutting relationship; and a steel casing snugly fitting about the combination of said core members, windings and bands with the casing and core bands remote from the said air-gaps.

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