

June 8, 1943.

C. P. BOUCHER

2,321,357

TRANSFORMER

Filed Sept. 25, 1939

3 Sheets-Sheet 1

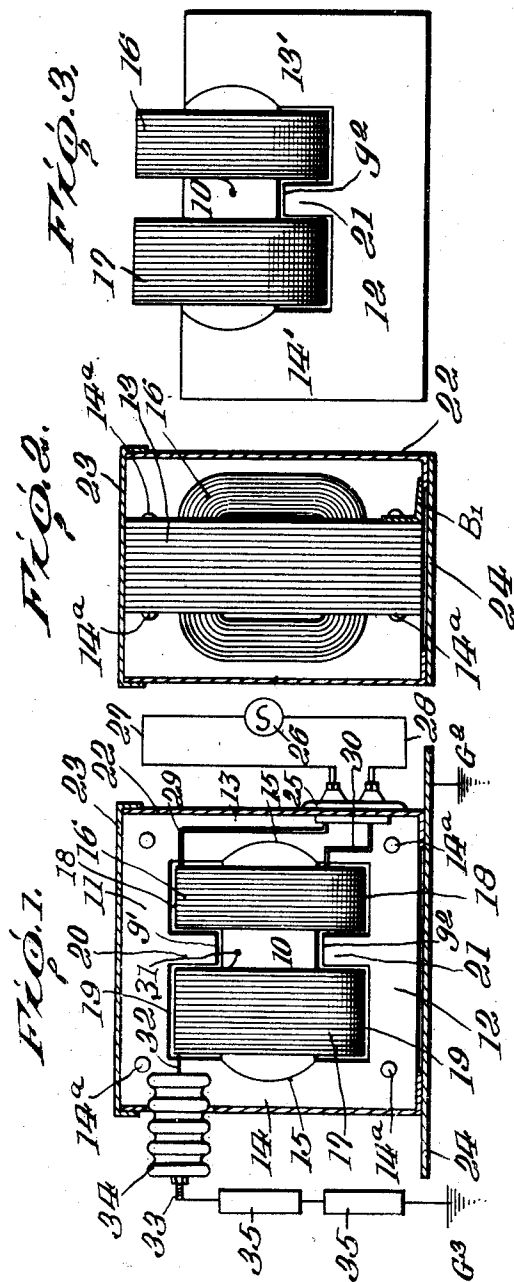


FIG. 2.

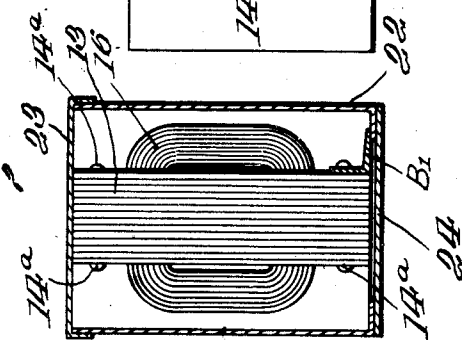


FIG. 3.

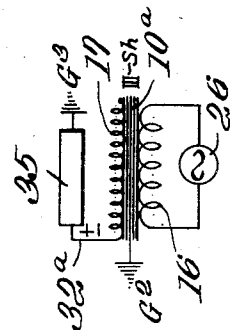
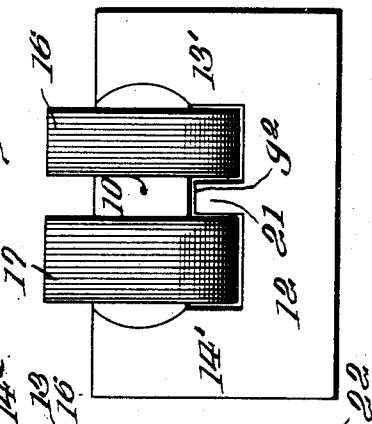
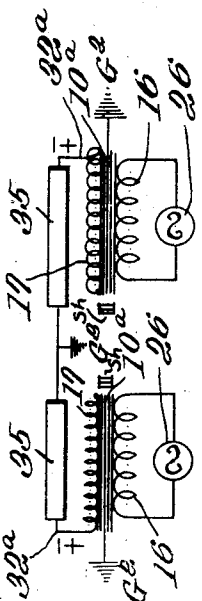


FIG. 5.



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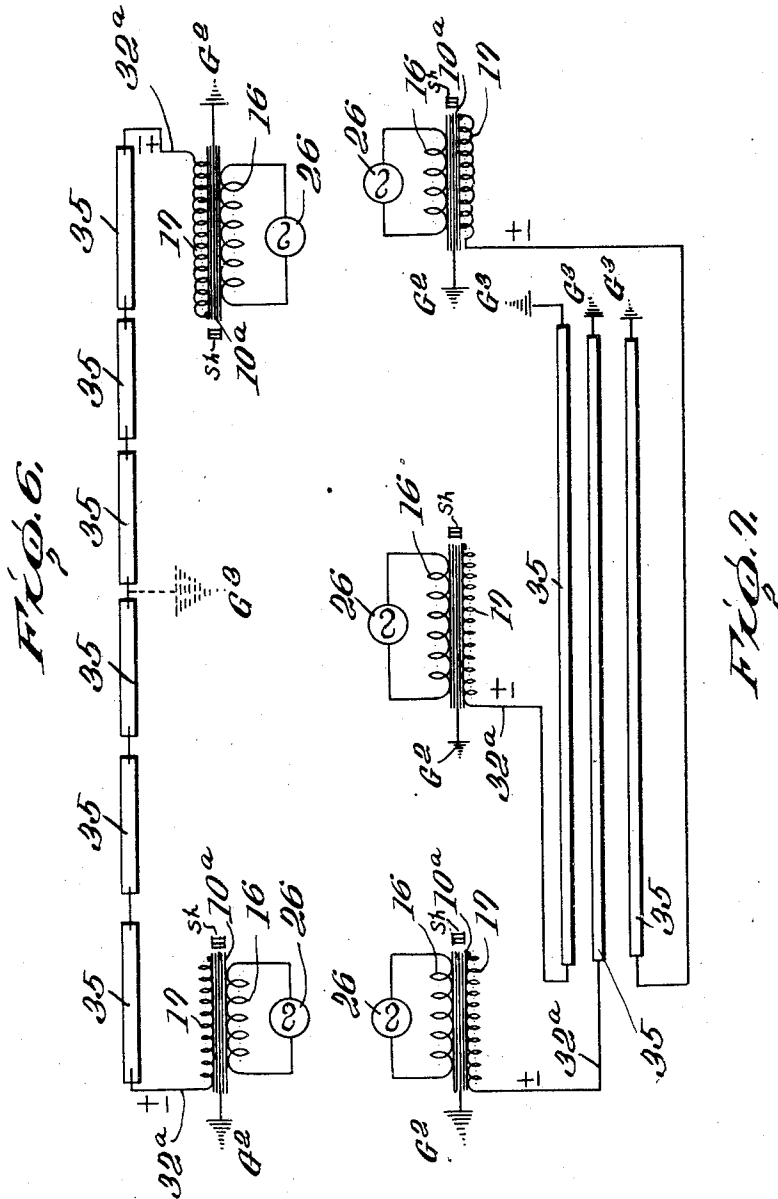
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TRANSFORMER

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3 Sheets-Sheet 2



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TRANSFORMER

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FIG. 8.

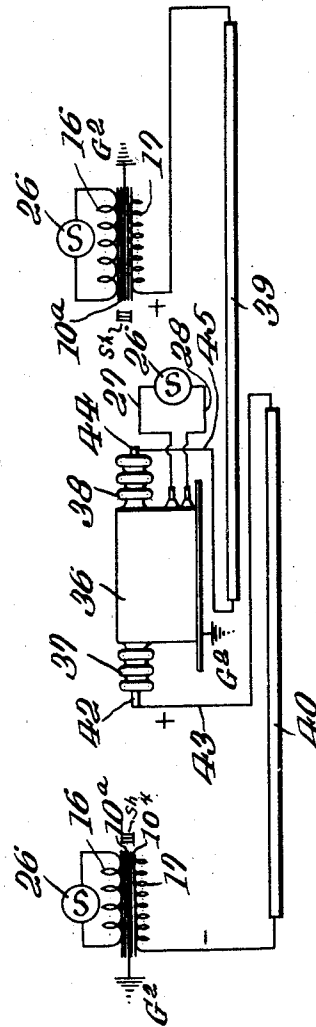
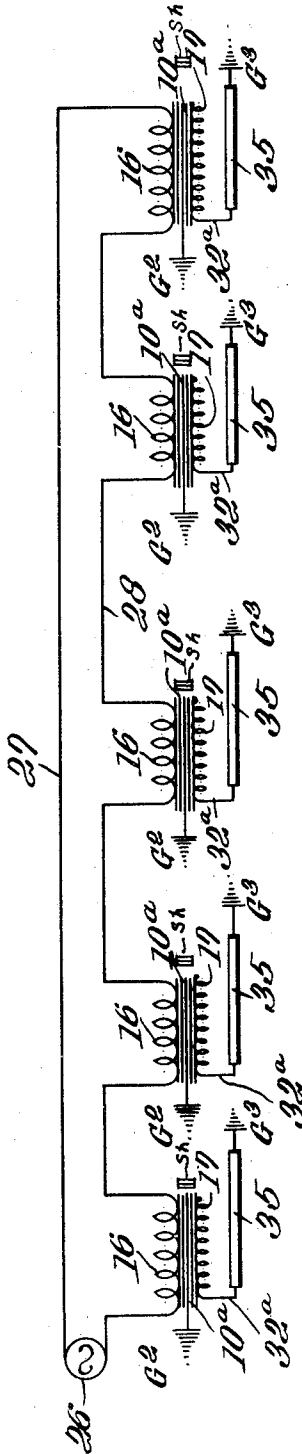


FIG. 9.

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2,321,357

TRANSFORMER

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Application September 25, 1939, Serial No. 296,522

11 Claims. (Cl. 176—124)

My invention relates to electrical transformers, and more particularly concerns transformers capable of operating luminescent gaseous discharge tubes, and to systems including the same.

An object of my invention accordingly is to produce a new high potential transformer unit which is characterized by its extreme simplicity, efficiency and flexibility, its increased load capacity, the low cost with which it can be connected to a sign to be energized thereby, and by its ruggedness and dependability under all operating conditions.

Another object is to produce such a transformer unit which can be readily and simply produced at appreciably reduced first cost, requiring a minimum of dies and tool equipment, and which is characterized by the comparative ease and low cost with which it can be either replaced in its entirety or serviced at the site where it is installed.

Still another object is to produce a new method of operating a plurality of luminescent gaseous discharge tubes by transformers, characterized by its simplicity and its flexibility in the disposition of both luminous and transformer units.

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 the relation of each of the same to one or more of the others, the scope of the application of the invention being indicated in the claims at the end of the specification.

In the drawings:

Figures 1 and 2 show in front and side elevation respectively, a shell-type transformer construction embodying my invention.

Figure 3 illustrates in front elevation my invention as applied to a core-type transformer unit.

Figures 4 through 9 inclusive illustrate the combination of transformer units according to my invention in various circuit connections.

As conducive to a more thorough understanding of my invention, it may be pointed out that in the operation of high potential negative loads, particularly in the operation of luminescent gaseous discharge tubes, it is customary to use high voltage constant current transformers. It is the usual practice to construct the secondary windings of such transformers in two coil sections and to ground the midpoint of the secondary. This splits the voltage, so that the effective voltage between the outermost turn of the transformer

and the ground is but one-half the potential difference existing between the terminals of the transformer secondary. Thus, while the full rated potential is impressed across the output electrodes of the transformer, no more than half of that potential will pass to any object shorted across the secondary at some point along its extent. It will be seen that the possibility of mischance resulting from accidental contact or abnormal operation is minimized.

Additionally, such multi-coil construction with grounded midpoint permits decreasing the amount of insulation required, because of the lower voltages to be insulated against. Because the insulation represents an important item in the cost of the transformer, an important saving in the quantity of such material employed is followed by a sharp decrease in the production costs.

The significant point of the foregoing discussion of the present-day transformer designed for luminous tube duty is that such transformers, even in their simplest embodiment and in their smallest units, comprise at least a core, a primary coil section, two secondary coil sections, and a casing.

Experience shows that despite all precautions employed in the manufacture of such transformers, it is the combination of the quality and quantity of insulation employed which is the controlling factor in determining the useful life of the transformer. Other factors being equal, the better the insulation is, the longer is the life of the transformer.

In connection with what follows, it should be kept prominently in mind that transformers of the type under discussion represent a highly developed and highly competitive field of commerce. Thus the realization of items of economy in the production of such transformers, be those economies immediate or far-reaching in their effect, is of the utmost practical importance. Particularly is this true when no loss in efficiency or serviceability attends the practice of such economies.

My investigations demonstrate that in the great majority of instances, transformers of the type under discussion having two secondary coil sections are discarded due to the defective operation of but one of the secondary coil sections. It is seldom indeed that the two secondary coil sections are damaged simultaneously, and I have found that the primary coil section almost never fails. From the foregoing, it follows that upon failure of but one secondary coil section, the en-

tire transformer must be removed from service and sent to the shop for repair or replacement. This is true despite the fact that the remaining secondary coil sections will still operate effectively. While one-half of the transformer is still capable of proper functioning, the transformer must be replaced by an entire new unit. As typical instances of such failures may be listed shorting of one of the secondary coil sections to the core or casing, or the like.

It becomes evident at once that the unavoidable loss resulting from discarding a transformer because of failure of one secondary coil section is materially increased where the transformer in question is of the multi-circuit type, that is, having a large number of secondary coil sections. In either event, the loss is considerable, and represents an item of some gravity in transformer operation.

An important object of my invention therefore is to remove the foregoing disadvantages attendant upon known high-tension constant-current transformer installations, and to produce a transformer unit in which loss of otherwise serviceable parts thereof will be reduced to a minimum when the transformer unit is rendered unserviceable due to failure of a secondary coil section thereof, and in which the total loss of investment attendant upon such failure will likewise be reduced to a minimum. A further object of considerable importance is to produce a transformer unit of such construction as to avoid the necessity of discarding the equivalent of an entire transformer of the known type upon failure of only part thereof, when the equivalent of one-half of the known transformer is still capable of functioning in normal manner.

Also, in connection with the prior transformer art, it is customary practice to design transformers having multi-coil secondary windings in certain standard ratings and load capacities. This practice may be due in part to the rapidity with which costs of tooling, and production costs mount up where, what I term "off-sizes," are manufactured in any variety.

Adherence to the practice of producing only certain standard sizes, however, results in lack of efficiency and economy in equipping many installations with transformers. Particularly is this true where the energy demand of the load is but slightly in excess of the rated output of a standard size transformer. To illustrate, assume a 15,000 volt transformer capable of operating say 60 feet of tubing, and also assume a sign to be energized, employing, say, 65 feet of tubing. In such case, although the amount of tubing to be energized over that which can be handled by the transformer at its rated output is only 5 feet, experience shows that such a 65 foot tube could not be operated by the one transformer alone without flickering or general dimming of the display. Prior to my present invention, the only solution to the foregoing was to employ in conjunction with the first transformer, a second transformer having a multi-coil secondary winding, of one of the standard ratings. It was necessary, in short, to double or nearly double the transformer cost in such an installation, simply to operate in safe manner a few additional feet of tubing which were essential to a proper sign display.

A further object of my invention therefore is to avoid the difficulties in transformer practice as hitherto known, and as pointed out in the fore-

going, and to produce a transformer unit which can be used in connection with other transformer units to produce a transformer installation nearly exactly suited to the load demand of the particular sign being energized, all at a minimum of cost of production, installation and maintenance. In the typical instance pointed out hereinbefore, for example, and employing a 15,000 volt transformer capable of operating 60 feet of tubing, to energize a 65 foot length of tubing, a half-transformer according to my invention, of 3000 or 4000 volts rating, can be added to the first transformer. This enables the 65 feet of tubing to be properly operated at a minimum cost of power and installation.

As a corollary to the foregoing statement of object, it may be said that a further object of my invention is to produce a flexible transformer unit of low cost and great durability, which can fill in the gaps in the ratings of standard voltages for which known transformer equipment is designed.

My invention may be applied with equal facility to either a shell-type transformer unit or a core-transformer unit. Examples of such constructions are illustrated in Figures 1 and 2, respectively. As shown in Figure 1, the transformer unit consist of a main leg 10, and peripherally-disposed return legs 11, 12, 13 and 14. Return legs 11 and 12 are substantially parallel to main leg 10, while legs 13 and 14 are substantially at right angles thereto. Legs 11 through 14 comprise a frame, and the main leg 10 lies in the frame thus formed and is joined to legs 13 and 14 substantially at the midpoints thereof. The joints between the return legs 13 and 14 and the main leg 10 may be of any suitable type, such as butt joints or the like. However, I find it desirable to form them as pressed-in magnetic joints 15, 15. The said main and return legs I prefer to form of laminated construction, and preferably the laminae are held together against vibration by means such as bolts or the like. Rivets 14a are illustrated as serving as such binding means. The main leg and return legs together form a closed magnetic path.

Although such construction is not essential, I prefer to construct the frame consisting of return legs 11 through 14 and shunt extensions 20 and 21 of laminations, each of which laminations comprises a single piece in order to enjoy a minimum magnetic reluctance in the main core path. However, I desire it to be understood that the magnetic core can be made of as many parts as is found desirable, and that any manner of holding such parts together can be used without materially altering the operation of my transformer.

A single primary coil section 16 and a single secondary coil section 17 are mounted on the main leg 10, in spaced relation to each other. These coil sections are snugly received in recesses 18, 18 and 19, 19 respectively, provided for that purpose in the core frame.

Shunt extensions 20, 21 are provided on return legs 11 and 12, respectively, extending between the primary and secondary coil sections inwardly towards and on opposite sides of the centrally-disposed main leg, to points just short thereof. The shunt extensions are seen thus to provide short air-gaps g1 and g2. These air-gaps preferably, but not necessarily, have the same electrical constants. The function of these air-gaps will be pointed out hereinafter. Similarly, the design of the coil sections and their

function will likewise be described at a later point herein.

I prefer to enclose the transformer unit in a suitable casing, fitting snugly thereabout, and provided with a suitable closure. Such casing is illustrated at 22, having closure 23. Suitable means, such as bracket B1 (Figure 2), serve to mount the transformer frame fixedly and rigidly in the center of the casing, so that the dimensions of the casing may be reduced to a minimum, thus reducing costs of material. Bracket B1 is formed of metal, so as to provide a suitable permanent metallic connection between the transformer core and the casing 22. This casing 22 in turn is grounded to earth, through its bottom member 24, at G2. While I have described and illustrated an embodiment in which a single transformer is housed in a casing, it is, of course, feasible to enclose several transformers in a single box, if such arrangement is found desirable.

A primary connecting block 25 is mounted on the wall of casing 22. This block is of suitable insulating material such as porcelain or the like. Any suitable source 26 of alternating-current potential may be connected as by leads 27, 28, to this connecting block. The primary coil section 16 of the transformer is energized from source 26 through conductors 29 and 30 which connect opposite terminals of said primary coil section to connecting block 25.

One terminal of the single high potential secondary coil section 17 is connected at 31 to the transformer core. Through bracket B1 (see Fig. 2) and G2 this terminal is thus maintained at ground potential at all times. The opposite terminal of coil section 17 is connected by high potential conductor 32 to conducting bolt 33. Bolt 33 extends through a high potential bushing 34, constructed of porcelain or similar suitable material, fitted in the wall of casing 22.

The high potential conducting bolt connects with one end of a suitable negative load, illustrated in a typical instance as comprising a series of luminescent gaseous discharge tubes 35, which at their other ends are grounded at G3.

The single secondary coil section 17 is designed to deliver one-half the voltage which is ordinarily developed across both coil sections of hitherto known single-circuit transformers designed for negative load work and having a plurality of coil sections cooperating to deliver the full rated secondary voltage. In other words, secondary coil section 17 is equivalent to one-half the complete secondary winding of single-circuit transformers having the multi-coil secondary windings referred to. It is for this reason that I choose sometimes to designate my new transformer units as half-transformers.

Assume now that current flows from source 26 to primary coil section 16, energizing the latter. Flux is generated in main leg 10, flowing in two separate paths through the return legs 13, 11 and 14 on the one hand, and 13, 12 and 14 on the other, reuniting and returning to main leg 10. Of course, in the opposite half-cycle of the charging current, or $\frac{1}{2}$ of a second later in the case of 60-cycle current, the direction of the current flow, and hence of flux flow, reverses.

As the flux courses through its path, it links the turns of coil section 17, and builds up a voltage therein. At first, when the current in primary coil section 16 starts building up at the beginning of any half-cycle of current flow, its value is small, as so too, by consequence, is the

value of the flux coursing through the magnetic core. The quantity of flux is as yet not enough to generate a voltage across the terminals of the secondary coil section 17 sufficient to overcome the combined starting resistance of tubes 35. That is, it has not yet reached the striking potential of the system of tubes. Consequently, no current courses through coil section 17, and the coursing of flux through the main leg 10 is unimpeded. During such times, the air-gaps g1 and g2 offer a relatively great impedance to the coursing of flux through shunt extensions 20 and 21, so that little, if any, of the flux follows these shunt paths.

At a certain point in each current half-cycle, however, secondary voltage becomes sufficient to overcome the starting resistance of tubes 35. When the value of secondary terminal voltage, known as the "striking potential" of the system of tubes, is reached, an arc is struck across tubes 35, and current begins to flow through coil section 17. This secondary current itself develops a magnetomotive force which opposes the flow of the main body of flux, it tends to impede the coursing of the main body of flux through the portion of main leg 10 that is linked by the secondary coil section 17. In short, the reluctance of the main flux path has momentarily become greater than that of the parallel shunt paths containing the air gaps g1 and g2.

As a consequence, after the flux had divided during one half-cycle of current flow at the right-hand end (Figure 1) of main leg 10, it flows in two separate paths to return legs 11 and 12. Being blocked in large part at the left-hand end of main leg 10, the two streams traverse shunt extensions 20 and 21, across air-gaps g1 and g2, and thence back through right-hand end of main leg 10. Just sufficient flux courses through the left-hand end of the main leg to ensure that the required current is developed in the latter. With current flow in primary coil section 16 still in the same direction, the value of current later begins to fall off, until the instantaneous voltage induced in secondary coil section 17 is no longer sufficient to maintain the discharge in tubes 35. Tubes 35 then extinguish, and the flux, no longer impeded, renews its coursing through the left-hand end of main leg 10. By consequence, coursing of the flux through the shunt paths 20 and 21 is substantially terminated.

During the next half-cycle the direction in which the flux courses through the core is reversed. When the voltage across the terminals of coil section 17, reaches the striking potential of tubes 35, a glow discharge is struck and the shunt paths again come into operation. This time the flux courses through main leg 10 towards the left in Figure 1, from primary coil section 16. It divides before it reaches coil section 17 (because of the counter magnetomotive force generated by the latter), and passes in two parallel paths across air-gaps g1 and g2, returning to the right in Figure 1 through the return legs, to the right-hand end of main leg 10. Just sufficient flux courses the left-hand end of main leg 10, returning through return legs 11 and 12, to ensure that sufficient current is developed in secondary coil section 17.

It will be seen that the action thus described is substantially the same in the instance that the secondary coil section becomes short-circuited for any reason, as by the tubes themselves becoming short-circuited. For example, assuming that coil section 17 becomes short-circuited in any

manner, the current tending to flow therethrough quickly builds up a counter magnetomotive force which results in flow of substantially all of the main flux through the shunt air-gaps.

Inasmuch as one terminal of coil section 17 is grounded, the opposite terminal thereof, which is connected to tubes 35, is first operated at the rated potential of the transformer unit above ground potential, and during the next half-cycle at the same potential below ground.

The basic construction of the core-type transformer unit of Figure 3 is quite similar to that of the shell-type transformer unit just described. A main leg 10 and return leg 12 are provided, as are return legs 13' and 14', similar to legs 13 and 14 of Figure 1. Shunt extension 21 and air-gap g2 are provided, while return leg 11, shunt extension 20 and air-gap g1, all included in the construction of Figures 1 and 2, are omitted in their entirety. Coil sections 16 and 17 are mounted on main leg 10. As described in connection with the construction of Figures 1 and 2, when a discharge is struck across the load on the transformer unit, the shunt extension 21 and air-gap g2 offer the path of least reluctance. The flux courses through this shunt path, to the exclusion of the left-hand end of main leg 10, save for just sufficient flux to maintain the current demand in coil section 17.

I construct my new transformer units from substantially the same materials as those used in a single-circuit transformer having a multi-coil section secondary winding of the same type and engineering. One of my new transformer units requires slightly more than half the iron, steel and copper employed in producing a transformer having a multi-coil secondary such as described in the foregoing. However, where two of my "half-transformers" are employed together to energize a negative load the increase in cost of materials over a transformer with a multi-coil secondary is more than compensated by the markedly decreased cost of servicing or replacing required by defective operation, as by aging of insulation, defective workmanship, accidents, and the like, as well as by the greater flexibility, represented by lower first cost of installation. Particularly where servicing is difficult or costly, manipulation of one of my transformer units, having a weight only slightly more than half that of a transformer with multi-coil secondary, represents a great advantage over practices hitherto required. In general, where luminescent sign tubes are to be serviced where they are located, I find that a transformer having two secondary coil sections can be replaced at a decided advantage by two of my transformer units as described herein.

As illustrative of the flexibility of my new transformer units, and to demonstrate their ready adaptability to various loading conditions, attention is directed to the several lighting systems depicted in Figures 4 through 9 inclusive. The transformer units shown schematically in these several depicted lighting systems resemble the units of Figures 1, 2 and 3, in that each unit comprises a main magnetic core 10a, a primary winding 16, a secondary winding 17, and a shunt core portion 8h associated with the main magnetic core magnetically between the primary and secondary windings.

Referring more particularly to Figure 4, it will be seen that in a typical instance, I ground one end of secondary 17 to the core 10a, in turn grounded at G2. The other end of the second-

ary I connect through lead 32a to one or more tubes 35, which at their opposite ends are grounded at G3. The secondary circuit may be traced as follows: Ground G2, core 10a, secondary 17, lead 32a, tube 35 and ground G3. Since one end of secondary 17 is grounded, the other end thereof alternately rises and falls above and below ground potential, as indicated by the plus and minus signs on Figure 4.

It has previously been demonstrated with reference to multi-circuit transformers that any secondary coil section thereof can be operated from a ground at one end thereof to an outside terminal at the other end thereof without interfering in any way with good results of high induced secondary voltage, secondary current control, and the like. This was found to be true regardless of the polarity of the coil sections, provided only that the load connected to the secondary was of a negative character. Consideration will show that a half-transformer according to my invention will operate at the same efficiency as either a single-circuit or multi-circuit transformer having all the secondary coil sections thereof individually connected to ground at one end thereof.

It may quite possibly happen that the load, represented by a luminescent gaseous discharge tube sign, for example, may be too large to be operated by a single transformer unit according to my invention. Or it may be impossible to ground the midpoint of such a tube assembly, or the ends of individual lengths of tubes. When the total resistance of the series of tubes constituting the load is too great for one transformer unit, then according to my invention I operate the tubes with two half-transformer units simply by connecting one end of the series of tubes to one transformer unit, and the other end of the series of tubes to another transformer unit. The two transformer units are preferably so selected that together they provide a voltage output substantially that required by the series of tubes. It is desirable that the transformers have substantially the same current ratings in order to enjoy maximum efficiency of both units. It is also desirable that the transformer units have like voltage ratings. However, this last requirement is not essential, and for example, the transformer at one end of the series of tubes may have a 7500 volt rating, while that at the other end may have say a 6000 volt rating.

One example of the foregoing is depicted in Figure 5, wherein the secondary windings of the transformer units are shown in series-opposition. In this case, the free end of the secondary winding of one transformer unit is connected to one end of a series of tubes, while the free end of the secondary winding of the other unit is connected to the other end of the tubes. The polarities of the secondaries, which may be changed as desired merely by reversing their respective primaries, are such that the voltages at their free ends are always positive or negative simultaneously. It is essential in such installations that the series of tubes have its electrical mid-point grounded. Parallel circuits may be traced from the secondary windings 17, through conductors 32a, tubes 35 and through grounds G3 back to the two secondary windings, grounds G2 and cores 10a.

Such series-opposition assembly may be likened to a parallel connection. It is also feasible to operate my transformer units in full parallel connection, wherein the secondary windings of

two or more units are connected in parallel at one or both ends of a series of tubes, or one long tube, to increase the available supply of current.

As a further possibility, I may connect two or more transformer units in series-aiding relationship. Such an assembly is illustrated in Figure 6. In that figure, the connections are much similar to those of Figure 5, except that the polarity of either one of the two transformers is now reversed with respect to what it was in Figure 5. This ensures that the voltage across the secondary of one transformer unit will aid that of the other transformer unit, and further ensures that the total voltage across the outside terminals of the string of tubes 35 will be the sum of the voltages developed by the two secondary windings. Thus the available voltage at tube terminals with the connections shown in Figure 6 will be twice that available with connections according to Figure 5. The further difference exists between the series-aiding connection of Figure 6 and the series-opposition connection of Figure 5 that while in the last-mentioned case a grounded midpoint of the chain of tubes is mandatory, in the first-mentioned case it is optional. As a practical matter, it may be dispensed with since the voltage to ground, assuming transformer units of equal voltage ratings, is never in excess of the voltage developed in one secondary. To illustrate that the transformer units need not be of the same secondary voltages, the right-hand secondary winding 17 in Figure 6 is shown as comprising more turns than the left-hand secondary, corresponding to say ratings of 7500 and 6000 volts, respectively.

An example of the manner in which series-opposition connections can be used to advantage is illustrated in Figure 7. Therein the polarities of all the secondary windings of the several transformer units are the same. The tubes 35 are all disposed extending in the same direction, with their grounded terminals all at the same end, and their transformer-connected terminals at the other end. In this manner, the tubes may be disposed closely adjacent each other, in order to produce a desired pleasing and effective display, without puncture or rupture of the tubes under electrostatic stress, regardless of the materials from which the tubes are formed. In point of fact, the tubes may actually touch each other, or two or more of them may use a common wall, without detrimental effect on their operation, because the potential difference existing across the wall between the tubes is substantially negligible at any point along the tube length.

For simplicity, it is highly desirable at times to connect the primary coil sections of a number of the transformer units in series across a source of supply. For example, four 110 volt primaries may be connected in series across a 440 volt supply, two 55 volt primaries across a 110 volt supply, etc. In general, it is sufficient, in order to employ this connection safely and advantageously, that the number of transformer units will be so large that upon failure of one secondary winding through open-circuiting, for example, an excessively high voltage will not be induced in remaining secondary windings. Practical operation and economical construction can be obtained, for example, by connecting five or six of my transformer units with their primary windings connected in series. In a typical case, by way of illustration, five 22 volt primary windings or six 18.3 volt primary windings may be successfully operated on a 110 volt circuit. Such

a connection is shown in Figure 8, wherein the five primary windings 16 are connected in series, by leads 27, 28, across a common source of supply 26, of conventional voltage output.

A series connection of the primary windings possesses the advantage of cheapness; but the disadvantage is present that an increase in secondary voltage occurs when one or more secondary coil section becomes inoperative. It is to be understood, of course, that the type of connection employed for the primary coil sections of my transformer units is independent of the type used with the corresponding secondary windings.

Finally, as illustrative of the great flexibility of my new transformer units, and their adaptability to all sorts of practical problems encountered in commercial practice, reference should be had to the construction of Figure 9, wherein is depicted a transformer 36 of multi-coil secondary design, having grounded midpoint, and high potential bushings 37, 38 for leading high potential current from the secondary circuits to tubes 39, 40. Energizing current from source 26 enters transformer 36 over leads 27, 28.

In the instance illustrated, the secondary coil sections of transformer 36 are considered as in series-aiding connection, although a series-opposition relation is perfectly feasible. One secondary transformer terminal 42 is connected through lead 43 to tube 40, while a second terminal 44 is connected through lead 45 to tube 39.

Now by way of illustration, let it be assumed that transformer 36 is rated at say 15,000 volts and can operate say 60 feet of tubing. Let it also be assumed that each tube 39 and 40 is say 33 feet in length, or a total of 66 feet. This is precisely the case recited in an earlier part of the specification. There it was stated that hazard was involved in attempting to operate the 66 feet of tubing by such a transformer. It was also suggested that great loss in investment, economy and efficiency resulted in using, for handling such a load, a second transformer of like rating, or a transformer of the next higher standard rating.

However, the problem is readily solved by the use, in conjunction with the main transformer 36, of one or more comparatively small transformer units according to my invention. Accordingly, a 3000 or 4000 volt or like transformer unit following my new invention is shown as connected at the one end of tube 40 opposite to transformer 36 and in series-aiding relationship with respect thereto. Similarly, a second transformer unit of 3000 or 4000 volts output is connected in series-aiding relationship at the free end of tube 39. In this manner, the lacking voltage is provided with a fair degree of precision, and loss resulting from installation, operation and possible repair of equipment of unnecessarily large capacity, is avoided.

It becomes apparent from the foregoing description that the transformer units according to my invention represent a decided advance in the art, having a lower first cost due to simplicity of tooling and low cost of dies and being subject to comparatively ready servicing or replacement when this is required. The lower production costs make it possible, without increasing the initial cost over known multi-coil secondary transformer installations, to improve the insulation of the secondary coil sections, thereby producing a transformer of longer life and increased durability and ruggedness.

My transformer units, all as pointed out in earlier parts of this specification, possess a flexibility not hitherto known. In various combinations, either among themselves or along with known transformers having multi-coil secondary windings, they can be adapted closely to the requirements of widely varying load conditions.

Since the size and construction of my transformer units make it possible to dispose them closely adjacent the tube assembly or other load, the quantity of high potential cable, and hence the cost thereof, can be reduced to a minimum. At the same time, a tube assembly is produced which is more compact than is hitherto known. Servicing in situ, hitherto accomplished only with difficulty, can, by the practice of my invention, be accomplished with comparative facility. Such servicing has been facilitated by reducing the weight of the transformer units to a minimum.

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 drawings, is to be interpreted as illustrative and not as a limitation.

I claim:

1. In combination, a plurality of luminescent gaseous discharge tubes each having one end thereof grounded; and a transformer at the other end of each tube, each said transformer comprising, a casing, a core including a shunt core portion positioned within said casing, and a single primary coil section, and a single secondary coil section mounted on said core in electrically independent relation and having the shunt portion of the core located therebetween, a first end of the secondary coil section being grounded to earth, and the second end of said secondary coil section being connected to an adjacent outer end of said plurality of tubes.

2. In combination, a plurality of luminescent gaseous discharge tubes connected together, with the electric midpoint of their lengths grounded; and a transformer at each end of said plurality of tubes, each said transformer having a core including a shunt core portion, a single primary coil section and a single secondary coil section mounted on said core in electrically independent relation and having the shunt portion of the core located therebetween, a first end of the secondary coil section being grounded to earth, and the second end of said secondary coil section being connected to the corresponding adjacent outer end of said plurality of tubes.

3. In combination, a plurality of luminescent gaseous discharge tubes disposed side by side, closely adjacent to each other, like ends of said tubes being grounded; a transformer connected to the other end of each said tube, each transformer comprising, a casing, a core including a shunt core portion positioned within said casing, a primary and a single secondary coil section mounted on said core with the shunt portion of the core located therebetween, the said secondary coil sections all being of the same polarity, and one end of each secondary coil section being connected to the adjacent end of a corresponding tube, the other end of each said coil section being grounded to earth.

4. In combination, a plurality of luminescent gaseous discharge tubes connected together; and a transformer at each free end of said plurality of tubes, each said transformer comprising, a casing, a core including a shunt core portion posi-

tioned within the casing, a single primary coil section and a single secondary coil section mounted on the core in electrically independent relation and having the shunt portion of the core located therebetween, first ends of the secondary coil sections being grounded to earth, and second ends of said secondary coil sections being connected to the corresponding free ends of said plurality of tubes.

5. In combination, a main transformer having a secondary winding, the midpoint of which is grounded; two luminescent gaseous discharge tubes of voltage demand substantially in excess of one-half of the rated voltage of said main transformer and each connected at one end to an outer end of said secondary winding; and two additional transformers of rated voltage approximately that required to supply the excess of voltage demanded over the rated voltage of the main transformer and each having a core including a shunt core portion, a primary and a single secondary coil section mounted on said core in electrically independent relation and having the shunt portion of the core located therebetween, one end of which latter being grounded, and the other end of which being connected to the free end of one of said tubes in series-aiding relationship with respect to the main transformer.

6. The combination of a plurality of luminescent gaseous discharge tubes connected together in series; and a transformer at each free end of the plurality of tubes, each said transformer comprising a core including a shunt core portion, a primary and a single secondary coil section mounted on the core in electrically independent relation and having the shunt portion of the core located magnetically therebetween, one end of said secondary coil section being grounded to earth, the other end of the secondary coil section being connected to a corresponding free end of the plurality of tubes, the polarities of the secondary coil sections with respect to each other being such that series-aiding relationship is ensured.

7. In combination, a plurality of luminescent gaseous discharge tubes each having one end thereof grounded; and a transformer at the free end of each said tube; each said transformer comprising, a core including a shunt core portion, and a single primary coil section and a single secondary coil section mounted on said core in electrically independent relation and having the shunt portion of the core located magnetically therebetween, one end of said secondary coil section being connected to ground, and a second end thereof being connected to a free end of one of said tubes.

8. In combination, a luminescent gaseous discharge tube, a unitary transformer disposed for connection to one end of said tube, and a separate unitary transformer disposed for connection to the other end of said tube; each said transformer having a core including a shunt core portion, a single primary coil section and a single secondary coil section mounted on said core in electrically independent relation and having the shunt portion of the core located magnetically therebetween, a first end of the secondary coil section being grounded to earth, and the second end of the secondary coil section being connected to the corresponding end of said tube.

9. In combination, a luminescent gaseous discharge tube load and transformers corresponding to respective ends of said tube load, each said transformer comprising, a core including a shunt

core portion, a primary winding and a single secondary coil section mounted on the core in electrically independent relationship and having the shunt portions of the core located magnetically therebetween; each said secondary coil section having one end connected with a point of common potential and having second ends connected with the respective ends of said tube load.

10. In combination, a plurality of electrically connected luminescent gaseous discharge tubes; and a plurality of transformers corresponding individually to free ends of said tubes, each said transformer comprising a core including a shunt core portion, a primary winding and a single secondary coil section mounted on said core in electrically independent relationship and having the shunt portion of the core located magnetically therebetween; each said secondary coil section of the transformers having one end connected with

a point of common potential and having second ends connected with the corresponding free ends of said tubes.

11. In combination, a plurality of luminescent gaseous discharge tube loads each having one end thereof connected with a point of common potential; and a corresponding plurality of transformers, each said transformer comprising, a core including a shunt core portion, a primary winding and a single secondary coil section mounted on said core in electrically independent relationship and having the shunt portion of the core located magnetically therebetween, one end of the secondary coil section being connected with said point of common potential and a second end thereof being connected with a free end of one of said tube loads.

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