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LIGHTING SYSTEM AND APPARATUS

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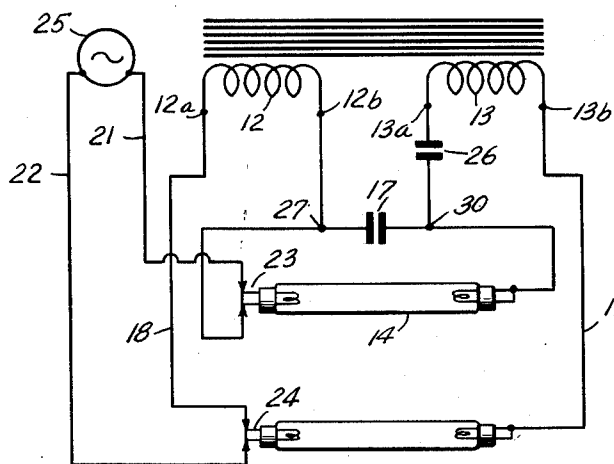


Fig. 1

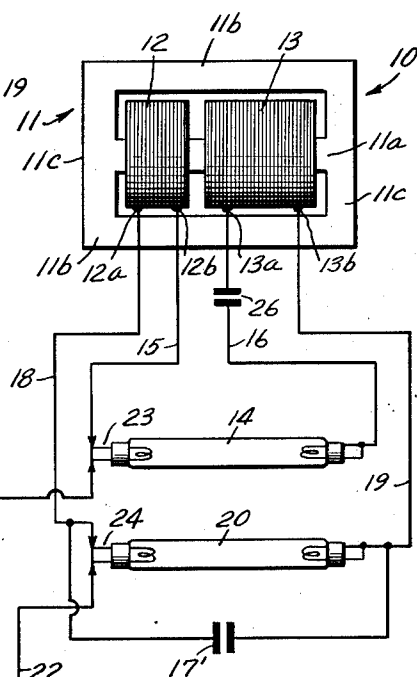


Fig. 3

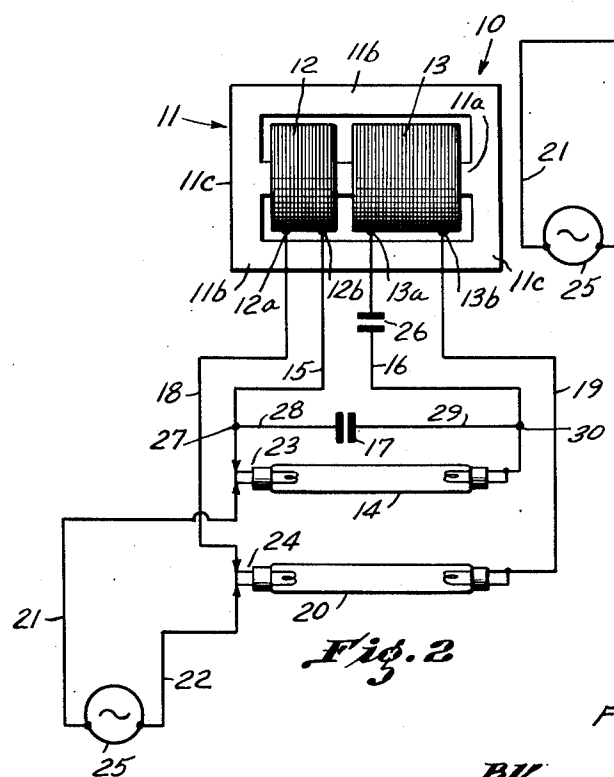


Fig. 2

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LIGHTING SYSTEM AND APPARATUS

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My invention relates generally to the field of illumination, and more particularly concerns gaseous discharge tube lighting systems, especially fluorescent tube systems.

An object of my invention is to provide a gaseous discharge tube lighting system, particularly a fluorescent tube system which instantaneously operates under practically all conditions of indoor and outdoor operation, thereafter remaining stable until the system is de-energized; in which tube removal will cause de-energization of the entire system; in which various safety requirements of the Fire Underwriters are satisfied; wherein current limitation is successfully achieved in simple manner; together with required good system power factor.

Another object is to provide a power unit for the lighting system of the general type just hereinbefore described; which unit is small, compact, unitary and self-contained, of extremely simple external contour; which is rugged, safe and certain under all operating conditions, employing but a minimum of iron and copper, while effectively precluding hazard of system overload; which operates under good temperature regulation; and which is further characterized by its low cost, rapidity and simplicity of construction; the ready manner in which, once assembled, it can be conditioned for operation; and by its long useful life, so that only infrequent repairs are required, simple in nature and easily carried into effect.

These and many other desirable objects and advantages attend upon the practice of my invention; as will be more fully pointed out hereinafter during the course of the following description.

My invention accordingly will be seen to reside in the several parts, elements and features of construction as described herein, the scope of the application of which will more fully appear in the claims at the end of this specification.

In the several views of the drawings, wherein I have disclosed those embodiments of the invention which I prefer at present:

Figure 1 is a wiring diagram of a gaseous discharge tube lighting system according to the practice of my invention;

Figure 2 is a schematic view of the lighting system and apparatus incorporating the wiring diagram of Figure 1; and

Figure 3 is a schematic diagram of a modified form of lighting system and apparatus according to my invention.

Like reference characters denote like parts throughout the several views.

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As conducive to a more thorough understanding of my invention it may be noted at this point that considerable time and effort has been devoted in the art, to the production of fluorescent tube lighting systems wherein a plurality of tubes are rapidly and certainly brought into operation under prevailing and available voltage supplies, and this regardless of variation in, and the existence of extremely adverse, weather conditions.

Because of the competitive nature of the art and the small margins of profit which are available, and because of the necessity that substantial operational advantages exist to justify replacement of existing incandescent lighting systems of fluorescent tube lighting, it is essential that such systems, in addition to possessing the several advantages hereinbefore referred to, as well, display the features of initial low cost, and sturdiness and reliability in operation. In short, the requirement must be satisfied that such equipment is capable of production through the use of assembly-line methods, so that following production, but little if any specialized attention will be required to condition a particular system for actual operation.

For one reason or another, known fluorescent tube lighting systems, and as well, known power units, have not satisfied all of the foregoing. To illustrate, one system employs a transformer having two or more secondary windings. This immediately increases the complexity of design of the transformer, and as well, increases its physical dimensions, the quantity of iron required and the amount of copper employed. The cost increases. Moreover, the use of such a transformer has required the provision of high leakage reactance air gaps. These immediately increase both the complexity of design, the initial cost of materials, and as well, the amount of test board work which is required in adjusting the transformer for its particular service, following initial assembly of the transformer parts.

In another a closely coupled transformer is employed but with choke coils or similar current-limiting means to effect current control. It is recognized that in many instances this is a practical disadvantage when measured from the standpoint of cost. The choke coils are expensive and add to the size and weight of the power unit.

It is an important object of my invention, therefore, to provide a gaseous discharge tube lighting system and apparatus in which the aforementioned objectives are achieved and which in large measure avoid the several disadvantages hereinbefore referred to.

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Briefly stated, my invention comprises two fluorescent discharge tubes of generally like rating, connected electrically in series with each other. To energize these, I employ a close-coupled transformer. This may be either of the shell-type or the core type. Preferably, I employ a shell-type core symmetrical in construction and formed of the usual laminations. While it is entirely possible to employ ordinary transformer connections with separate primary and secondary windings, I prefer, to achieve economies in the quantity of copper employed, to connect these windings in autotransformer connection and to the tube in series.

An important part of my invention is to make provision that the arcs will be struck across the tube almost instantaneously, and this at a voltage approximately that of one tube only. To achieve quick starting and low secondary voltages, I shunt a small capacity condenser across one of the two tubes. The impedance of this condenser being substantially less than that interposed by the initially high resistance of the associated fluorescent tube, the current initially transverses this shunt path, by-passing the associated tube, and thus contributes to the build-up of potential across the terminals of the second tube to almost the full secondary terminal voltage. Instantaneously the arc is struck across this second tube. Current commences to course the secondary system.

As soon as conductive current flow is established across the one tube, the negative resistance characteristic of this tube brings about an important decrease in the voltage drop thereacross. Substantially all of the secondary voltage is now made available across the terminals of the first tube, so that the arc is quickly struck across that tube. Both tubes are thus brought into operation in practically instantaneous manner. The impedance interposed by the ohmic resistance across this first tube is now lower than that interposed by the by-pass condenser, so that for all practical purposes, the latter is effectively shunted out of the system operation.

I provide a condenser of substantial size in one leg of the secondary circuit in order to limit the flow of current in the transformer and tubes. Such current-limiting condenser, moreover, serves the further highly advantageous function of restoring to within permissible operational limits the basically lagging system power-factor resulting from the inductive nature of the transformer.

As a refinement of my invention, and to satisfy the requirement of the Fire Underwriters, I contemplate the provision of short-circuiting lamp holders or sockets at one end of each tube and so connect these with the primary winding of the transformer that upon the removal of either lamp from its corresponding sockets, the primary circuit of the lamp will be interrupted.

It will be noted from the foregoing that should that tube across which the by-pass condenser is shunted, fail for any reason, the system will continue in operation without appreciable electrical disturbance, inasmuch as the by-pass condenser will effectively substitute for the disabled tube, for all electrical purposes. Should the second tube, however, be disabled, the entire secondary system will go out of operation. Upon failure of either tube, the primary circuit remains energized. It is only upon removal of either tube that, in accordance with the prac-

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tice of my invention, the primary circuit is de-energized.

And now referring more specifically to my novel gaseous discharge tube lighting system, attention is directed to the several views of the drawings wherein I disclose a shell-type transformer indicated generally at 10. While I disclose and prefer to use a shell-type transformer core, it is within the province of my invention to employ a core-type transformer. The shell-type core, indicated generally at 11, comprises a central leg 11A and paired outer legs 11B, 11B, closed by end pieces 11C, 11C in close-coupled relation, and without the interposition of any high reluctance leakage barriers. I provide a primary winding and a secondary winding, indicated at 12, 13, respectively.

It will be seen from the foregoing that fundamental simplicity is achieved in the design of my transformer. The number of component parts is small, and these parts are quite simple. The iron content is reduced to a minimum, while at the same time provision is made for ready coursing of adequate flux throughout the transformer core, at substantially under saturation value.

By connecting the transformer windings in auto-transformer connection, important savings are achieved in amount and cost of copper employed, and this without appreciable sacrifice in system performance. To this end I provide the primary winding with terminals 12A, 12B, while the secondary winding is provided with terminals 13A, 13B. The terminals 12A, 13A, disposed physically adjacent each other, constitute one pair, while the terminals 12B, 13B physically remote from each other, constitute a second pair.

Across the paired terminals 12A, 13A, and by means of leads 15, 16, I connect a fluorescent tube 14. Preferably, and as is shown in the present embodiment, I provide the tube 14 of the hot-cathode type, to facilitate ready striking of the arc at comparatively low terminal voltages, and under adverse operating conditions. It is entirely within the purview of my invention, however, to employ cold-cathode tubes where desired, thereby achieving greater sturdiness and longer life. Across the leads 15, 16, and shunting tube 14, I provide a condenser 17 of low capacity rating, say in the order of 0.5 microfarad capacity. The function of this condenser will be disclosed at a later point herein.

While I have shown the by-pass condenser 17 as shunted across the tube 14, disposed between the physically adjacent terminals 12A, 13A of the transformer primary and secondary, this is by no means mandatory; it is equally within the contemplation of my invention to insert the condenser 17 across the tube 20 as indicated generally at 17' in Figure 3.

It is within the contemplation of my invention that an ohmic resistance be inserted in the stead of the by-pass condenser 17. Experience has disclosed, however, that where an ohmic resistance is employed, and for any reason the associated tube 14 fails, then the full voltage which theretofore existed across tube 14 is impressed across the by-pass resistance, so that this latter is soon burned out, unless it be designed for the passage of heavy current. To construct the resistor to handle such heavy currents results in a product which generally is considered initially too costly and which is too bulky for operation. Such a resistance would have to be in the neighborhood of 50,000 ohms. A physically large re-

resistor is definitely impractical. An ohmic resistor of smaller dimensions would be complicated by the requirement of some auxiliary protection, such, for example, as a fuse. All in all, therefore, the use of a by-pass condenser is definitely indicated, in preference to an ohmic resistance.

Across terminals 12B, 13B, as by leads 18, 19, I insert, in series-connection, a second fluorescent tube 20. This fluorescent tube is of the same type and commercially the same rating as the tube 14.

The primary winding 12 is energized from any suitable source 25 of primary service say of 110 or 220 volt rating, by means of leads 21, 22 connected to lead 15 and to lead 18, respectively, and thence to primary terminals 12A, 12B. Included in this circuit preferably are shorting type lamp holders or sockets 23 and 24 for tubes 14 and 20 respectively.

The connection of the tube sockets, as conveniently illustrated, is such that upon the insertion of the tube within the socket, a break theretofore existing in the primary circuit is closed, and remains closed so long as the tube is carried within the socket. Upon the removal of either tube from its corresponding socket, however, the primary circuit is again interrupted, so that the system stands de-energized. To illustrate, upon removal of tube 14 from socket 23, a break occurs in the lead 21, 15 to terminal 12A, and the primary circuit is de-energized. Similarly, upon removal of tube 20 from its corresponding socket 24 a break occurs in the lead 22, 18, and the primary circuit is again de-energized. Thus, the system is fool-proof so far as concerns the removal of either tube, and the requirements of the Fire Underwriters are satisfied in this respect.

It will be noted from the foregoing that no provision has been made in the transformer as heretofore disclosed for the introduction of some high leakage reactance or other current-limiting means. Because of the negative resistance characteristics of the tube, therefore, it would appear that without more, the current build-up in the system would reach damaging values. The simplification of the transformer construction as heretofore described is made possible, however, by the introduction into the system of a current-limiting condenser 26. This condenser 26 also tends to introduce a leading component into the quadrature geometry of the basically lagging power-factor, and tends to restore the same sufficiently towards unity value as to be within permissible limits.

In operation of my system, for an assessed half-cycle of the supply, primary current flows to the left (Figure 2) from source 25, through lead 22, short-circuiting terminal 24, lead 18 to terminal 12B of primary winding 12. The primary current then courses to the right in Figure 2 across the primary winding 12 and then across terminal 12A, lead 15, short-circuiting terminal socket 23, and lead 21 to the right-hand side of the primary energizing source 25.

When the primary winding 12 is first energized, the arcs across the tube 14 and 20 are not yet struck. In operation the arc across the tube 20 will first be struck inasmuch as the design of my new system is such that substantially all of the secondary output voltage is first impressed across the terminals of this tube. Thereafter, following striking of the arc thereacross, sub-

stantially all of the secondary terminal voltage is impressed across the tube 14.

For the given half-cycle of current flow the initial secondary circuit may be traced, illustratively, from primary winding 12 to the left across terminal 12B, lead 18, short-circuiting socket 24, tube 20, lead 19, terminal 13B, across secondary winding 13 to terminal 13A, then lead 16 and current-limiting condenser 26, to junction 30. There, because of the lower impedance of by-pass condenser 17, the larger part of the secondary current courses lead 29, by-pass condenser 17 and lead 28 to junction 27 and thence back through lead 15 and terminal 12A to the point of beginning. In this manner substantially the entire secondary voltage is impressed across the tube 20.

Upon ignition of tube 20, the resistance sharply falls. Current flows through the tube limited only by the system current-limiting means 26. The voltage drop thereacross likewise diminishes substantially. Substantially the entire secondary voltage is now impressed across the terminals of the tube 14. The arc across tube 14 thereupon strikes after the passage of but a few additional cycles of secondary current flow. Upon the occurrence of the sharp decrease in the ohmic resistance of tube 14 in its energized condition, its total impedance becomes substantially less than that of the by-pass condenser 17, so that the arc discharge is maintained across both said tubes until the system becomes de-energized for any reason, as by opening the line switch, removal of either tube, or failure of the tube 20.

With stabilized operating conditions, after initial striking of the arcs, the flow of output current for the assessed half-cycle is from the left-hand end of primary winding 12, across terminals 12B and lead 18, short-circuiting socket 24, tube 20, lead 19, to the right-hand terminal 13B of secondary winding 13, lead 16, current-limiting condenser 26, across junction 30, and through tube 14 to short-circuiting socket 23. Thence the current flows up and across the lead 15 and junction 27 to the right-hand terminal 12A of primary winding 12 and thence across this winding to the point of beginning.

For the reverse half-cycle of primary current flow, and corresponding reverse of secondary current, the flow is in the opposite direction.

While as noted above, condenser 26 is illustratively introduced into the lead 16 connecting the right-hand terminal of tube 14 (Figure 2) with the terminal 13A of secondary winding 13, it may be inserted in lead 19, in lead 15, or in lead 18. The capacity of this condenser is nicely chosen of such rating as will represent the best practical compromise between the required current limiting impedance and the required correction necessary to restore the system power factor to within permissible limits. Illustratively, I have found highly satisfactory operation to attend upon the use of a condenser of approximately 1.75 microfarads capacity.

Reliance on the condenser 26 as the current-limiting means has made possible extreme simplification of transformer design as has been suggested hereinbefore, attended by the substantial elimination of test board operation after initial assembly. In particular, the adjustment of the high leakage reactance shunts as included in transformers heretofore frequently employed, is eliminated. Heretofore it has been necessary to place each unit on a test board to calibrate the

same to rated reluctance. This necessity results from variation in thicknesses of the laminations of which the transformer cores are comprised, resulting from permissible manufacturing tolerances. Illustratively, while say twelve laminations may be required in one assembly to achieve a rated reluctance, thirteen laminations may be required in another assembly in order to lower the reluctance of the air-gap to the required value.

It has heretofore been pointed out that an important feature of novelty resides in the fact that in the use of my new system, tube failure is not necessarily accompanied by de-energization of the system. The further important advantage has been alluded to, that upon tube failure with the system being retained in operation, no possibility exists of damage to the component system parts. In this connection reference to Figures 1 and 2 will show that upon failure of tube 14, with consequent extinguishment of the arc thereacross, there remains a conductive path across the by-pass condenser 17. This shunt circuit, now constituting part of the main secondary circuit, interposes a secondary impedance somewhat greater than theretofore existed and thereby imposes an additional limitation on the effective secondary current which can flow. Additional protection is thereby afforded to the tube 20, which remains energized and in operation, with the arc remaining struck thereacross. However, upon failure of the tube 20, then since there is no by-pass condenser about this tube, and since the tube is introduced in series-connection in the secondary circuit, the entire secondary circuit will become de-energized, although the primary circuit will remain closed.

The further highly advantageous feature exists, moreover, as provided for by my use of short-circuiting sockets 23, 24 for the tubes 14, 20, respectively, that upon removal of either tube from the socket, the primary circuit is thereby broken, so that the entire system stands de-energized.

A further important feature of my invention is the very compact power unit which is made possible by the practice of my invention. To insure this construction the transformer 10 is of minimum size since no shunt is employed and the voltage required is only approximately that for one tube. Moreover, the by-pass condenser 17 and the current limiting condenser 26 preferably are found in a single container; this appearing as a single condenser with terminals for the small capacitor and others for the large capacitors. Where desired, however, separate individual condensers may be used.

I arrange the transformer and condensers in juxtaposed position, snugly fitting within an outer casing or housing contoured and proportioned for snugly receiving these elements. The power unit is therefore of smallest possible compass, and can be handled as a single element.

By the employment of my new construction, it is made practical to obtain satisfactory system operation which attends the use of transformer powering equipment. At the same time the complexity of the transformer design is reduced to a minimum, and the costs thereof likewise minimized. Quick starting is achieved under the most adverse operational conditions, including outdoor service under damp, frigid weather conditions. The system is absolutely fool-proof in that upon removal of either tube from the socket, the primary energizing system is broken. Failure of either tube interposes no serious hazard

in that when one such tube fails for any reason, the entire secondary system is de-energized, while should the other tube fail, the secondary impedance is slightly increased and the remaining tube continues in operation. This has been verified by removing the tubes while maintaining the primary circuit closed through the corresponding socket.

Simplification of transformer design removes any requirement of adjusting the shunts of the high leakage reactance transformers heretofore employed. At all times the current is maintained within safe limits through the use of a current-limiting condenser. This condenser not only serves for its intended purpose, but as well, corrects the system power factor to within permissible limits. It is observed that the introduction of this condenser into the system is not accompanied by any adverse resonance peak potentials, wave form being entirely satisfactory.

Through the use of my new system, series-connected tubes can be both initially started and subsequently operated from a single transformer, while complying with all requirements of the Fire Underwriters and operating from readily available service supplies of usual voltage ratings. A compact power unit is made possible, with substantial savings in both iron and copper. From the standpoint of method, simplified starting and subsequent operation of the tubes is made possible.

Since many embodiments of my invention will readily suggest themselves to those skilled in the art, and since many modifications of the present embodiment will likewise occur, once the broad aspects of my invention are disclosed, I intend that the foregoing be construed as simply illustrative, and not by way of limitation.

I claim as my invention:

1. A fluorescent tube lighting system, comprising a close-coupled transformer having a primary winding adapted to be connected across a source of alternating current supply of predetermined frequency and a secondary winding, a positive column fluorescent gaseous discharge tube connected between one end of said primary and one end of said secondary windings, a second positive column fluorescent gaseous discharge tube connected between the other ends of said windings and placing said primary winding, said secondary winding and said two tubes in series connection, a by-pass condenser shunting one of said tubes, and a power-factor correcting condenser in series with both of said tubes.

2. A fluorescent tube lighting system, comprising a close-coupled transformer having a primary winding adapted to be connected to a source of alternating current supply of predetermined frequency and a secondary winding, a pair of series-connected positive column fluorescent gaseous discharge tubes of generally like rating connected across said transformer, one being connected between one end of each of the windings and the other being connected between the other ends of the windings, a capacitive reactance shunted about one of said tubes, and two short-circuiting sockets for receiving said tubes and connected in series with the primary winding of said transformer and with the connection to said source to break the primary current upon removal of either of said tubes.

3. A fluorescent tube lighting system, comprising a close-coupled transformer having a single primary winding adapted to be connected to a source of alternating current of predeter-

mined frequency and a single secondary winding, a positive column fluorescent gaseous discharge tube connected between one end of each of said two windings, a second positive column fluorescent tube connected between the other ends of said windings, a by-pass condenser connected in shunting relation across one of said tubes, a power-factor connecting condenser connected in series with both of said tubes, and short-circuiting sockets in which said tubes are received, one socket of each tube being connected in series with the primary winding of the transformer.

FREDERICK H. SKROTZKI. 15

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