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LUMINESCENT TUBE SYSTEM AND APPARATUS

Filed Aug. 12, 1943

2 Sheets-Sheet 1

FIG. 1.

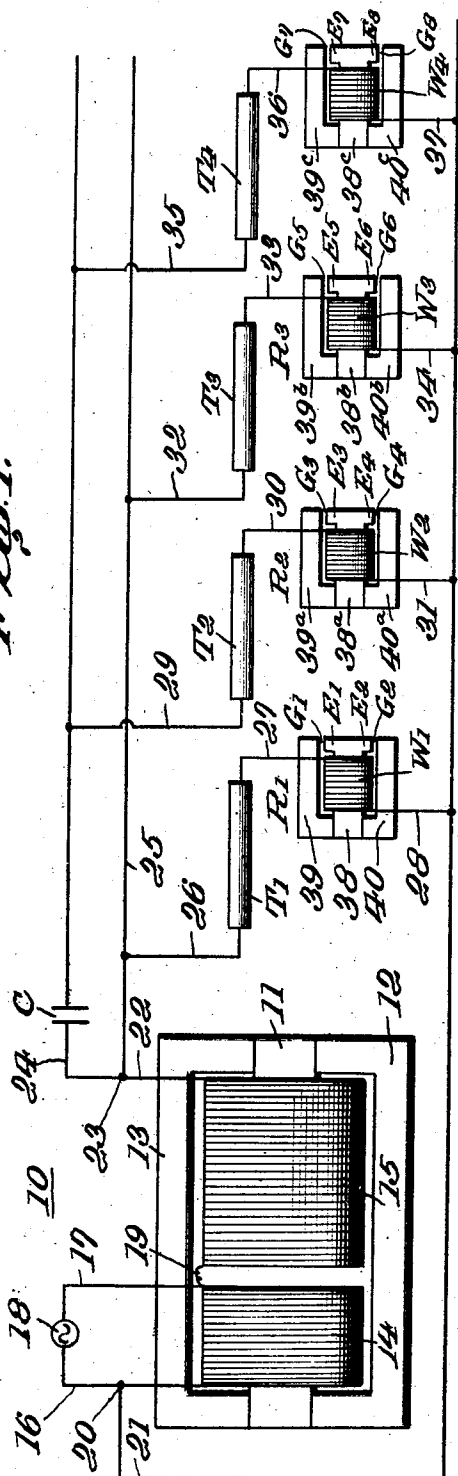
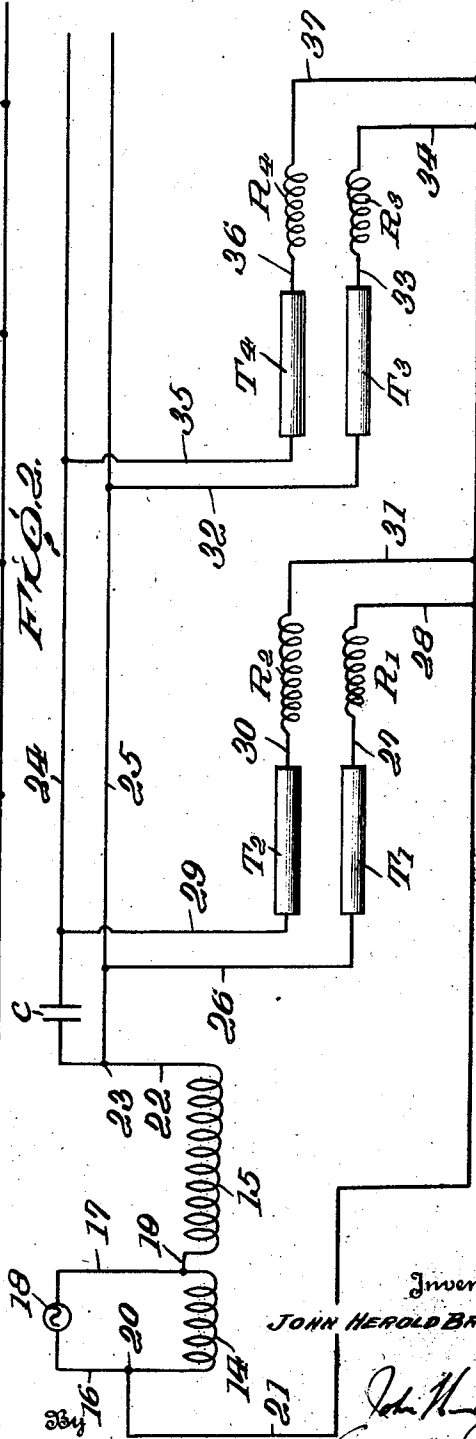


FIG. 2.



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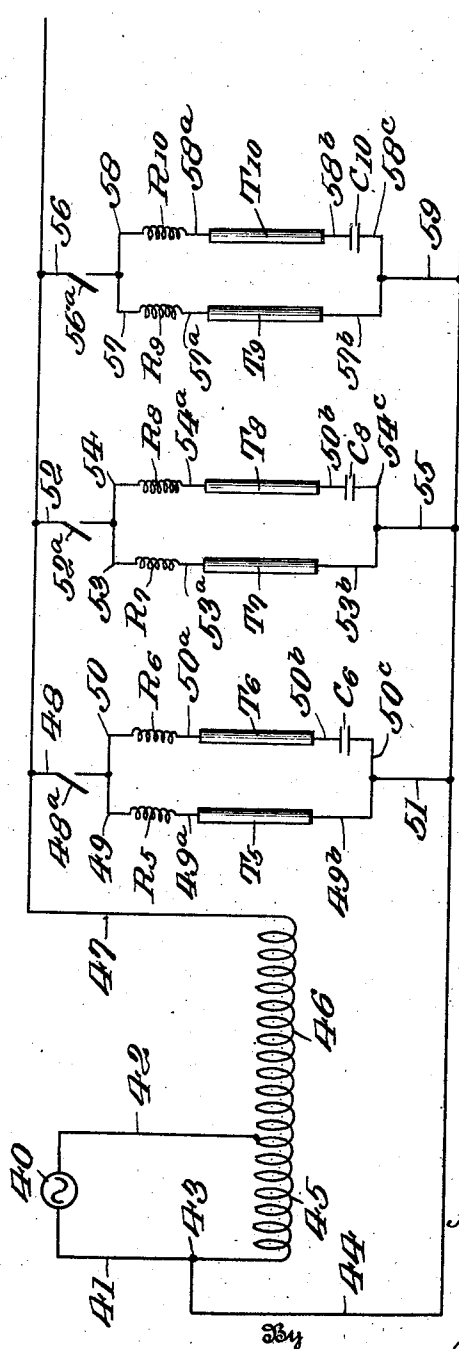
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2 Sheets-Sheet 2

FIG. 3.



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LUMINESCENT TUBE SYSTEM AND APPARATUS

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mesne assignments, to National Inventions
Corporation, a corporation of New Jersey

Application August 12, 1943, Serial No. 498,344

3 Claims. (Cl. 315—257)

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My application is a continuation in part of my copending application Serial No. 469,365 of December 17, 1942, entitled Luminescent tube system and apparatus, which issued January 7, 1947, as United States Patent No. 2,413,681, and the invention relates in general to electric lighting systems and more especially concerns luminescent tube systems of illumination and apparatus therein.

The object of my invention is the provision of a safe, reliable and highly practical gaseous electric discharge tube lighting system including a transformer source of electrical energy and a plurality of tubes, which system is characterized by thoroughly satisfactory distribution of current to the tubes, by prompt and substantially simultaneous energization of the tubes, in which there is displayed but little stroboscopic effect, and which during operation has an exceedingly good power factor.

Another object of my invention is the provision of a gaseous electric discharge tube lighting system including a single-transformer source of electrical supply, which system is especially adapted for operating four up to as many as ten or more included light tubes, which achieves highly effective control over the tube-energizing current, and which is capable of continued operation in a safe and efficient manner despite failure of one or more of the plurality of included tubes.

Other objects will in part be obvious and in part pointed out hereinafter in connection with the following description taken in the light of the accompanying drawing.

In the accompanying drawing

Figure 1 represents a gaseous electric discharge tube lighting system including certain features of my invention, while;

Figure 2 is a diagram of the circuit employed in Figure 1 and additionally illustrates an advantageous grouping of tubes, and;

Figure 3 depicts a modified form of system in accordance with my invention.

As conducive to a clearer understanding of certain features of my invention, it may be noted at this point that gaseous electric discharge tube lighting systems are today in wide acceptance in various fields of illumination where incandescent lighting systems formerly were employed. There are numerous advantages which more than justify the employment of such lighting systems, among these being characteristically low power consumption, coolness of operation, simplicity, sturdiness, improved dissemination of light, and

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wide choice in the physical form of tube or tubes employed. A number of different physical dispositions or arrangements, moreover are possible in obtaining desired lighting effects as in factories, stores, and private homes; and the use of a variety of fillings such as fluorescent salts on phosphorus as active ingredients of the tubes enables the provision of a number of different colors of light.

Although, as pointed out, there has been wide acceptance of gaseous electric discharge tube lighting, many of the systems present features which for practical reasons are not wholly desirable: Certain of the systems essentially operate at low voltages and the tubes require preheating before initial starting is successfully achieved. These systems usually include a heater circuit and switchover mechanism which, as appurtenances, represent items of expense and a source of possible trouble in operation. A further objection exists in that the tubes flicker during the preheating period and considerable delay occurs before steady operation is achieved. Hot cathode tube systems also are found to be unstable in operation at low temperatures, such as under temperature conditions frequently encountered in outdoor use.

In certain heretofore known gaseous electric discharge tube systems of the multi-tube type, failure of one or more of the included tubes disrupts further operation until full and proper replacement of the worn out tubes is made. This latter objection is notable particularly in lighting systems which include a single transformer source of power and a plurality of tubes connected in series with each other and with the source of power. Such systems also require an increase in operating potential where the number, size, or length of tubes is increased. On the other hand an upper limit on voltages is imposed by the fire underwriters and thus the number of tubes employed as well as the dimensions thereof are sharply curtailed.

There too, are multi-tube systems wherein the tubes are connected in parallel across a source of electrical supply. In these systems lower operating potentials are made possible than should series connection of tubes be employed. There is, however, a tendency in such systems for an included tube of low starting potential or of high conductance to draw such a large part of the load current available that other included tubes either fail to start, or when they do start, draw such low currents that the current densities are whol-

ly insufficient to produce the desired brilliant glow.

Still another objectionable feature, commonly termed stroboscopic effect, is encountered in gaseous electric discharge tube lighting. Stroboscopic effect is a rapid, pulsating effect of the light emitted and gives the impression of unsteady illumination. It is quite tiring to the eyes, very discomfoting, and in all is wholly undesirable.

One of the outstanding objects of my invention, accordingly, is the provision of a system of illumination including a plurality of gaseous electric discharge tubes and a single transformer source of electrical supply, in which system continuous operation of the tubes is not disrupted by failure of one or several of the tubes, in which all tubes promptly reach substantially full conductance and brilliance and give a stable quality of illumination in and after starting, and in which a maximum length of tubing is safely and efficiently operated.

Referring now to the general practice of my invention, I provide an electrical illuminating system which comprises a step-up transformer, and a plurality of gaseous electric discharge tubes, advantageously eight to ten or more, or even as few as four tubes individually connected in parallel circuits with a single output source of the transformer. Each tube circuit includes an inductive reactance, and a gaseous electric discharge tube connected in series. One or more of the tube circuits, such as alternate circuits additionally include a condenser connected in series with the tube and inductive reactance. The inductive reactances preferably are of such type as is more fully pointed out hereinafter.

As illustrative of the practice of my invention in Figure 1 of the drawing there is shown an electric lighting system comprising a shell-type step-up transformer 10 having an inner core portion 11 flanked on opposite sides by C-shaped outer core portions 12 and 13. The transformer core is made of paramagnetic material such as of laminated iron. The inner portion of the core preferably has a cross-sectional area substantially twice as large as either of the outer core portions.

In assembled condition the transformer core provides two main magnetic circuits on flux paths mutually including inner core portion 11 and respectively including outer core portions 12 and 13. It will, however, be understood that despite certain advantages being achieved through the use of a shell-type transformer, a core type transformer may instead be employed in my lighting system.

The transformer shown includes a primary coil 14 wound for example of heavy gauge wire and disposed about inner core portion 11. Supply leads 16 and 17 extend from an alternating current source of electrical supply 18, conveniently of 110 or 220 volt rating, to opposite ends of the transformer primary coil. A secondary coil 15 also disposed about inner core portion 11 adjacent the primary coil preferably is wound of small gauge wire and possesses such number of turns as to have induced therein a desired stepped-up output voltage. At times I mount the primary and secondary coils on the transformer core in superimposed relationship so as to gain maximum advantage of compactness and savings in materials.

While it is within the province of my invention to employ the transformer 10 as an ordinary transformer with the primary and secondary

windings related only inductively, I prefer to produce the necessary high output voltages by means of autotransformer connection. Thus, in the present embodiment of my invention, I connect adjacent terminals of primary winding 14 and secondary coil 15, such as by lead 19, placing the coils in series-aiding relationship. Then, when current flows from source 18 through primary winding 14, induced magnetic flux courses through the transformer core along the flux paths mentioned hereinbefore. Assume, for example, a momentary flow of primary current through winding 14 from left to right in Figure 1 of the drawing. The flux induced courses from the primary winding to the right along inner core portion 11 linking secondary coil 15 and returning through outer core portions 12 and 13 to the primary winding. A high terminal voltage, accordingly, is induced in the transformer secondary winding, which winding for autotransformer connection consists of the series-connected coils 14 and 15.

In the ensuing half-cycle of primary current the direction of current is reversed and flux courses from the primary winding through inner core portion 11 to the left in Figure 1. The flux, in returning to the primary winding courses to the right along outer core portions 12 and 13 and to the left back through inner core portion 11. The coils 14 and 15 again are linked magnetically and an electromotive force of opposite direction to that resulting from the first half cycle of primary current builds up across the transformer secondary winding.

In the illustrative embodiment of my invention shown in Figure 1, I employ some eight to ten or more, or as few as four fluorescent gas discharge tubes; such as tubes T1, T2, T3, T4, etc.; connected in parallel across the autotransformer windings of transformer 10. One of the parallel tube circuits conveniently is traced from the righthand side of secondary coil 15 over lead 22 to terminal 23; thence over leads 25 and 26, through tube T1; along lead 27, winding W1 of reactor R1, and lead 28; over lead 21 to terminal 20; and thence along lead 16, across coil 14, lead 19 and coil 15 back to the point of beginning.

A second tube circuit is traced beginning at the righthand side of secondary coil 15 over lead 22 to terminal 23; lead 24, condenser C and lead 29 to tube T2, through tube T2, over lead 30, and across winding W2 of reactor R2; over leads 31 and 21 to terminal 20; and thence along lead 16, across coil 14, lead 19, and coil 15 back to the point of beginning.

Tube T3 is energized in a circuit traced from the righthand side of coil 15 over lead 22 to terminal 23; thence over leads 25 and 32, through tube T3; across lead 33, winding W3 of reactor R3, and lead 34; along lead 21 to terminal 20; and across lead 16, coil 14, lead 19 and coil 15 back to the point of beginning.

Another tube circuit, beginning at the righthand end of coil 15, extends over lead 22, through terminal 23 across lead 24, condenser C, and lead 35 to tube T4; thence across tube T4, lead 36 and winding W4 of reactor R4; along leads 37 and 21 to terminal 20; and over lead 16 through coil 14, lead 19, and coil 15 back to the point of beginning.

Still other serially-connected tubes and reactors may be connected across leads 21 and 24 so as to form parallel condensive circuits with the transformer output winding, and/or in parallel across leads 21 and 25 so as not to include the

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condenser C. The tubes of the entire system provided advantageously are grouped or banked such as in pairs of adjacent or contiguous tubes with one tube only of each pair being in a condensive circuit. Other groupings may be used in which at least one tube in condensive circuit is present, even to the extent of all the tubes of the system being in one bank. Each tube circuit may be closed by a separate switch (not shown) or each bank may be controlled through a separate switch, as pointed out more particularly hereinafter with respect to the embodiment illustrated in Figure 3. Where the tubes of the entire system form but one bank, I find advantage in placing alternate tubes in condensive circuits and controlling pairs of adjacent tubes with corresponding switches.

Through the use of a reactor in each of the tube circuits, any tendency for one circuit to draw such high currents that the current density in the remaining circuits is insufficient to produce light at full brilliance, is substantially dispelled. The additional use of a condenser in several of the tube circuits lends an improved power factor to the entire lighting system. Tubes in the condensive circuits, moreover, operate in out of phase relationship with the tubes in the remaining circuits so as to maintain stroboscopic effect of light emitted from the system as a whole at a minimum.

The lighting system is highly efficient in operation and has particular utility where some eight or ten or more gaseous electric discharge tubes, or even as few as four of such tubes, of substantial length, are to be energized. The tubes employed are found to have long life due at least partially to the excellent control over energizing current maintained in the system. With an increased number of tubes in the system, initial installation costs are readily justified, especially when account is given to the cost of installing and maintaining a like number of tubes in accordance with the prior art. By operating on increased number of tubes with a single transformer, as for example, up to 70 inches or more of 25 millimeter tubing, core losses in the system decrease, and operational efficiency increases all the more. The characteristic reduction in stroboscopic effect achieved is enjoyed at full maximum by grouping the tubes so as to obtain blended light from the tubes operating in different phase relationship. One advantageous grouping of tubes is shown diagrammatically in Figure 2 of the drawing where paired tubes in adjacent side by side relationship are connected as in Figure 1 for out of phase operation.

I prefer to use reactors in my lighting system which display little, if any, current controlling action when no-load conditions prevail, but which instantly interpose high reactances when the tube loads are energized and high currents begin to flow.

A reactor, illustrative of the type just mentioned, is indicated generally in Figure 1 by inference character R1. The embodiment shown includes a shell-type core comprising a longitudinal inner core portion 38 having a reactor winding W1 thereon and terminating at one end in oppositely extending transverse portions E1, E2. Outer core portions 39 and 40 extend from the other end of inner core portion 38 around winding W1 to points just short of the ends of extensions E1, E2, respectively. The outer core portions thus form magnetic paths through and around the winding W1, which paths respectively include air-gaps G1, G2, of calibrated high

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reluctance. I prefer to make core portions 39 and 40 of like cross-section and the inner core portion approximately twice as large in cross-section as either of the outer core portions. I also prefer to maintain a symmetrical disposition of all component core legs in the reactor assembly and equal calibration of air-gaps so as to obtain balanced magnetic conditions in the several magnetic paths of the reactor.

Similarly, reactors R2, R3 and R4 comprise inner core portions 38a, 38b and 38c, respectively, and corresponding laterally extending end portions E3, E4; E5, E6; and E7, E8. Reactor windings W2, W3, W4 are mounted on respective inner core portions of the reactors. Outer core portions 39a, 40a; 39b, 40b; 39c, 40c extending from opposite sides of the lefthand ends of the inner core portions, form air-gaps G3, G4; G5, G6, G7, G8 of calibrated reluctance with the laterally extending end portions.

In the present embodiment the reactors R1—R4 are designed for the same or similar tube loads, and one substantially alike in construction. It will be understood, however, that the reactors may possess different current limiting qualities depending, for example, upon the tube loads to be energized in the individual parallel circuits. The reactors also may to good advantage be of the core-type having single magnetic circuits interrupted by an included air-gap of calibrated reluctance.

When the primary circuit of transformer 10, including alternating current source of supply 18, lead 16, primary winding 14 and lead 17, is closed by means of a suitable switch (not shown) an induced voltage is impressed across the transformer output terminals 20, 23. This voltage rises and falls at the same rate as does the current through the primary winding 14 and a tendency exists to develop a flux in the magnetic paths or circuits of the reactor cores. The direction of this flux is such as to induce in the coils W1, W2, W3 and W4, by self-inductance, a voltage tending to oppose the provision of the included air-gaps G1—G8 in the reactor cores the decrease in secondary voltage could reach important values and could appreciably retard the initial energization of the tubes. It is to nullify the effect of the self-induced voltage that the air-gaps G1—G8 are provided.

The tubes thus are energized readily, and a high current tends to flow through the system while the tubes remain energized. As soon as this high current flow is established the reactor coils W1, W2, W3 and W4, however, the conditions in the magnetic circuits of the corresponding reactor cores undergo material change. A high flux is set up in the magnetic core circuits, this flux crossing air-gaps G1—G8 in considerable quantity. A voltage, proportionate to the increased current, is induced in coils W1—W4 to oppose further increase in current through the coils and to limit current flow through the tubes T1—T4.

It will, therefore, be seen that the reactors not only permit substantially full terminal voltage to be impressed across the corresponding tube loads at the time of starting, but seem to counteract the tendency for increase in current flow due to negative resistance characteristics of the tube loads or due to short-circuiting. The air-gaps in the reactor magnetic circuits, I being of such calibrated reluctance as to prevent a substantial amount of no-load flux from passing thereacross and yet not being of such

high reluctance as to prevent an appreciable amount of flux from crossing while the tubes are energized, are instrumental in maintaining the tube-energizing current within safe and properly controlled limits without impairment of the rapid starting characteristics of the tubes.

In Figure 3 of the drawing a somewhat modified lighting system in accordance with any invention is illustrated. The system is particularly useful where a plurality of light sources controlled by separate switches are needed as in auditorium or stage lighting or in illuminating a number of rooms of a building. A step-up transformer 40, such as autotransformer having a primary winding 45 and a secondary winding including coils 45 and 46, is employed for energizing some eight to ten or more or even as few as four gaseous electric discharge tubes, illustratively tubes T5—T10, connected in parallel with the transformer secondary winding. The tubes preferably are arranged in remotely spaced or contiguous banks, each bank comprising two or more tubes, such as tubes T5—T6, T7—T8 and T9—T10. At least one tube of each bank, as one of tubes T6, T8 and T10, is provided with an energizing circuit which includes condenser and reactor means; and at least one other tube, as one of tubes T5, T7, and T9 is controlled by reactor means without the aid of a condenser. The tubes in each bank advantageously are grouped together as in side by side relationship illustratively in a fixture having a suitable reflector, and are controlled by switch means, as for example one of the switches 48, 52 or 56, independently of tubes in the other banks.

In the embodiment system illustrated in Figure 3, a secondary circuit may be traced from the righthand side of coil 46 over leads 47 and 48 including switch 48a; lead 49 through reactor R5, lead 49a, tube T5 and leads 51, 44 to junction 43, and thence along lead 43 through autotransformer coils 45 and 46 back to the point of beginning. A parallel circuit is traced from the righthand side of coil 46 across leads 47 and 48 including switch 48a, lead 50, reactor R6 lead 50a, through tube T6 and over lead 50b, through condenser C6, leads 50c, 51 and 44 to junction 43, and along lead 41 and through coils 45 and 46 back to the point of beginning.

Likewise, parallel circuits are closed across the transformer output line 44, 47 through lead 52 including switch 52a, first along lead 53, through reactor R7, lead 53a, across tube T7 and through lead 53b and lead 55; and, secondly, along lead 54b through condenser C8 and across leads 54c and 55.

Similarly, two other parallel circuits are closed across the transformer output leads 44, 47, first through lead 56, including switch 56a, across lead 57 and reactor R9, thence over lead 57a and through tube T9, and over leads 57b and 59; and, secondly, by way of lead 56 including switch 56a, lead 58 and reactor R10, thence across lead 58a and tube T10, along lead 58b through condenser C10, and leads 58c and 59, respectively.

While the tubes in the several parallel circuits may be energized from the transformer secondary winding through individual switches in each energizing circuit, particular advantage is gained by energizing the tubes in banks including out of phase tubes through a switch corresponding to each bank as a whole. Thus when a particular switch is closed, out of phase

operation is insured and light emitted from the energized bank is substantially free of stroboscopic effect.

The gaseous electric discharge tubes which I employ in my lighting systems preferably are cold-cathode tubes such as hot-cathode tubes adapted for cold-cathode operation. In this connection it should be noted that ordinary hot-cathode tubes are readily available on the market, while at this stage of the art standard cold-cathode tubes are available only on special order. I, therefore, find advantage in shunting the terminals of hot-cathode tubes so as to adapt the tubes for cold-cathode operation. So employed, the tubes display long life and thoroughly satisfactory light-emissive qualities. I also prefer to employ tubes lined with a fluorescent coating or phosphor and filled with a gas such as neon, argon, helium, or the like, with or without mercury vapor.

In my lighting system the particular parallel network distributes higher operating voltages for given output voltage than does the conventional series connection heretofore employed. The tubes strike extremely rapidly and give off a steady light during operation even where cold weather conditions prevail. I find that in using a high secondary terminal voltage of, for example, 550 or 600 volts, which still is within the limits permitted by the fire underwriters for autotransformer equipment, a maximum length of tubing is quite successfully energized.

Thus it will be seen that with my invention there is provided a system of illumination in which the objects hereinbefore noted, together with many thoroughly practical advantages, are successfully achieved. It will be seen that a single transformer output source is used in supplying energizing current to a plurality of gaseous electric discharge tubes in several parallel circuits, and that the voltage in the several circuits is not only high but of substantially uniform value. It will further be seen that the particular choke-condenser principles employed lend to prompt energization of the tubes, a steady character of illumination substantially free of stroboscopic effect where the tubes are closely grouped as hereinbefore described, and a highly satisfactory power factor; and that the system is adapted for operating a maximum length of included tubing and capable of safe, continued operation despite the failure of one or more of the several tubes.

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. A gaseous electric discharge tube lighting system, comprising in combination, a transformer; at least four gaseous electric discharge tubes; a connection from one side of said transformer to the one ends of said tubes; two connections from the other side of said transformer, one being connected to the other ends of one half of said number of tubes and the other being connected to the other ends of the other one half of said number of tubes; current-limiting self-inductances corresponding in number to said number of tubes, each of said inductances having a magnetic core with included air-gap, individually connected in series with said tubes; and a

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condenser connected in series with one of said two output leads for effecting a phase shift with respect to the other of said output leads.

2. A gaseous electric discharge tube lighting system, comprising in combination; a transformer having a primary winding and a secondary winding; at least two pair of closely disposed gaseous electric discharge tubes; and a corresponding number of pairs of parallel circuits interconnecting said pairs of tubes with said transformer secondary winding; each of said pairs of parallel circuits including a pair of reactors having magnetic cores with included air-gaps with inductive windings respectively connected in series with the corresponding pair of tubes, and one of each pair of parallel circuits additionally including a condenser in common for effecting a phase displacement with respect to the remaining two circuits.

3. Apparatus for operating at least four gaseous electric discharge tubes, comprising in combination; a transformer having a primary winding

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and a secondary winding; at least four individual parallel circuits connected with said transformer secondary winding, each of said parallel circuits including an individual current-limiting self-inductance having a magnetic core and an included air-gap; and a condenser in common with one half the number of said individual parallel circuits and in series therewith for effecting a phase shift with respect to the other one half.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,298,935	Freeman	Oct. 13, 1942
Re. 20,142	Boucher	Oct. 27, 1936
1,926,423	Barclay	Sept. 12, 1933
2,050,135	Tour	Aug. 4, 1936
2,025,471	Osborne	Dec. 24, 1935