

Feb. 24, 1948.

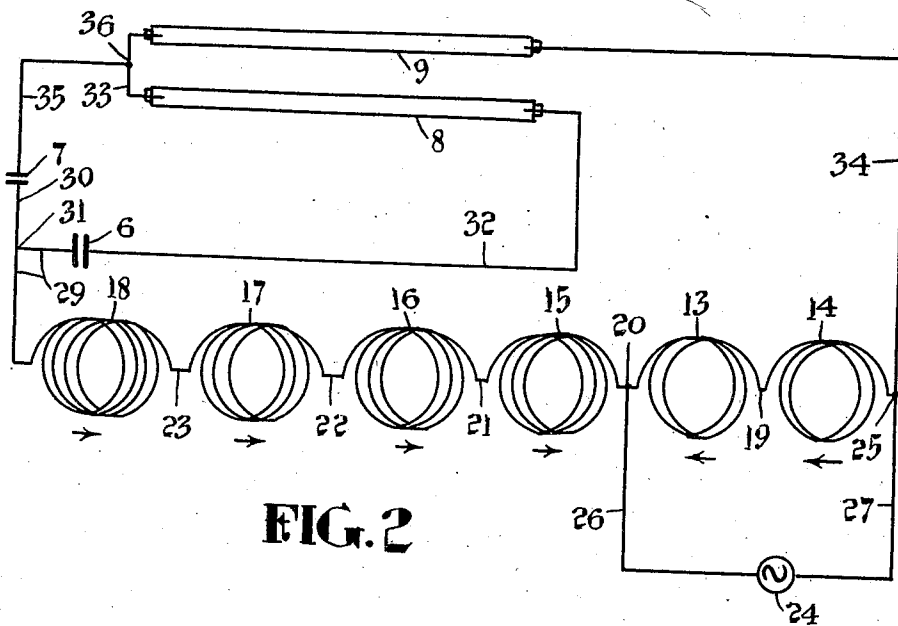
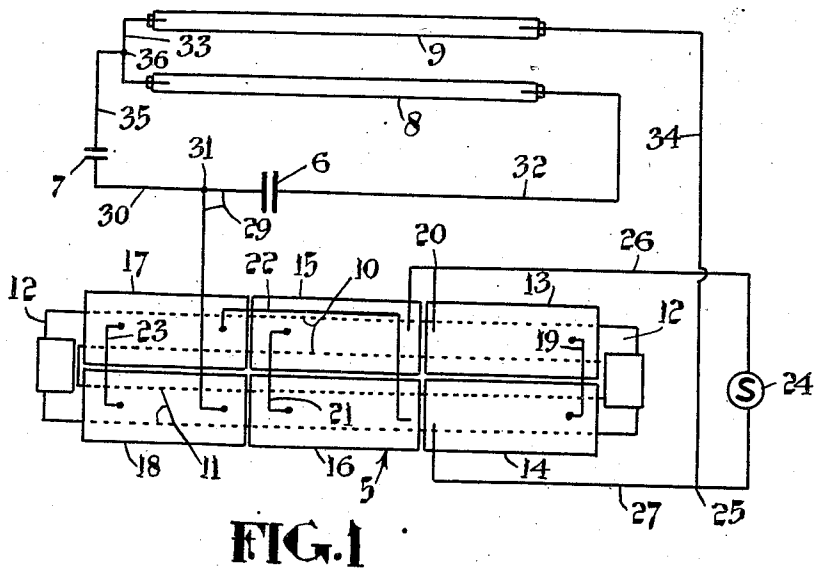
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2,436,400

FLUORESCENT TUBE LIGHTING SYSTEM

Filed March 20, 1947

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

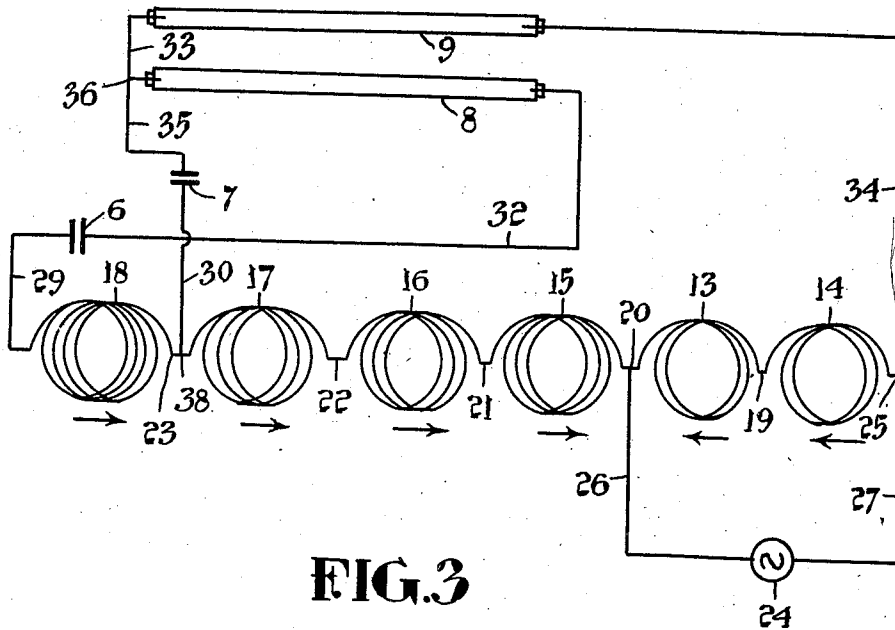


FIG. 3

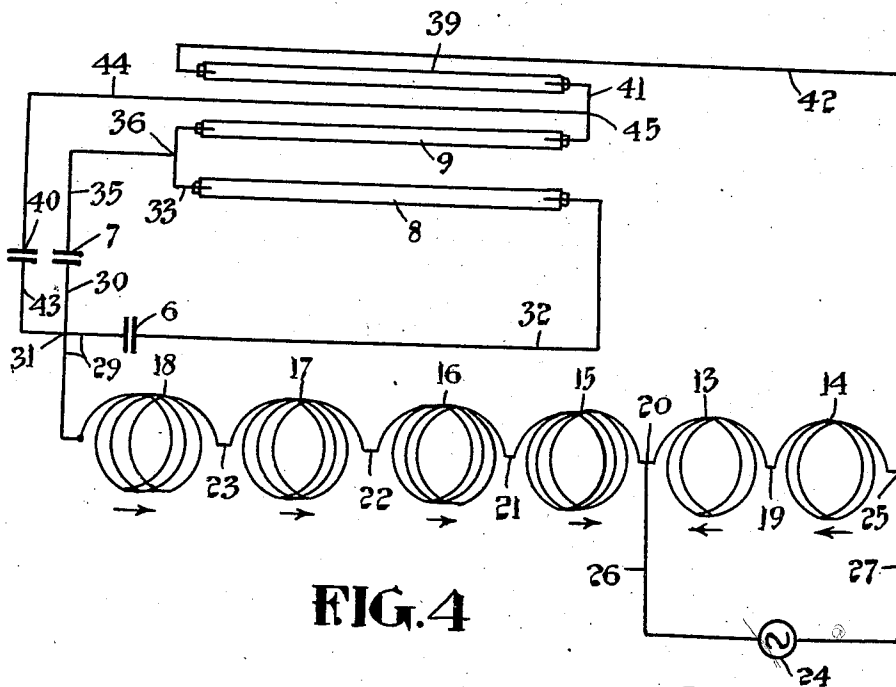


FIG. 4

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FLUORESCENT TUBE LIGHTING SYSTEM

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Application March 20, 1947, Serial No. 736,009

2 Claims. (Cl. 315-278)

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This invention relates to improvements in fluorescent tube lighting systems of the type set forth in my co-pending application Serial No. 692,906, filed August 24, 1946.

The principal feature of the systems described in said application is the operation of a plurality of series connected fluorescent tubes at a voltage not substantially greater than that required for operating the same tubes when connected in parallel with each other. This is accomplished by the provision of suitable by-pass or bleeder connections through the agency of which a relatively low voltage impressed across the terminals of the tube circuit is rendered effective to ionize said tubes in rapid succession and to establish and maintain in all of said tubes the current density required for efficient and satisfactory operation. The purpose of the present invention is to provide simplified circuit arrangements whereby a standard type of auto-transformer may be utilized in conjunction with suitable by-pass connections and current-limiting means to operate a single tube load consisting of two or more fluorescent tubes connected in series with each other in the secondary circuit of the transformer.

Other purposes, advantages and characteristic features of the present invention will be more readily understood from the following detailed description of the accompanying drawings, in which—

Fig. 1 is a diagrammatic elevational view of an auto-transformer and other component elements of a fluorescent lighting system embodying my invention.

Fig. 2 is a wiring diagram shown in Fig. 1.

Fig. 3 is a view similar to Fig. 2 but showing a slight modification; and

Fig. 4 is a view similar to Figs. 2 and 3 but showing a further modification.

In the system shown in Figs. 1 and 2, an auto-transformer 5 is employed, in conjunction with condensers 6 and 7, to operate two series connected fluorescent tubes 8 and 9 at a voltage not substantially greater than that required for operating the tubes in parallel with each other.

Transformer 5 is shown as an auto-transformer having two laterally spaced core legs 10 and 11 connected by end pieces 12. The primary winding comprises a coil section 13 arranged on core leg 10 and a second coil section 14 arranged on core leg 11. The secondary winding comprises coil sections 15 and 17 arranged on core leg 10 and coil sections 16 and 18 arranged on core leg 11. These primary and secondary coil sections are electrically connected in auto-transformer relationship as indicated at 19, 20, 21, 22 and 23. The transformer is designed so that the secondary coils 15, 16, 17 and 18 have a high inductive reactance.

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The primary coils 13 and 14 are energized by a source of alternating current energy 24 which may be of any suitable voltage and frequency rating.

Condensers 6 and 7 are connected in the transformer secondary circuit so that condenser 6 is in series with both tubes 8 and 9 while condenser 7 is in series with tube 9 and in parallel with tube 8.

In tracing the circuit connections as shown in Fig. 2, it will be noted that primary coils 13 and 14 of transformer 5 are connected across the alternating current potential source 24 by leads 25 and 27. The left hand end of primary coil 13 is connected, at junction 28, to lead 26 and to the right hand end of secondary coil 15. The right hand end of primary coil 13 is connected at 19 to the left hand end of primary coil 14. The right hand end of primary coil 14 is connected, at junction 25, to lead 27. The left hand end of secondary coil 15 is connected, at 21, to the right hand end of secondary coil 16 which has its left hand end connected, at 22, to the right hand end of secondary coil 17. The left hand end of secondary coil 17 is connected, at 23, to the right hand end of secondary coil 18. The left hand end of secondary coil 18 is connected to the transformer side of condenser 6 by a series lead 29 and to the transformer side of condenser 7 by way of by-pass lead 30 which joins series lead 29, at junction 31. The tube side of condenser 6 is connected to the right hand electrode of tube 8 by lead 32. The left hand electrode of tube 8 is connected to the left hand electrode of tube 9 by lead 33. The right hand electrode of tube 9 is connected, by lead 34, to the right hand end of coil 14 at junction 25. The tube side of condenser 7 is connected, by lead 35, to lead 33 at junction 36. From this tracing of the circuit connections for tubes 8 and 9 and condensers 6 and 7, it will be seen that condenser 7, with its connecting leads 30 and 35, provides a current limiting by-pass through which current is shunted around tube 8 and through tube 9.

In the operation of the system shown in Figs. 1 and 2, the line voltage impressed across primary coils 13 and 14 by way of leads 26 and 27 is increased, by transformation, to a higher output voltage across the terminals of the secondary circuit in which the tubes and condensers are connected. This higher secondary output potential is maintained within the maximum limits prescribed for safe operation and, in fact, corresponds to the potential (approximately 450 to 500 volts for a 40 watt tube) ordinarily employed for operating fluorescent tubes connected in parallel with each other.

The current limiting condenser 7 and its connecting leads 30 and 35 afford a high impedance by-pass or bleeder connection through which a

limited amount of current is shunted around tube 8 to initially establish an ionized or conductive condition of tube 9. The impedance of tube 9 is thus reduced to a value at which the voltage drop across said tube is approximately low in comparison with the voltage required to establish an ionized or conductive condition of the tube. In this connection, it will be understood that condenser 7 is designed so that its capacitive reactance or impedance is high enough to limit the flow of by-pass current in tube 9 to an amount of current which is just sufficient to establish and maintain the ionized or conductive condition of said tube. As will hereinafter be apparent, this limitation of the amount of by-pass current supplied to tube 9 is necessary to keep the ultimate flow of operating current in this tube within proper limits.

In the ionized and conductive condition of tube 9 the potential available across the electrodes of tube 8 is immediately effective to establish an ionized and conductive condition of tube 8 and to cause sufficient operating current to flow through the series connected condenser 6 and tubes 8 and 9 to establish and maintain in both of said tubes the current density required for satisfactory operation. In this connection it will be understood that condenser 6 is designed to act as an impedance limiting current flow in tubes 8 and 9 to the current limits for which the tubes are designed. For example, in the case of a 40 watt tube the current limit is approximately 430 milliamperes.

An important characteristic of the system described in the foregoing is that the high inductive reactance of the transformer secondary coils 15 to 18 inclusive is balanced against the high capacitive reactance of condensers 6 and 7 to give a high power factor (over 90%). Another important advantage of this system is that both tubes are ionized and illuminated almost instantly at an operating voltage which is little more than that required to ionize one tube alone and this enables a substantial saving in transformer costs to be realized.

The condensers 6 and 7 may be replaced by other suitable current limiting devices capable of giving the same effects. For example, the condenser 7 may be replaced by a suitable resistor or reactor of the linear or non-linear type. In practice we have found that the best results are obtained by using a condenser 7 of approximately 0.3 mfd. capacity for 118 volt (40 watt tube) 60 cycle supply (24). Such a condenser would allow a current of approximately 50 milliamperes to flow through lamp 9 and would be satisfactory for initially establishing the desired ionized or conductive condition of said tube.

The arrangement shown in Figs. 1 and 2 is merely illustrative of one of numerous arrangements whereby a plurality of fluorescent tubes may be economically operated in series in accordance with principles of my invention within permissible voltage limits and with a minimum increase in the size of the transformer.

In Fig. 3 I have shown a slightly modified system in which the transformer side of condenser 7 is connected, by conductor 30, to a junction point 38 between the secondary coils 17 and 18. This modification has the effect of increasing the output efficiency of the system.

The system shown in Fig. 4 is the same as that shown in Fig. 2, except for the addition of a third tube 39 and an additional bleeder or by-pass condenser 40. In the arrangement shown in Fig.

4 the right hand electrode of tube 9 is connected by lead 41 to the right hand electrode of tube 39. The left hand end of tube 39 is connected, by lead 42, to the right hand end of coil 14 at junction 25. The transformer side of condenser 40 is connected to junction 31 by lead 43. The transformer side of condenser 40 is connected by lead 44 to lead 41 at junction 45.

In the operation of the system shown in Fig. 4, the condenser 40 and its connecting leads 43 and 44 afford a high impedance bleed or by-pass connection through which a limited amount of current is shunted around tubes 8 and 9 to initially establish an ionized and conductive condition of tube 39. A similar ionized and conductive condition of tube 9 is then established by virtue of the by-pass or bleeder connection afforded by condenser 7 and its connecting leads 30 and 35. When both tubes 39 and 9 are illuminated the voltage across tube 8 is effective to immediately establish an ionized and conductive condition of tube 8 and to cause sufficient operating current to flow through the series-connected condenser 6 and tubes 39, 9 and 8 to establish and maintain in the three tubes the current density required for satisfactory operation.

The condensers shown in Figs. 3 and 4 may be replaced by any suitable equivalent current limiting devices as previously pointed out in connection with the system shown in Figs. 1 and 2.

Having thus described the nature of my invention and several preferred embodiments, it will be understood that various modifications may be resorted to within the scope and spirit of the invention as defined by the appended claims.

I claim:

1. In a fluorescent tube lighting system, a source of alternating current energy having a plurality of voltage connection terminals including end terminals and an intermediate terminal, a plurality of fluorescent tubes connected in series with each other across said source, and a high by-pass impedance connected respectively to said intermediate terminal of the said source and to a series connection between adjacent tubes, and a low impedance in series with all of said tubes and connected to one of said end terminals of said source, the impedances being in series across one of said tubes, and being of such values that after the remainder of said tubes have become conductive the break-down voltage will be applied to said one of said tubes, all of said tubes being operated in series with each other at a voltage substantially lower than the sum of the break-down voltages required for each tube.

2. In a fluorescent tube lighting system, a source of alternating current energy having an intermediate voltage connection terminal between a series of transformer coils, a plurality of fluorescent tubes connected in series with each other across said source, and a high by-pass impedance connected respectively to said intermediate terminal of the said source and to a series connection between adjacent tubes, and a low impedance in series with all of said tubes and connected to an end terminal of said source, the impedances being in series across one of said tubes, and being of such values that after the remainder of said tubes have become conductive the break-down voltage will be applied to said one of said tubes, all of said tubes being operated in series with each other at a voltage substantially lower than the sum of the break-down voltages required for each tube.

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