Feb. 17, 1953 M. NATHANSON 2,629,072

GASEOUS DISCHARGE TUBE LIGHTING SYSTEM

Filed July 2, 1948 3 Sheets-Sheet 1

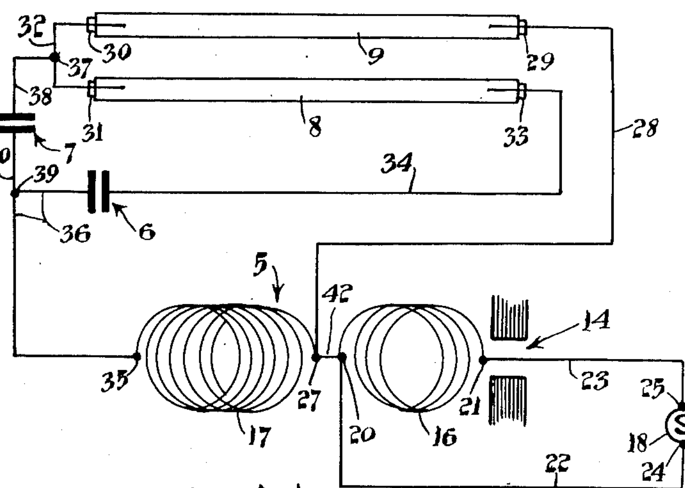

FIG. 1

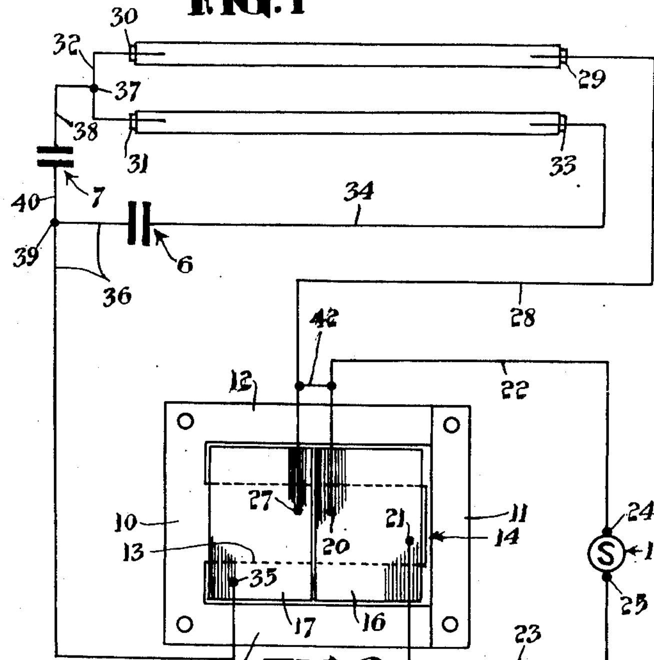

FIG. 2

INVENTOR
MAX NATHANSON
BY Fetherstonhaugh & Co.
ATTORNEYS

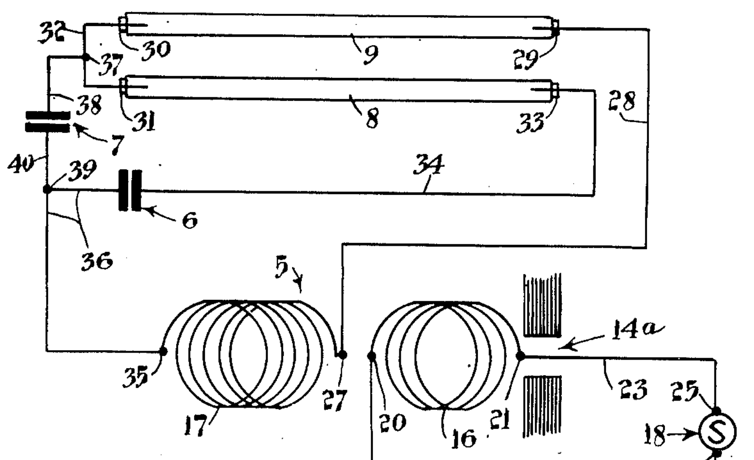

FIG.3

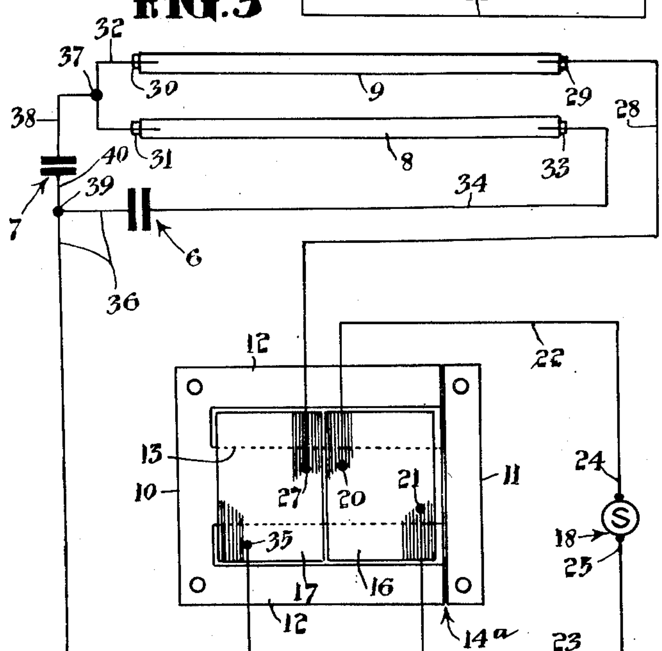

FIG. 4

INVENTOR
MAX NATHANSON
BY Fetherstonhaugh & Co.
ATTORNEYS

Feb. 17, 1953 M. NATHANSON 2,629,072

GASEOUS DISCHARGE TUBE LIGHTING SYSTEM

Filed July 2, 1948 3 Sheets-Sheet 3

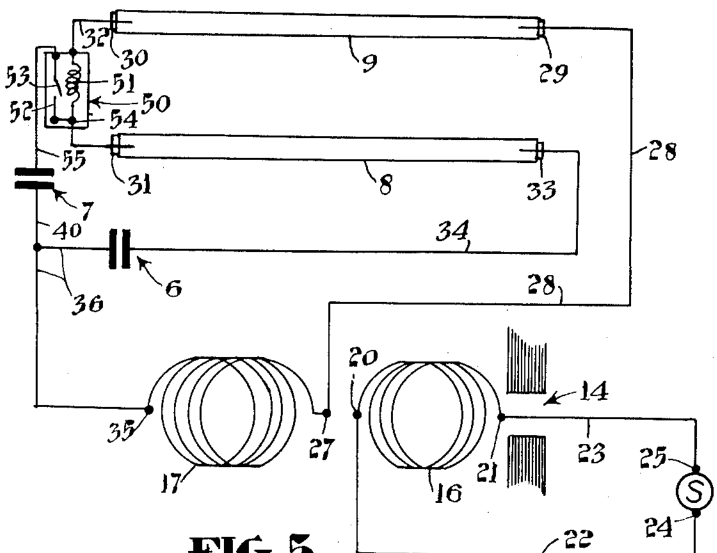

FIG.5

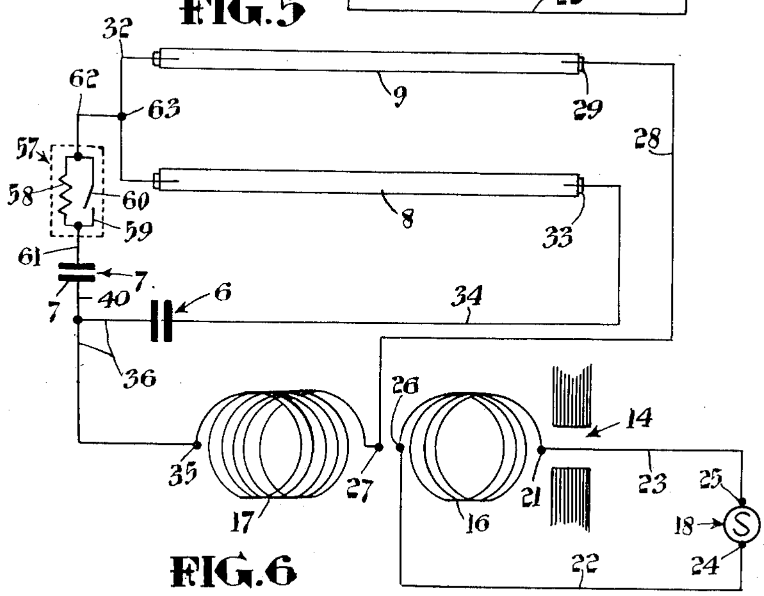

FIG.6

INVENTOR
MAX.NATHANSON
BY Fetherstonhaugh & Co.
ATTORNEYS

Patented Feb. 17, 1953

2,629,072

UNITED STATES PATENT OFFICE

2,629,072

GASEOUS DISCHARGE TUBE LIGHTING SYSTEM

Max Nathanson, Montreal, Quebec, Canada

Application July 2, 1948, Serial No. 36,732
In Canada June 18, 1948

11 Claims. (Cl. 315—188)

1

This invention relates to improvements in gaseous discharge tube lighting systems in which the tube load comprises a plurality of gaseous discharge tubes connected in series across the output terminals of a step-up transformer and in which provision is made for breaking down the series connected tubes in turn by the application of a breakdown potential lower than the sum of their individual breakdown potentials.

Examples of the type of gaseous discharge tube lighting systems to which the present invention is particularly applicable are disclosed in my U. S. Patent No. 2,436,400, granted February 24, 1948.

In one of the gaseous discharge tube lighting systems disclosed in the above mentioned patent, the tube load consists of a pair of tubes connected in series across the output terminals of a step-up transformer, with a series condenser and a by-pass condenser connected in the tube circuit so that the tubes are broken down in quick succession by application of a breakdown potential lower than the sum of their individual breakdown potentials. The secondary of the transformer employed in this two-tube circuit is in series with the condensers and has a high inductive reactance which offsets or is balanced against the leading load current to give a high power factor. It has been found that this method of obtaining a high power factor is characterized by wave shape distortions which are excessive for certain commercial applications.

One object of the present invention is to provide a two-tube system of the same general character as that disclosed in my U. S. Patent No. 2,436,400 but in which a high power factor is obtained without major wave shape distortion. This object is achieved by the use of a transformer in which the inductive reactance of the transformer secondary is kept low enough in relation to the impedance of the series and by-pass condensers connected in the tube circuit to avoid major wave shape distortions and in which the transformer core is provided with an air gap which has the effect of increasing the exciting current flowing in the transformer primary. This increased exciting current, which is inductive and lagging in nature, combines vectorially with the leading load current to give a high power factor current with minimum wave shape distortion. This is an unusual way of obtaining power factor correction.

Another object of the invention is to ensure a more even distribution of current between the two series connected tubes following ignition thereof. This object is achieved by the provision of a starter switch through the agency of which

2

the by-pass condenser is rendered ineffective or cut out of the circuit as soon as the ionized and conductive condition of both tubes has been established.

Other objects, advantages and characteristic features of the invention will be more readily understood from the following detailed description taken in connection with the accompanying drawings, in which—

Fig. 1 is a diagrammatic elevational view of a transformer and other component elements of a gaseous discharge tube lighting system embodying my invention.

Fig. 2 is a wiring diagram of the system shown in Fig. 1.

Figs. 3 and 4 are views corresponding respectively to Figs. 1 and 2 but showing a slightly modified system.

Fig. 5 is a view, similar to Fig. 1, but showing a starter switch included in the tube circuit.

Fig. 6 is a view similar to Fig. 5 but showing a slightly modified form of starter switch.

In the gaseous discharge tube lighting system shown in Figs. 1 and 2, a step-up transformer 5 is employed in conjunction with condensers 6 and 7 to operate a pair of tubes 8 and 9 in series at a voltage substantially lower than the sum of the individual voltages of the tubes.

The transformer 5 is shown as a shell type transformer having a laminated core comprising an E-shaped section 10 and an I-shaped section 11. The outer legs 12 of E-section 10 are longer than the central leg 13 and are connected at their free ends by I-section 11. The free end of central leg 13 of I-section 10 is spaced from I-section 11 to provide an air gap 14 of suitable high reluctance.

The primary and secondary transformer coils 16 and 17 are arranged on central core leg 13 in side by side relation with primary coil 16 lying between secondary coil 17 and air gap 14. Primary coil 16 is energized by a source of alternating current energy 18 which may be of any suitable voltage and frequency rating.

Condensers 6 and 7 and tubes 8 and 9 are connected across the terminals of secondary coil 17 so that condenser 6 is in series with both tubes while condenser 7 is in series with tube 9 and in parallel with condenser 6 and tube 8.

In tracing the circuit connections as shown in Fig. 2 it will be noted that terminals 20 and 21 of primary coil 16 are connected, by leads 22 and 23, to terminals 24 and 25 of the alternating current potential source 18. The right hand terminal 27 of secondary coil 17 is connected by lead 28 to the right hand electrode 29 of tube 9. The left hand electrode 30 of tubes 9 is connected to the left hand electrode 31 of tube 8 by series lead 32. The right hand electrode 33 of tube 8 is connected to the tube side of condenser 6 by lead 34. The transformer side of condenser 6 is connected to the left hand terminal 35 of secondary coil 17 by lead 36. The tube side of condenser 7 is connected to series lead 32 at juncture 37 by lead 38. The transformer side of condenser 7 is connected to lead 36 at juncture 39 by lead 40.

Condenser 7 and its connecting leads 38 and 40 provide a current limiting bleed connection or by-pass through which a limited amount of current is initially shunted around tube 8 and through tube 9 to initially establish an ionized and 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 relatively low in comparison with the voltage required to initially establish an ionized and conductive condition of the tube. In this connection it will be understood that the capacitive reactance or impedance of condenser 7 should be 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 be hereinafter apparent this limitation of the amount of by-pass current initially 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 of the order of 410 to 430 milliamperes.

The system shown in Figs. 1 and 2 has highly satisfactory power factor and wave shape characteristics due largely to the provision of the gap 14 in the core structure of the transformer. By virtue of this gap, the exciting current in the primary coil is greatly increased and this current, being inductive and lagging in nature, offsets the leading load current to an extent sufficient to give a high power factor of over 90% with good current distribution and minimum wave shape distortion. In this connection, it will be understood that the lagging exciting current combines vectorially with the leading load current to give a high power factor current which is less than either the exciting current alone or the load current alone.

It would be possible, in a system of the type shown in Figs. 1 and 2, to obtain a high power factor by the use of a transformer having a secondary coil 17 of sufficiently high inductance but this method of obtaining a high power factor is characterized by the excessive wave shape distortion. By providing the gap 14 in the core structure of the transformer, the present invention makes it possible to obtain the desired high power factor with a secondary coil of sufficiently low inductance to avoid major wave shape distortion.

In some cases it has been found that in a system of the type shown in Figs. 1 and 2, the effects obtained are somewhat improved by providing a jumper connection 42 between the primary and secondary coils 16 and 17.

Assuming that the series connected tubes 8 and 9 are 40-watt tubes and that the input to the transformer is 110 volts 60 cycles, the ratio of the primary to the secondary winding of the transformer should be approximately 1 to 5 so that the voltage across the output terminals of the transformer will be approximately 500 volts. In this case, the series condenser 6 should have an impedance value of approximately 1.85 and the bypass condenser 7 should have an impedance value of approximately 0.15.

Figs. 3 and 4 illustrate a slight modification in which the outer legs 12 as well as the inner leg 13 of E-section 10 of the transformer core are separated from the I-section 11 by an air gap 14a corresponding to the air gap 14. This modification has certain advantages from a transformer manufacturing standpoint.

The system shown in Fig. 5 includes a starter switch 50 which functions to cut by-pass condenser 7 out of the circuit after both of the tubes 8 and 9 have been ignited. This arrangement ensures a more even distribution of current between the two tubes following ignition thereof.

Switch 50 is here shown as a standard thermal starter switch comprising heating coil 51, stationary contact 52 and movable bi-metallic contact 53. Heating coil 51 is inserted in the series lead 32 connecting the left hand electrodes of tubes 8 and 9. Contact 52 is connected to series lead 32 at junction 54. Contact 53 is connected to the tube side of condenser 7 by conductor 55. In the cold condition of heater coil 51, contacts 52 and 53 are engaged with each other to close the circuit between the condenser 7 and series lead 32.

In the operation of the system shown in Fig. 5 an ionized and conductive condition of tube 9 is initially established by the small amount of current which is by-passed through condenser 7 and through the closed contacts and heater coil of thermal switch 50. Tube 8 is then ignited as described in connection with Figs. 1 and 2 and the full required current is allowed to flow through both tubes. Since the heater coil 51 of thermal switch 50 is in series with both tubes, it will be seen that when both tubes are ignited, this coil will carry the full tube current plus the bleeder current by-passed through condenser 7 and thermal switch contacts 52 and 53. The resulting heating of coil 51 causes the bi-metallic switch contact 53 to bend and move away from contact 52, thereby cutting condenser 7 out of the circuit. Since the heating coil 51 is in series with both tubes, the full tube current flowing through this coil generates sufficient heat to maintain the bi-metallic contact 53 in its open-circuit position.

In the system shown in Fig. 6, the thermal starter switch 50 is replaced by a resistance type starter switch 57. As here shown, switch 57 comprises a heater resistance coil 58, a stationary contact 59 and a movable bi-metallic contact 60. The tube side of condenser 7 is connected by conductor 61 to one end of coil 58 and to stationary contact 59. The other end of coil 58 and the bi-metallic contact 60 are commonly connected by conductor 62 to series lead 32 at junction 63. In the cold condition of the heater resistance coil 58, the bi-metallic contact 60 is closed against the stationary contact 59.

In the operation of the system shown in Fig. 6, an ionized and conductive condition of tube 9 is initially established by the small amount of current which is by-passed through condenser 7 and through the parallel paths provided by the coil 58 and contacts 59 and 60 of starter switch 57. When both of the tubes 8 and 9 have been ignited and the full current required is flowing therethrough, the bi-metallic switch contact 60 is heated and caused to bend and move away from the stationary contact 59, thereby opening the circuit at these contacts and rendering the condenser 7 ineffective by reason of the high resistance of the resistance heater coil 58. The small current flowing through coil 58 when both tubes are in operation is sufficient to maintain the bi-metallic contact 60 in its open circuit position.

Having thus described the nature of my invention and several applications thereof, it will be understood that various modifications may be resorted to within the scope and spirit of the appended claims.

Having thus described my invention, what I claim is:

1. In a gaseous discharge tube lighting system, a transformer including a core provided with an air gap and primary and secondary windings arranged on said core the primary coil being connected across a source of alternating current of predetermined frequency, a tube circuit comprising a pair of gaseous discharge tubes connected in series with each other across the output terminals of the transformer, a series condenser connected in the tube circuit in series with both tubes, a by-pass impedance connected in the tube circuit in series with one tube and in parallel with the other tube, the transformer secondary being arranged to have an inductive reactance in the operating frequency which is lower than the impedance of the said series condenser and the by-pass impedance at the operating frequency to avoid major wave shape distortions, and the transformer primary by reason of the air gap carrying an appreciable exciting current, the arrangement of the system being such that the exciting current is inductive and lagging in nature and combined vectorially with the leading load current to provide a high power factor operation with a minimum of wave shape distortion.

2. A system as set forth in claim 1 including a jumper lead-connection interconnecting the primary and secondary windings of the transformer.

3. A system as set forth in claim 1 including means for effecting substantially uniform distribution of current between the two tubes when both of said tubes have been ignited, said means comprising an automatic device which operates to interrupt current flow through the by-pass impedance in response to the establishment of current flow in both of said tubes.

4. A system as set forth in claim 1 including a thermal switch device connected in the tube circuit so that said device operates in response to the establishment of current flow in both of said tubes to interrupt the flow of current through said by-pass impedance.

5. In a gaseous discharge tube lighting system, a shell type transformer comprising a core structure having outer and central core legs with an air gap at one end of the central leg, primary and secondary windings arranged on the central core leg in side by side relation at one side of the air gap with the primary winding lying between the secondary winding and the air gap the primary coil being connected across a source of alternating current of predetermined frequency, a tube circuit comprising a pair of gaseous discharge tubes connected in series across the secondary output terminals of said transformer, a series condenser connected in the tube circuit in series with both tubes and a by-pass impedance connected in the tube circuit in series with one tube and in parallel with the other tube and the series condenser, the transformer secondary being arranged to have an inductive reactance at the operating frequency which is lower than the impedance of the said series condenser and by-pass impedance at the operating frequency to avoid major wave shape distortions, and the transformer primary by reason of the air gap carrying an appreciable exciting current, the arrangement of the system being such that the exciting current is inductive and lagging in nature and combines vertorially with the leading load current to provide a high power factor operation with a minimum of wave shape distortion.

6. In a gaseous discharge tube lighting system, a transformer comprising a core structure including end members and laterally spaced outer and inner core legs extending between said end members, the outer core legs being terminally joined to both end members and the inner core leg being terminally joined to one end member and separated from the other end member by an air gap, primary and secondary windings arranged on the core leg in side by side relation with the primary winding lying between the secondary winding and the air gap, the primary coil being connected across a source of alternating current of predetermined frequency, a tube circuit comprising a pair of gaseous discharge tubes connected in series with each other across the output terminals of the transformer, a series condenser connected in the tube circuit in series with both tubes and a by-pass impedance connected in the tube circuit in series with one tube and in parallel with the other tube, the transformer secondary being arranged to have an inductive reactance at the operating frequency which is lower than the impedance of the said series condenser and by-pass impedance at the operating frequency to avoid major wave shape distortions, and the transformer primary by reason of the air gap carrying an appreciable exciting current, the arrangement of the system being such that the exciting current is inductive and lagging in nature and combines vertorially with the leading load current to provide a high power factor operation with a minimum of wave shape distortion.

7. A gaseous discharge tube lighting system, a transformer comprising a core structure including end members and laterally spaced outer and central core legs extending between said end members, all of said core members being terminally joined to one of said end members and being separated from the other end member by an air gap, a primary and a secondary winding arranged on the central core leg with the primary winding lying between the secondary winding and the air gap, the primary coil being connected across a source of alternating current of predetermined frequency a tube circuit comprising a pair of gaseous discharge tubes connected in series with each other across the output terminals of the transformer, a series condenser connected in the tube circuit in series with both tubes, and a by-pass impedance connected in the tube circuit in series with one tube and in parallel

with the other tube, the transformer secondary being arranged to have an inductive reactance at the operating frequency which is lower than the impedance of the said series condenser and by-pass impedance at the operating frequency to avoid major wave shape distortions, and the transformer primary by reason of the air gap carrying an appreciable exciting current, the arrangement of the system being such that the exciting current is inductive and lagging in nature and combines vectorially with the leading load current to provide a high power factor operation with a minimum of wave shape distortion.

8. A gaseous discharge tube lighting system comprising, in combination, a transformer, a tube circuit including a pair of gaseous discharge tubes connected in series with each other across the out-put terminals of the transformer, a series condenser connected in the tube circuit in series with both tubes, a by-pass impedance connected in the tube circuit in series with one tube and in parallel with the other tube and means operating automatically in response to the establishment of current flow in both tubes to eliminate the unequal current distributing effect of the by-pass impedance.

9. In a gaseous discharge tube lighting system, a transformer, a tube circuit including a pair of gaseous discharge tubes connected in series with each other across the output terminals of the transformer, a series condenser connected in the tube circuit in series with both tubes, a by-pass impedance connected in the tube circuit in series with one tube and in parallel with the other tube and a normally closed thermal switch connected in the tube circuit so that the opening of the switch contacts by the heating effect of current passing through the heating coil of the switch serves to open circuit the bypass impedaance, the heating coil of said switch being connected in circuit in series with both of said tubes.

10. In a gaseous discharge tube lighting system, a transformer, a tube circuit including a pair of gaseous discharge tubes connected in series with each other across the output terminals of the transformer, a series condenser connected in

the tube circuit in series with both tubes, a by-pass impedance connected in the tube circuit in series with one tube and in parallel with the other tube, the transformer side of said series condenser and the transformer side of said by-pass impedance being connected to the same output terminal of the transformer anr the tube side of the by-pass impedance being connected to the series connection between the tubes through a normally closed starter switch which operates in response to the establishment of current flow in both of said tubes to open circuit said by-pass impedance.

11. In a gaseous discharge tube lighting system, a transformer, a tube circuit including a pair of gaseous discharge tubes connected in series with each other across the output terminals of the transformer, a thermal starter switch including a heating coil, a stationary switch contact and a movable bi-metallic switch contact normally engaged with the stationary contact, said heating coil being inserted in the series connection between said tubes, a series condenser connected in the tube circuit in series with both tubes and a by-pass impedance connected in the tube circuit in series with one tube and in parallel with the other tube, the transformer side of said series condenser and the transformer side of said by-pass impedance being connected to the same terminal of the transformer and the tube side of the by-pass impedance being connected through the contacts of the starter switch to the series connection between said tubes.

MAX NATHANSON.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,030,426	Blok	Feb. 11, 1936
2,291,355	Simmon	July 28, 1942
2,423,031	Kurtz	June 24, 1947
2,436,399	Nathanson	Feb. 24, 1948