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1,988,459

LUMINOUS DISCHARGE TUBE SYSTEM

Filed Feb. 15, 1932

2 Sheets-Sheet 1

Fig. 1.

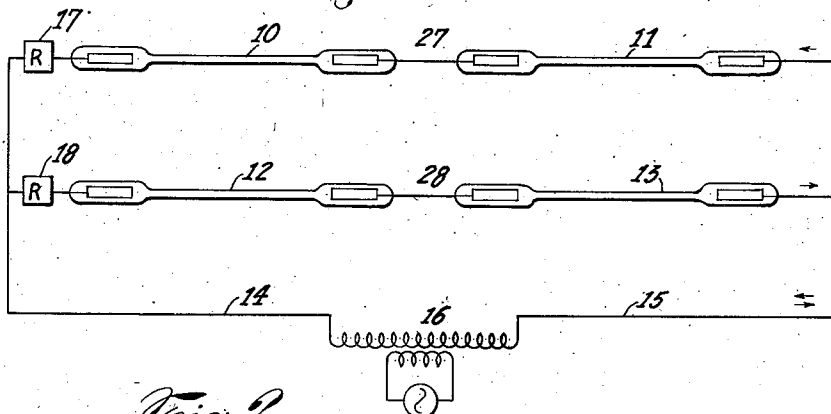


Fig. 2.

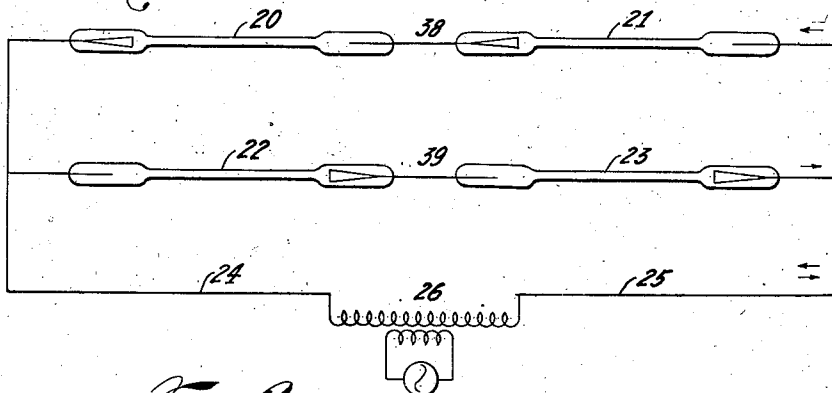
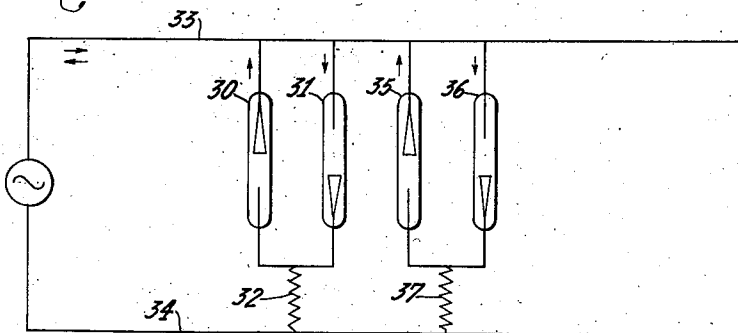


Fig. 3.



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2 Sheets-Sheet 2

Fig. 4.

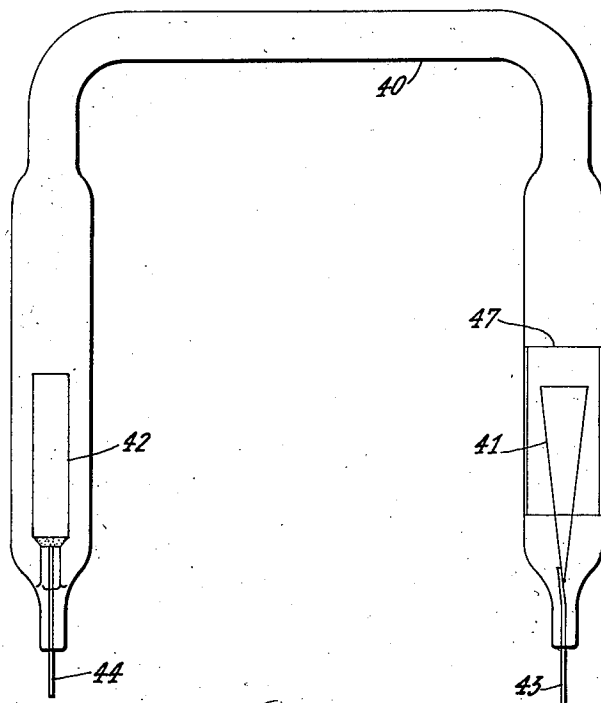


Fig. 5.

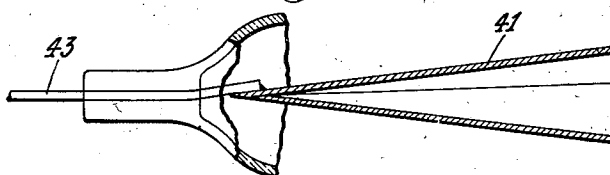
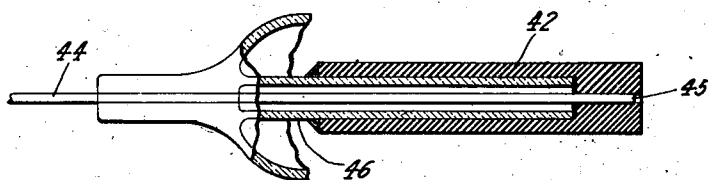


Fig. 6.



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LUMINOUS DISCHARGE TUBE SYSTEM

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15 Claims. (Cl. 176—124)

This invention relates to luminous discharge tubes utilizing an alternating voltage source of electric power. It is an object of the invention to provide improved circuits for such tubes. It is a further object of the invention to provide an improved luminous discharge tube adapted for use in such circuits. Other objects and advantages of the invention will appear hereinafter.

The nature and objects of the invention will be better understood from the description of certain illustrative embodiments thereof, and for the purpose of such description reference should be had to the accompanying drawings forming a part hereof, and in which:

Figs. 1, 2 and 3 are circuit diagrams illustrating how a plurality of luminous discharge tubes may be supplied with power from a single source of current;

Fig. 4 is a view of a luminous discharge tube having substantially unidirectional conductivity under the circuit conditions described; and

Figs. 5 and 6 are enlarged sectional views of the electrodes of the tube shown in Fig. 4.

The resistance of luminous discharge tubes decreases rapidly as the discharge begins. As a result it has not heretofore been practical to operate luminous discharge tubes in parallel from a single source of current except by the use of ballasting reactors or resistances in series with each tube. Without such reactance or resistance one tube will discharge before the others, and thereupon the resistance of the discharging tube will decrease to such an extent that the other tubes will not discharge. Because of this fact, luminous discharge tubes which are to be energized from a single source of current commonly are connected in series, thereby necessitating the use of higher voltages than would be necessary if the tubes could be operated in parallel.

According to this invention two luminous discharge tubes, or two branches of series-connected tubes, may be operated in parallel from a single source of alternating current without employing separate external reactances or resistances in series with each tube or parallel branch. This is accomplished by causing one of the parallel branches to have a relatively high impedance to current flow in one direction compared to the other branch, and a relatively low impedance to current flow in the opposite direction compared to said other branch.

Referring to Fig. 1 of the drawings, the tubes 10 and 11 are connected in series to form one branch 27 of a parallel circuit and the tubes 12 and 13 are connected in series to form the other

branch 28 of the parallel circuit. The two parallel branches 27 and 28 are connected across the current supply mains 14 and 15, which conveniently are supplied with alternating current of suitable voltage by a high reactance transformer 16. Such high reactance transformers are commonly used in this art, and, as is well known, they serve to limit the current flowing through the load connected thereto. Connected in the branch 27 in series with the tubes 10 and 11 is means indicated diagrammatically at 17 which offers a higher resistance to the flow of current in one direction, for example from left to right, than it does to the flow of current in the opposite direction. Connected in the branch 28 in series with the tubes 12 and 13 is similar means 18.

The means 17 and 18 are connected in reversed direction so that one of the parallel branches 27 offers a high resistance to the flow of current in one direction, while the other parallel branch 28 offers a high resistance to the flow of current in the opposite direction, and the two branches of the parallel circuit may be said to have substantially unidirectional conductivity in opposite directions when connected in this manner. By way of example, the means 17 and 18 may take the form of a suitable current rectifier, or of a source of direct current. As is ordinarily the case, the rectifier should not limit the current of the circuit in which it is placed, but should be so chosen that its maximum current is well above the current required by the tubes in series therewith.

It will be seen that with the arrangement shown in Fig. 1, as the voltage increases in one direction during a portion of its cycle it tends to discharge through both of the parallel branches. However, one of the branches offers a higher resistance to discharge than does the other branch. When the voltage reaches a certain value, dependent on the characteristics of the tubes and the means 17 and 18, the branch having lower resistance will discharge and as that branch discharges its resistance will decrease rapidly relative to the resistance of the other branch, with the result that the other branch will not discharge. When the voltage decreases below that necessary to sustain discharge, discharge will cease, and as the voltage passes through zero and increases in the opposite direction there will be another discharge, but this time through the other of the parallel branches. It will be seen that the tubes in the two branches discharge alternately, one branch discharging when the voltage is ap-

plied in one direction, and the other branch discharging when the voltage is reversed.

The frequency most commonly used today in alternating current supply lines is 60 cycles per second, which will produce 60 discharges per second in each of the parallel branches. This frequency is sufficiently high so that there will be no flickering apparent to the naked eye. Since each tube discharges only when the voltage is applied in one direction there will be a reduction in the brilliancy for any one tube as compared with operation of the same tube when connected to discharge as the voltage is applied in each direction. For the purposes of electric sign lighting this reduction in brilliancy is in most instances permissible, and does not appear to the naked eye to amount to or even approach the figure of 50%. Moreover, it may be compensated for by an increase in current density, either by reducing the tube diameter for the same current, or by increasing the current with the same diameter. By this means an equivalent or greater apparent brilliancy may be obtained in each tube with less power consumption per unit of tube length than is obtained in the ordinary bi-directional operation, and with greater total footage of tube on the same applied voltage. Consequently, by the use of this invention the length of luminous tubes operated from a single source of current supply may be greatly increased with an apparent increase in light output for the same power input.

The unidirectional means 17 and 18 shown in Fig. 1 may be dispensed with by designing one or more of the luminous discharge tubes so that the parallel tube branches themselves have substantially unidirectional conductivity, or offer a higher resistance to the flow of current in one direction than to the flow of current in the opposite direction. With two parallel branches of series connected tubes it may suffice if a single tube has substantially unidirectional current characteristics. Referring to Fig. 2, the luminous discharge tubes 20 and 21 are connected in series, anode to cathode, to provide one branch 38 of a parallel circuit. The luminous discharge tubes 22 and 23 also are connected in series, anode to cathode, to form the other branch 39 of the parallel circuit. The two branches are connected parallel across the alternating current supply mains 24 and 25, which conveniently are supplied with alternating current of suitable voltage by a high reactance transformer 26.

The two parallel branches 38 and 39 forming the tube circuits are connected across the mains 24 and 25 in reverse directions so that one of the branches offers a relatively low resistance to flow of current in one direction, while the other branch offers a relatively low resistance to the flow of current in the opposite direction. It will be apparent from what has been said regarding Fig. 1 that normally the tubes in the branch circuit 38 will discharge only when the voltage is applied in one direction, and the tubes in the other branch 39 will discharge only when the voltage is reversed.

Applicant's arrangement has distinct advantages over an arrangement in which a single unidirectional tube is connected to a source of alternating current, and also over an arrangement in which a plurality of such tubes are connected in the same direction, each in series with a suitable ballasting reactor or resistance, in parallel across a source of alternating current. With the arrangements shown diagrammatically in Figs. 1

and 2 all of the tubes will discharge unidirectionally, but neither branch is required to withstand the maximum reverse voltage of the current supply mains, because the lower resistance branch will discharge before the voltage wave reaches a maximum value.

A further advantage arising from applicant's invention lies in the greatly increased operating life of the tubes. The life of the tube operated will be substantially doubled as compared to the life of a similar tube with large electrodes at either end and connected to discharge in both directions. Also it is possible to operate the tubes with a higher peak current density with a given power input because of the reduction of time during which current flows. Such operation increases the efficiency of the tubes as light producers, and the spectral color range is widened. Moreover, the power factor of the circuit is improved.

If it is desired to connect more than two tubes or more than two series of tubes in parallel across alternating current supply mains, as for example in low voltage discharge tubes, this may be done conveniently as shown in Fig. 3. Two luminous discharge tubes 30 and 31 are connected in parallel, and the parallel circuit is connected in series with a ballasting reactor or resistance 32 across the alternating current supply mains 33 and 34. Two other tubes 35 and 36 are connected in parallel, and this parallel circuit is connected in series with a ballasting reactor or resistance 37 across the supply mains 33 and 34. Conveniently, the tubes have substantially unidirectional conductivity, and the two tubes comprising each of the parallel circuits are connected in reverse direction.

With the arrangement shown in Fig. 3, the tubes 30 and 35 will discharge at substantially the same time only when the voltage is applied in one direction, and the tubes 31 and 36 will discharge only when the voltage is reversed. The arrangement shown in Fig. 3 contemplates the use of ballasting reactors or resistances, but since a single reactor or resistance suffices for two tubes there is a decided advantage over arrangements heretofore known in which each tube has required a separate reactor or resistance to insure satisfactory parallel operation.

Fig. 4 shows an improved luminous discharge tube having substantially unidirectional conductivity which when filled with neon, helium or others of the noble gases, is suitable for use in the circuits illustrated in Figs. 2 and 3. Ordinarily, such a tube will be several feet long and may be formed into suitable letters or figures. The sealed tube 40 has enlarged ends in which are a cathode 41 and an anode 42 separated by a column of rarefied atmosphere contained within the tube. Electrical connection may be made to the electrodes 41 and 42 by means of the terminals 43 and 44 passing through and sealed in the wall of the tube 40. A cylindrical shield 47 of insulating material such as mica may be employed around the cathode 41 on the interior of the tube.

The tube illustrated in Fig. 4 has substantially unidirectional conductivity by reason of the fact that at the range of gas pressures normally used, i. e. from 5 to 25 millimeters of mercury, and within the normal operating current range of from 15 to 60 milliamperes, the cathode has a relatively low cathode drop by reason of its large area, and the anode has a relatively high cathode drop by reason of its small area. For

example, in such a tube containing one or more of the noble gases, the exposed area of the anode desirably is less than the area required for normal cathode drop at an instantaneous current of 1.6 milliamperes, and the area of the cold cathode is desirably more than 30 times as great.

If it is assumed that the relatively small area required to maintain a low anode drop is available at the anode, it may be said that in general the lower the drop at the cathode during discharge and the higher the drop at the anode during reverse voltage, the stronger the unidirectional tendency, the more stable the operation of the tube, and the greater the unbalance of relative lengths of tube permitted in the two parallel branches. Applicant has found that a good working rule to follow to insure this difference in drop between the anode and the conventional designs of cathode is to have the exposed area of the anode such that its normal current density if used as a cathode would be exceeded when current in the reverse direction is less than 2% of the normal discharge peak current.

The construction of the electrodes 41 and 42 will be better understood by reference to Figs. 5 and 6. In the illustrative embodiment the cathode comprises a conical metal member having its open end toward the column of gas contained in the tube, and its apex connected as by welding to the terminal 43. Conveniently the conical electrode may be nickel or iron, and its inner surface may be treated to reduce the cathode fall of potential. By using a conical electrode of narrow angle the most efficient electrode diameter is assured for all reasonable variation in gas pressure within the tube.

The electrode 42 conveniently comprises a wire 45, which may be tungsten or nickel, connected to the terminal 44 and extending through an insulating tube 46, conveniently glass, leaving the end portion only of the wire exposed beyond the end of the tube 46. If the manufacturing of the tube involves the well known internal current discharge bombardment process instead of external heating during evacuation the wire desirably is further insulated, as by means of an outer tube of lava or isolantite which telescopes over the end of the glass tube 46 and leaves only the end surface of the wire 45 exposed.

The term "luminous discharge tube" as used herein is intended to include tubes, bulbs and receptacles of various shapes and materials which are adapted to pass a luminous positive column electric discharge through an atmosphere of gases. The term "discharge" is used to describe the main body of the luminous discharge, and not the small or transient discharge which may occur with the relatively small current which may flow in the reverse direction to the main current in each branch.

It will be apparent from the foregoing description that applicant has provided a novel circuit for utilizing luminous discharge tubes. A plurality of tubes may be operated from a single source of alternating current with an increase in brilliancy for the same power input, and with increased life of the tubes. Furthermore, luminous discharge tubes are operated unidirectionally on alternating current without being required to withstand the full reverse voltage of the current supply.

The foregoing description of certain specific embodiments of the invention is illustrative

merely, and is not intended as defining the limits of the invention.

I claim:

1. A luminous discharge tube system comprising in combination a branch circuit having substantially unidirectional conductivity and including at least one luminous discharge tube, a second branch circuit having substantially unidirectional conductivity and including at least one luminous discharge tube, means for connecting said two branch circuits in parallel and in opposition to one another, a current-limiting impedance common to said parallel branch circuits, and means for supplying alternating current to said system, whereby luminous discharge occurs alternately in the two branch circuits and neither branch circuit is required to withstand the full reverse voltage of the alternating current source during operation of the other branch.

2. A luminous discharge tube system comprising in combination a branch circuit having substantially unidirectional conductivity and including at least one luminous discharge tube, a second branch circuit having substantially unidirectional conductivity and including at least one luminous discharge tube, means for connecting said two branch circuits in parallel and in opposition to one another, a current-limiting reactance common to said parallel branch circuits, and means for supplying alternating current to said system, whereby luminous discharge occurs alternately in the two branch circuits and neither branch circuit is required to withstand the full reverse voltage of the alternating current source during operation of the other branch.

3. A luminous discharge tube system comprising in combination two branch circuits each including at least one luminous discharge tube and connected in parallel, means in one of said branch circuits for permitting the flow of current substantially only in one direction and means in the other of said branch circuits for permitting the flow of current substantially only in the opposite direction, a current-limiting impedance common to said parallel branch circuits, and means for supplying alternating current to said system, whereby luminous discharge occurs alternately in the two branch circuits, and each of said two unidirectional means having such characteristics that the discharge current therethrough is limited by said impedance.

4. A luminous discharge tube system comprising in combination two branch circuits each including at least one luminous discharge tube and connected in parallel, means in each of said branch circuits for permitting current to pass in one direction and for substantially preventing its passage in the other direction, said means in one of said branch circuits being connected in opposition to said means in the other of said branch circuits, a current-limiting reactance common to said parallel branch circuits and connected in series therewith, and means for supplying alternating current to said system, whereby luminous discharge occurs alternately in the two branch circuits, and said unidirectional means offering an impedance to the discharge current less than that of said reactance, whereby the discharge current through said branch circuits is limited by said reactance.

5. A luminous discharge tube system comprising in combination a step-up high reactance transformer having a primary and a secondary, a source of alternating current connected to said primary, two branch circuits each including at

least one luminous discharge tube and connected in parallel across said secondary, means in each of said branch circuits for permitting current to pass in one direction and for substantially preventing its passage in the other direction, said means in one of said branch circuits being connected in opposition to said means in the other of said branch circuits, whereby luminous discharge occurs alternately in the two branch circuits, and said means offering an impedance to the discharge current less than that of said transformer, whereby the current in said system is limited by said transformer.

6. A luminous discharge tube system comprising in combination two branch circuits each including at least one luminous discharge tube and connected in parallel, an impedance in one of said branch circuits having a high impedance to current flow in one direction and a relatively low impedance to current flow in the opposite direction, an impedance in the other of said branch circuits having a high impedance to current flow in the direction in which said first branch impedance has its low impedance and having a relatively low impedance to current flow in the opposite direction, a current-limiting reactance common to said parallel branch circuits and connected in series therewith, and means for supplying alternating current to said system, whereby luminous discharge occurs alternately in the two branch circuits, and said two branch circuit impedances having such characteristics with respect to the characteristics of said luminous tubes and said reactance that the current flow in said system is limited by said reactance.

7. A luminous discharge tube system comprising in combination two branch circuits each including at least one luminous discharge tube and connected in parallel, a gaseous conduction rectifier in one of said branch circuits permitting the flow of current substantially only in one direction, and a gaseous conduction rectifier in the other of said branch circuits permitting the flow of current substantially only in the opposite direction, a current-limiting reactance common to said parallel branch circuits and connected in series therewith, and means for supplying alternating current to said system, whereby luminous discharge occurs alternately in the two branch circuits and the discharge current therethrough is limited by said reactance.

8. A luminous discharge tube system comprising in combination two branch circuits each including at least one substantially unidirectional luminous discharge tube, means for connecting said two branch circuits in parallel and in opposition to one another, a current-limiting impedance common to said parallel branch circuits and connected in series therewith, and means for supplying alternating current to said system, whereby luminous discharge occurs alternately in the two branch circuits and the discharge current therethrough is limited by said impedance.

9. A luminous discharge tube system comprising in combination two branch circuits each including a plurality of substantially unidirectional luminous discharge tubes connected in series with the anode of one tube connected to the cathode of the next, means for connecting said two branch circuits in parallel and in opposition to one another, a current-limiting reactance common to said parallel branch circuits, and means for supplying alternating current to said system, whereby luminous discharge occurs alternately in

the two branch circuits and the discharge current therethrough is limited by said reactance.

10. A luminous discharge tube system comprising in combination a step-up high reactance transformer having a primary and a secondary, a source of alternating current connected to said primary, two branch circuits each including a plurality of substantially unidirectional luminous discharge tubes connected in series with the anode of one tube connected to the cathode of the next, and means for connecting said two branch circuits in parallel and in opposition to one another across said secondary, whereby luminous discharge occurs alternately in the two branch circuits and the discharge current therethrough is limited by said transformer.

11. A luminous discharge tube system comprising in combination two branch circuits each including at least one substantially unidirectional luminous discharge tube having a cold cathode and an anode, the exposed area of said cathode being at least thirty times greater than the exposed area of said anode, means for connecting said two branch circuits in parallel and in opposition to one another, a current-limiting impedance common to said parallel branch circuits and connected in series therewith, and means for supplying alternating current to said system, whereby luminous discharge occurs alternately in the two branch circuits and the discharge current therethrough is limited by said impedance.

12. A luminous discharge tube system comprising in combination a step-up high reactance transformer having a primary and a secondary, a source of alternating current connected to said primary, two branch circuits each including a plurality of substantially unidirectional luminous discharge tubes having a cold cathode and an anode connected in series with the anode of one tube connected to the cathode of the next, the exposed area of said cathode being at least thirty times greater than the exposed area of said anode, and means for connecting said two branch circuits in parallel and in opposition to one another across said secondary, whereby luminous discharge occurs alternately in the two branch circuits and the discharge current therethrough is limited by said transformer.

13. A luminous discharge tube system comprising in combination two branch circuits each including at least one substantially unidirectional luminous discharge tube, means for connecting said two branch circuits in parallel and in opposition to one another, a current-limiting resistance common to said parallel branch circuits and connected in series therewith, and means for supplying alternating current to said system, whereby luminous discharge occurs alternately in the two branch circuits and the discharge current therethrough is limited by said resistance.

14. A luminous discharge tube system comprising in combination a source of alternating current and a plurality of luminous discharge tube circuits connected in parallel across said source, each of said circuits consisting of two branch circuits each including at least one substantially unidirectional luminous discharge tube, means for connecting said two branch circuits in parallel and in opposition to one another, and a current-limiting impedance common to said parallel branch circuits and connected in series therewith, whereby luminous discharge occurs alternately in the two branch circuits and the dis-

charge current therethrough is limited by said impedance.

15. A luminous discharge tube system comprising in combination two branch circuits each including at least one luminous discharge tube, a discharge tube in at least one of said branch circuits having substantially unidirectional conductivity, means for connecting said two branch circuits in parallel, an impedance common to said

parallel branch circuits and connected in series therewith, and means for supplying alternating current to said system, the electrical characteristics of said system being such that luminous discharge occurs alternately in the two branch circuits and the discharge current therethrough is limited by said impedance. 5

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