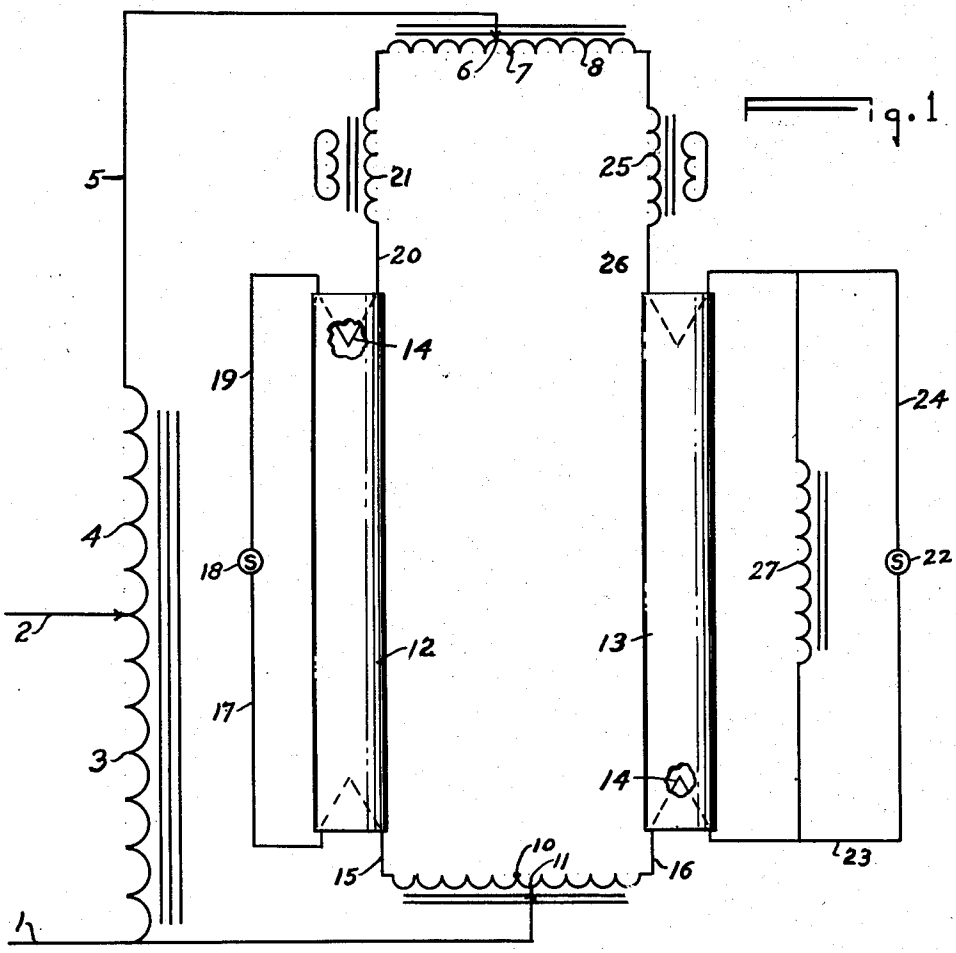
Nov. 10, 1953 W. C. HALL 2,659,034

CIRCUIT FOR SPACE DISCHARGE LAMPS

Filed March 17, 1950 2 Sheets-Sheet 1



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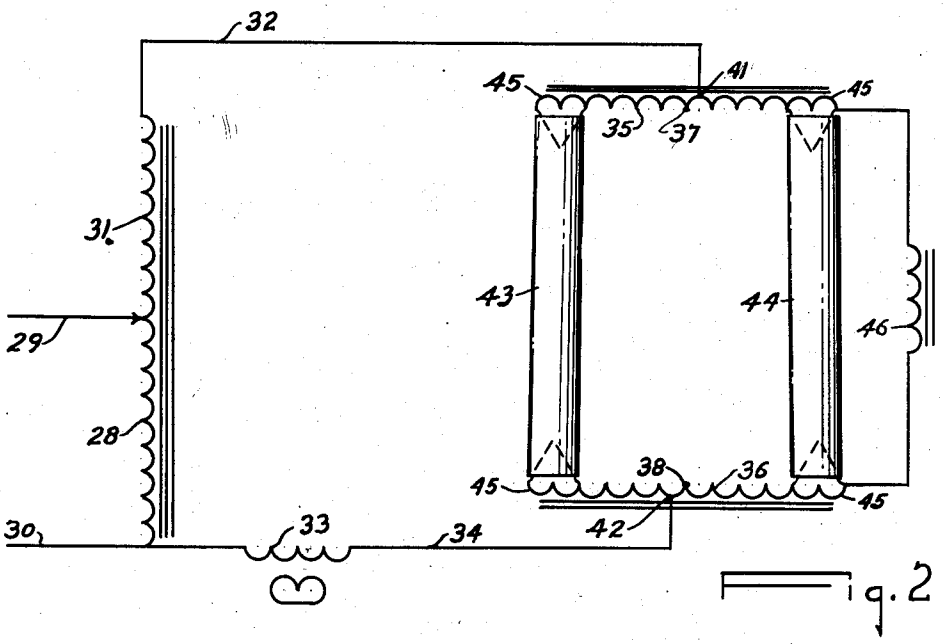

Fig. 2

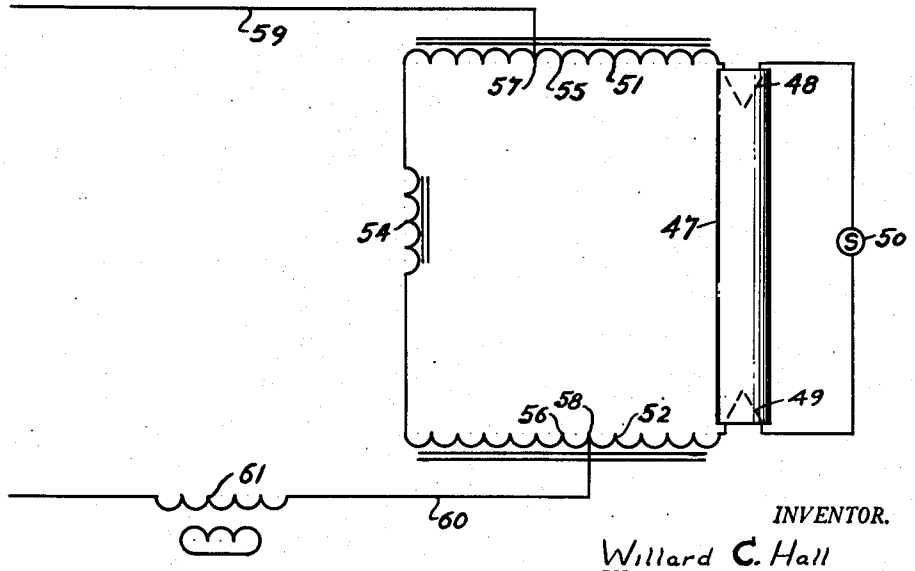

Fig. 3

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CIRCUIT FOR SPACE DISCHARGE LAMPS

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6 Claims. (Cl. 315—97)

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This invention belongs to that general class of devices and methods of efficiently regulating and operating electric lighting circuits and relates particularly to discharge lamp circuits which may include fluorescent tubular lamps and the like. The invention has among its pertinent objects the production of condenserless control and operating space discharge lamps at a high power factor; a circuit and included elements which are simple, durable, and compact in structure, inexpensive to make, manufacture and operate, dependable and efficient in use and service, and a combination that is very satisfactory for use whenever and wherever found applicable.

Other more specific objects, advantages and features of this particular invention will appear from a careful perusal of the accompanying drawings, the subjoined detailed description, the preamble of these specifications, and the claims appended hereto.

Below, applicant describes one of the preferable forms of his invention in order to teach the art thereof and show how to make and use the same, but it is to be understood that the drawings and description thereof are not to limit the invention in any sense whatsoever except as the same is limited by the prior art. Language employed herein is not to be construed as giving any unauthorized person or organization the right to make, use and/or sell the invention herein disclosed.

In the drawings:

Figure 1 is a schematic plan view of an electrical circuit for starting and operating fluorescent lamps and similar lighting devices,

Figure 1*a* is a schematic plan view of a typical starter switch for fluorescent lamps,

Figure 2 is another schematic plan view of another circuit for starting and operating space discharge lamps and the like,

Figure 3 is another schematic plan view of still another circuit for starting and operating space discharge lamps and the like.

As shown in Figure 1 of the drawings, the preferred form of the invention, an autotransformer is provided having the coil means 3 and 4 supplied with a suitable electric current through the line wires 1 and 2. The line voltage may be about 115, but the coil 4 is of sufficient turns to cause a difference in potential between lines 5 and 1 of about 155 volts. By this arrangement, the current through lines 1 and 2 is about 1 amp. and the current through line 5 is about 0.84 amp. The line 5 leads to an autotransformer 8 which has a center point 7, but

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the line 5 is electrically attached to the coil 8 at about five to ten percent to one side of the center 7 thereof. The grounded line 1 makes connection with the autotransformer 9 at about five to ten percent off the center 10; this connection is indicated at 11.

A pair of fluorescent lamps, or any other type of discharge lamp, are shown at 12 and 13, and each one of the lamps has a suitable electrode 14 at each end thereof. These electrodes are indicated as of the preheated type, but cold electrodes may be substituted therefor by making certain slight changes to be hereinafter explained. The end conductors 15 and 16 of the autotransformer 9 connect with one side of their respective lamp electrodes 14 at the lower end of the lamps 12 and 13, as shown; the other side of the lower electrode 14 in lamp 12 connects with a conductor 17, through a glow type starter switch 18 and then through conductor 19 to one side of the top electrode in lamp 12. The other side of this top electrode connects with conductor 20 and to one side of the primary of a shorted secondary transformer or current regulator 21. The other side of the primary makes connection with one end of the autotransformer 8.

The other side of the lower electrode in lamp 13 makes connection with the starter switch 22 through conductor 23, and the other side of the starter switch makes connection to one side of the top electrode through conductor 24. The other side of this latter electrode makes connection with a current regulator 25 through conductor 26; this regulator being a shorted secondary just like 21. The high side of regulator 25 makes connection with one end of the autotransformer 8, as shown. Between the conductors 23 and 24 there is connected a high-impedance lamp starting reactor 27. In the event it is desired to employ cold electrodes in place of the preheated ones shown at 14, then the switches 18 and 22 are dispensed with and in place of the switch 18 there is inserted a high impedance lamp starting reactor like 27. This would necessitate increasing the output potential of the autotransformer 3—4.

The secondary volt-ampere rating of the line step-up transformer is approximately 155 volts at 0.840 ampere, under normal conditions, and the line current at 117 volts is one ampere. The lamp currents would be 0.41 each and the input PIF 90 to 95%. It is important to note that the autotransformers connected to the output of the line autotransformer 3—4 are of special design and perform several important functions, to wit:

Coils 8 and 9 may have as much as 10% tap from the center points 7 and 10, respectively, and this introduces the desired reactance in a balanced manner; and at no-load during the starting cycle, these autotransformers will approximately double the line voltage across autotransformer coil 3 when the impedance reactor 27 is active.

By use of the balancing features of the lamp autotransformers 8 and 9, the discharge lamps 12 and 13 draw equal currents. This arrangement eliminates auxiliary lamp reactors and the core noises and interferences associated with this type of auxiliary reactor or reactors. Applicant employs two specially designed current limiting reactors 21 and 25 that draw an inphase current when series connected as shown. These reactors are small transformers having turn ratios of three to one and values twenty to one or more. The secondary of each reactor is short circuited and its primary in series with its respective lamp, the primary having the greater number of turns and the smaller wire size. In effect, the current change is considerably greater in the secondary short circuited winding for a corresponding change in resistance and this may be only a fraction of an ohm for a small change in current in the primary, thus by the principle of reflected resistance, the primary resistance may be made to change approximately in direct proportion to an increase in voltage applied to the primary, and thus giving a constant current regulation for an increase or decrease in applied voltage. Current density increases in the short circuited secondary of each reactor is the same as reducing the circular mill per ampere rating of the secondary winding.

The transformers 21 and 25 may have 126 turns of #27 enameled copper wire for the primary and 43 turns of #25 enameled copper wire for the secondary which is shorted, thus presenting an approximately 3 to 1 ratio when the primary current is 0.420 amp. and hence the secondary current would be 1.26 amps. and the voltage across the primary would be 25.2 volts, the total resistance by reflection being 60 ohms. A shell type core stack of silicon would be used and have a size of ¾ in. by ¾ in. This is an in-phase regulating means.

The out-of-phase lamp regulating coils total 840 turns of #27 enameled copper wire, the 5% tap being taken at the 440th turn. The silicon shell type core is ¾ in. by ¾ in. The ratios may vary, however, as the following ratios may be used when control advantages warrant, to wit: 1.05/1—1.1/1—1.2/1 etc.

The lamp starting reactor 27 has 3200 turns of #32 enameled copper wire with a D. C. resistance of 150 ohms, and is wound on a ½ in. by ⅛ in. silicon steel shell type of core. This reactor has a very small core and a large number of exciting ampere turns so that when the lamp running voltage is established across the coil (108 volts), the exciting or magnetizing current drops to a very low value, that is, no load the current is 0.750 ampere and under load the current is 0.045 ampere.

Note, in connection with the lamp autotransformers 8 and 9, that the greater the distance from the centers 7 or 10 that the lines 5 and 1, respectively, are equally shifted in opposite directions, the greater is the series impedance introduced in the lamp circuit.

As illustrated in Fig. 2 of the drawings, a similar autotransformer is employed having the coil 28 across the feed lines 29 and 30, and the series coil 31 which has the lead 32. The line 30 connects with one side of a shorted transformer 33 and from the other side of this transformer is the conductor 34. A pair of lamp autotransformers 35 and 36 having their respective centers at 37 and 38 are provided and their respective taps to their respective conductors 32 and 34 are at 39 and 40, as shown, and these taps are about 5% off center, and are indicated by the reference characters 41 and 42, respectively. The heater electrode at each end of each fluorescent lamp 43 and 44 is connected at the ends of the lamp autotransformers, as shown, and bridge 95 volts thereof, each such autotransformer section of coil being indicated by the common numeral 45. A starting impedance 46 is connected across or shunts a pair of electrodes of one of the lamps as shown.

The above arrangement of Fig. 2 at a line voltage of 118, provides a voltage of 155 across lines 30—32 and a current in line 32 of about 0.8 ampere. The electrode to electrode voltage across each lamp is 310 which is sufficient to start the space discharge. The values of the various elements in this form of the invention is substantially the same as in that of Fig. 1. Note, that no starter switch is needed in this circuit.

Figure 3 shows another circuit which is similar to the basic circuit of Fig. 1, but only one lamp 47 is shown. This lamp has the usual preheated electrodes 48 and 49, one side of which are connected through the switch 50 which may be the well known glow switch. The other sides of the electrodes are connected to the ends of their respective autotransformers 51 and 52, and the other ends of these transformers are connected to opposite ends of the out-of-phase starting and regulating reactor 54. The center of these autotransformers 51 and 52 are indicated at 55 and 56, respectively, and the line taps are indicated at 57 and 58, respectively; these taps being 5 to 10% off center.

The tap 57 connects with the line wire 59 and the other tap with the line wire 60 which has inserted therein the regulator 61. To provide suitable voltage and current, an autotransformer may be employed across the lines 59 and 60 as in the other showings.

It is to be noted, that in this instance the lamp autotransformers 51 and 52 are connected in series, not staggered, with respect to their voltage taps, but their primaries are split series connected through a reactance 54 which gives the lag component in the regulating circuit.

It is, of course, understood that various changes and modifications may be made in the details of form, style, design, and construction of the whole or any part of the specifically described embodiment of this invention without departing from the spirit thereof in that such changes and modifications are considered as being within the scope of the following claims.

I claim:

1. In an electrical circuit for starting and maintaining space discharge lamps and the like; a pair of space discharge lamps, each lamp having an electrode at each end thereof, each electrode having a pair of end leads which extend exteriorly of its respective lamp to present a pair of terminals, each lamp having one electrode terminal connected to one of the terminals of its other electrode through an automatic starter switch; a first autotransformer with end terminals and having an off-center tap, the end ter-

minals of this transformer having connection across a pair of other electrode terminals from different lamps, a second autotransformer having an off-center tap and having end terminals which have connection with still other electrodes through choke coils in parallel which coils have their secondaries shorted, a main autotransformer with a variable intermediate tap and its ends connected in series with leads extending from the off-center taps, and feeder conductors connected across the variable tap and one end of the main transformer which are adapted to be connected to a suitable source of electrical current.

2. The electrical circuit recited in claim 1 wherein the off-center taps are from 5 to 10% off true center coil position.

3. In a circuit for starting and maintaining space discharge types of lighting units; the circuit including a main transformer provided with end terminals and an intermediate terminal, a pair of lighting units consisting of first and second space discharge lamps, each lamp having an electrode at each end thereof and each electrode having a pair of exterior terminals; a first autotransformer and a second autotransformer, each having end terminals and an intermediate off-center terminal, a pair of choke coils each having their secondaries shorted and the primaries of which are connected in series on opposite sides of the first autotransformer, the other ends of these choke coils having connection with one electrode terminal of each lamp, means including a starter switch connecting the electrode terminals at opposite ends of the first lamp and other means including a starter switch connecting the end electrodes of the second lamp, and means connecting one electrode terminal of each lamp with the second autotransformer so that the autotransformers, choke coils, electrodes and switches are in series connection, and conductors connecting the off-center terminals with the opposite end terminals of the main transformer which supplies the electric current.

4. The circuit recited in claim 3 wherein the off-center terminals are 5 to 10% off true center position.

5. In a circuit for starting and maintaining the illumination of space discharge lamps; the circuit comprising a main current supply transformer with terminals in connection with the load and having terminals for connection to a source of electrical energy; first and second space discharge lamps having end electrodes, an automatic starter means for each lamp, each starter means having conductors making connection in series with one side of its respective electrodes, a first and a second autotransformer each having end terminals with an intermediate terminal connected therein at an off-center electrical position, a pair of reactors in series with the first autotransformer and connected to opposite ends thereof, the other ends of the reactors having connection with electrode terminals of different lamps, the second autotransformer having its end terminals connected to the electrode terminals of different lamps so that the autotransformers, reactors, switches and electrodes have a series connection with each other for starting purposes until after the lamps have been energized when the switches are automatically opened.

6. The circuit recited in claim 5 wherein the intermediate terminals of the autotransformers are set as much as 10% from the reactance centers thereof.

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