May 9, 1950 W. C. HALL 2,507,101

FLUORESCENT LAMP CIRCUIT

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Fig. 1

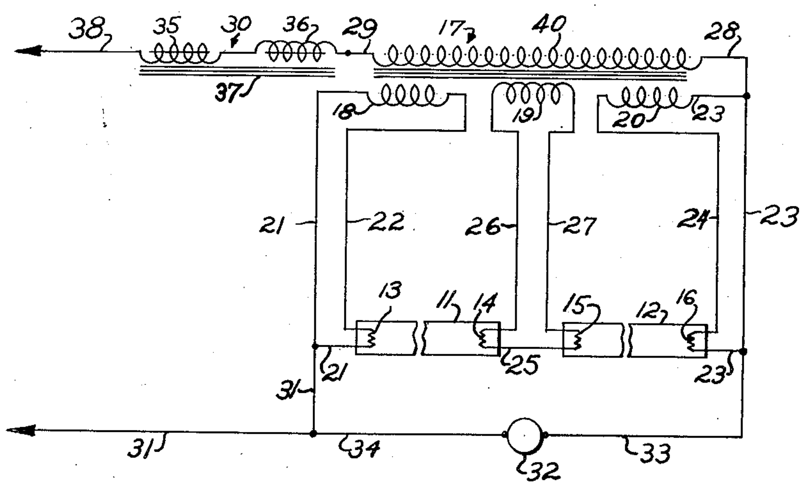
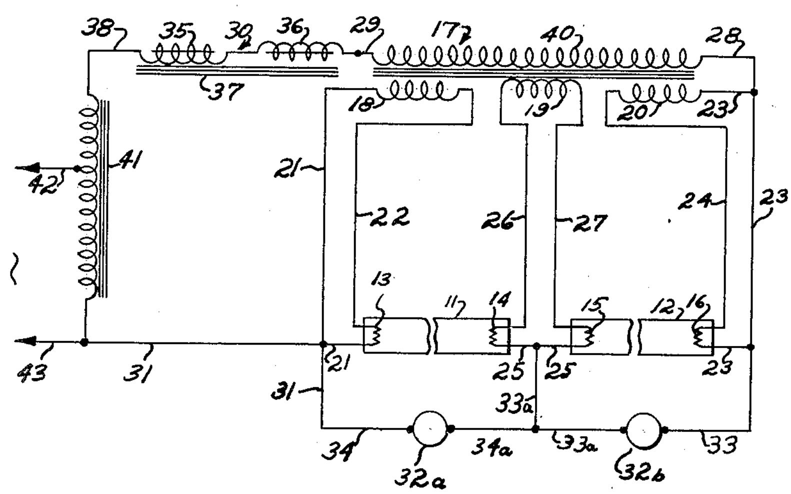


Fig. 2



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FLUORESCENT LAMP CIRCUIT

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4 Claims. (Cl. 315—257)

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This invention relates in general to gaseous electric discharge devices and, more particularly, to an improved fluorescent lamp circuit of the condenserless type.

Devices of this character, having negative resistance characteristics, require a current limiting means or ballast in the circuit to prevent the source current from rising rapidly and destroying the lamps. Such ballast generally includes a transformer to provide the proper voltage conditions, as well as a reactor-capacitor network to throw the necessary impedance into the line without too great a loss of efficiency.

The purpose of the capacitor in the conventional circuit is for power-factor correction, and in order to compensate for the phase shift which occurs in a reactor supplying sufficient ballast impedance, the capacitance employed must be relatively large, requiring the use of a condenser of several microfarads capacity. Such a condenser is relatively expensive and has the additional disadvantage of introducing undesirable harmonics into the lamp line.

Accordingly, it is an object of my invention to provide an adequately ballasted fluorescent lamp circuit in which the use of a condenser or condensers is eliminated and which nevertheless operates efficiently at a relatively high power factor, as, for example, greater than 90%.

Another object is to provide a more efficient ballast system whereby a portion of the energy absorbed in the ballast impedance is used to supply the filament heat to the lamps and is not dissipated as ballast wattage loss as in the conventional fluorescent lamp circuit.

A further object is to provide in such a circuit, current regulating means which will compensate for changes in the line voltage applied to the lamp circuit and maintain a relatively uniform discharge current through the lamps, thus prolonging their service life.

Another object is to provide an inexpensive arrangement for connecting fluorescent lamps which is simple to install and has but few components in the ballast circuit and which may be compactly mounted in a small housing or case and operate noiselessly therein.

Further objects and advantages of the invention will be apparent hereinafter.

My invention achieves its objects by the use of a circuit employing, in series with the lamp or lamps, the primary of a transformer having one or more opposed or "bucking" secondary windings in series with the discharge path of the current, which secondaries compensate for phase shift in the primary and thus raise the power factor in the circuit. I also employ one or more in-phase secondary windings to improve stability and voltage regulation and use both opposed and in-phase secondary windings in heating the lamp filaments.

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My circuit also includes, as additional ballast, a reactor of relatively high ohmic resistance in comparison to its reactance, the small degree of phase shift introduced by such reactor being largely corrected in the transformer in series therewith. And for the line voltage step-up required in connection with the use of relatively high wattage lamps, I may also employ an autotransformer in combination with the other components of the circuit.

In the drawing which accompanies this specification, and which is intended as illustrative only, I show two embodiments of the invention as follows:

Fig. 1 is a schematic view of a pair of fluorescent lamps of relatively low wattage and a circuit therefor; and

Fig. 2 is a similar view showing a pair of relatively high wattage fluorescent lamps and a circuit therefor.

Referring to Fig. 1 of the drawing, I show fluorescent lamps 11 and 12 each having two electrodes, indicated at 13 and 14 for lamp 11, and at 15 and 16 for lamp 12. The lamps 11 and 12 are preferably of the standard commercial thermionic type of, for example, 15-watt rating, although the circuit shown may be employed with lamps of various sizes which have a discharge voltage capable of being supplied directly from the line.

The electrodes 13, 14, 15 and 16 are the conventional coated filament type consisting of a coiled wire, such as tungsten or nickel, coated with an oxide to provide high electron emission characteristics.

Such electrodes have positive resistance characteristics, that is, the ohmic resistance of the tungsten coil increases with a rise in temperature, and this factor is important in maintaining current stability in the circuit, as will be described in greater detail hereinafter.

The electrodes 13, 14, 15 and 16 are connected to secondary coils 18, 19 and 20 of a transformer, indicated generally at 17, and are supplied with the rated filament voltage by such secondaries. Coils 18 and 20 are wound in out-of-phase or "bucking" direction with respect to the primary 40 of the transformer 17 and are connected to the electrodes 13 and 16 by conductors 21, 22 and 23, 24, respectively. I have found that a transformer having a 4:1 ratio of turns of the primary coil 40 to each of the equal secondaries 18 and 20 operates most advantageously in my circuit, altho other turn ratios may be successfully employed in the transformer 17. The electrodes 14 and 15 are interconnected at one terminal by a conductor 25 and are connected to the secondary winding 19 by conductors 26 and 27. The secondary winding 19 is wound in the conventional in-phase direction with respect to the primary coil 40 and has approximately twice the number of turns as the secondary windings 18 and 20.

The right side of the primary coil 40 is connected to the secondary coil 20 by conductors 28 and 23, while the left side leads to an alternating current source through a conductor 29 and a choke indicated generally at 30. The opposite connection to the current source is made through conductors 31 and 21 to the left side of the secondary winding 18. A starting switch 32, which may be of the manual, thermal, or glow type, is connected between the electrodes 13 and 16 by means of conductors 21, 31, 34, 33 and 23.

The choke 30 may be any type of reactor having a relatively high ohmic resistance in relation to its reactance, such as a choke having a reactance ratio of 40% or less. I have shown in the drawing a preferred reactor for this purpose which consists of a pair of equal opposed windings 35 and 36 on a common magnetic core 37, the winding 35 being connected to one side of the alternating current source through a conductor 38.

In Fig. 2, I show a circuit similar to that of Fig. 1, but adapted for use with lamps 11 and 12 of higher wattage, such, for example, as 40-watt lamps. In order to raise the line voltage to the rated voltage for the lamps 11 and 12, an autotransformer 41 is connected through conductors 42 and 43 to the alternating current source. The autotransformer 41, which preferably has a relatively high turns-per-volt ratio in order to minimize its exciting or magnetizing current, is connected through conductor 38 to choke 30 at one side and through conductors 31 and 21 to the left side of the secondary winding 18 at the other.

Multiple starting switches 32*a* and 32*b* are provided in place of the single switch 32 shown in Fig. 1, switch 32*a* being connected to the electrodes 13 and 14 by means of conductors 21, 31, 34 and 34*a*, 33*a*, 25, respectively, and switch 32*b* being connected to the electrodes 15 and 16 through conductors 25, 33*a*, and 33, 23, respectively.

In all other respects the circuit shown in Fig. 2 is similar in its components and connections to that shown in Fig. 1 and described above.

When current is applied to the circuit shown in Fig. 1 and the switch 32 is in closed position the lamps 11 and 12 are short circuited so that the current flows through the transformer primary 40 and through the secondary windings 18, 19 and 20, so as to heat the electrodes 13, 14, 15 and 16 to discharge temperature within a very brief period of time, thus lighting the lamps 11 and 12. Thereafter, with the switch in its open position, the discharge is maintained, the path of the current being from the A. C. source through the choke 30, the primary coil 40, the secondary coil 20, across the lamp 12 between the electrodes 16 and 15, across the lamp 11 between the electrodes 14 and 13, through the secondary coil 18 and thence to the A. C. source.

Such phase shift as results from the current passage through the choke 30 and transformer primary 40 is largely corrected by the "bucking" secondary windings 18 and 20. Provided that the impedance ratio of the choke 30 is relatively low, within the limits above specified, the power factor in the circuit has been found to be exceptionally high, as for example, 93%.

I have found that if all of the secondaries are wound in opposing or "bucking" direction, a power factor close to 100% is attained. However, a loss of stability results which causes variations in the line voltage to materially affect the discharge current through the lamps. The in-phase secondary winding 19 in my circuit, on the other hand, smoothes out variations in the current through the lamps by reflecting greater or lesser resistance into the transformer primary winding 40 from the electrodes 14 and 15 as the line voltage alters. Any line voltage increase, even though slight, increases the resistance of the electrodes 14 and 15, which in turn has the effect of increasing the impedance of the transformer primary 40, thereby automatically regulating the current through the lamps. Such automatic current regulation greatly prolongs the service life of the fluorescent lamps and is an important feature of my invention.

The circuit illustrated in Fig. 2 also operates at a relatively high power factor despite the introduction of the autotransformer 41 to step up the voltage to the value required for high wattage lamps. I have attained a power factor of 90% or better with the use of an autotransformer 41 of low magnetizing or exciting current which injects into the circuit only a small current lag capable of correction by the "bucking" secondary coils 18 and 20.

Although I have described this invention in connection with two-lamp ballast, it may also be employed effectively with a single lamp. Under such conditions, high power factor and current regulation will be achieved by the use of only two transformer secondaries, one wound in-phase and the other "bucking" or out of phase. Moreover, my circuit may be employed for use with a larger number of lamps than the two shown in the drawing, merely by increasing the number of transformer secondary windings and providing the proper discharge voltage across the lamps. And proper supply voltage for lamps of various wattage, used singly, in pairs, or in larger numbers, may be easily supplied in each instance by the use of an autotransformer to step up or step down the line voltage as required, without material lowering of the power factor.

Although I have shown and described above certain novel features of my circuit for use with thermionic electrode fluorescent lamps, it will be readily appreciated by anyone skilled in the art that my invention is also applicable to provide a high power factor ballast circuit in conjunction with cold cathode lamps or with various other electric discharge devices and accordingly I do not wish to be specifically limited to the embodiments or applications hereinbefore set forth, but desire to be afforded the full scope of the appended claims.

I claim:

1. In a circuit for starting and maintaining fluorescent lamps; a pair of conductor lines from a source of suitable alternating current; a choke coil, the primary of a transformer, and a starting

switch all in series connection across the said lines; the transformer having a central in-phase secondary coil and a pair of secondary end coils which latter ones are out-of-phase with respect to the primary; a pair of fluorescent lamps having a heater type electrode at each end of each lamp, one electrode of each lamp having one side connected together and their other sides connected across the in-phase secondary coil, the other electrode of one lamp having connection across one of the secondary out-of-phase coils and to one side of the switch, and the other electrode of the other lamp having connection across the other out-of-phase secondary coil and to the other side of the switch for the purposes described.

2. In an electrical circuit for starting and maintaining fluorescent lamps and the like; a pair of current supply lines from a source of suitable alternating current; a plurality of electrical units connected in series across the lines which consist of a choke coil, the primary of a transformer, and a starting switch; the transformer having an in-phase secondary central coil and a first and second secondary end coil which are out-of-phase with respect to the primary; a first and second fluorescent lamp each having a heater type electrode at each end thereof, one electrode of each lamp having one side connected together and their other sides connected across the in-phase secondary coil, the other electrode of the said first lamp having connection across one of the secondary out-of-phase coils and to one side of the switch, and the other electrode of the said second lamp having connection across the other out-of-phase secondary coil and to the other side of the switch, said choke coil consisting of a pair of coils which are 180 degrees out-of-phase with each other.

3. In an electrical circuit for starting and maintaining fluorescent lamps and the like; a pair of conductor lines for supplying alternating

current from a suitable source; a plurality of electrical units connected in series across the lines which consist of a choke coil, the primary of a transformer, and a starting switch means; the transformer having an in-phase secondary central coil and first and second secondary coils which are out-of-phase with respect to the primary; first and second fluorescent lamps wherein each lamp has at each end thereof a cathodic electrode from each of which extend a pair of leads, one lead of one electrode of each lamp having a common connection and the other leads of these electrodes being connected across the central in-phase secondary coil, the other electrode of the said first lamp having its leads connected across the said first out-of-phase secondary coil and one of these leads being connected also to one side of the switch means, and the other electrode of the said second lamp having its leads connected across the said second secondary coil which is out-of-phase and one of these leads being connected to the other side of the switch means.

4. The circuit recited in claim 3 wherein the switch means consists of a pair of series connected glow switches with a central tap, the central tap being connected with the said common connection.

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