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R. L. KEIFFER

2,719,937

CATHODE PREHEAT CONVERSION UNIT FOR FLUORESCENT LAMPS

Filed Nov. 23, 1949

2 Sheets-Sheet 1

Fig. 1.

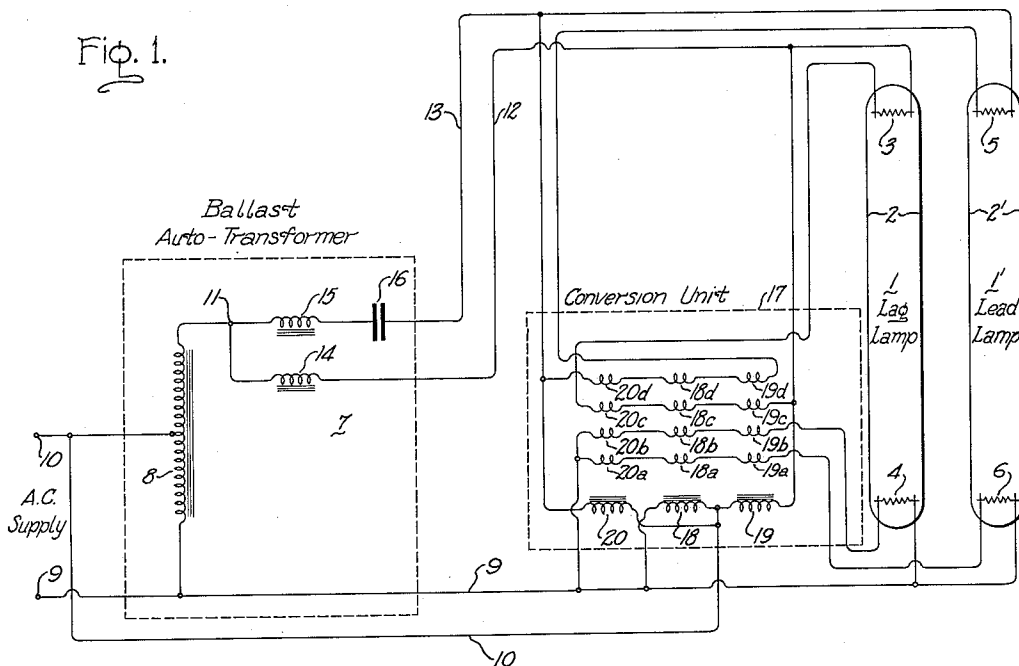
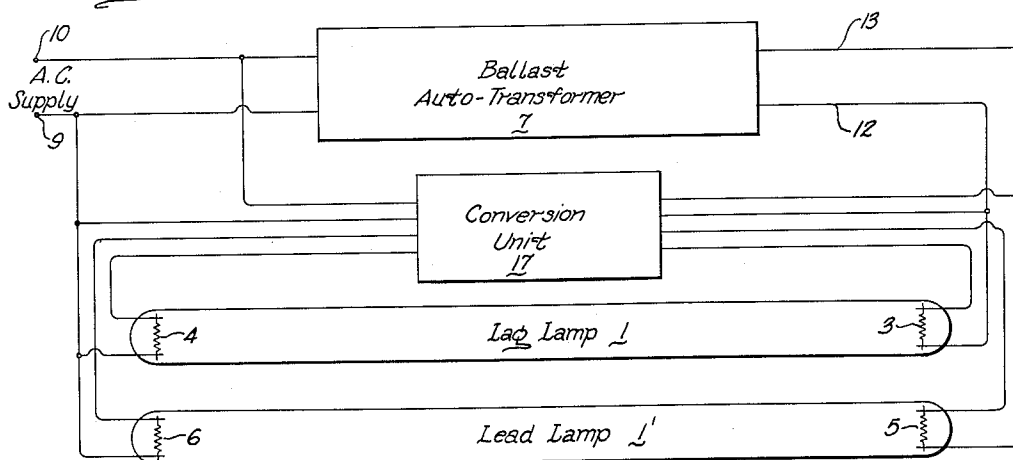


Fig. 2.



Inventor:
Raymond L. Keiffer,
by *Vernit C. Kauffman*
His Attorney.

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2 Sheets-Sheet 2

Fig. 3.

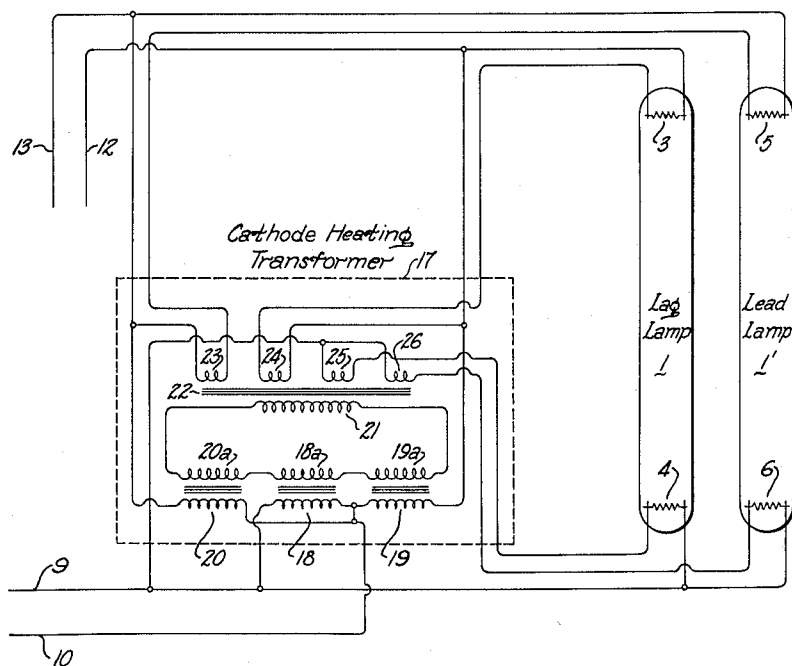


Fig. 4.

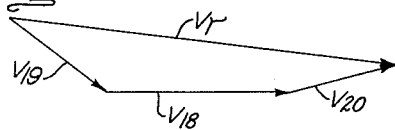
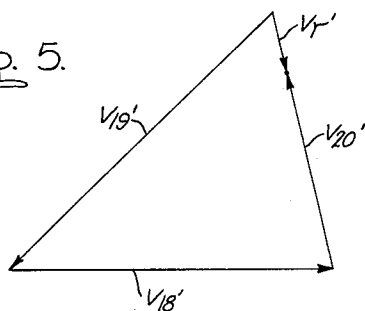


Fig. 5.



Inventor:
Raymond L. Keiffer,
by *Vernit C. Kauffman*
His Attorney.

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CATHODE PREHEAT CONVERSION UNIT FOR FLUORESCENT LAMPS

Raymond L. Keiffer, Chagrin Falls, Ohio, assignor to General Electric Company, a corporation of New York

Application November 23, 1949, Serial No. 129,156

5 Claims. (Cl. 315—97)

This invention relates generally to starting and operating circuits for electric discharge devices such as fluorescent lamps, and more particularly to a conversion unit, utilized in conjunction with the more common types of fluorescent lamp ballasts, for preheating the filamentary cathodes of such lamps.

Circuits presently in commercial use for operating fluorescent lamps are generally provided, either with switching means to allow preheating of the lamp electrodes to an electron-emitting temperature, or with high voltage high leakage reactance transformers to start the lamps directly without any preheating of the electrodes. The first method of operation necessitates an undesirable delay in starting the lamp after the initial application of voltage to the circuit, and often results in undesirable flickering when the lamp fails to start on the first attempt; the second method places considerable electrical stress on the lamp electrodes, which, other factors being equal, results in a shorter lamp life.

In the copending United States application Ser. No. 731,488 of Eugene Lemmers and myself jointly, filed February 28, 1947, now U. S. Patent No. 2,504,549 assigned to the same assignee as the present invention, there is disclosed a circuit and transformer structure for impressing heating voltages across the filamentary electrodes of a fluorescent lamp at starting, and for neutralizing these voltages through changes in phase and magnitude of the currents through transformer windings consequent upon conduction in the lamps during operation. Another circuit and transformer structure derived from the above is disclosed in copending application Ser. No. 129,158 of myself and Eugene Lemmers jointly, filed on this date, and assigned to the same assignee as the present invention.

This invention is concerned with the conversion of already existing fluorescent lamp circuits of the preheat switch type, to operation with switchless heating voltage neutralization in accordance with the principles disclosed in the above-mentioned applications, and it is accordingly an object of my invention to provide a conversion unit for effecting this purpose.

Another object of my invention is to provide a conversion unit for starting and operating circuits for fluorescent lamps, which permits the application of heating voltages to the filamentary electrodes of such lamps previous to starting, and which, immediately upon initiation of a discharge within said lamps, discontinues said heating voltages by means of changes in the phases and magnitudes of the components thereof.

A further object of my invention is to provide a conversion unit of the aforementioned type which may, in addition, be utilized for operating any number of fluorescent lamps with adequate heating current neutralization.

For further objects and advantages and for a better understanding of my invention, attention is now directed to the following description and accompanying drawings. The novel features of my invention will be more particularly pointed out in the appended claims.

In the drawings:

Fig. 1 is a schematic diagram of a starting and operating circuit for a pair of fluorescent lamps, which circuit includes a ballast autotransformer of conventional design, a pair of fluorescent lamps, one operating with lagging current and the other with leading current, and a cathode preheating conversion unit embodying my invention and connected into the circuit in a manner to achieve the mode of operation desired.

Fig. 2 is a wiring diagram applicable to the circuit of Fig. 1, and illustrates the method of wiring a conversion unit, in accordance with my invention, into a conventional starting and operating circuit.

Fig. 3 is a schematic diagram of part of a starting and operating circuit for fluorescent lamps, illustrating a modified version of a cathode preheating transformer conversion unit also embodying my invention.

Figs. 4 and 5 are vector diagrams for the purpose illustrating the voltage relationships in the windings of the cathode heating conversion unit, under starting and operating conditions respectively.

Referring to Fig. 1, there is shown a pair of electric discharge devices 1, 1' such as fluorescent lamps, which will be referred to henceforth as the lag and lead lamps, respectively. These lamps comprise elongated tubular or cylindrical envelopes 2, 2' which have sealed into their ends filamentary electrodes 3, 4 and 5, 6 respectively, of the two-terminal preheatable type. These electrodes may be constituted by a coil of tungsten wire activated with oxides of alkaline earth metals such as barium or strontium oxides. The envelopes 2, 2' contain rare gases such as krypton, neon, argon, or mixtures thereof, at a pressure of a few millimeters, and a small quantity of mercury. The devices 1, 1' may be low pressure, positive column lamps of the fluorescent type provided with a suitable phosphor coating. This fluorescent coating upon excitation by the radiation produced by an electric discharge between the electrodes, transforms a short wave length radiation due to the discharge into a longer wave length radiation occurring within the visible range.

The lamps 1, 1' are energized from the lag and lead circuits respectively of an autotransformer unit 7. Unit 7 is a commercial design well known in the art, and comprises a voltage step-up autotransformer 8 having an end terminal 9 and an intermediate tap terminal 10 adapted to be connected to an alternating current supply such as the usual 115 volt, 60 cycle mains, and an end terminal 11.

Lag and lead circuits 12, 9 and 13, 9 are connected to the end terminals of autotransformer 8, the lag circuit being connected in series with an inductor 14 and the lead circuit being connected in series with an inductor 15 and a capacitor 16. In accordance with well known principles, after the discharges have started in the lamps, the phase of the current through lamp 1 is retarded with respect to the phase of the supply voltage by an amount dependent upon the magnitude of inductor 14; conversely, the phase of the current through lamp 1 is advanced with respect to that of the supply voltage by an amount dependent upon the reactance values of inductor 15 and capacitor 16, capacitor 16 having a higher reactance than inductor 15 in order to effect a phase advance.

In accordance with my invention, voltages for heating the filamentary electrodes of the lamps are provided by means of a cathode preheating transformer conversion unit 17. Unit 17 comprises three windings, 18, 19, and 20, which windings may be located on separate cores of permeable material or on a common core structure incorporating the usual three-phase design considerations. Associated with each winding 18, 19, and 20, are four secondary windings 18a-d, 19a-d, and 20a-d, respec-

tively. The secondary windings bearing like subscript letters such as 18a, 19a, and 20a are connected in series, and each group of three secondary windings constitutes a single filamentary electrode heating circuit. Primary winding 18 is connected directly across the A.-C. supply terminals 9, 10; primary winding 19 is connected to the lag circuit conductor 12, and primary winding 20 is connected to the lead circuit conductor 13. The secondary winding groups bearing subscript letters a, b, c, and d are connected to energize filamentary electrodes 6, 4, 3, and 5 respectively.

By properly proportioning the turns ratio of the different windings in conversion unit 17, it is possible to have the secondary windings supply heating voltages to the lamp electrodes to which they are respectively connected and to have the phases and magnitude of the three component voltages in each secondary group shift in such a way, after the lamps have started, that the resultant heating voltages are substantially neutralized.

The wiring of a preheat conversion unit such as I have described is illustrated in Fig. 2 wherein like reference numerals refer to corresponding elements. An inspection of Fig. 2 will show that cathode heating transformer 17 may be connected into a standard lamp starting and operating circuit comprising ballast autotransformer 7, lag lamp 1 and lead lamp 1', without any changes being required in the internal wiring of autotransformer 7. Such a feature, naturally, is a prime requisite of a conversion unit which must be added to already existing installations by personnel of relatively limited skill.

Referring to Figs. 4 and 5, the vector diagrams therein illustrate the phase and magnitude of the voltages in the secondary heating windings of transformer 17, Fig. 4 being applicable to the voltages existing while starting, and Fig. 5 being applicable to voltages existing during lamp operation. These vector diagrams may be applied to any one of the four series secondary winding groups constituted by the different subscript letters a through d. When the supply voltage is initially applied to terminals 9, 10, the voltages provided to the lag and lead circuits 12, 9 and 13, 9 are normally in the same phase and differ only by the phase changes resulting from the flow of current through inductance 14 and inductance 15 along with capacitance 16. Thus, when voltage is first applied and before the lamps have started conducting, the only current drawn from the autotransformer is that flowing to primary windings 19 and 20, respectively, of the cathode heating transformer 17, which is comparatively small. As a result, the voltage applied to winding 19 will lag a slight amount behind the line voltage, and that applied to winding 20 will lead by a slight amount; and, accordingly, the voltages provided to windings 18, 19 and 20 may be represented by vectors V_{18} , V_{19} , and V_{20} , respectively, in Fig. 4. Voltages of like phase and magnitude are induced in the secondary windings such as 18a, 19a, and 20a, respectively, and these add up vectorially to produce a resultant voltage V_r , which has a substantial magnitude sufficient to provide heating of the filamentary electrodes in the lamps. After the lamps have attained an electron-emitting temperature, the arcs or discharges strike within them, and the phases of the voltages in circuits 12, 9 and 13, 9 are respectively retarded and advanced by a substantially greater number of degrees than before. The phases of the voltages provided to the primary windings of unit 17 thereupon shift in like fashion, as represented by vectors $V_{18'}$, $V_{19'}$, and $V_{20'}$ in Fig. 5. These three vectors now form a loop that is almost closed; and, accordingly, the resultant voltage in the secondary windings is reduced to an inconsequential small figure, as illustrated by V_r .

The following table illustrates typical voltage values obtained with an actual construction of a conversion unit embodying my invention. The vector diagrams in Figs.

4 and 5 are scaled representations of the voltages herein tabulated.

Starting voltages:

	Volts
V_{18} -----	7.1
V_{19} -----	4.0
V_{20} -----	4.8
V_r -----	15

Operating voltages:

$V_{18'}$ -----	12.5
$V_{19'}$ -----	7.5
$V_{20'}$ -----	12.9
V_r -----	3.3

Referring to Fig. 3, I have there illustrated another version of my invention, wherein the internal disposition of the elements in conversion unit 17 has been modified in order to provide an easier adaptation to energizing a greater number of filamentary electrodes. In this figure, similar reference numerals on conversion unit 17 refer to corresponding conductors and circuit elements in Fig. 1. In this particular embodiment of my invention, unit 17 likewise comprises three primary windings 18, 19, and 20 which are connected across the A.-C. supply, across the lag circuit, and across the lead circuit, respectively. Associated with each primary winding is a single secondary winding, these being 18a, 19a, and 20a, respectively. These secondary windings are connected in series, and the end terminals brought out to a primary winding 21 of a second transformer 22. Transformer 22 is provided with as many secondary windings as there are filamentary cathodes to be heated, namely 4, in this particular embodiment. The secondary windings 23, 24, 25, and 26 of transformer 22 energize electrodes 5, 3, 4, and 6 respectively. The operation of the circuit is similar to that of Fig. 1, except that the voltages instead of being added up in the component windings of each filamentary heating circuit, are added up once and for all in the main secondary circuit constituted by windings 18a, 19a, and 20a in series, and the resultant is supplied to primary winding 21 of filament transformer 22. Thereafter, in accordance with well-known principles, each secondary winding is provided with heating voltages of like phase and magnitude, and the magnitude of the secondary heating voltages depends upon the resultant of the voltages induced in windings 18a, 19a, and 20a in the same fashion as in the circuit of Fig. 1.

While certain specific embodiments have been shown and described, it will, of course, be understood that various modifications may be made without departing from the invention. Thus, whereas in the circuit of Fig. 1, I have shown four parallel filamentary heating circuits and in the circuit of Fig. 3, I have shown only one which is subsequently transformed into four parallel circuits, it will be evident that many variations may be made in such combinations. Likewise, whereas I have shown one particular step-up autotransformer ballast circuit which has found wide commercial acceptance for providing lagging and leading voltages for energizing a pair of lamps, and which I utilize to energize my cathode preheating conversion unit, it will be evident that any circuit which produces like lagging and leading voltages may be utilized in lieu of the one which I have illustrated. The appended claims are, therefore, intended to cover any such modifications coming within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In combination, a pair of electric discharge devices each having a pair of electrodes at least one of which is a two-terminal preheatable electrode, a source of alternating voltage, means including transforming means connected to said source and supplying voltages to said devices which become lagging at one device and leading at the other after starting, and a preheating unit com-

prising three primary transformer windings, respective ones of said windings having connections to said source and to said transforming means for energization from said source and from said lagging and said leading voltages respectively, and three secondary windings inductively coupled to respective ones of said primary windings, said secondary windings being connected in series and poled in aiding voltage relationship on the basis of the phase relationships in said secondary windings previous to starting of said devices, whereby to produce a resultant voltage the magnitude of which decreases with the changes in phase and magnitude of said lagging and leading voltages consequent upon current flow through said devices, and means for applying said resultant voltage across said electrodes.

2. In combination, a pair of electric discharge devices each having a pair of two-terminal preheatable electrodes, a source of alternating voltage, transforming means connected to said source and supplying voltages to said lamps which decrease in magnitude and whereof one is retarded and the other advanced in phase during normal operation of said devices, and a preheating unit comprising three primary transformer windings, respective ones of said windings having connections to said source and to said transforming means for energization by said source and by said phase-retarded voltage and by said phase-advanced voltage respectively, and three secondary windings inductively coupled to respective ones of said primary windings, said secondary windings being connected in series across one of said preheatable electrodes and poled in aiding voltage relationship on the basis of the phase relationships in said secondary windings previous to starting of said devices, whereby to produce a resultant voltage the magnitude of which decreases with the changes in phase and magnitude of the voltages across said devices.

3. In combination, a pair of electric discharge devices each having a pair of two-terminal preheatable electrodes, a source of alternating voltage, transforming means connected to said source and including an inductive circuit supplying voltage to one of said devices which becomes lagging after starting and a capacitive circuit supplying voltage to the other of said devices which becomes leading after starting, and a preheating unit comprising three primary transformer windings, respective ones of said windings having connections to said source and to said devices for energization by said source and by said lagging voltage and said leading voltage respectively, and three secondary windings inductively coupled to respective ones of said primary windings, said secondary windings being connected in series across one of said preheatable electrodes and poled in aiding voltage relationship on the basis of the phase relationships in said secondary windings previous to starting of said devices, whereby to produce a resultant voltage the magnitude of which decreases with the changes in phase and magnitude of said lagging and leading voltages consequent upon current flow through said devices.

4. In combination, a pair of electric discharge devices each having a pair of two-terminal preheatable electrodes, a source of alternating voltage, transforming means con-

nected to said source and including an inductive circuit supplying voltage to one of said devices which becomes lagging after starting and a capacitive circuit supplying voltage to the other of said devices which becomes leading after starting, and a preheating unit comprising three primary transformer windings, the first of said windings being connected directly across said source, the second of said windings being connected in series with the first across said one device for energization by lagging voltage, and the third of said windings being connected in series with the first across the other of said devices for energization by said leading voltage, and a plurality of secondary winding groups, each of said groups comprising three serially connected windings inductively coupled with respective ones of said primary windings, the windings within a group being connected in series across one of said electrodes and poled in aiding voltage relationship on the basis of the phase relationships existing in said secondary windings previous to starting of said devices, whereby to produce a resultant voltage the magnitude of which decreases with the changes in phase and magnitude of said lagging and leading voltages consequent upon current flow through said devices.

5. In combination, a pair of electric discharge devices each having a pair of two-terminal preheatable electrodes, a source of alternating voltage, transforming means connected to said source and including an inductive circuit supplying voltage to one of said devices which becomes lagging after starting and a capacitive circuit supplying voltage to the other of said devices which becomes leading after starting, and a preheating unit comprising three primary transformer windings, the first of said windings being connected directly across said source, the second of said windings being connected in series with the first across said one device for receiving said lagging voltage, and the third of said windings being connected in series with the first across said other device for receiving said leading voltage, three secondary windings inductively coupled to respective ones of said primary windings, said secondary windings being connected in series and poled in aiding voltage relationship on the basis of the phase relationships existing in said secondary windings previous to starting of said devices, whereby to produce a resultant voltage the magnitude of which decreases with the changes in phase and magnitude of said lagging and leading voltage consequent upon current flow through said devices, and an auxiliary transformer having a primary winding connected in a series circuit with said three secondary windings and a plurality of secondary windings coupled to said primary auxiliary winding and connected to respective ones of said electrodes for supplying heating current thereto.

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