Aug. 21, 1951 E. Q. ADAMS 2,565,110

POLYPHASE FLUORESCENT LAMP CIRCUIT

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Fig. 1.

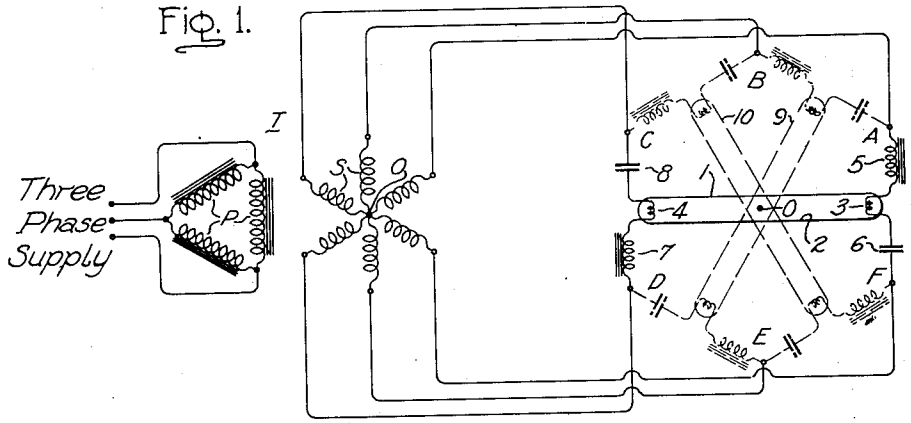


Fig. 2.

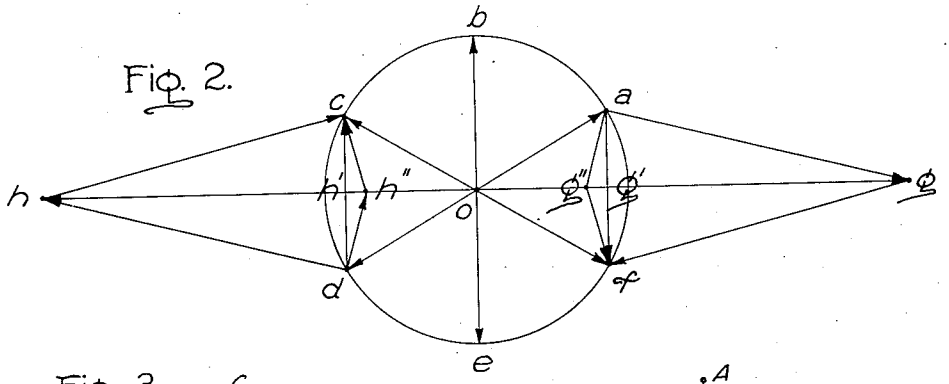


Fig. 3.

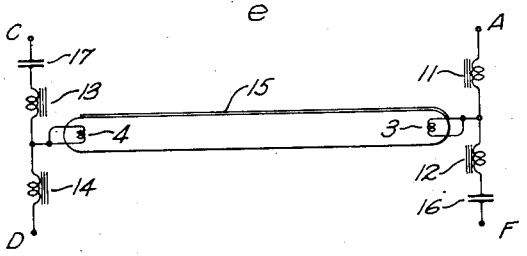
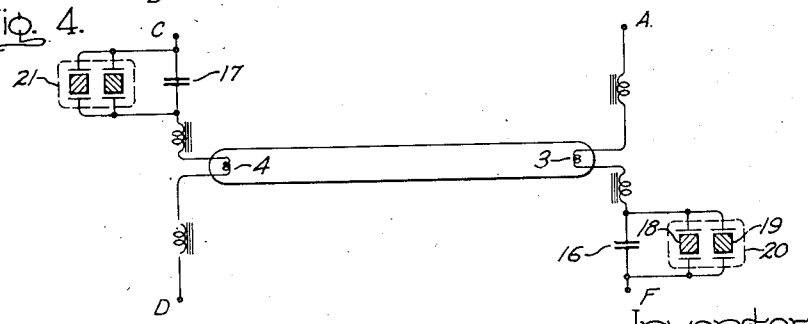


Fig. 4.



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POLYPHASE FLUORESCENT LAMP CIRCUIT

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5 Claims. (Cl. 315—100)

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This invention relates generally to the operation of electric discharge devices of the type employing ionizable mediums, such as the well known fluorescent lamps, and more particularly to polyphase starting and operating circuits therefor.

An object of my invention is to provide new and improved circuits for starting and operating electric discharge devices from a polyphase alternating voltage source.

Another object of my invention is to provide a polyphase operating circuit for a fluorescent lamp wherein resonant conditions between selected phases are utilized to start the lamp, and are subsequently eliminated as a result of phase changes caused by the discharge current flowing through the lamp during operation.

A feature of my invention is the possibility of operating fluorescent lamps in groups of three from a 6-phase circuit in such manner that, as soon as the lamps have started, circulating currents which had been used for heating the filaments, are substantially balanced and eliminated as a result of the phase relations set up in the circuit. This feature permits avoidance of the necessity for switches, either of the glow or of the thermal type, for opening the filament heating circuits after the lamps have started in order to prevent unnecessary and destructive heating thereof.

A further feature of my invention is the possibility of operating the lamps in a group of three, with phase intervals, one from the other, displaced by 120°, so that stroboscopic effects are substantially eliminated.

Still another object of my invention is to provide various protective devices for use in conjunction with my circuit in order to prevent the maintenance of dangerously high voltages if some of the circuit elements should become defective.

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

In the drawings:

Fig. 1 is a schematic diagram illustrating the adaptation of a starting and operating circuit for a fluorescent lamp, in accordance with my invention, to a six-phase alternating voltage source.

Fig. 2 is a vector diagram for the purpose of illustrating the phase and voltage relationships in the circuit of Fig. 1.

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Fig. 3 is a schematic diagram of a starting and operating circuit similar to that of Fig. 1 wherein certain modifications have been made in order to accommodate a different type of fluorescent lamp.

Fig. 4 is a schematic diagram of a similar circuit further modified by the addition of certain protective devices for safeguarding the circuit elements in case the lamp should become defective.

As will shortly become apparent, my invention is applicable to any polyphase circuit containing an even number of phases in excess of four. However, for ease of explanation and understanding, it is most readily described with reference to a six-phase source. Such a source is readily obtained, through suitable transformer connections, from a commercial three-phase supply. Thus, referring to Fig. 1, there is shown a three-phase transformer T consisting of a delta connected primary P, and of a star connected secondary S, of which the windings are connected in common at their center points designated O. The input terminals of the primary P are adapted to be connected to a commercial three-phase supply. The secondary terminals have been brought out to points A, B, C, D, E, and F, all symmetrically disposed about the common point O in order to illustrate graphically the 6 phase relations of the voltages provided at those points.

In accordance with my invention, an electric discharge device or fluorescent lamp 1 may be operated in the position shown, or in either of the other positions illustrated in dotted lines. Lamp 1 comprises a sealed glass envelope 2 containing a mixture of rare gases and a vaporizable metal such as, for instance, a small amount of mercury. Sealed into opposite ends of the lamp are a pair of thermionic electrodes 3 and 4. These may consist of coils of tungsten wire, preferably coated with an electron-emissive material such as oxides of alkaline earth metals, for instance, barium and strontium oxides. The interior surface of the lamp may, if desired, be coated with a fluorescent material or a phosphor which, upon excitation by the short wave length radiation produced by a discharge in the lamp, generates a longer wave length radiation within the visible spectrum. One filamentary end of electrode 3 is connected, by means of an inductor 5, to terminal A, and the other filamentary end is connected, by means of a capacitor 6, to terminal F. Similarly the filamentary ends of cathode 4 are connected, by means of an inductor 7 and

a capacitor 8, to terminals D and C respectively. Inductors 5 and 7, and capacitors 6 and 8, are selected to have substantially equal reactances at the frequency of the three-phase supply, which would normally be 60 cycles per second, so that each filamentary electrode is connected in a series resonant circuit.

Referring to Fig. 2, the vector diagram therein illustrates the voltage and phase relationships in the circuit when a three-phase voltage is supplied at the terminals of transformer winding P. The vectors *o—a* through *o—f* represent the voltages, both in phase and magnitude, at terminals A through F with respect to the common point O. Accordingly, the vector *a—f* represents the voltage applied across the terminals of the resonant circuit of electrode 3. Since the reactance of inductor 5 is substantially equal and opposite in sign to that of capacitor 6, the current therein is limited almost solely by the resistance of electrode 3 which, accordingly, heats up rapidly. In addition, the current flowing through inductor 5 and capacitor 6 produces voltage drops thereacross which may be represented by vectors *a—g* and *g—f* respectively. These voltages add vectorially with the phase voltages at terminals A and F respectively, to establish electrode 3 at a potential *o—g* from the common point O. Similarly, the large current flowing through electrode 4 raises its temperature, and at the same time establishes it at a potential *o—h* with respect to the common point O. Thus the voltage existing across the lamp from electrode 3 to electrode 4 is increased or boosted to the value *g—h*, so that the discharge starts without difficulty.

As soon as the discharge has started, the current flowing through the lamp causes voltages *a—g*, *g—f* to come more nearly into phase, so that the large starting voltage across the lamp electrodes is eliminated. If the normal voltage drop across the lamp is equal to what might be referred to as the delta voltage of secondary winding 3, the voltage drop across the lamp is reduced to *g'—h'*, and for such a combination no heating current whatsoever flows through electrodes 3 and 4 except the discharge current which flows in substantially equal amounts in opposite directions from the midpoint of the electrode filament. Where the normal voltage drop across the lamp is less than the delta voltage of the transformer, the voltage across the lamp may, for instance, be represented by *g''—h''*. In such case sufficient reactive current circulates through inductor 5 and capacitor 6 to provide the voltage drop *g'—g''*. Where the required voltage drop across the lamp is greater than the delta voltage, the reactive currents flow in an opposite direction and generate the small boosting voltage necessary to maintain the discharge through the lamp.

It will be apparent that lamps 9 and 10, which have been illustrated in dotted outline, will operate in an identical fashion and, when connected symmetrically as shown, will serve substantially to eliminate reactive volt amperes in the combination. Moreover, the voltages supplied to the three lamps in the combination are at 120° phase intervals, so that a substantially constant luminous intensity is obtained from the combination and stroboscopic effects are eliminated.

While I have shown lamp 1 and its associated circuit connected across adjacent and opposite terminals of a six-phase supply, it will be apparent that my invention is not in any way limited to this particular combination. For instance, an eight-phase supply may readily be utilized and in such case, four lamps might be utilized in a combination with the discharge current established at 90° phase intervals. However, as a matter of commercial practice, it is believed that the six-phase system which is readily obtained from a standard three-phase supply is the most practical.

Referring to Fig. 3, there is shown a discharge circuit wherein similar reference characters refer to similar elements as in Fig. 1, and which is adapted to be connected, in the same manner, to opposite and adjacent terminals of a six-phase supply. In this particular circuit, the filamentary ends of electrodes 3 and 4 are short circuited together and connected to the junction points of similar pairs of equal inductors 11, 12 and 13, 14. Moreover, device 1 is provided with a starting electrode or stripe 15 which is connected at one end to electrode 3. Inductor 11 is connected to terminal A, and inductor 12 is connected to terminal F through a capacitor 16. Similarly, inductor 13 is connected to terminal C through a capacitor 17 and inductor 14 is connected directly to terminal D.

The lamp utilized herein is of the so-called instant-start variety, wherein electrode heating current is not utilized, but the heating consequent upon high voltage emission is relied upon to bring the electrodes up to a temperature capable of providing sufficient electron emission to ionize the lamp and start the arc therein. With this variety of lamp, starting occurs in the same way as with the lamp shown in Fig. 1 except that the feature of supplying heating current to the electrodes is not utilized, and the resonant voltages provided by the circulating currents are alone utilized for starting.

In this circuit, the inductors are selected to have substantially equal reactances at the operating frequency and the capacitors are selected to have double the reactance of any one of the inductors. Accordingly, the circuits are still resonant at the operating frequency, but, since the reactance of the capacitor is twice what it was before, smaller size capacitors may be employed and this may be economically advantageous under certain circumstances. Moreover, the life of the fluorescent lamp appears to be lengthened when inductive ballasts are provided in series with the electrodes and the voltage source, rather than exclusively capacitive ballasts, and this circuit fulfills this requirement.

Referring to Fig. 4, wherein like reference characters denote corresponding elements as in the preceding figures, there is provided a protective device for short circuiting capacitors 16 and 17 in case of failure of the lamp to start, for some reason or other. It will be apparent that if the lamp should fail to start, a large current would continue to flow through the filamentary electrodes 3 and 4 and large resonant voltages would be created across the circuit elements. This might cause dangerous heating of the circuit elements and possibly bring about their destruction. This occurrence could be safeguarded against by fusing each of the electrode circuits A—F and C—D. Another means of safeguarding the circuit might be to insert a thermal switch with a lockout feature in series with each.

In accordance with my invention, I prefer to utilize another means which has the added advantage of simplicity and economy and which does not require any resetting after operating. The protective element consists of a varistor 18

and a thermistor 19 connected in a parallel with capacitor 16, both elements being included in a container 20 (shown in dotted outline) in order to maintain them in thermal contact. Varistor 18 is composed of a material whose resistance decreases rapidly with an increase in the applied potential; thermistor 19 is composed of a material whose resistance decreases rapidly with a rise in temperature. With the combination shown, if lamp 1 fails to start and a large current should continue to flow through the electrode circuits, the large voltage developed across capacitor 16 causes a substantial current to flow through varistor 18. Accordingly, varistor 18 heats up and in turn causes thermistor 19 to heat up and its resistance to decrease to the point where capacitor 16 is effectively short circuited. From then on, the current through thermistor 19 is sufficient to maintain it at a high temperature and short circuit capacitor 16 so that resonance is effectively destroyed in circuit A—F. A similar device 21 may be connected in circuit C—D to operate as a protective element therein.

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, as has been mentioned before, various polyphase sources may be utilized instead of the six-phase supply which has been described. Likewise, it need hardly be mentioned that other circuit elements capable of performing the same electrical functions may be substituted for those shown. The circuit is adaptable to the operation of large numbers of lamps in parallel and these may be combined, as to their starting circuits, so that all the starting elements need not be duplicated in each individual lamp. 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. Apparatus for starting and operating an electric discharge device of the type including a pair of thermionic electrodes, comprising said device, a polyphase source of alternating voltage of predetermined frequency containing an even number of phase terminals not less than four, first and second pairs of reactive circuit elements respectively connecting said electrodes to diametrically opposite pairs of adjacent phase terminals, one of said elements in each pair of elements being substantially equal in magnitude but opposite in sign to the other in order to constitute a resonant circuit at said frequency.

2. Apparatus for starting and operating an electric discharge device of the type including a pair of thermionic electrodes, comprising said device, a six-phase source of alternating voltage of predetermined frequency, first and second pairs of reactive circuit elements respectively connecting said electrodes to diametrically opposite pairs of adjacent phase terminals, one of said elements in each pair of elements being substantially equal in magnitude but opposite in sign to the other in order to constitute a resonant circuit at said frequency.

3. Apparatus for starting and operating an electric discharge device of the type including a pair of thermionic electrodes, comprising said device, a polyphase source of alternating voltage of predetermined frequency containing an even number of phase terminals not less than four, first and second pairs of reactive circuit elements respectively connecting said electrodes to diametrically opposite pairs of adjacent phase terminals, one of said elements in each pair of elements being substantially equal in magnitude but opposite in sign to the other in order to constitute a resonant circuit at said frequency, the reactances of said elements being selected in proportion to the voltage required for starting a discharge within said device and occurring as a result of the flow of current through said resonant circuit from adjacent phase terminals.

4. Apparatus for starting and operating an electric discharge device of the type including a pair of thermionic electrodes, comprising said device, a polyphase source of alternating voltage of predetermined frequency containing an even number of phase terminals not less than four, first and second pairs of reactances respectively connecting said electrodes to diametrically opposite pairs of adjacent phase terminals, the reactances in each pair being substantially equal in magnitude, but one being inductive and the other capacitive in order to constitute a resonant circuit at said frequency for augmenting the voltage across said electrodes at starting as a result of the flow of current within said circuit from adjacent phase terminals, said current serving simultaneously to heat said electrodes.

5. A circuit for operating and starting a fluorescent lamp of the type comprising a pair of filamentary thermionic electrodes, comprising said lamp, a polyphase source of alternating voltage of predetermined frequency containing an even number of phase terminals not less than four, a circuit for one of said electrodes including an inductive reactance connecting one end thereof to a first phase terminal and a capacitive reactance of substantially equal magnitude connecting the other end thereof to a second phase terminal adjacent said first one, a similar circuit for the other of said electrodes including an inductive reactance and a capacitive reactance of equal magnitude connecting the ends thereof to a third and to a fourth phase terminal adjacent to each other and diametrically opposite to said first and second phase terminals, said circuits serving simultaneously to heat said electrodes and to increase the voltage applied between them at starting.

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REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,265,323	Spanner	Dec. 9, 1941
2,298,935	Freeman	Oct. 13, 1942
2,354,654	Abbott	Aug. 1, 1944