Jan. 20, 1959 L. F. BIRD 2,870,379

OPERATING CIRCUIT FOR COMPACT TYPE ARC LAMPS

Filed Aug. 13, 1958

FIG. 1

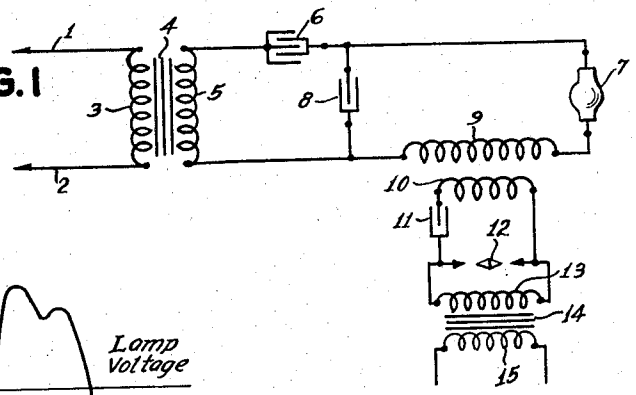


FIG. 2

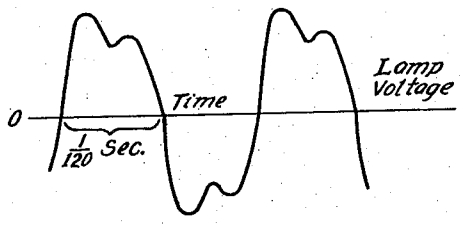


FIG. 3

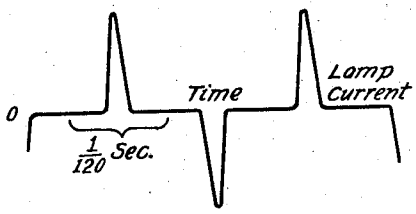


FIG. 4

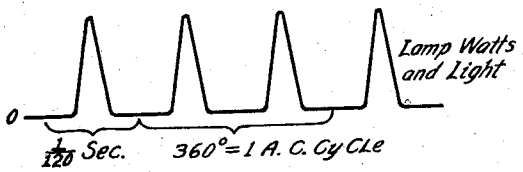


FIG. 5

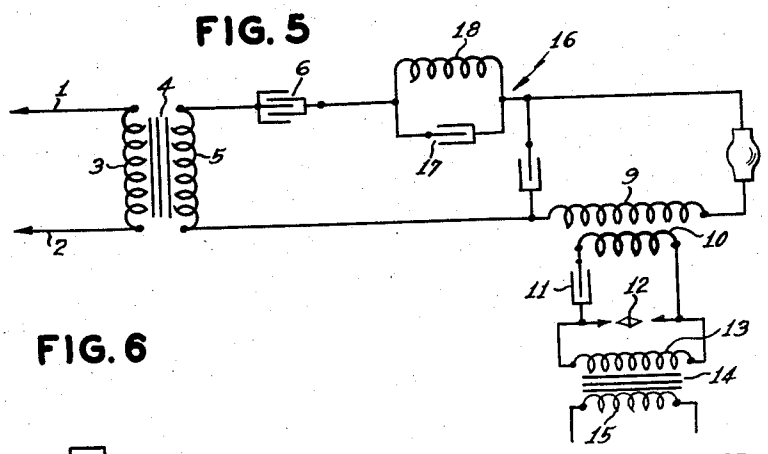
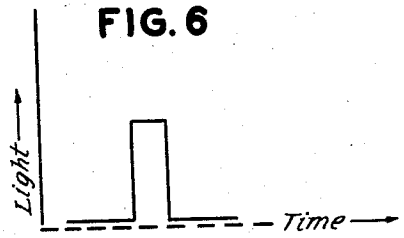


FIG. 6



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OPERATING CIRCUIT FOR COMPACT TYPE ARC LAMPS

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Application August 13, 1958, Serial No. 754,734

3 Claims. (Cl. 315—174)

The present invention deals with an electrical operating circuit for high pressure and super high pressure arc lamps and more particularly with an operating circuit for compact type arc lamps.

This application is a continuation-in-part of application Serial No. 433,954, filed June 2, 1954 and now Patent No. 2,858,481.

There are applications notable in the field of motion picture projection where it is desirable to have the light of a light source emitted in the form of light pulses of relatively short duration with an out or dead space between pulses. With a light source having such characteristics it is possible to eliminate the shutter commonly employed with the motion picture projector and move the frame of the film during the out periods of the light source.

There are many reasons for the desirability of such an arrangement, notably the possibility of increasing the effective light reaching the screen and the possibility of more efficient use of the light source as well as the utilization of the same light source in larger projection areas.

It is an object of the present invention to provide an operating circuit particularly suited for operating compact type arc lamps from which the emitted light is in the form of discrete pulses with substantially non-emission phases therebetween. It is another object of the present invention to provide an operating circuit for compact type lamps from which the emitted light is in the form of discrete light pulses lasting from less than ⅓ to ⅔ of the time of ½ cycle. It is a further object of the invention to limit the peak currents of the lamp arc and to provide light pulses of desirable shape for maximum lamp life. Other objects and advantages of this invention will become apparent from the description hereinafter following and the drawings forming a part hereof, in which:

Figure 1 is a schematic representation of the circuit according to the invention,

Figure 2 is an oscilloscopic diagram of the voltage characteristics across a lamp forming part of this circuitry,

Figure 3 is an oscilloscopic diagram of the current characteristics across a lamp forming part of the circuitry,

Figure 4 is a diagrammatic representation of the pulsating light output in accordance with this invention,

Figure 5 is a schematic representation of a modification of Figure 1, and

Figure 6 illustrates a diagrammatic representation of a modified pulsating light output. The present invention deals with an operating circuit for producing particular discrete light pulses with substantially non-emission phases therebetween, said discrete light pulses lasting from less than ⅓ to ⅔ of the time of ½ cycle. The lamp is a compact type arc lamp comprising a light transmissive envelope enclosing spaced electrodes of solid metal spaced apart from each other less than 2 cm. in an ionizable atmosphere. High pressure and super high pressure lamps of the compact type are well known in the art.

Referring to Figure 1, input leads **1** and **2** lead to a source of alternating current power capable of maintaining operating of a compact lamp containing an ionizable atmosphere exceeding one atmosphere and preferably of at least 2 atmospheres pressure, said leads being connected across a transformer primary winding **3** of transformer **4** in spaced relation with a secondary winding **5**, the transformer having magnetic leakage shunts as an integral part of the core construction.

A series capacitor **6** is connected in one of the secondary leads between the transformer secondary **5** and a lamp **7** in series with one terminal of the secondary winding **5** and lamp **7**, and is an operable chosen capacitor having a volt ampere rating of several times that of the lamp **7**, which, for example, operates at a voltage of 35 volts and 30 amperes. A shunting capacitor **8** is shunted across both secondary leads between the capacitor **6** and lamp **7**. This shunt capacitor serves two functions, one function being that of a radio-frequency by-pass across the lines, and the other function being to assist in the ignition of the arc lamp. Between the shunt capacitor **8** and the lamp **7**, in one of the lines, is a secondary coil of a radio-frequency transformer which provides high voltage, high frequency current for igniting the arc lamp. A primary coil **10** of the radio-frequency transformer is operatively associated with the secondary coil **9**. A radio-frequency capacitor **11** is connected into one line leading to the R. F. primary coil, and a sparking gap **12** is connected across the primary leads of the R. F. transformer between the capacitor **11**, and the secondary **13** of a high voltage transformer having core **14** and primary winding **15**. The circuit for the R. F. generator for ignition is purely diagrammatic and may be varied in many details without effecting either its performance or the performance of the rest of the circuit.

Before the lamp **7** is ignited, the transformer **4** is delivering about 150 volts across the lamp. Immediately upon ignition of the lamp, the secondary voltage of the transformer jumps to a higher value which may be about 300 volts and assumes a condition of considerable stability at this level because of high saturation of the core iron under the secondary coil of the transformer. Also the reactance of the secondary coil of the transformer has been reduced to a comparatively low value because of the saturation of the iron under the secondary coil. The reactance of this coil is very unsteady under these conditions and varies rapidly with changes in the induced voltage in the secondary winding. These changes in reactance in combination with the reactance of the capacitor combine to produce an overall circuit reactance that increase with increasing line voltage and is reduced with reducing line voltage. In this manner the secondary compensates for the changing input voltage conditions. Also the wattage delivered to the lamp and, consequently, the light output of the lamp becomes quite stable and uneffected by the line supply voltage.

When an arc lamp of this type is operated from a 60-cycle supply, the light is emitted at a continuous varying rate having peaks at twice the line frequency or 120 cycles per second. Since it is accepted practice to project motion pictures at a rate of 24 frames per second there would normally be 5 peaks of light from the arc during each frame of the motion picture. These peaks are at such a frequency that there is no flicker apparent to the human eye from such a light source. The only requirement for the use of such a light source in a projector is that the mechanical movement of the film from frame to frame occurs during a time when the light is very low or out. With the light emitted in discrete pulses with dead spaces between, it is possible to move the film when

there is no light from the arc lamp and so have no problem with film motion and light.

The transformer 4 is a special type of reactive transformer having a core structure built up of thin low loose lamination steel on which are placed the primary coil 3 in spaced relationship to the secondary coil 5 and having a magnetic leakage plug or plugs between the said coils so providing loose coupling between the magnetic structures beneath these coils. The voltage that is delivered from the secondary coil 5 is between about 90 volts as a minimum and possibly 250 volts as a maximum. Voltages below 90 volts from the transformer are not suitable because of instability in the arc lamp which may cause it to be extinguished. The 90 volts corresponds to the minimum possible line voltage on the primary of the transformer. It may be desirable to have higher voltages to reduce the size and cost of the second unit of the control, that is the capacitor 6, which is connected to one terminal of the secondary winding 5 of the transformer 4. This capacitor is chosen to have a voltage rating corresponding with the capacitor reactance and the current through it. The kva. of this capacitor is chosen, for example, to be from 3 to about 12 times the kva. of the arc lamp 7, such that when the arc lamp is operating at a voltage of 35 volts and a current of 30 amperes, the capacitor is operating at a voltage of possibly 300 volts and a current of 30 amperes. Such a capacitor has a reactance of 10 ohms and at 60 cycles has a capacity of about 265 microfarads.

The operating circuit comprises the ignition system which may be made up in a number of forms and is not concerned with the operation of the arc lamp after it is lighted and in steady operating condition.

Upon closing a switch leading to the power supply, the transformer 4 is excited and voltage is applied to the lamp circuit by the secondary coil 5. The lamp will not start on this low voltage and it remains out. Voltage is then applied to the primary circuit of the transformer 14, which in turn delivers high voltage to the capacitor 11. When the voltage across the capacitor reaches the potential that will break down the spark gap, this spark gap breaks down and becomes essentially a short circuit. Oscillations are established as the condenser 11 is discharged through the inductance 10. High voltage is supplied from the secondary coil flowing through the lamp and condenser 8. The high frequency currents ionize a path through the enclosed gas of the arc lamp and the low voltage follows through the ionized path, so establishing an arc at the low voltage.

With this kind of control device for the arc, the voltage delivered by the secondary of the transformer 4 is distorted from a sine wave and is quite flat-topped, indicating the presence of harmonics some of which have considerable magnitude. They are mainly 3rd and 5th harmonics of the supply. Referring to Figures 2, 3 and 4, there is shown the shape of the voltage wave existing across the lamp as displayed on the screen of an oscilloscope. Because there is no current flowing for the major part of the cycle the voltage wave tends to follow the shape of the voltage from the secondary of the transformer 4 without load until the current starts to flow, at which time, there is a dip in the voltage wave corresponding to the time of current flow.

The current wave is particularly shown by Figure 3 representing the current wave of the lamp as displayed on a screen of an oscilloscope. The current flows in the form of sharp pulses of current at the time when the voltage is approaching its maximum.

Figure 4 shows the form of the pulses of wattage as demonstrated by the light output of the lamp. The light is emitted in the form of discrete pulses with an out period between when there is no light nor power consumption.

Since a photocell picking up the light is a linear device, and the current is an average of the light response, the

lamp consuming, for example, 100 watts, is emitting at a much higher rate than this during the light flashes which last, for example, ⅓ or less of the time period.

The voltage across such an arc lamp is commonly of a certain well established form. The voltage starts at 0 and rises very rapidly to a peak which may be appreciably higher than the average voltage. Beyond the peak the voltage falls to a relatively flat region for an appreciable portion of the half cycle and then drops again to 0 for the excursion in the opposite direction.

The current through the arc lamp may be quite distorted and effectively displaced in phase from the voltage wave. When viewed on an oscilloscope, the current wave is observed to be a very narrow shape pulse at about the middle of the half cycle.

Since the light from the lamp follows the wattage consumption closely, it is notable that the only time there is wattage for the lamp is during the time when both current and voltage are present across the arc tube. This condition is met for only a short period at the middle of the half cycle during the current time. As a result the light has to follow the current pulses and does so in practice.

The advantages to be gained in the field of motion picture projection by the use of the pulsed light has been described above. The overall efficiency of light use is increased more than100 percent when the pulsed light is employed instead of the steady arc with the associated shutter mechanism. With the pulsed light it is possible to confine the light emission to those periods when the shutter is open and have the shutter cut out an absolute minimum of light from the screen.

The principle is well known in the electrical art that the light from a lamp follows in some relationship the consumed wattage. If the same amount of light is emitted from a lamp in a shorter time the wattage consumption during that period must be increased. With an arc of the type used here the voltage of the arc is essentially fixed by the physical features of this construction so the variable concerned with varying wattage appears in the instantaneous currents. If the same wattage is consumed in one half of the time the current must be increased to twice the value that would be necessary for a steady consumption of power.

Life tests upon lamps indicate that there is a definite relation between peak currents in the arc and the blackening of the lamp that limits its useful life. Higher current peaks increase the blackening of the bulb. It is desirable, therefore, to limit the peak currents of the arc as much as possible if maximum life is desired.

It has been found that an alteration in the circuit as described above will so shape the light pulses that the peak currents demanded of the arc can be greatly reduced without reducing the value of the pulse form otherwise. Instead of the pulse existing in the form of a sharp spike coming to a point, it is formed to have vertical sides and essentially a flat top, as illustrated by Figure 6. The altered shape makes it possible for the arc wattage to be unaffected with a greatly reduced peak current requirement. This is accomplished by introducing in series with the lamp a trap circuit 16 illustrated by Figure 5, comprising a capacitor 17 and a linear inductance 18 which is independent of the current flowing through it. This trap circuit is tuned to approximate the second harmonic of the main alternating current frequency. The nature of the inductance used in the trap circuit is critical, and the phase relationships in the pulse must be determined to establish the shape required in the pulse. This adjustment can be made upon an operating lamp by having the light received and exhibited upon an oscilloscope screen.

The values of the capacitor and the inductance must be chosen not only for the tuning frequency but for the impedance offered in the series circuit. All of the parts react upon each other and the shape of the light pulse

is the resultant of the interaction of all of the components of the circuit.

For instance it is possible to modify the shape of the light pulse in the original circuit by altering the open circuit voltage of the transformer and the kva. involved in the capacitor. These must be chosen to permit the proper operation of the circuit.

The actual values chosen for the trap of my invention are intimately tied up with the design and performance of the transformer and capacitor of the invention.

The following are values for a trap circuit that operated successfully with the particular transformer and capacitor in operation at the time. The capacitor is chosen to be 135 microfarads having a reactance of 9.8 ohms at 120 cycles. The inductance is chosen to be 9.8 ohms at 120 cycles with an inductance of 13 millihenries.

The effect of the trap was to greatly increase the impedance of the series circuit through the lamp at the frequency of 120 cycles. The trap had but little effect for harmonics of the alternating current supply aside from the second harmonic.

Various modifications of the light pulse producing system of this invention are contemplated within the scope of the appended claims.

What is claimed is:

1. A light pulse producing system for compact type arc lamps, comprising in combination a transformer having mounted thereon a primary input coil and a secondary inductive coil in spaced relation to each other with a magnetic shunt between the coils, a compact type arc lamp containing an ionizable atmosphere, leads connecting the lamp to the secondary coil, a capacitor in one of the leads in series with the lamp, the capacitor having a volt ampere rating greater than the lamp, a tuned trap in one of said leads in series with the capacitor and lamp, said trap comprising a parallel system of an inductive coil and capacitor, said combination being a light pulse producing system characterized by light flashes having a duration of up to two-thirds the time of one-half cycle.

2. A light pulse producing system according to claim 1, wherein the ionizable atmosphere is of at least one atmosphere pressure.

3. A light pulse producing system according to claim 1, comprising high frequency ignition means connected to one of the leads.

No references cited.