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2,619,615

CIRCUIT FOR OPERATING ELECTRIC DISCHARGE LAMPS

Filed Oct. 8, 1946

2 SHEETS—SHEET 1

FIG. 1

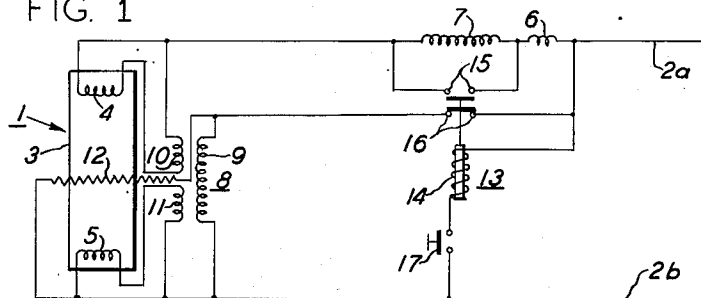


FIG. 2

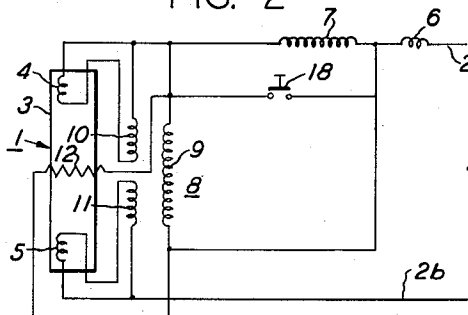


FIG. 3

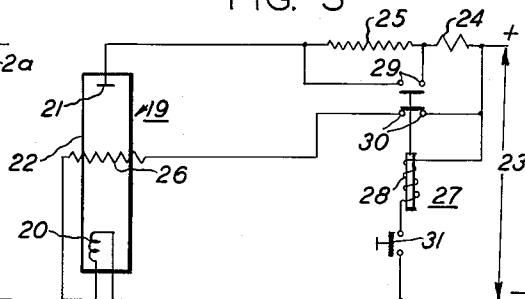
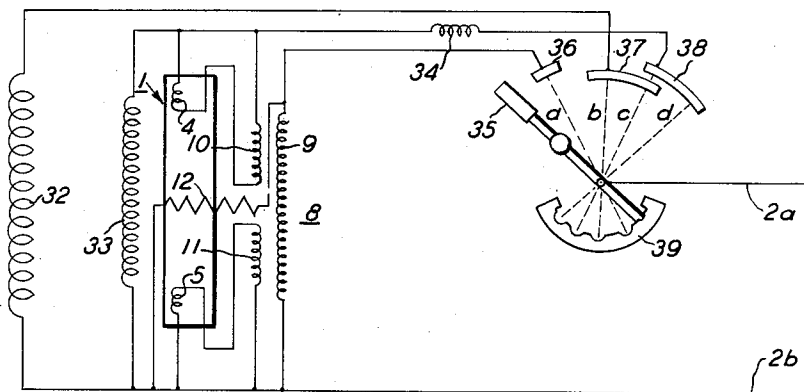


FIG. 4



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2 SHEETS—SHEET 2

FIG. 5

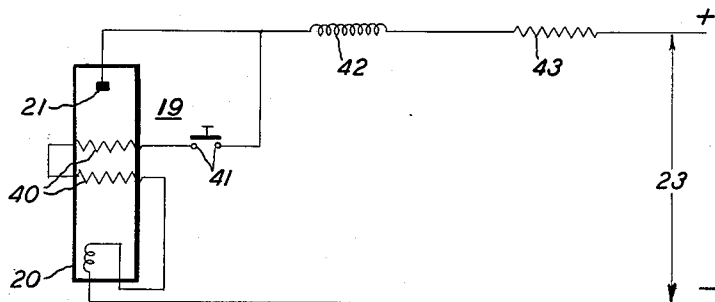
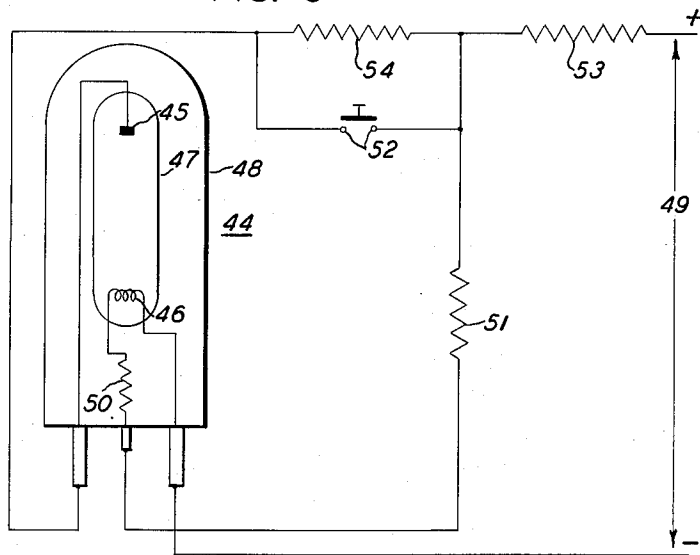


FIG. 6



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CIRCUIT FOR OPERATING ELECTRIC
DISCHARGE LAMPSHarold Robert Ruff and Harry Kebbell Bourne,
Rugby, England, assignors to General Electric
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3 Claims. (Cl. 315—98)

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This invention relates to circuits for electric discharge lamps and to methods of operating such lamps.

It is well known that there are instances where it is desirable to be able to switch a source of light rapidly on and off. One such use is that of transmitting messages by signalling. For these purposes the electric discharge lamp has a considerable advantage relative to the incandescent filament lamp owing to the elimination of thermal inertia. In many cases, however, the luminous efficiency of the electric discharge lamp can be greatly increased if the pressure of the gas or vapor present can be raised to a high value. An example of such a lamp is the high pressure mercury vapor lamp such as is now well known, but as the pressure of the vapor is increased there is an increased difficulty in striking an arc and use has been made of circuits whereby the arc is not extinguished but is reduced in power consumption by switching into the circuit an additional impedance.

For signalling purposes, it is desirable that the power consumption of the arc in its reduced power condition shall be as small as possible, as this enables the maximum difference between the light output in the reduced and high power conditions to be obtained.

An object of the present invention is to provide improved means for obtaining flashes of light by the use of a high pressure metal vapor discharge device in which the ratio of power consumption in the high power and reduced power condition is improved while ensuring that the discharge is maintained during the intervals of low power consumption.

It is another object of the present invention to provide new and improved methods for operating electric discharge lamps.

It is a further object of our invention to provide new and improved systems for pre-conditioning and operating electric discharge lamps intermittently or periodically, whereby the ionizable medium employed in the lamp is maintained at a predetermined temperature or pressure suitable for supporting an arc discharge operable at high power levels to produce commensurate flashes of light of large luminous value.

In accordance with our invention there are provided circuit arrangements for producing flashes of light by operating intermittently electric discharge lamps of the kind employing a metal vapor at high pressure during operation. The lamps used may be provided with a cathode or electrode adapted to be heated by means independent of

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the discharge, and the systems are provided with a series-connected impedance, the value of which is adapted to be varied intermittently to cause the lamps to operate at two different wattages of widely differing values, auxiliary means being provided for supplying heating current to the electrodes at least during the intervals at which the lamps are operating at lower wattage values, thereby to maintain the pressure of vapor within the lamps during such intervals and to maintain the electron emissivity of the electrodes.

The heating current to the cathode or electrodes of the lamp may continue to be supplied during periods in which the lamp is operated at its higher wattage value, and the heating current is then preferably reduced. The heating of the cathode or electrodes may be, and preferably is, supplemented by additional heating of the lamp by means of a heating element which may be located outside the lamp envelope. The heating of the electrode, and the supplementary heating of the envelope, enable the vapor pressure within the lamp to be maintained during periods when the power consumption is reduced, thereby enabling the arc immediately to jump to its higher power consumption level without delay.

In some cases it is even possible, when the electrodes are maintained in a heated condition and the envelope of the lamp is provided with supplementary heating, to reduce the power consumption during the intervals to zero if means are provided for applying a high voltage to restart the arc.

For a better understanding of our invention reference may be had to the following description taken in connection with the accompanying drawings and its scope will be pointed out in the appended claims. Fig. 1 diagrammatically illustrates an embodiment of our invention as applied to a system for intermittently operating an electric discharge lamp at high power input levels, and wherein provision is made for supplying electrode heating current, and auxiliary heat external to the lamp envelope during periods of low or reduced power consumption. Figs. 2 and 3 are modifications of the arrangement shown in Fig. 1. Fig. 4 diagrammatically illustrates a comprehensive system wherein in addition to the electrode heating circuit and the external or auxiliary heating circuit, high voltage starting means is provided for applying a starting voltage across the lamp electrodes, and selector switch means is also provided for also selectively and sequentially connecting the various circuit components in operative relation. Fig. 5 is a simplified

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circuit arrangement for operation on direct current. Fig. 6 is a still further modification wherein a lamp designed for direct current operation is provided with auxiliary heating means for use in a system in the above-described type.

Referring now to Fig. 1 our invention is there illustrated as applied to a system for intermittently or periodically operating an electric discharge lamp 1 from a suitable source of current, such as an alternating current circuit comprising conductors 2a and 2b. The electric lamp 1 is preferably of the high pressure metal vapor type such as a high pressure mercury vapor lamp, having an envelope 3 and a plurality of electrodes 4 and 5 which are preferably of the filamentary type. These electrodes, of course, may be of either the activated or unactivated type. Between the alternating current supply circuit and the lamp 1, we provide impedance means such as inductances 6 and 7 which control the magnitude of the current supplied to the lamp 1.

In order to pre-condition the lamp 1 by pre-establishing a definite pressure of the ionizable medium therein to put the lamp in condition for immediate operation at high power levels, we provide electrode heating means, such as a cathode heating transformer 8 having a primary winding 9 and a pair of secondary windings 10 and 11, which are respectively associated with and supply current to electrodes 4 and 5. In addition we also provide auxiliary or additional heating resistance 12, which is positioned external to the envelope 3 but in heat exchanging relation with respect thereto to control or raise the vapor pressure in the lamp 1.

As a means for controlling the power supplied to the lamp 1 and for controlling the electrode heating means and the external heating means, we provide an electro-responsive device such as a relay 13 having an actuating coil 14 and sets of contacts, such as normally open contacts 15 connected across inductance 7, and normally closed contacts 16 connected in circuit with transformer 8 and resistance 12. As a means for initiating circuit operation, and for controlling the length of the flashes of light produced by lamp 1 and also for controlling the periods of time between flashes, we provide a suitable initiating means, such as a key 17, connected in series relation with the actuating coil 14 across conductors 2a and 2b.

Upon energization of the supply circuit comprising conductors 2a and 2b, due to the fact that the contacts 16 are normally closed, a predetermined amount of heat will be supplied to the lamp 1 by virtue of the energization of transformer 8 and resistance 12. Transformer 8 through its secondary windings supplies electrode heating current to the filamentary electrodes 4 and 5, and the resistance 12 supplies heat externally to the lamp envelope 3, in this way pre-conditioning and establishing a minimum vapor pressure within the envelope so that upon increase of current thereto the lamp responds substantially instantaneously to produce a flash of light of high luminous value. Under this condition of operation, prior to the closure of key 17, only a very small amount of current flows between electrodes 4 and 5, due to the fact that the current supplied to the lamp is limited by both inductances 6 and 7. Thus the lamp operates at or under low power consumption conditions.

Upon the closure of key 17, relay 13 operates causing simultaneous opening of contact 16 and closure of contacts 15, the former operation ef-

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fecting interruption of the circuit to transformer 8 and resistance 12, and the latter operation short-circuiting inductance 7 thereby increasing the power supplied to lamp 1. By reducing the heat supplied to the electrodes, the electrodes are prevented from becoming overheated when the full arc current is transmitted. Of course, the interruption of the circuit to resistance 12 is also beneficial in this respect. Since the vapor pressure in the discharge lamp has been pre-established at its desired value, and the electrodes 4 and 5 are at their full electron-emitting temperature, the lamp transmits the increased current and a corresponding light output is obtained practically instantaneously.

In Fig. 2 a further modification of our invention is illustrated, the system being similar in many respects to that shown in Fig. 1 and corresponding elements have been assigned like reference numerals. In the arrangement of Fig. 2 a suitable initiating means such as a key 18 is connected across the inductance 7 thereby serving itself as the short-circuiting means therefor. In addition, the electrode heating transformer 8 and the resistance 12 are energized in response to the voltage appearing across inductance 7 and are connected directly thereacross. Due to the fact that key 18 when it is closed short-circuits not only inductance 7 but also transformer 8 and resistance 12, it will be appreciated that when key 18 is closed to increase the power supplied to the lamp 1, the electrode heating and the external resistance heating are also simultaneously decreased or interrupted. Resistance 12 may not be required if electrodes 4 and 5 are made to have a relatively large power consumption, and it may be that the impedance of transformer 8 may be such that it will operate as the impedance 7.

Furthermore, it will be appreciated that certain aspects of the above described circuits are applicable to direct current systems, such as that shown in Fig. 3 wherein an electric discharge lamp 19, having a filamentary electrode or cathode 20, an anode 21 and an enclosing envelope 22, is energized from a direct current circuit 23 through resistances 24 and 25. The cathode 20 is shown as being heated or connected in series relation with an external heating resistance 26. A suitable relay 27, having an actuating coil 28 and normally open contacts 29 and normally closed contacts 30, is provided for simultaneously short-circuiting resistance 25, disconnecting heating resistance 26 and interrupting cathode energization in response to operation of a key 31.

Fig. 4 diagrammatically illustrates a further embodiment of our invention wherein electric lamp cathode heating circuits and external heating circuits are similar to that discussed above in connection with Fig. 1 and corresponding elements have been assigned like reference numerals. In addition to the auxiliary heating apparatus, the modification shown in Fig. 4 comprises a high voltage transformer for applying starting voltage to the electrodes 4 and 5 of the lamp. This transformer comprises a primary winding 32 and a secondary winding 33, the latter of which is connected across the electrodes 4 and 5. In addition a stabilizing impedance 34 is connected in series relation with the lamp 1.

We provide selector switching means whereby the aforementioned circuit elements may be selectively and sequentially connected in circuit in the following manner. For example, we provide a selector switch having a movable contact 35 and stationary contacts 36-38 establish-

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ing in conjunction with a positioning member 39 a plurality of positions *a, b, c, d*. This selector switch may be manually or automatically operated.

The lamp 1 is connected in series relation with its normal stabilizing inductance 34. The electrodes 4 and 5 are heated by the secondary windings 10 and 11 and the resistance heater 12 is arranged so that the heat from it maintains the vapor within the envelope of lamp 1 at the required high pressure suitable for operation at high power input. When the movable contact 35 is in the position *a*, lamp 1 is operated with the electrodes 4 and 5 heated by means of the current flowing from secondary windings 10 and 11, but no arc discharge is present within the lamp 1, that is, there is no arc discharge current passing between electrodes 4 and 5. In addition, resistance 12 is also energized. As the contact 35 is moved to position *b*, the electrode heating and the external heating provided by resistance 12 are interrupted or removed, and the high voltage transformer comprising windings 32 and 33 is connected in circuit through contact 37. This provides a voltage sufficiently great to strike an arc between electrodes 4 and 5, while the current it affords is also sufficiently great to bring the arc tube voltage below the critical value required to enable the arc to be stabilized on the supply circuit. Then as the contact 35 moves on to position *c*, engaging contact 38, connection is made with the electrodes and under this condition the arc is maintained between the electrodes through the stabilizing inductance 34. As the contact 35 is moved to position *d* the transformer primary winding is open circuited so that the rating of this transformer can be relatively small by virtue of its load factor.

A further circuit is shown in Fig. 5 illustrating a further way in which our invention may be applied to direct current circuits. In this circuit, the discharge lamp similar to lamp 19 of Fig. 3 is uniquely adapted for direct current operation, and the cathode 20 is heated in series relation with heating resistances 40. When switch 41 is closed current passes from the direct current circuit 23 through inductance 42 and resistance 43 thereby heating the cathode 20 and energizing resistances 40, which maintain the discharge path of lamp 19 at the correct mercury vapor operating pressure. Inductance 42 is employed and is designed to have characteristics to effect the storage of substantial magnetic energy. Resistances 40 in series with the cathode 20 constitute a relatively low resistance circuit which upon the closure of switch 41 effects the transmission of appreciable current through inductance 42 thereby storing energy in magnetic form therein. Upon opening switch 41 rapidly there is produced across the terminals of the lamp a relatively large voltage, and at least a part of the energy stored in the inductance 42 is used to energize the lamp causing it to produce a flash of light of large luminous value. We have found that this circuit can be arranged so that this voltage will initiate a discharge in lamp 19 and sufficient current will pass to enable the voltage drop across the lamp to decrease to a value below the supply circuit voltage so that the arc will stabilize from the direct current circuit and be stabilized by resistance 43.

A still further modification of our invention suitable for operation from direct current circuits is shown in Fig. 6 wherein an electric discharge lamp 44, having an anode 45 and a fila-

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mentary cathode 46 enclosed in an envelope 47, is also provided with an outer enclosing jacket 48 in which the aforementioned elements are positioned. Cathode 46 is heated from a direct current supply circuit 49, the cathode heating current being transmitted through an auxiliary heating resistance 50 which is positioned within the outer jacket 48 within the vicinity of the cathode 46. A suitable current limiting or controlling external resistance 51 may also be employed and connected in series relation with a heating element or resistance 50. Thus when the lamp is operating at its reduced power consumption level, that is when actuating key 52 is open, the external heating circuit and cathode circuit will have across them a voltage equal to the supply circuit voltage less the small amount of voltage drop in the resistance 53 which is connected in series relation between the supply circuit 49 and the lamp 44 and which is connected in series with a further resistance 54. When the lamp is flashed or operated at its higher value by short-circuiting resistance 54 by the closure of key 52, the voltage across the cathode and the heating circuit will then become much lower, being equal to the voltage drop of the lamp, and therefore the wattage dissipated in the heating resistance and in the cathode will automatically be reduced.

In a particular lamp which has been made to operate from a direct current supply, the light output from the lamp when flashing is 5000 candlepower and the light output when simmering or operating at its lower value is only 15 candlepower. When the lamp is simmering the cathode circuit has across it 220 volts, and when the lamp is flashing it has across it only a voltage of 50 volts. By this means overheating of the lamp and of the cathode is prevented when the lamp is flashed.

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

1. A system for preconditioning and starting a lamp of the high pressure metal vapor type in order to permit its instantaneous operation at high power levels, comprising a source of alternating voltage, an electric discharge lamp having an envelope containing a pair of filamentary thermionic electrodes and an ionizable medium in the form of a vaporizable metal filling sealed therein, an external resistance heater for said lamp, a heating transformer having secondary windings connected to said electrodes, a starting transformer having a high voltage secondary winding connected across said electrodes, a stabilizing impedance connected in series with said electrodes for constituting a main discharge circuit, and switching means providing connections from said source to said resistance heater, to said heating transformer, to said starting transformer, and to said main discharge circuit, said switching means being disposed to energize in sequence said resistance heater and said heating transformer, then said starting transformer, and finally said main discharge circuit.

2. A system for preconditioning and starting a lamp of the high pressure metal vapor type in order to permit its instantaneous operation at high power levels, comprising a source of alternating voltage, an electric discharge lamp having an envelope containing a pair of filamentary thermionic electrodes and an ionizable medium in the form of a vaporizable metal filling sealed therein, a preconditioning circuit comprising a heating transformer and an external resistance

heater for said lamp, said transformer having a primary winding connected in parallel with said resistance heater and a pair of secondary windings connected to said filamentary electrodes, a starting circuit comprising a transformer having a primary winding and a high voltage secondary winding connected across said electrodes, a main discharge circuit comprising a stabilizing ballast impedance connected in series with said electrodes, and switching means providing connections from said source to said preconditioning circuit for energizing same, from said source to the primary winding of said starting transformer for energizing said starting circuit and initiating a discharge within said lamp, and finally from said source to said main discharge circuit for providing normal operation of said lamp.

3. A system for preconditioning and starting a lamp of the high pressure metal vapor type in order to permit its instantaneous operation at high power levels, comprising an electric discharge lamp having an envelope containing a pair of filamentary thermionic electrodes and an ionizable medium in the form of a vaporizable metal filling sealed therein, a source of alternating voltage, a four-position selector switch having a movable contactor connected to one side of said source, and three cooperating fixed contacts, said movable contactor making connection to said first contact in its first position, to said second contact in its second and third positions, and to said third contact in its third and fourth positions, an external resistance heater for said lamp connected between said first contact and the other side of said source, a heating transformer having a primary winding also connected between said first contact and the

other side of said source, and a pair of secondary windings connected to said electrodes for providing heating current thereto, a starting transformer having a primary winding connected between said second contact and the other side of said source and a high voltage secondary winding connected across said electrodes, a stabilizing impedance connected in series with said electrodes between said third contact and the other side of said source for constituting a main discharge circuit, said contactor being operated through said four positions in sequence in order to precondition said lamp, initiate a discharge therein and finally produce a high power level arc.

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HARRY KEBBELL BOURNE.

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