April 17, 1951 A. H. WILLOUGHBY 2,549,353

CIRCUITS FOR OPERATING ELECTRICAL DISCHARGE DEVICES

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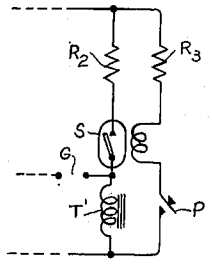

FIG. 3

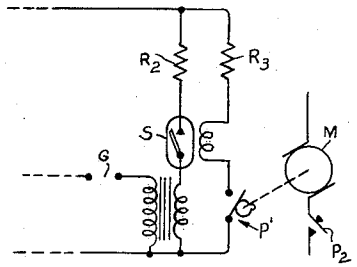

FIG. 4

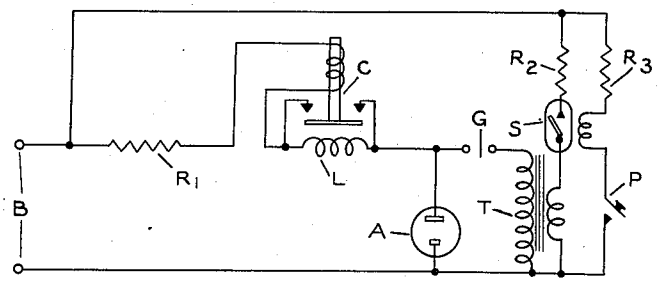

FIG. 1

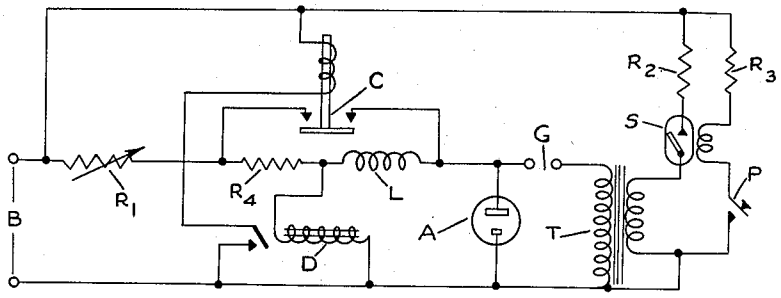

FIG. 2

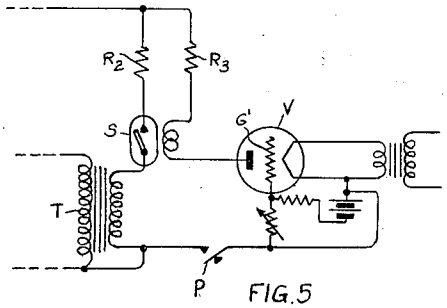

FIG. 5

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CIRCUITS FOR OPERATING ELECTRICAL DISCHARGE DEVICES

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8 Claims. (Cl. 315—246)

1

This invention relates to circuits for operating electric discharge devices of the kind in which a discharge takes place in normal operation through gas or vapour contained in an envelope and in which no auxiliary electrode is used for starting; the main object of the invention is to provide an improved arrangement for starting such devices and especially for restarting them when still hot. The invention is mainly intended for use with discharge devices, for example high pressure mercury vapour lamps, where the voltage needed to start or restart the discharge greatly exceeds the open-circuit voltage of the supply needed to run the device, but may also have use where the excess of starting voltage over open-circuit voltage is not so great.

According to the present invention a circuit for operating an electric discharge device of the kind set forth comprises both a starting circuit and a main supply circuit, the said main supply circuit having device-operating terminals for connection to the discharge device and main supply terminals for connection to a current source for the supply of normal operating current to the device, and the said starting circuit comprises the secondary of a transformer connected in series with a spark gap across the said device-operating terminals, connections from the primary of the said transformer to starting terminals for connection to a current source for the supply of current to the said primary, and a switch adapted to be operated so as to interrupt the flow of current in the said primary and thereby produce across the device-operating terminals a voltage pulse for starting the discharge in the device, and a high frequency choke is included in the main supply circuit so as substantially to prevent the said voltage pulse from being fed back to the said main supply terminals.

The circuit arrangement may be such that the main supply circuit and the starting circuit are operable from a common current source.

In operation of the circuit arrangement, when the said switch is operated to break the current in the primary of the said transformer a pulse of relatively high voltage is induced across the secondary terminals of the transformer and is applied across the discharge device, which is thereby enabled to start; the spark gap serves to steepen the wave front of the pulse. When the device is operating on alternating current, the operation of the switch must be synchronised to a sufficiently large value of the current in the transformer primary. The instant of operation must also have the correct relation to the voltage across the discharge device, i. e., the voltage must be sufficiently large or increasing so as to enable the discharge to be maintained. The transformer will usually be of the step-up type, and it may be auto-transformer. In an extreme case where a 1-to-1 ratio is suitable and an auto-transformer is selected, the transformer will take the form of a choke, which is here to be regarded as an auto-transformer of 1-to-1 ratio.

2

The high-frequency choke included in the main supply circuit provides a high impedance to the pulse, and this choke may be short-circuited by a contactor arranged to operate in response to the flowing of current from the source to the discharge device, or in response to the drop in voltage across the electrodes of the device which accompanies the striking thereof. The high-frequency choke is so designed that it can carry the full discharge current for a short time and have an impedance which is high to the pulse applied by the transformer but not so high as to retard unduly the growth of the discharge current through it.

The invention will be described by way of example with reference to the accompanying drawings in which Figures 1 and 2 show two circuits in accordance with the invention, like parts in the two figures being given like references. Figure 3 shows a slight modification in the transformer; Figure 4 shows a repetitive switch for use when the supply is alternating current; and Figure 5 shows a switching arrangement comprising a thermionic valve.

Referring to Figure 1, a discharge device A, such for example as a mercury vapour lamp, has its electrodes connected to a main supply circuit comprising, in series, a main stabilising resistor R_1, the operating coil of a contactor C and a high frequency choke L. The contacts of the contactor C are so connected that they short circuit the choke L when the contactor is operated. This main supply circuit has terminals B for connection to D. C. mains.

There is also connected across the lamp electrodes a starting circuit comprising a spark gap G in series with the secondary winding of a transformer T. The primary winding of this transformer is connected in series with the contacts of a vacuum switch S and a current limiting resistor R_2 across the terminals B. The operating coil of the switch S is connected in series with a current limiting resistor R_3 and a push button switch P across the terminals B.

When the terminals B are connected to D. C.

mains the full mains voltage appears across the electrodes of the lamp A but this voltage is insufficient to start the discharge and no current passes in the main supply circuit. When it is desired to start the discharge the push button P is pressed and released. This causes the vacuum switch S to close and open. The opening of the switch S produces a voltage pulse, the wave front of which is steepened by the presence of the spark gap G. This voltage pulse is arranged to be of sufficient amplitude to start the main discharge in the lamp A. The choke L serves to prevent appreciable pulse voltage from being fed back into the mains.

When the lamp A strikes and the normal operating current passes through the coil of the contactor C, the contactor operates and short-circuits the choke L. The main stabilising resistor R_1 is designed to perform its normal stabilising function.

By using a vacuum switch S there is rapid extinction of the arc formed when it opens. Since the transformer T is required to operate only for very short periods it may be correspondingly rated.

The circuit described has certain limitations. Thus if the normal operating current is allowed to vary over an excessively wide range, there is a danger of the contactor C dropping out and the choke L and the energising coil of the contactor becoming overheated. Moreover unless the choke L is made of relatively large dimensions its resistance may be too great and the current flowing in the main supply circuit before the contactor closes may be insufficient to actuate the contactor.

These limitations are eliminated in the circuit shown in Figure 2. In this circuit the contactor C is voltage operated instead of current operated as in Figure 1. A resistor R_4 is arranged in series with the choke L, on the side thereof remote from the lamp A and the winding of a relay D is connected between the junction of the resistor R_4 and the choke L and the lower terminal B. The contacts of this relay are connected in series with the operating winding of the contactor C across the terminals B. The contactor serves to short-circuit both the resistor R_4 and the choke L.

In this example the choke L may be of small dimensions without impairing the operation of the circuit. In one example it has a D. C. resistance of 15 ohms, the resistor R_4 being also of 15 ohms. The winding of the relay D may have a D. C. resistance of 6000 ohms and the relay is adjusted in such a way that its contacts open when the voltage across the winding is above 205 and close when the voltage across it is below 150, the mains voltage being assumed to be 220. The stabilising resistor R_1 may be variable between 1 and 20 ohms.

When D. C. mains are connected to terminals B, the lamp A does not strike and 220 volts appears across the winding of the relay D opening its contacts. When the push button P is pressed and released and the lamp A strikes, the operating current in the main supply circuit causes a voltage drop across resistors R_1 and R_4 of say 120 volts, leaving about 100 volts across the relay winding. The relay contacts therefore close, operating the contactor C and short-circuiting the resistor R_4 and choke L. The relay winding is then effectively in parallel with the lamp A and may therefore have a voltage of 40–80 across it. The current in the main supply circuit can then be varied at will by varying the value of the resistor R_1 and since the voltage across the relay winding will remain substantially below 150, the contacts of the contactor C will remain closed.

Figure 3 shows a portion of a circuit employing a transformer T' of 1-to-1 ratio in the form of a choke, as referred to hereinbefore.

If it is required to operate a lamp from an A. C. supply, a circuit such as that in Figure 1 or 2 may be used, the stabilising resistor R_1 being preferably wholly or partly replaced by a choke, and it is arranged that the opening of the switch S is substantially synchronised to a suitably large value of the current in the primary of the transformer T and to the voltage across the device as hereinbefore said. One way of achieving this is to operate the push button a number of times in succession until the lamp strikes owing to one of the switch openings having occurred at a suitable instant. Such repeated operations of the switch S may be effected automatically by the use of a rotary switch P', as shown in Figure 4, in place of the push button P, such rotary switch being, for example, driven by a motor M started by pressing a push button P_2. Alternatively the rotary switch may be arranged to be spun mechanically on pressure of a push button, for example with the aid of a ratchet engaging a toothed wheel on the rotary switch.

Instead of arranging that the switch S is operated a sufficient number of times to ensure that there will be correct synchronisation on at least one operation thereof, positive means may be provided for closing the switch at the correct instant. Such means as shown in Figure 5, may comprise a thermionic valve V having the supply voltage applied to its control grid G' and having its control grid backed off negatively to such an extent that only the peak portion of the wave form produces a change in anode current, such anode current being applied to actuate the switch S. Suitable phase adjusting means may be provided if necessary.

I claim:

1. A circuit for operating an electric discharge device of the kind in which a discharge takes place in normal operation through gas or vapour contained in an envelope and in which no auxiliary electrode is used for starting, said circuit comprising both a starting circuit and a main supply circuit, said main supply circuit having device-operating terminals for connection to the discharge device and main supply terminals for connection to a current source for the supply of normal operating current to the device, said starting circuit comprising the secondary of a transformer connected in series with a spark gap across the said device-operating terminals, connections from the primary of the said transformer to starting terminals for connection to a current source for the supply of current to the said primary, and a switch adapted to be operated so as to interrupt the flow of current in the said primary and thereby produce across the device-operating terminals a voltage pulse for starting the discharge in the device, the said main supply circuit including also a high frequency choke serially connected therein for substantially preventing said pulse from being fed back to said main supply terminals, said choke having a sustained current-carrying capacity substantially less than said normal operating current, a contactor connected across said choke, and means for automatically closing said con-

tactor upon the flow of said normal operating current in order to short-circuit said choke and prevent overheating thereof.

2. A circuit according to claim 1 wherein said contactor operates electromagnetically, its operating coil being arranged in series in said main supply circuit.

3. A circuit according to claim 1 wherein relay means are provided to actuate said contactor in order to short-circuit said choke when the voltage across the electrodes of said device falls below a predetermined value, said value being greater than the running voltage appearing across the electrodes in normal operation of the device.

4. A circuit for operating an electric discharge device of the kind in which a discharge takes place in normal operation through gas or vapour contained in an envelope and in which no auxiliary electrode is used for starting, said circuit comprising both a starting circuit and a main supply circuit, said main supply circuit having device-operating terminals for connection to the discharge device and main supply terminals for connection to a current source for the supply of normal operating current to the device, said starting circuit comprising the secondary of a transformer connected in series with a spark gap across the said device-operating terminals, connections from the primary of the said transformer to starting terminals for connection to a current source for the supply of current to the said primary, and a switch adapted to be operated so as to interrupt the flow of current in the said primary and thereby produce across the device-operating terminals a voltage pulse for starting the discharge in the device, the said main supply circuit including also a high frequency choke so as substantially to prevent the said voltage pulse from being fed back to the said main supply terminals, and wherein there is provided a contactor adapted to operate automatically upon the flow of said normal operating current to short-circuit the said high frequency choke, said contactor being actuated by a relay having its operating winding connected in parallel with said device operating terminals and its contacts connected in series with the energising winding of said contactor across the current supply terminals of said main supply circuit, the arrangement being such that when the voltage across said electrodes is relatively high, before said operating current starts, said relay maintains its contacts open and hence maintains said contactor inoperative, and when said operating current starts and the voltage across the electrodes falls below a predetermined value, which is greater than the running voltage appearing across the electrodes in normal operation of the device, said relay closes its contacts and actuates said contactor to short-circuit said choke.

5. A circuit according to claim 4 wherein a resistor is connected in series with said choke and on the side thereof remote from said discharge device, one terminal of the energising winding of said relay being connected to the junction of said resistor and said choke.

6. A circuit according to claim 4 wherein a resistor is connected in series with said choke and on the side thereof remote from said discharge device, one terminal of the energising winding of said relay being connected to the junction of said resistor and said choke, and said contactor being connected to short circuit both said choke and said resistor whereby actuation of said contactor reduces the voltages across the winding of said relay.

7. A circuit for operating an electric discharge device of the kind in which a discharge takes place in normal operation through gas or vapour contained in an envelope and in which no auxiliary electrode is used for starting, said circuit comprising both a starting circuit and a main supply circuit, said main supply circuit having device-operating terminals for connection to the discharge device and main supply terminals for connection to a current source for the supply of normal operating current to the device, said starting circuit comprising the secondary of a transformer connected in series with a spark gap across the said device-operating terminals, connections from the primary of the said transformer to starting terminals for connection to a current source for the supply of current to the said primary, and a switch adapted to be operated so as to interrupt the flow of current in the said primary and thereby produce across the device-operating terminals a voltage pulse for starting the discharge in the device, and the said main supply circuit including also a high frequency choke so as substantially to prevent the said voltage pulse from being fed back to the said main supply terminals, wherein said circuit is adapted for operation from A. C. mains and means are provided for automatically operating said switch a plurality of times on operation of a starting means for said switch.

8. A circuit according to claim 7 wherein means including a backed-off thermionic valve are provided for automatically operating said switch at an instant at which the current in the transformer primary is of a sufficiently large value to produce the voltage pulse required for starting the discharge and at which the voltage across the discharge device is such as to enable the discharge to be maintained.

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