Sept. 23, 1958 C. E. WILLIAMS 2,853,653

SEQUENCE BOOST CIRCUIT FOR DISCHARGE LAMPS

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Fig. 1

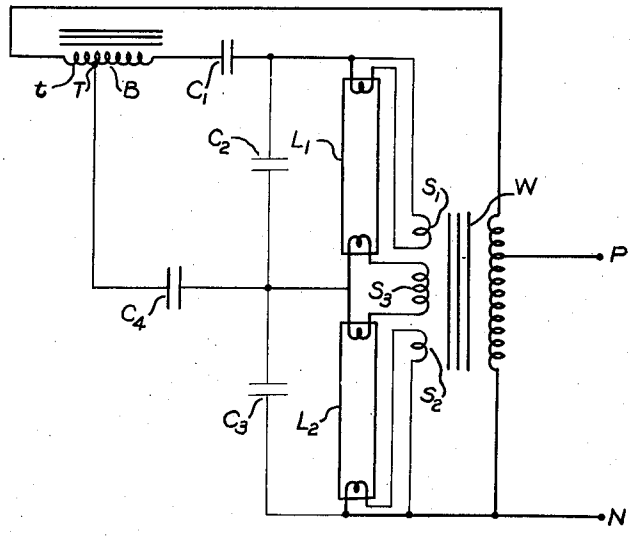
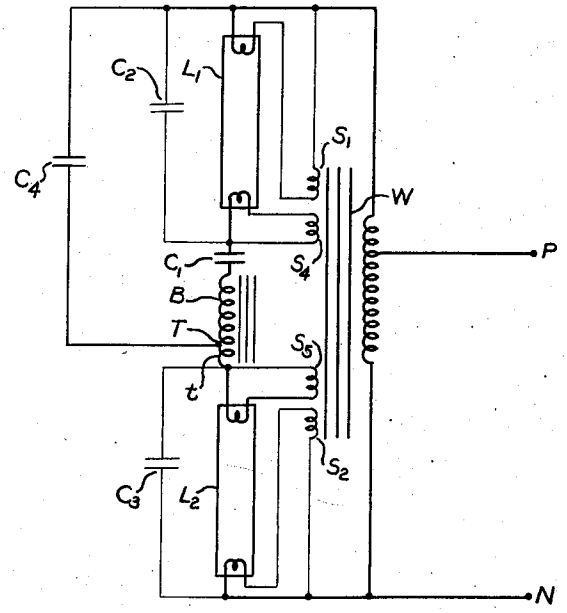


Fig. 6



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Fig. 2

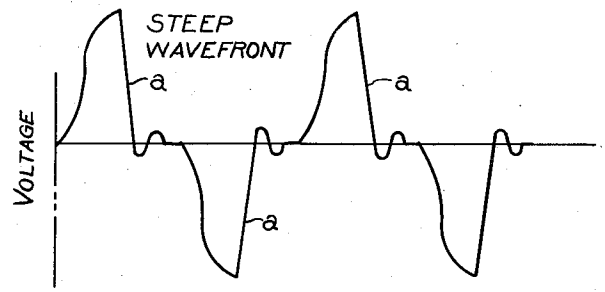


Fig. 3

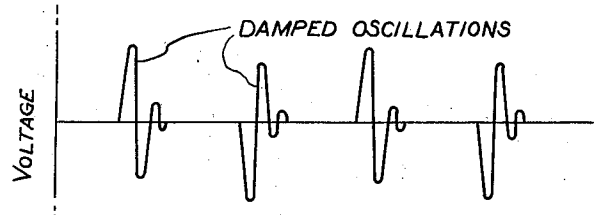


Fig. 4

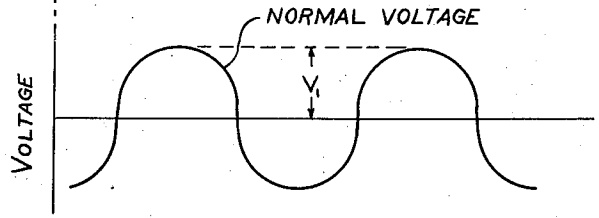
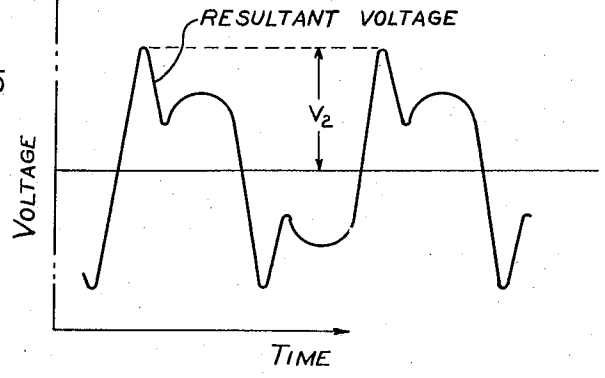


Fig. 5



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SEQUENCE BOOST CIRCUIT FOR DISCHARGE LAMPS

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Application February 2, 1954, Serial No. 407,637

Claims priority, application Great Britain April 16, 1953

3 Claims. (Cl. 315—97)

This invention relates to circuit arrangements for starting and operating from an alternating supply electric discharge devices having a gas or vapour filling. It relates more particularly, though not exclusively, to arrangements for starting and operating low pressure electric discharge lamps, such as the well known fluorescent lamps.

In electric discharge devices of the instant kind, the voltage required to be applied between the electrodes of the device for starting the discharge (hereinafter referred to as the starting voltage) is considerably greater than the voltage required between the electrodes for maintaining the discharge when started (hereinafter referred to as the running voltage). In addition, such devices have inherently a negative characteristic in operation and require to be operated in series with a ballast impedance which will give the arrangement an over-all positive characteristic.

In cases where the steady operating voltage normally applied between the electrodes prior to starting is less than the starting voltage of the device, some form of starting means is required. A form of such means widely used at present is a starting switch connected between the electrodes of the device. This switch is initially closed to produce a flow of current through a choke providing part or the whole of the ballast impedance. It is thereafter opened to produce an inductive kick across the choke which provides a voltage pulse between the electrodes of the device which exceeds the starting voltage and causes the discharge to start.

In the case of two devices operated in series, similar considerations apply, regarding the two devices as equivalent to a single device whose starting and running voltages are the sum of the starting and running voltages, respectively, of the two devices. However, when the steady operating voltage available is less than the sum of the starting voltages but greater than the individual starting voltages, an alternative method of starting, usually referred to as sequence starting, is sometimes used. In sequence start arrangements the two devices are connected to the source of operating voltage in series with each other and with a suitable ballast impedance, and the junction between the devices is also connected to the source of operating voltage through a starting impedance, usually a capacitor. At starting the whole of the operating voltage is first applied across only one device and causes that device to start, whereupon the residual operating voltage, other than that dropped across the started lamp, is automatically applied between the terminals of the second device and causes that device to start. The starting impedance is arranged to be of relatively high value so as to draw a negligibly small current in normal operation of the two devices.

The object of this invention is to provide a circuit arrangement for starting and operating two devices in series which incorporates an improved form of starting means. It will be seen that the arrangement in accordance with the invention effects a sequence starting of the

devices but operates in a different manner from the known sequence start arrangements.

According to the invention in a circuit arrangement designed for starting and operating two electric discharge devices from an alternating supply of a given frequency, the said devices are connected in series with each other and with a ballast choke forming part or the whole of the ballast impedance for the two devices. A by-pass capacitor is shunted across one of the devices, said capacitor being connected on one side to a tapping or tap point on said choke and being of such capacity that the capacitor and the tapped-off part of the choke which lies in series therewith with respect to the supply form a series-resonant circuit whose resonant frequency is higher than the supply frequency. The arrangement is such that in use and at starting substantially the whole of the operating voltage is first applied through the by-pass capacitor to one device to effect starting thereof. Thereafter said series-resonant circuit is excited by virtue of the non-sinusoidal nature of the waveform of the voltage appearing across the started device so as to produce by step-up autotransformer action of the tapped choke a resultant alternating voltage across the second device whose peak value is greater than it would be if the tapped-off part of the choke were reduced to zero and is such as to effect starting of the second device.

The choke may in some cases provide the whole of the ballast impedance for the two devices, but in other cases the choke may be included in series with a ballast capactitor and form part of an over-all capacitative ballast impedance. The latter form is in fact especially advantageous when the operating voltage is not much greater than the combined running voltages of the two devices since more stable operation, relative to fluctuations in the supply voltage, is then obtained than would be the case with an equivalent purely inductive ballast impedance.

The ohmic value of the by-pass capacitor at the supply frequency should, of course, be sufficiently large to ensure that a tolerably small current is drawn by it in steady operation of the devices. The position of the tapping on the choke, that is to say the inductance of the tapped-off portion and step-up ratio of the autotransformer formed thereby, and the capacity of the by-pass capacitor are preferably chosen to obtain the maximum value of the peak voltage applied to the second device. In view of the effect on voltage waveform of the various circuit components, the optimum values of the capacitor and tapping are best determined by trial for each design of circuit. We have found that the best results are usually obtained when the resonant frequency of the series-resonant by-pass circuit is about ten times the supply frequency and the tapped-off part of the choke included in it is about $\frac{1}{25}$ of the total inductance of the choke.

It will be appreciated that the tapping on the choke need not be a connection to a point on a single winding; the choke may in some cases be formed with two series-connected windings with the tapping point to which the by-pass capacitor is connected located between these windings. The expression "tapped-off part of the choke reduced to zero" in the foregoing statement of the invention is intended to mean that the tapping point is to be regarded as moved to the corresponding end of the choke and not that the tapped-off part of the choke is to be regarded as removed.

The invention will be further explained with reference to the accompanying drawings, in which:

Fig. 1 shows schematically one circuit arrangement in accordance with the invention;

Figs. 2, 3, 4 and 5 are diagrams explanatory of the operation of the arrangement; and

Fig. 6 shows another circuit arrangement in accordance with the invention.

Referring now to Fig. 1, the arrangement shown comprises two tubular electric discharge lamps L_1 and L_2 of the positive column type having a filling of inert gas at a few millimeters' pressure. The filling may include mercury for providing a mercury vapor discharge in operation, and the lamp envelopes in such case are coated internally with fluorescent material. The lamps are of the preheatable, two-terminal filamentary cathode type and are connected to the main secondary winding of a step-up autotransformer W (which serves also as a filament heating transformer), in series with an iron-cored ballast choke B and a ballast capacitor C_1 which are such that the over-all ballast impedance is capacitive.

The primary winding of the transformer W is connected to the circuit input terminals P and N, representing the phase and neutral terminals, respectively, or, in other words, the high and low sides, respectively, of the supply. The nonadjacent cathodes of the lamps L_1 and L_2 are connected to separate electrode heating secondary windings S_1 and S_2, and the adjacent cathodes of the lamps are connected to a common electrode heating secondary winding S_3, of the transformer W. The lamps L_1 and L_2 may be provided with earthed starting strips (not shown) for facilitating starting and are shunted by radio interference suppression capacitors C_2 and C_3 of low capacitance.

In accordance with the invention, a tapping T on the choke B is connected through a by-pass capacitor C_4 to the junction of the lamps L_1 and L_2, so that the arrangement operates substantially in the following manner. At starting, when the terminals P and N are connected to a suitable source of alternating supply, for example, a public mains supply of frequency 50 C. P. S., substantially the whole of the operating voltage, which in this case is the stepped-up supply voltage, is first applied to the lamp L_2 through the by-pass capacitor C_4, and this causes the lamp to start.

Lamp L_2 alone being started, the voltage which then appears across it is nonsinusoidal and has approximately the waveform shown in Fig. 2. In this figure, and also in Figs. 3, 4 and 5, the ordinates represent voltage and the abscissae time. The wavefront at *a* is of the steeply falling kind suitable for exciting oscillation of the series resonant circuit constituted by the capacitor C_4 and the tapped-off part *t* of the choke B. The oscillations are excited across the part *t* of the choke and are of the nature shown in Fig. 3, the oscillations being damped because of energy consumed by the lamp L_2 and by ion losses in the choke.

The voltage which would appear across the second lamp L_1 if the tapped-off part *t* of the choke were reduced to zero is shown in Fig. 4. Fig. 5 shows the resultant voltage which is in fact applied across the lamp L_1, being the combination of a voltage of the form shown in Fig. 4 with a voltage of the form shown in Fig. 3 amplified by the autotransformer action of the choke B. It will be seen that the peak value of the voltage available for starting the lamp L_1 is increased from the value V_1 in Fig. 4 to the value V_2 in Fig. 5.

The increased voltage available for starting the second lamp may be utilized for rendering the starting more certain and less dependent, for example, on supply voltage variations and on external conditions such as humidity. On the other hand it may be utilized to enable lamps of given starting voltages to be run with lower operating voltages than considered practicable hitherto. Alternatively, with a given operating voltage, it may be utilized to enable lamps of higher starting voltages than hitherto considered practicable for that operating voltage, to be operated satisfactorily. In either case the advantage is attained that the ballast choke is required to drop a smaller voltage than in the comparable known arrangements and may be constructed more cheaply.

By way of example, in a circuit arrangement of the kind shown in Fig. 1, it was found possible to operate

two 5-foot, 80-watt low pressure mercury vapor fluorescent lamps of 1½ inches diameter from a 250-volt, 50-cycle mains supply using a choke B of total inductance 0.795 henry and a ballast capacitor C_1 of capacity 6 microfarads. The capacity of the by-pass capacitor C_4 was 1 microfarad and the value of the tapped-off part *t* of the choke was 0.0318 henry. The filament heating transformer secondary windings S_1, S_2 and S_3 were arranged to give a total step-up of 32 volts in the voltage applied across the two lamps and the autotransformer W was arranged to step-up the supply voltage by 20 volts.

In a modification of the circuit arrangement of Fig. 1, for operation on the same supply, the capacitor C_1 was omitted to provide an inductive ballast for the lamps and the following alternative values for the circuit components in question were used:

Total inductance of choke B	henry	0.71
Inductance of tapped-off part *t*	do	0.0284
Capacity of by-pass capacitor C_4	microfarad	1
Step-up of supply voltage provided by the autotransformer W	volts	50

Usually it will also be necessary in an inductive circuit to include a power factor correction capacitor between the supply terminals. The arrangement in accordance with the invention has the advantage that the by-pass capacitor C_4 acts also to some extent to correct the power factor and reduces the value of the power factor correction capacitor required.

Referring now to Fig. 6, this shows another modification of the arrangement of Fig. 1 in which the ballast choke B and ballast capacitor C_1 are included between the lamps. The mode of operation of this further modification is similar to that of Fig. 1 and corresponding reference numerals in the two figures represent corresponding parts. The common electrode heating winding S_3 for the adjacent electrodes of the lamps is now replaced by the separate heating windings S_4 and S_5.

It will be appreciated that the invention is not limited to use with devices having heatable electrodes and can be applied with lamps, or other devices, of the cold-cathode or nonheated thermionic cathode type. Also each of the two devices in a circuit arrangement in accordance with the invention as hereinbefore described may be replaced by two or more lamps in series. It is intended that these and other modifications of similar nature be included within the present invention whose scope is to be determined by the appended claims.

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

1. In combination, an alternating current supply of given frequency, a pair of gaseous electric discharge devices each having two-terminal preheatable electrodes, a ballast inductance, said devices and said inductance being connected in series across said supply, means supplying preheat current to said electrodes, a tap point in said inductance between relatively close-coupled portions, a by-pass capacitor connected to said tap point and shunted across one of said devices to apply initially a higher voltage across the other device to start it, said capacitor being proportioned relative to the tapped-off portion of said inductance to effect series resonance therewith at a frequency higher than the supply frequency, whereby the nonsinusoidal voltage developed across said other device after it has started produces damped oscillations in said inductance which increase the starting voltage across said one device.

2. In combination, an alternating current supply of given frequency, transforming means having an input circuit connected to said supply and an output circuit, a pair of gaseous electric discharge devices each having two-terminal preheatable electrodes, a ballast inductance, said devices and said inductance being connected in series across said output circuit, auxiliary windings in said transforming means connected across said electrodes to pro-

vide preheating current thereto, a tap point in said inductance between relatively close-coupled portions, a by-pass capacitor connected to said tap point and shunted across one of said devices to apply initially a higher voltage across the other device to start it, said capacitor being proportioned relative to the tapped-off portion of said inductance to effect series resonance therewith at a frequency higher than the supply frequency, whereby the nonsinusoidal voltage developed across said other device after it has started produces damped oscillations in said inductance which increase the starting voltage across said one device.

3. In combination, an alternating current supply of given frequency, transforming means having an input circuit connected to said supply and an output circuit, a pair of gaseous electric discharge devices each having two-terminal preheatable electrodes, said devices and said inductance being connected in series across said output circuit, preheating windings in said transforming means connected across said electrodes to provide preheating

current thereto, a tap point in said inductance between relatively close-coupled portions, a by-pass capacitor having one side connected to said tap point and shunted across one of said devices to apply initially a higher voltage across the other device to start it, said capacitor being proportioned relative to the tapped-off portion of said inductance to effect series resonance therewith at a frequency about ten times higher than the supply frequency in order to increase the starting voltage across said one device after said other device has started.

References Cited in the file of this patent

UNITED STATES PATENTS

2,301,671	Abadie	Nov. 10, 1942
2,436,399	Nathanson	Feb. 24, 1948
2,496,981	Boucher	Feb. 7, 1950
2,504,548	Lemmers	Apr. 18, 1950
2,611,885	Bridges	Sept. 23, 1952