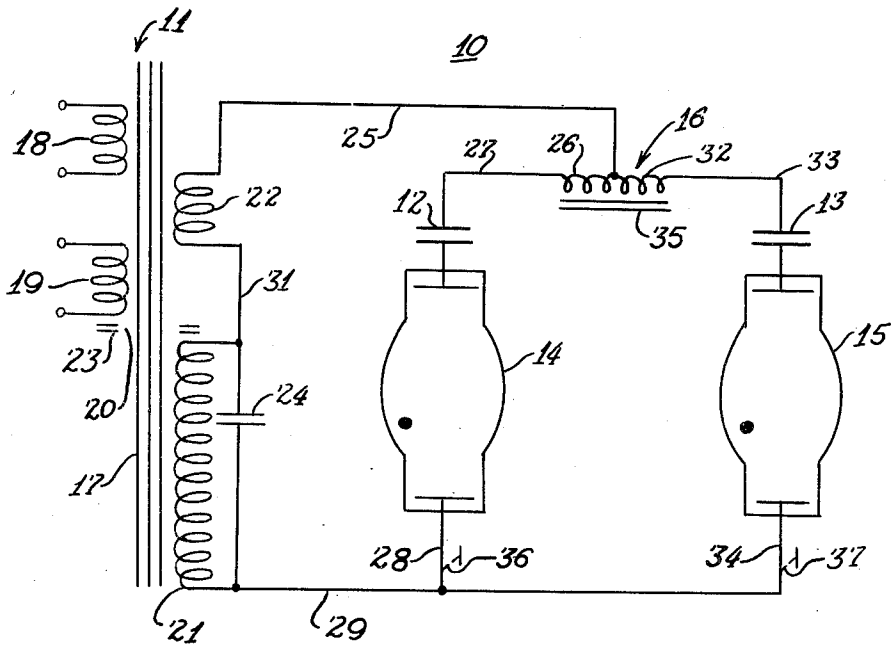
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APPARATUS AND SYSTEMS FOR OPERATING TWO OR MORE GASEOUS DISCHARGE DEVICES IN PARALLEL

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APPARATUS AND SYSTEMS FOR OPERATING TWO OR MORE GASEOUS DISCHARGE DEVICES IN PARALLEL

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This invention relates to starting and operating systems and apparatus for two or more gaseous discharge devices in parallel, more particularly to such systems and apparatus which are not subject to the characteristic of prior systems and apparatus, wherein the struck one of the discharge devices in parallel would become extinguished when the second or unstruck discharge device in parallel struck, and it is an object of this invention to provide improved apparatus and systems of this character.

The characteristic described and similar characteristics are known as flip-flop, because the process of the struck discharge device going out when the unstruck discharge device in the system strikes, usually repeats itself several times with the on and off devices alternating until stability is reached.

It is a well-known phenomenon that high pressure mercury vapor lamps, such as the EH–1 lamp, for example, strike at about 300 volts and after striking the voltage across the struck device falls to a very low value but builds up, after a starting interval of about 5 minutes, to full value of about 135 volts. During the warm-up period, the internal pressure of the vapor in the lamp builds up from a low value to a much higher value, thereby increasing the striking voltage. If the mercury lamp is extinguished when fully heated up, it cannot be restruck at the cold starting voltage of about 300 volts; the restriking voltage has to be much higher, perhaps several thousand volts. Thus, before such heated lamp can be restruck, it must first cool down until the pressure inside of the lamp drops to a lower value at which 300 volts is sufficient to strike it. When a single high pressure mercury vapor lamp is thus operated, the only problem on restriking after extinguishing is the one of time delay.

In certain prior circuits arranged for operating two such mercury vapor lamps in parallel, e.g., EH–1, 400 watt lamps, the phenomena of flip-flop occurs. In at least one such prior circuit, the ballast arrangement for the discharge devices included a series capacitor for each lamp supplied from a high reactance transformer. Flip-flop occurs most usually when the lamps operating at full brilliance are turned off or extinguished, and energy applied to restart them before the lamps have completely cooled. In such cases, one lamp usually strikes first because it cools down to striking voltage first. Some relatively short interval later, as the first struck lamp builds up its voltage and the second lamp cools down further, the second lamp strikes and at the same time the first struck lamp goes out. The second struck lamp now heats up, building up its pressure and voltage, and the first lamp cools down, until at some later time, the first lamp again strikes and the second struck lamp goes out. The process repeats itself until after one or more cycles of flip-flop, the on lamp remains struck as the off lamp strikes and the two heat up together. In some instances the flip-flop condition may continue for several hours.

The flip-flop condition is erratic in that it does not always require the same number of cycles for the two lamps to stabilize, nor does the same lamp always strike first, and on some occasions, both lamps may strike at the same time. Evidently, striking voltage requirements, as determined by temperature and other factors, are somewhat peculiar to each lamp and combine to produce the indicated undesirable result. Since it takes about 5 minutes for a hot lamp of the EH–1 type to cool down after extinguishment, so as to be able to restrike, it can be seen that the phenomena of flip-flop can seriously delay the final stable operating period of the lamps.

It has been found in the prior art systems that when two lamps are energized in the completely cold condition, that is, after they have been extinguished for a long time, the tendency for flip-flop to occur is substantially reduced.

It is a further object of the invention to provide improved apparatus and systems of the character indicated for providing starting stability for a pair of gaseous discharge devices to be operated in parallel.

It is a further object of the invention to provide an improved apparatus and system of the character indicated which is small in size, efficient in operation and economical to manufacture.

While the invention will be described in this specification in connection with mercury vapor lamps, it will be understood that this is exemplary only, and that the invention has application to other types of gaseous discharge devices as will be apparent to those skilled in the art.

In carrying out the invention in one form, there is provided, in a starting and operating circuit for at least two gaseous discharge devices in parallel, including ballast means to be energized from a source of alternate current, means for providing starting stability for said devices comprising current maintaining means in the circuit of one of the said devices, responsive to current in the circuit of the other of said devices.

For a more complete understanding of the invention, reference should be made to the accompanying drawing in which the sole figure is a schematic representation of a circuit embodying the invention.

Referring to the drawing, the invention is shown embodied in circuit **10**, including the transformer **11**, capacitors **12** and **13**, gaseous discharge devices **14** and **15**, and the center tapped inductor or choke **16**.

The transformer **11** is schematically shown and is of the high reactance type, including an iron core **17**, primary windings **18** and **19**, secondary winding **21** and a compensating winding **22**. The primary windings **18** and **19** together and the secondary winding **21** are disposed on the iron core **17** on opposite sides of a high reluctance magnetic shunt **23** which may include an air gap **20**, thereby to provide the high reactance. The compensating winding **22** is disposed on the core **17** in closely coupled relationship to the primary windings **18** and **19**, and is connected in the circuit in bucking relationship to the voltage developed by the secondary winding **21**. Connected across the secondary winding **21** is a capacitor **24** which is selected as to microfarad value so as to produce in combination with the secondary winding **21**, a voltage of sufficient magnitude for striking the discharge devices **14** and **15**.

The primary windings **18** and **19** are essentially identical and may be connected either in series or in parallel depending upon the value of the primary or source voltage to be used, as is well understood.

The gaseous discharge devices **14** and **15** are shown as being of the full wave type and, by way of example only, may be 400 watt high pressure mercury vapor lamps identified as EH–1 lamps by the manufacturers thereof, such lamps having been used in a particular example, which was constructed and operated according to the invention.

The circuit for operating the lamp **14** may be traced from compensating winding **22** through conductor **25**, part **26** of choke **16**, conductor **27**, capacitor **12**, lamp **14**, conductors **28** and **29**, secondary winding **21** and conductor **31** to winding **22**. Similarly, the circuit for lamp **15**

may be traced from compensating winding **22** through conductor **25**, part **32** of choke **16**, conductor **33**, capacitor **13**, lamp **15**, conductors **34** and **29**, secondary winding **21**, conductor **31** to winding **22**.

The circuit described, excluding the center tapped inductor **16**, but including the transformer **11**, the capacitors **12** and **13** and the lamps **14** and **15**, is essentially the circuit disclosed and claimed in the patent of Joseph G. Sola, No. 2,870,398, dated January 20, 1959. The circuit shown in the Patent No. 2,870,398 discloses only a single discharge device whereas the circuit of the present invention discloses two discharge devices, and except for the differences in size of conductors, and the size of the core, etc., for supplying two discharge devices, instead of one, as is well known to those skilled in the art, the construction and operation of the circuit of the subject invention, except for inductor **16**, is the same as that disclosed in the said Patent No. 2,870,398.

Thus, it will be understood that the capacitor **24** produces in combination with secondary winding **21**, a voltage having a high percentage of third harmonic and having a magnitude of about 300 volts which is sufficient to strike the discharge devices **14** and **15** under normal or cool conditions, that the capacitors **12** and **13** are of such microfarad value as to produce a substantially constant wattage operation of the discharge devices **14** and **15**, and that the capacitors **12** and **13** cooperate with the secondary winding **21** to produce a condition of substantial saturation in that part of the iron core **17** which is associated with the secondary winding.

Considering the circuit as described and without the presence of center tapped choke **16**, the circuit would be subject to the characteristic of flip-flop already referred to in this specification. That is to say: if the lamps **14** and **15** operating at full brilliance are turned off or extinguished, such as by opening the supply circuit to primary windings **18** and **19**, and if the primary windings are reenergized to restrike the lamps before they have had an opportunity to cool down, the lamps **14** and **15** will not restrike because the 300 volts available for this purpose from the transformer **11** is not sufficient to strike the lamps in the heated condition; however, as the lamps **14** and **15** cool down, a point will be reached where the 300 volts available, is sufficient to strike the lamps, but because of different cooling rates and other factors, one lamp will reach the striking voltage first and therefore strikes, this being, for example, lamp **14**; lamp **14** having struck takes about 5 amperes initially which decreases to about 3.2 amperes at full value, and the voltage across lamp **14** again increases from zero to 135 volts in a typical case; a relatively short interval later lamp **15** having cooled down sufficiently also strikes, because the 300 volts of striking potential is available, and the center tapped choke **16** being missing, the lamp **14** extinguishes instantly while lamp **15** heats up; and the striking current of about 5 amperes reduces to 3.2 amperes in lamp **15** and the voltage thereacross increases from about zero volts to 135 volts; the now extinguished lamp **14** cools down, and after a relatively short interval it cools to a point where the 300 volts available again strike it and immediately the struck lamp **15** goes out. This on and off condition of the lamps **14** and **15** continues until at some time after one or more flip-flops the two lamps ignite together and heat up together.

The condition of flip-flop is more apt to occur when the lamps **14** and **15**, after operating at full brilliance, are turned off and an effort made to immediately restart them. If the lamps **14** and **15** have been unenergized for a long time, and are completely cooled down, there is less tendency for flip-flop to occur at starting, although it does occur.

It has been found according to the invention, that the presence of a center tapped inductor or choke **16** connected as shown and constructed as will be described, prevents the flip-flop condition. The choke **16** may be

quite small, for example, each of the parts **26** and **32** in one typical case had only 16 turns. The parts or coils **26** and **32** are disposed on an iron core schematically shown as **35** and the windings may be disposed directly over each other in the manner of conventional transformer coils. The coils **26** and **32** should be wound in effect as a continuous winding in order that current flowing therethrough from conductor **27** and conductor **33**, for example, or in the reverse direction, produces a flux in the core in the manner of an ordinary coil or transformer. Correspondingly, therefore, when current flows into the center tap of the choke from conductor **25**, it divides equally in passing through coils **26** and **32** to conductors **27** and **33**, respectively, and the fluxes generated by such equally divided currents in coils **26** and **32** cancel each other within the iron core **35**, thereby eliminating any inductive effects in coils **26** and **32** and leaving only the resistance thereof. Thus, during ordinary normal operation of the discharge devices **14** and **15**, the currents flowing through the two coil halves **26** and **32** are divided equally and produce no flux in the core **35**. For all practical purposes therefore the center tapped choke **16** has no effect on normal operation.

When one of the devices, for example, lamp **15** is out, and the other is on, current flowing from conductor **25** through coil **26** produces a field of flux in core **35** and thus induces a voltage into coil **32**. Similarly, if discharge device **14** is out, and discharge device **15** is on, current in coil **32** induces a voltage into coil **26**.

During the initial condition, as already described, and assuming that discharge device **14** is on and discharge device **15** is out, the voltage across coil **32** is small, being on the order of 3 to 5 volts. When the discharge device **15** strikes, it takes an initial current of about 5 amperes as compared with the normal operating current of 3.2 amperes which is flowing through device **14**. The voltage magnitudes involved are small on a steady state basis, but it has been found that the surge of current into the striking device **15** produces a voltage or current effect on a transient basis which prevents the device **14** from going out, and the two devices remain on after both have struck and continue to remain on. No flip-flop condition occurs. Observation of the wave forms of voltage across coils **26** and **32** and of the wave forms of currents through discharge devices **14** and **15** under various flip-flop conditions, indicates the presence of a high degree of harmonics and sharp voltage and current transients. The harmonics and transients work out in such fashion in the choke **16**, that the on device remains on when the off device strikes. The current in the on device is maintained, as a result of the choke, by the starting current through the off device as it comes on.

It has been found that the size of the choke **16** in order to perform its function satisfactorily, must increase in size with the increase of the wattage requirements of the discharge devices. The increase, however, is not in direct proportion and in any event the choke **16** remains a very small component as compared with the transformer **11**.

Switches **36** and **37**, shown dotted, are disposed in conductors **28** and **34**, respectively. In the ordinary operating circuit, the discharge devices **14** and **15** are turned on by the application of energy to the primary windings **18** and **19**. In the event that it should be desired to control the discharge devices **14** and **15** individually, the switches **36** and **37** may be provided.

In prior art circuits, that is ones not utilizing the center tapped choke **16**, the use of individual control for each discharge device such as switches **36** and **37** would not be satisfactory. Thus, assuming that discharge device **14** is functioning as by closure of its switch **36**, the closure of switch **37** for igniting discharge device **15** would immediately extinguish discharge device **14** with the resulting flip-flop condition described. However, according to the invention, utilizing the center tapped choke **16**,

when discharge 14 is ignited by the closure of its switch 36, the closure of switch 37 ignites discharge device 15, but discharge device 14 remains ignited and does not go out.

In one practical form of device constructed and operated, utilizing two mercury vapor EH–1 lamps of 400 watts rating at 3.2 amperes and 135 volts, the following constants applied: for transformer 11 the primary windings 18 and 19, designed for a normal line or supply voltage varying from 105 to 135 volts in parallel or 210 to 270 volts in series, each had 153 turns of #15 wire. The secondary coil 21 had 345½ turns of #12 wire and the compensating coil 22 had 51 turns of #15 wire. The core 17 consisted of a stack of 26 gauge grade M–22 cold reduced electrical steel having a cross-sectional area of 2.97 square inches for that portion upon which the windings are disposed. The capacitors 24 had a value of 5.6 microfarads and each of capacitors 12 and 13 had a value of 31 microfarads. The center tapped choke 16 had 16 turns in each of winding parts 26 and 32 of #16 size wire. The cross-sectional area of the core upon which windings 26 and 32 were disposed was .14 square inch.

While particular embodiments of the invention have been shown, it will be understood, of course, that the invention is not limited thereto since many modifications may be made, and it is, therefore, contemplated by the appended claims to cover any such modifications as fall within the true spirit and scope of the invention.

The invention having thus been described, what is claimed and desired to be secured by Letters Patent is:

1. In a starting and operating circuit for two full-wave gaseous discharge devices in parallel, including ballast means to be energized from a source of alternating current, and having a pair of capacitors, one each of which is disposed in the circuit of each such device, means for providing starting stability for said devices, comprising a pair of substantially like winding means disposed on a common magnetic core, one terminal each of such winding means being connected to a common terminal which is connectable to such ballast and each one of the other terminals of said pair of winding means being connectable to a respective one of said gaseous discharge devices, the turns of each of such pair of winding means being wound in a flux cancelling direction for current into said common terminal.

2. In a starting and operating circuit for two full-wave gaseous discharge devices in parallel, including ballast means of the high reactance transformer type to be energized from a source of alternating current, having a secondary winding and having a pair of capacitors, one each of which is disposed in the circuit of each such device, said secondary winding and said capacitors being related so as to produce a substantially constant wattage in said discharge devices, means for providing starting stability for said devices, comprising a pair of substantially like winding means disposed on a common magnetic core, one terminal each of such winding means being connected to a common terminal which is connectable to such ballast and each one of the other terminals of said pair of winding means being connectable to a respective one of said gaseous discharge devices, the turns of each of such pair of winding means being wound in a flux cancelling direction for current into said common terminal.

3. In a starting and operating circuit for two full-wave gaseous discharge devices in parallel, including ballast means to be energized from a source of alternating current, and having a pair of capacitors, one each of which is disposed in the circuit of each such device, means for providing starting stability for said devices, comprising a center tapped inductor, including two end terminals, said center tap being connectable to such ballast and each one of said end terminals being connectable to a respective one of said discharge devices.

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