

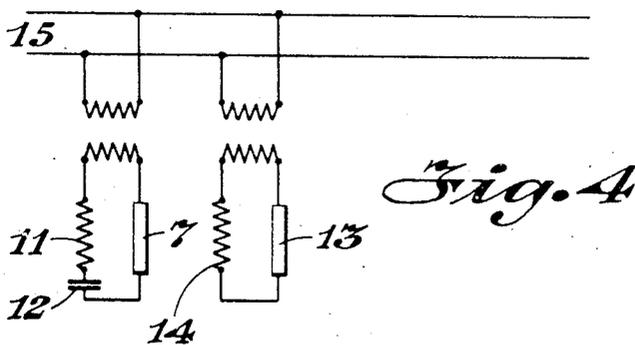
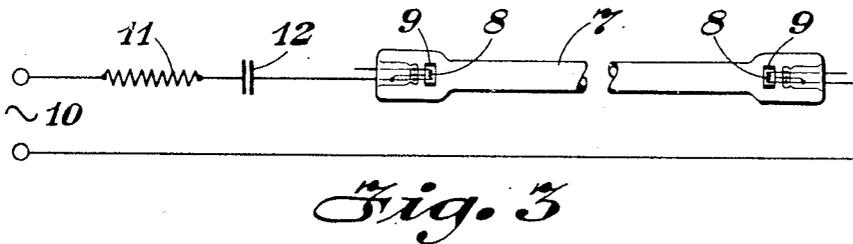
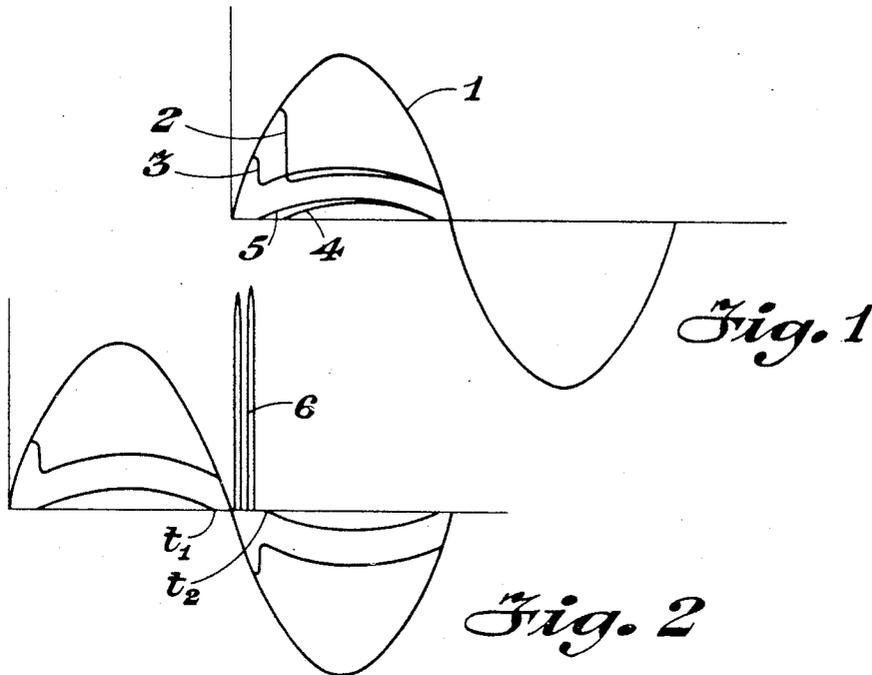
Oct. 6, 1936.

W. UYTERHOEVEN ET AL

2,056,629

ELECTRIC DISCHARGE DEVICE

Filed April 17, 1934



INVENTORS
Killem Uyterhoeven
Mari Johan Druyverstein
Cornelis Verburg
Lowrens Blok
BY Harry E. Dunham
ATTORNEY

UNITED STATES PATENT OFFICE

2,056,629

ELECTRIC DISCHARGE DEVICE

Willem Uyterhoeven, Mari J. Druyvesteyn, Cornelis Verburg, and Lourens Blok, Eindhoven, Netherlands, assignors to General Electric Company, a corporation of New York

Application April 17, 1934, Serial No. 721,058
In the Netherlands April 24, 1933

3 Claims. (Cl. 176—124)

The present invention relates to electric discharge devices generally and more particularly the invention relates to electrical circuits comprising such devices.

5 The object of the invention is to provide a circuit incorporating a gaseous electric discharge lamp device the gaseous atmosphere of which comprises a metal vapor whereby the metal vapor is at an effective pressure in said device shortly after the start of said device. Another
10 object of the invention is to provide a circuit incorporating a gaseous electric discharge lamp device wherein the effect of voltage changes in the current supply source on the lamp is reduced to
15 a minimum. Still further objects and advantages attaching to the device and to its use and operation will be apparent to those skilled in the art from the following particular description.

20 According to the invention a self-inductance and a capacitance are connected in series with the discharge tube energized by an alternating-current source, while this self-inductance and capacitance are dimensioned in such a way that
25 the reactance due to the capacitance is larger than 1.4 times the reactance due to self-inductance (the reactance due to the capacitance is

$$\frac{1}{\omega C}$$

30 where ω is the basic frequency of the alternating-current source multiplied by 2π , and C is the value of the capacitance; the reactance due to the self-inductance is ωL , where L is the value
35 of the self-inductance).

40 The discharge tubes which are present in the circuit according to the invention are operated in series with a stabilizing impedance. For a normal operation of the discharge tube, a certain value of this impedance is required which can be obtained in various manners. For instance, it is possible to use an ohmic resistance
45 for the impedance which has the disadvantage of a high power loss in this resistance and, consequently, causes a poor efficiency of the circuit, for which reason it is customary to use a self-inductance as the stabilizing impedance, which causes a lower power factor but a smaller power loss. It would also be possible to use a capacitance as the stabilizing impedance but it has
50 been found that in this case the life of the discharge tube is extremely short. In the arrangement according to the invention, the stabilizing impedance is used which contains a self-inductance and a capacitance which are dimensioned

in a certain manner. These values are selected in such a way that the reactance due to capacitance is considerably larger than that due to self-inductance whereby the advantages described hereafter are obtained.

5 When a discharge tube with a metal-vapor filling is placed in operation, the metal vapor present in the tube has at the beginning only a small pressure so that mainly the gas which is present in the discharge tube takes part in the
10 discharge. This discharge heats the vaporizable metal present in the tube whereby the metal vapor attains a higher pressure and participates intensively in the discharge. For instance, it is known that discharge tubes which contain
15 neon and a quantity of mercury first emit the reddish neon light and later the blue mercury light. The time necessary for obtaining the mercury light is short in general but it is different in case metals are used which are less volatile
20 than mercury, for instance sodium. In the case of discharge tubes which contain a quantity of sodium in addition to gas filling it takes, as a rule, quite a time before the tube has reached the normal operating temperature and until the
25 sodium vapor has obtained such a pressure that it participates intensively in the emission of light.

30 As in the arrangement according to the invention, an impedance is used instead of a self-inductance, which impedance contains a self-inductance and a capacitance which are dimensioned in the above-indicated manner, the time required by the discharge tube to reach the normal operating temperature is considerably
35 shortened.

The invention will be readily understood from an inspection of the accompanying drawing and a perusal of the following detailed description thereof.

In the drawing,

40 Fig. 1 is a graph on which curves are drawn representing the relationship between the voltage of the current source, the voltage of the discharge between the electrodes of the tube and
45 the vapor pressure of the tube,

Fig. 2 is a similar graph on which the curves 2 and 4 of Fig. 1 have been omitted and additional curves 6 are shown,

Fig. 3 is a wiring diagram showing one embodiment of the invention, and

Fig. 4 is a wiring diagram showing another embodiment of the invention.

Like numbers denote like parts in the drawing.

In order to make this advantage clear, that is, 55

shortening the time for the tube to reach its operating temperature it should be mentioned that the ignition voltage of the discharge tube in the case of a low metal-vapor pressure is higher than in the case of a high metal-vapor pressure which exists in the tube during the normal operation. This is illustrated in Fig. 1 in which, by way of example, the line 1 indicates the voltage of the current source, the line 2 the voltage between the electrodes of the discharge tube in the case of a low vapor pressure, and finally the line 3 in the case of a higher vapor pressure. The peak of the curve 3 is considerably lower than that of curve 2. In Fig. 1, the curves 4 and 5 belong to the curves 2 and 3 respectively and indicate the shape of the current through the tube in the case of a low and high vapor pressure, respectively. The current indicated by the line 4 has more intensive higher harmonics than the current indicated by the line 5. In other words, at the time that the tube is placed in operation and during the time in which the discharge tube has not yet attained the normal operating temperature (hereinafter called the heating time), the current shows more intensive higher harmonics than in the case of normal operation.

That means that when the stabilization impedance consists exclusively of a self-inductance, the reactance during the heating time will be larger than in normal operation so that during this heating time not only the current but also the power factor is less than in the case of normal operation, which causes that the power which is consumed by the discharge tube and which takes care of the heating of the tube, is smaller during the heating time than in the case of normal operation.

However, if the stabilization impedance consists of a self-inductance and a capacitance while the latter is in excess as described above, then the higher harmonics cause during the heating time an increase of the reactance due to inductance but also a more intensive decrease of the reactance due to the capacitance so that the total impedance is smaller than in the case of normal operation. That means that during the heating time the current and the power factor are larger and that the tube consumes a larger quantity of power than during the normal operation, which causes a more rapid heating of the discharge tube.

Another advantage of the arrangement according to the invention, lies in the fact that the arrangement is less sensitive with respect to the fluctuations in voltage of the current source which energizes the discharge tube. This may be explained as follows: (the voltage of this current source will be indicated, for the sake of brevity, as the "network" voltage).

An increase in the network voltage causes an increase of the current flowing through the discharge tube and of the temperature of the tube. The ignition voltage is thereby decreased whereby the discharge current, as described above, will have less higher harmonics.

When using a stabilization impedance consisting of a self-inductance, this means a decrease of the reactance due to inductance which has the tendency to increase the current also as a result of the fact that the decreased reactance causes an increase of the power factor and consequently an extra increase of the power consumed by the tube, and finally an increase of the temperature of the tube.

If, on the other hand, the stabilization impedance consists of a series-connected self-inductance and capacitance with the latter considerably in excess, then the reactance due to inductance will become smaller because of the weakening of the higher harmonics, while the reactance due to capacitance is increased to a greater extent which causes an increased impedance. The increase of the current flowing through the discharge tube is thereby counteracted, not only as a result of the influence of the increased impedance on the current but also because of the decrease of the power factor.

This explanation holds in a similar manner for the decrease of the network voltage also.

The influence of such a decrease is aided by a stabilization impedance consisting of a self-inductance while it is counteracted by an impedance consisting of a self-inductance and a capacitance which exceeds the self-inductance.

In the case of a temporary increase of the network voltage, the front of the voltage impressed on the discharge tube will also become steeper whereby the ignition will take place at an earlier moment in each half cycle. The current will show weaker higher harmonics as a result thereof. Inversely, the higher harmonics will become more intensive in the case of a temporary drop of the network voltage. This has, as explained above, a favorable influence on the insensitivity to fluctuation of the network voltage. This reason for the greater insensitivity to fluctuation in the network voltage does not only apply for discharge tubes with vapor filling but also for tubes which are filled exclusively with gas. It will, therefore, be evident that the invention is also of importance for the last-mentioned type of discharge tubes.

It has already been shown by the above consideration that the capacitance and the self-inductance are of such size that the reactance due to capacitance is considerably greater than that due to the inductance, as these elements would otherwise not have the above-described specific effect. It is evident that the arrangement according to the invention differs fundamentally from the suggested design according to which a self-inductance and a capacitance are connected in series with the discharge tube, which are dimensioned in such a way that the reactances due to capacitance and due to inductance are equal or approximately equal, in other words, so that resonance will occur. In this case, the total impedance is zero or approximately zero so that a stabilization impedance is no longer in existence; in addition, this resonance circuit does not have the advantage that the heating time of the discharge tube is shortened and that the arrangement is less sensitive to fluctuation in the network voltage.

Tests have shown that the reactance due to capacitance must in general be larger than 1.4 times the reactance due to inductance. In the selection of the self-inductance and the condenser, it is preferable to take the following also into account. It has been shown that when the reactance due to capacitance is too small, (the capacitance too large) discharge current impulses of very great intensity occur during the so-called "dark period". The "dark period" is the periodically recurring time between the interruption of the discharge current and the renewed ignition of the discharge. In Fig. 2, for instance, a dark period is located between the times t_1 and t_2 . If the reactance due to capacitance is too small,

current impulses of very high intensity occur during this dark period, which are indicated in Fig. 2 by way of illustration by the lines 6. These current peaks cause a considerable shortening of the life of the tube. The reactance due to capacitance can be selected in such a way that it is larger than the value below which these current impulses begin to take place. This value can be determined in a simple manner for each tube, with the aid of a few tests.

On the other hand, the reactance due to capacitance shall preferably not exceed a certain value. It has namely been found that when this reactance is too large (the capacitance too small), the discharge tube has the peculiarity of skipping a few cycles now and then. In other words, that during one or more cycles no discharge takes place at all. This value of the reactance due to capacitance at which this phenomenon begins to occur can also readily be determined by means of tests.

Very good results have been obtained when the self-inductance and the condenser have been selected in such a way that the reactance due to capacitance is twice as large as that due to inductance.

As the reactance due to capacitance is larger than that due to inductance, the current supplied by the current source will be leading. In case the discharge tube is energized from a network which has an inductive load (which is frequently the case), this leading current can only be advantageous. In many circumstances however, it is desired to have the largest possible power factor of an installation which is to be connected to a network, making the power factor preferably equal to one. In this case, the discharge tube which is provided with a capacitive stabilization impedance according to the invention, can to advantage be combined with a discharge tube provided with an inductive stabilization impedance. The lead or lag can then be selected in such a way that the total current is in phase with the voltage. If both discharge tubes contain the same metal-vapor filling, the tube with the inductive impedance will, of course, have a longer heating time than the one with the capacitive impedance. If necessary, this objection may be eliminated by special means, for instance by heating the tube with the inductive series impedance by means of heating elements.

The described disadvantage will occur to a considerably lesser degree if the tube with the inductive series impedance contains a metal which vaporizes more readily than the metal present in the tube with the capacitive impedance. This is, for instance, the case if a discharge tube with sodium vapor is combined with a discharge tube with a mercury vapor filling. In this arrangement, the former tube can be provided with a capacitive impedance and the latter with an inductive impedance.

The indicated disadvantage does not occur at all if the vapor discharge tube is combined with a discharge tube filled exclusively with gas. In order to obtain white light, it has for instance been suggested to combine a mercury or sodium vapor discharge tube with a neon tube. As in the neon, no metal vapor needs to be developed, this tube is provided to advantage with an inductive stabilization impedance while the tube with metal vapor filling is provided with a capacitive stabilization impedance.

The disadvantage that one of the discharge tubes is heated more slowly as the result of the

inductive stabilization impedance, can also be decreased by placing this tube so near to the discharge tube with the capacitive series impedance, that they can heat each other, in other words that heat is exchanged between the two tubes which are sealed in the bulb which surrounds them or, better yet, which are surrounded by a double walled cover with an evacuated space between the two walls of this cover.

Figs. 3 and 4 show schematically, by way of example, two physical embodiments of the invention.

The arrangement according to Fig. 3 shows a discharge tube 7 which is provided on each end with an incandescent electrode 8 which is electron emitting when heated and a plate shaped electrode 9 which surrounds the former. Each of said electrodes 8 consists of a coiled tungsten filament having a nickel filament wrapped around the tungsten filament and a coating of electron emitting material, such as barium oxide. The electrodes 8 and 9 are connected together while the electrodes 8 can be heated by means of heating current transformers. However, it is also possible to heat these electrodes by the discharge. The tube 7 contains a rare gas such as neon at a low pressure, while in addition there is a quantity of sodium in the tube, the vapor of which emits during normal operation an intensive yellow light.

The discharge tube 7 is connected to an alternating current source 10 which consists for instance of the secondary winding of a transformer. In series with the discharge tube, a choke coil 11 and a condenser 12 have been connected. The reactance due to the capacitance of the condenser (for the fundamental frequency of current source 10) is considerably larger than the reactance due to the inductance of the choke coil 11. The following figures may be cited by way of illustration:

In a certain sodium vapor discharge tube, energized by an alternating current source of 50 cycles and an effective potential of 250 volts, the distance between the electrodes was 120 cm. and the internal tube diameter was 35 mm. The choke coil was of 0.24 henry while the condenser had a capacitance of 18 microfarads. Consequently, the reactance due to the capacitance was 177 ohms and that due to inductance was 75.5 ohms. It was found that after 15, 18, 35 minutes, respectively, after the beginning of the operation, the intensity of the emitted light was 70, 78, and 100%, respectively, of the ultimate intensity while these percentages were 17, 20 and 30, respectively, when a series impedance was used consisting solely of the self inductance, the other conditions remaining the same.

The arrangement according to Fig. 4 contains two discharge tubes. One of these tubes, namely tube 7, is connected in series, in the manner described in connection with Fig. 3, with the self inductance 11 and the capacitance 12, while the reactance due to capacitance is considerably higher than that due to inductance. The other discharge tube 13 is connected to the secondary transformer winding through the choke coil 14 only. As a result thereof, the current taken from the network 15 by the discharge tube 7 will lead and the current taken by the tube 13 will lag with respect to the network voltage. The power factor of the entire arrangement will thereby become very favorable and can be made practically equal to 1. If the discharge tubes 7 and 13 contain the same metal vapor filling, the tube 7 will heat more rapidly than the tube 13. As previously remarked, this disadvantage is eliminated if the tube 13 is

provided with a metal which vaporizes more readily or with a filling consisting entirely of gas.

It is evident that the invention is not limited to the arrangements with one discharge tube only.

5 It is self evident that a large number of tubes can be present which are connected in the manner indicated by the invention. All tubes can be provided with a series impedance consisting of a self inductance and capacitance (with the reactance
10 due to capacitance being larger than that due to inductance), or a part of the number of tubes can be provided with an inductive series impedance in the manner suggested in Fig. 4. For instance, if the arrangement is used for illumination of
15 roads, squares, or the like, the discharge tubes can be provided alternately with a capacitive series impedance and with an inductive series impedance.

20 The above considerations show clearly that the invention is mainly of importance for discharge tubes which contain the vapor of a metal that is hard to vaporize such as sodium, cadmium, magnesium, thallium, rubidium, lithium.

25 If it is not necessary or desirable to make use of the higher insensitivity to the fluctuations of the network voltage which is attained by the invention, then it is possible to use the combination series impedance (self inductance and capacitance with the reactance due to capacitance considerably in excess of the reactance due to the inductance) only during the heating of the discharge tube after which, when the tube has attained a sufficiently high temperature, another series impedance is connected, for instance one
30 consisting of a self inductance.

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

1. The combination of an alternating current source, a gaseous electric discharge device, an inductance and a capacitance, said discharge device, said inductance and said capacitance being connected in series to said source, said discharge device having a thermionic electrode, the dimen-

sions of said inductance and said capacitance being such that the reactance due to the capacitance is approximately 1.4 to 2.35 times the reactance due to the inductance.

2. A lighting installation comprising the combination of an alternating current source, a gaseous electric discharge device, an inductance and a capacitance, said discharge device, said inductance and said capacitance being connected in series to said source, the dimensions of said inductance and said capacitance being such that the reactance due to the capacitance is more than 1.4 times the reactance due to the inductance and another gaseous electric discharge device having an inductive stabilizing impedance connected in series therewith to said source, said last mentioned device having a gaseous atmosphere comprising an easily vaporizable metal and said first mentioned device having a gaseous atmosphere comprising a difficultly vaporizable material.

3. A lighting installation comprising the combination of an alternating current source, a gaseous electric discharge device, an inductance and a capacitance, said discharge device, said inductance and said capacitance being connected in series to said source, the dimensions of said inductance and said capacitance being such that the reactance due to the capacitance is more than 1.4 times the reactance due to the inductance and another gaseous electric discharge device having an inductive stabilizing impedance connected in series therewith to said source, said last mentioned device having a gaseous atmosphere comprising an easily vaporizable metal and said first mentioned device having a gaseous atmosphere comprising a difficultly vaporizable material, said discharge devices being closely adjacent to radiate heat to each other.

40
WILLEM UYTERHOEVEN.
MARI J. DRUYVESTYEN.
CORNELIS VERBURG.
LOURENS BLOK.