March 11, 1952 F. LEHMANN 2,588,858

CIRCUIT ARRANGEMENT FOR DISCHARGE TUBES, PARTICULARLY GLOW DISCHARGE TUBES

Filed Sept. 28, 1948 3 Sheets-Sheet 1

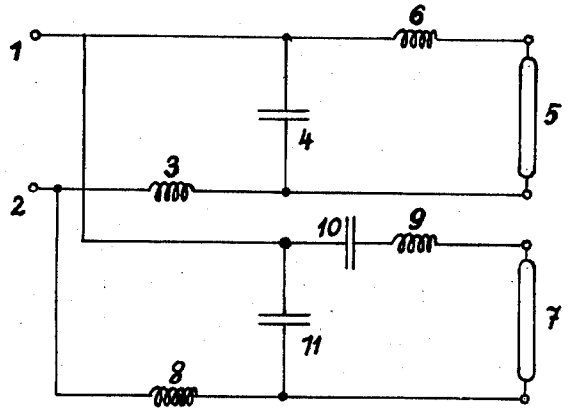



Fig. 1

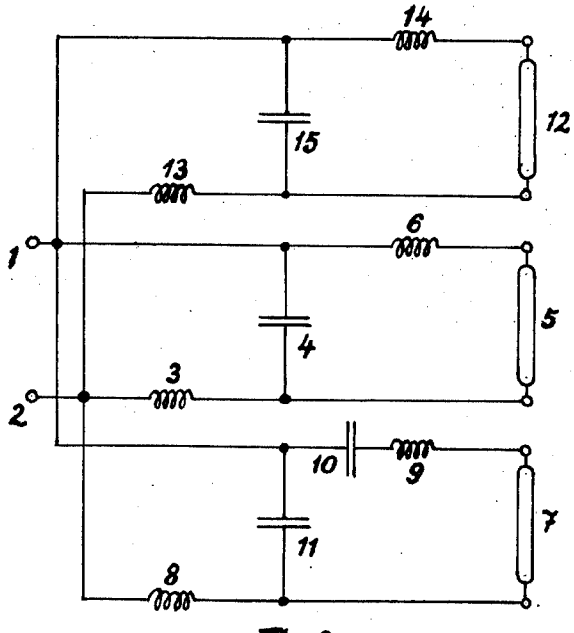



Fig. 2

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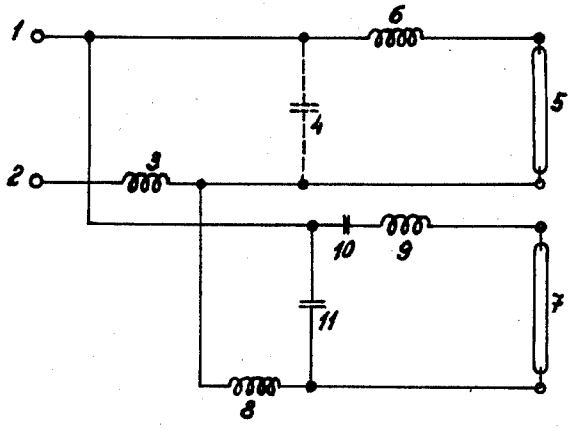



Fig. 3

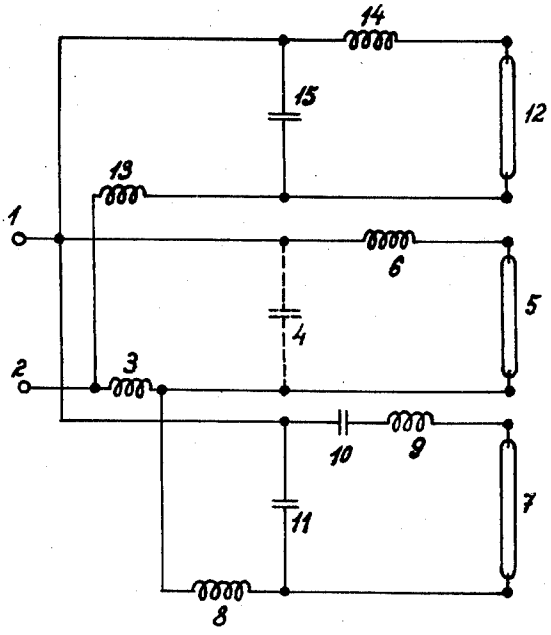



Fig. 4

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3 Sheets-Sheet 3

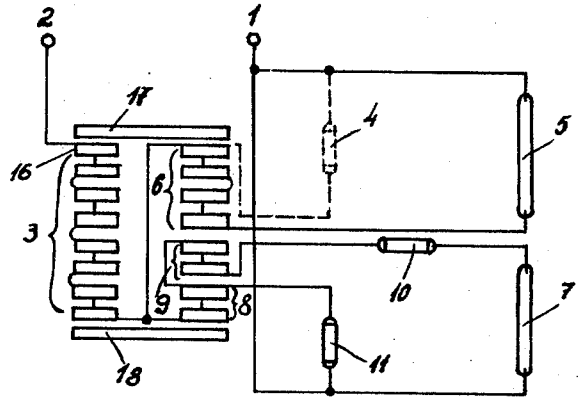



Fig. 5

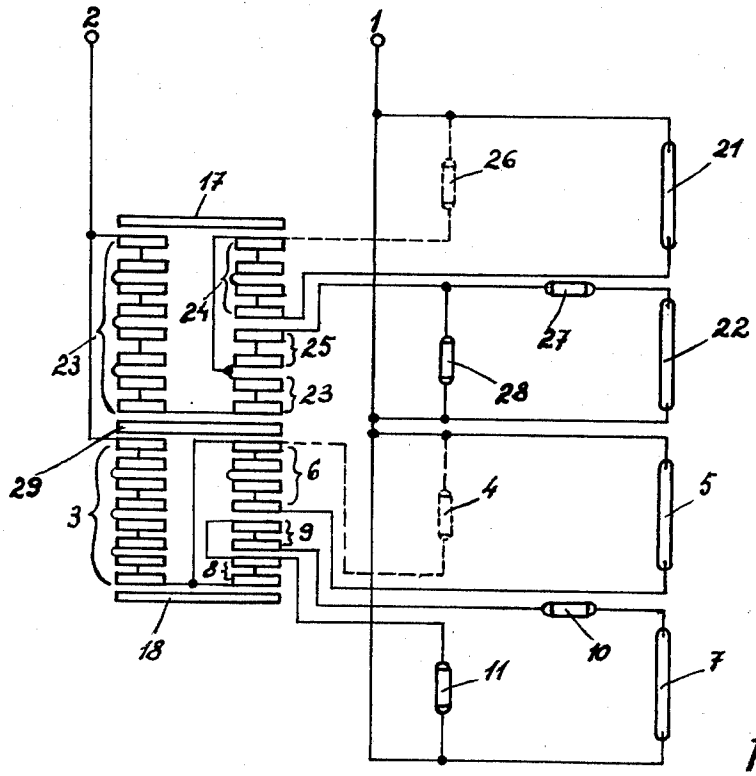



Fig. 6

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# UNITED STATES PATENT OFFICE

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## CIRCUIT ARRANGEMENT FOR DISCHARGE TUBES, PARTICULARLY GLOW DISCHARGE TUBES

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7 Claims. (Cl. 315—250)

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The discharge tubes and more particularly the glow discharge tubes, which due to their low current requirements and other advantages have been more widely used recently, show in practical utilisation certain less favourable characteristics which are inherent to such tubes and for the elimination of which a number of methods have been proposed directed more particularly to the circuit arrangement of the tubes. Those characteristics of the discharge tubes to which the proposed improvements relate substantially have bearing on the ignition difficulties, the stabilisation necessity, the flickering in each half cycle (stroboscopic effect) and on the unfavourable alteration of the phase shift of the network current due to the use of choke coils.

However, the means hitherto proposed permit to eliminate usually a single of the difficulties referred to and are complicated in themselves so that a combination of such proposed means, which might permit to eliminate at the same time the other disadvantages, would be still more complicated, whereby the practical use of glow discharge tube would be seriously affected.

One object of the invention as described hereinafter is to eliminate or suppress all the aforementioned disadvantages at the same time. The invention resides substantially in connecting up, between one or more discharge tubes fed in parallel from one phase of an alternating current network and the network itself, such a combination of inductances and capacities that an easy ignition of the discharge tubes, a suitable stabilisation of their current, the elimination of the stroboscopic effect and a compensation of the phase shift are obtained at the same time.

In accordance with the present invention the desired effect is achieved by connecting each of the discharge tubes to the same phase of the network in series with an inductance, a capacity being connected up in parallel with at least each alternate discharge tube and with a part of its series connected inductance adjacent to the network, while a further capacity is connected up in the circuit of at least one discharge tube in series with the latter.

In a circuit arrangement for two or three discharge tubes it is sufficient to connect up the said further capacity only in the circuit of one of the tubes; with four discharge tubes the capacity referred will be connected up in two circuits etc.

The aforementioned parallel capacities by means of which resonant circuits for the ignition proper are obtained should be connected up in parallel with at least each alternate discharge tube, as stated hereinbefore; of course they may

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be included also in the circuits of more than each alternate discharge tube, and if desired in the circuit of all the discharge tubes.

If the parallel ignition capacities are included only in the circuits of some of the discharge tubes, first those discharge tubes are ignited whose circuits include the said capacities and then the ignition of the other tubes takes place. For this purpose such ignition circuits are practically quite sufficient in which the corresponding ignition voltages approximate more or less the resonant voltage. A particularly advantageous arrangement is obtained when the resonances, even partial ones, in the circuits of the various discharge tubes are produced by the effect of higher, may be different, harmonics of frequences contained in the network current.

In the circuit arrangements of the invention relatively very small ignition condensers are quite sufficient; this is of advantage not only from the aspect of losses and thus of economy of operation but also in view of the stability of the discharge. Indeed, too large condensers connected up in parallel to the discharge tubes usually lead to flickering.

In accordance with the invention, certain portions of the inductances connected in series with the discharge tubes may be used at the same time in the circuits of two or more discharge tubes. As is explained in connection with the example described in the body of the specification, a particularly advantageous arrangement is that one, in which a portion of the inductances is made common to the circuits of at least two discharge tubes, the said common portion being that one which is adjacent to the network.

The inductances which are connected up in the circuits of the various discharge tubes may be formed by a number of choke coils, preferably two choke coils. These component chokes, if desired together with the chokes from the circuits of the other discharge tubes, may be assembled into a structural unit. In this connection it is of advantage to make use of a combined choke coil which preferably may be formed of ferromagnetic, especially iron spools as disclosed in my application Ser. No. 767,275, filed August 7, 1947, now abandoned.

Further details and possibilities of application of the circuit arrangement for discharge tubes in accordance with the present invention are disclosed in the following description of examples in conjunction with the accompanying drawings in which

Fig. 1 shows a circuit arrangement for two glow discharge tubes in which ignition capacities

are connected up in both circuits and the series connected inductances are formed each by two independent chokes;

Fig. 2 represents a similar circuit arrangement as that shown in Fig. 2, but for three glow discharge tubes;

Fig. 3 shows a circuit arrangement for two glow discharge tubes in which a choke is used in common for the two circuits;

Fig. 4 shows a similar circuit arrangement as that of Fig. 3, but for three glow discharged tubes;

Fig. 5 represents a circuit arrangement similar to that of Fig. 3 in which, however, a combined coil choke is used, and

Fig. 6 shows a similar circuit arrangement as that of Fig. 5, but for four glow discharged tubes.

The circuit arrangements shown in Fig. 1 and likewise in Fig. 2 represent, as far as the use of the individual components is concerned, one of the most perfect embodiments of the invention, and accordingly these examples are the most suitable for explaining in detail the circuit arrangement.

In the circuit arrangement shown in Fig. 1 the terminals 1 and 2 of a single phase low voltage source of alternating current have connected thereto a main ignition circuit, which consists of a choke 3 and a condenser 4, a glow discharge tube 5 being connected to the plates of the condenser over a stabilising choke 6. The chokes 3 and 6 form together the stabilisation impedance of the glow discharge tube 5, and the ignition condenser 4 is so selected as to produce a resonant effect with the choke 3 preferably for any higher harmonic of the supply network current. When the terminals 1 and 2 have been connected to the network an increased voltage is obtained on the condenser 4 and this voltage leads to the ignition of the glow discharge tube 5. In accordance with the present invention this circuit arrangement, which is substantially known per se, has connected in parallel the circuit of another glow discharge tube 7 which differs from the aforedescribed circuit in that the stabilisation impedance in addition to the chokes 8, 9 comprises a condenser 10. The values of the choke 8 and of the condenser 11 in the ignition circuit are selected preferably in such a way that resonance is obtained in this circuit for a different higher harmonic than in the ignition circuit of the glow discharge tube 5.

The circuit arrangement just described secures an instantaneous ignition of the two glow discharge tubes 5 and 7 even at a lower supply voltage and without preheating the electrodes. Under the influence of the condensers used the dark periods overlap each other on the lighting tubes so that permanently at least one of the glow discharge tubes emits light whereby the stroboscopic effect, which often is very troublesome, is eliminated in a relatively simple way. The condensers connected up in the circuit, especially the condenser 10, exert an influence on the power factor of the supply network and not only can completely compensate the harmful phase shift produced by the chokes employed, but also when necessary they can insure an over-compensation of the said shift.

For the sake of completeness numerical indications will be given for a typical practically tested embodiment of the above described circuit arrangement in accordance with the present invention. With standard glow discharge tubes having an input power of 40 watts at a voltage of 220 volts on the terminals 1 and 2, a choke 3 was used having an inductance of 1.18 henrys and a condenser 4 having a capacity of 1 microfarad, these values corresponding to a resonance for the third harmonic of an alternating current of 50 cycles/sec. Upon switching on the current from the network an ignition voltage of 280 volts was measured on the terminals of the condenser 4 which voltage was reduced to 105 volts after the ignition was completed. With a stabilising choke 6 having an inductance of 0.53 henry, a current of 0.5 ampere was obtained through the glow discharge tube 5 in stabilised condition and a current of 0.13 ampere through the condenser 4.

In the ignition circuit of the glow discharge tube 7 a choke 8 of 0.53 henry and a condenser 11 of 3 microfarads were used, which values correspond to a resonance for the second harmonic. On the terminals of this condenser a voltage of 240 volts was measured and in operation this voltage increased to 300 volts. The choke 9 had an inductance of 0.58 henry and the condenser 10 a value of 4 microfarads. In stabilised condition a voltage of 220 volts was measured on the terminals of this condenser and a current of 0.475 ampere passed through the glow discharge tube. A current of 0.213 ampere flowed through the condenser 11 and a current of 0.65 ampere passed through the choke 8.

The power factor of the lighting current was compensated to 0.9. It was found that the sum total of the capacities of the condensers used was lower than the total capacity which would be otherwise required for such a compensation of the phase shift.

Still better results are obtained when the circuit arrangement in accordance with the present invention is used for three glow discharge tubes as is shown in Fig. 2. In addition to the components 1 to 11 which are formed in the same way and denoted by the same reference numerals as in Fig. 1, the parallel by connected circuit of the glow discharge tube 12 is used and this last mentioned circuit corresponds to the circuit of the glow discharge tube 5.

In connection with the numerical values of the components in the just described example, it should be noted that the values in the two circuits of the glow discharge tubes 5 and 7 are also the same as in the first example. In the ignition circuit of discharge tube 12 the same inductance of the choke 13 was used as that of the choke 3 and the capacity of the condenser 15 was 2 microfarads so that a resonance for the second harmonic was obtained. Upon switching on the current from the network a voltage of 320 volts was measured on the terminals of the condenser 15 and in operation this voltage was reduced to 110 volts. With the same inductance for the choke 14 as that used for the choke 6 a current of 0.525 ampere flowed through the glow discharge tube, a current of 0.136 ampere flowed through the condenser 15 and a current of 0.45 ampere flowed through the choke 13.

The circuit arrangement as thus far described may be applied in similar way also for a larger number of discharge tubes. Thus, for instance, in a parallel connection of four discharge tubes it is possible to combine two pairs of discharge tubes which are connected up as shown in Fig. 1, and by this method the combination may be further developed for a larger number of discharge tubes.

The other examples shown represent simplified circuit arrangements in accordance with the present invention. Thus Fig. 3 shows a parallel connection of two glow discharge tubes 5 and 7, the

circuit of the glow discharge tube 5 being quite similar to the arrangement of Fig. 1, while the second glow discharge tube 7 is connected over portions of its stabilising circuit directly to the terminal 1 of the network, and is connected to the terminal 2 of the network behind the choke 3. The supply conductors of the glow discharge tube 7 include the chokes 8 and 9 corresponding to the chokes 3 and 6, the equalising condenser 10 being connected up between the choke 9 and the network. The ignition condenser 11 is connected in parallel with the glow discharge tube 7 to the choke 9 and condenser 10 and constitutes the ignition circuit with the chokes 3 and 8. An advantage of this arrangement consists more particularly in the simultaneous utilisation of the choke 3 for the series circuits of both glow discharge tubes 5 and 7 whereby the material for the otherwise necessary second choke is saved and this single choke 3 may be very small since in view of the predominantly inductive load in the circuit of the glow discharge tube 5 and the capacitive load in the circuit of the glow discharge tube 7, the total working current flowing through the choke 3 is extraordinarily small because the just mentioned currents neutralise each other in the choke. Moreover, in view of the fact that in the ignition circuit of the glow discharge tube 7 the two chokes 3 and 8 are in series and therefore their inductances are added to each other, a relatively small condenser 11 is sufficient for an appropriate increase in the ignition voltage.

As it has been stated hereinbefore usually it is not necessary in these cases that a complete resonance should be obtained in the ignition circuits, it being sufficient to obtain a voltage lower than the resonant voltage in order to impress on the terminals of the tube at least the ignition voltage. This remark applies to both the last mentioned ignition circuits, i. e. for the circuits including the condenser 11 and the condenser 4.

Another advantage of the aforedescribed simplified arrangement consists in the possibility of omitting the ignition condenser 4 in the circuit of the glow discharge tube 5. For this reason the condenser 4 is shown in dotted lines in Fig. 3. In this case first the glow discharge tube 7 is ignited under the effect of the ignition circuit when the voltage has been connected to the terminals 1 and 2, and thereafter also the glow discharge tube 5 is ignited due to the effect of the voltage increased by the voltage drop across the choke 3 and may be also across the choke 6.

The practically tested values for the various components in the above described examples are the following:

The choke 3 having an inductance of 1.2 henrys, the choke 6 has an inductance of 0.5 henry and the condenser 4 a capacity of 0.5 microfarad; the choke 8 has an inductance of 1.2 henrys, the choke 9 an inductance of 0.75 henry, the condenser 10 a capacity of 4 microfarads and the condenser 11 a capacity of 2 microfarads.

Similarly as in the first described case the circuit arrangement may be conveniently used for more than two discharge tubes connected in parallel, as is shown in Fig. 4, where in addition to the circuits of the glow discharge tubes 5 and 7 another circuit is provided for the glow discharge tube 12. This circuit includes two chokes 13 and 14 and a capacity 15 and is connected up in parallel directly to the network terminals 1 and 2.

The corresponding values of the components of this circuit may be the following:

The choke may have an inductance of 1.2 henrys, the choke 14 an inductance of 0.25 henry and the condenser 15 a capacity of 3 microfarads.

All the chokes included in the circuit arrangements as far described, or some of them, may be conveniently and easily formed into a structural unit by connecting the circuits of the various chokes to a common magnetic circuit.

In the usual so-called core construction of chokes, the cores of a common magnetic frame carry either the corresponding individual chokes or their separate coils, the magnetic frame being closed by means of end yokes. In the case of a circuit arrangement with more than two glow discharge tubes the two magnet cores may be conveniently connected also by means of a middle yoke.

The construction of such a choke is shown diagrammatically in Fig. 5, in which the circuit arrangement corresponds fully to that of Fig. 3 and therefore the individual components are denoted by the same reference numerals. The combined choke is assembled in this case of separate component chokes 3, 6, 8 and 9 and is composed of windings 16 which are wound spirally, e. g. of an insulated iron strip. The various windings are assembled in two columns which are connected at each end by means of a yoke 17 and 18, respectively.

The choke construction shown in Fig. 5 is very advantageous especially in respect of economy of the material for making the chokes and also in respect of the advantageous mutual magnetic coupling of the various parts of the circuit during operation. In this way different irregularities may be equalised, and if one of the glow discharge tubes becomes extinguished for any reason it is immediately ignited again. In this embodiment of the invention it is possible precisely to omit one ignition circuit for one of the glow discharge tubes, that is to omit the condenser 4, whereby the voltage drop across the component choke 3 and that across the component choke 6, as well, are added to the supply voltage on the terminals 1 and 2 and thus produce an increased ignition voltage causing the glow discharge tube 5, which does not yet glow or has been just extinguished, to be struck when the other discharge tube 7 has been previously ignited.

The embodiment of the combined choke just described may be used with advantage in a similar way for three parallelly connected glow discharge tubes in an arrangement corresponding to that shown in Fig. 4. The common choke may be conveniently provided with a yoke in a central position.

In this connection Fig. 6 shows diagrammatically the use of a common choke for feeding in parallel four glow discharge tubes 5, 7, 21 and 22 from a single phase network 1, 2. The lower part of this figure shows a pair of glow discharge tubes 5, 7 with accessories, which pair corresponds to Fig. 5. In addition thereto a second pair of glow discharge tubes 21 and 22 is provided which may be connected up together with their respective circuit elements to form an arrangement quite similar to that of the first pair 5 and 7, and it is of advantage to chose the values of the elements so as to secure in the ignition circuits an increase of the voltage under the effect of different harmonics.

However, Fig. 6 shows in its upper part a somewhat modified circuit arrangement for the second pair of glow discharge tubes 21 and 22. The component chokes 23 and 24 correspond

fully as to their effect to the chokes 3 and 6 of the lower pair 5 and 7, but the choke 25 replaces both chokes 8 and 9; in other words, the circuit of the glow discharge tube 22 has the total series connected self inductance concentrated in the ignition-resonant circuit. This represents in part another possibility of simplifying the described apparatus, such simplification being suitable in such cases where a quiet and continuous burning of the discharge tubes is not an absolutely necessary requirement.

The effect of the condensers 26, 27 and 28 is quite the same as that of the condensers 4, 10 and 11 of the lower pair of glow discharge tubes 5 and 7. Similarly as in the foregoing circuit arrangement, the condensers 4 and 26, shown in dotted lines, may be omitted, and then all the four glow discharge tubes will be struck by the ignition circuits containing the condensers 11 and 28. The condensers 10 and 27 serve for compensation and their operation has been explained in the foregoing description.

Fig. 6 shows the end yokes, 17 and 18, which correspond to the yokes denoted by the same references in Fig. 5, and a middle yoke 29, the construction of which is adapted to its function. The use of such a middle yoke represents a relatively great saving of material as compared with the use of two independent chokes corresponding to a separate feeding of the two pairs of glow discharge tubes, the pair 5 and 7 on the one hand, and the pair 21 and 22 on the other hand. The middle yoke 29 may be made weaker than the edge yokes 17 and 18.

Referring now to the values of the circuit elements in the arrangement shown in Fig. 6 each pair of windings of the lower half of the chokes has a self inductance of 0.2 henry and the corresponding condenser 4 has a capacity of 3 microfarads, the condenser 10 has a capacity of 4 microfarads and the condenser 11 has a capacity of 3 microfarads. In the upper half of the chokes each pair of windings has a self inductance of 0.3 henry, and the corresponding condenser 26 has a capacity of 2 microfarads, the condenser 27 has a capacity of 4 microfarads and the condenser 28 has a capacity of 3 microfarads. Of course, as it has been stated in the foregoing description, the condenser 4, and if desired also the condenser 26, may be omitted.

By the use in accordance with the present invention of combined chokes assembled of component chokes, first of all a large amount of material is saved, as previously stated, which material would be required otherwise for the construction of the individual chokes separately from one another. A further advantage in the present case consists in the provision of a common magnetic coupling for all the component chokes, such a coupling having a favourable effect on the compensation of any irregularities which may appear during the operation of the glow discharge tubes.

The advantage of using ferro-magnetic windings for the combined chokes appears from the part of the description relative to Figs. 5 and 6 of the drawings. Apart from the possibility of substituting ordinary iron for the more valuable copper, an exceedingly simple construction, which is very advantageous from the standpoint of manufacture and is much superior to the constructions as hitherto used, is secured for such chokes. Another important advantage consists in the possibility of obtaining combined chokes which have distinct electrical characteristics of any desired value, by assembling identical windings manufactured in mass production.

The examples described do not exhaust all the possibilities of utilisation of the invention. Still further possibilities exist consisting in various combinations of the elements referred to in the present specification.

What I claim is:

1. In combination with a single phase source of alternating current of a predetermined frequency, a circuit arrangement for starting and feeding first and second glow discharge tubes connected to said source via parallel circuits, the circuit to each tube from said source including a starting inductance and a stabilizing inductance connected in series with the tube and a capacity connected in parallel with the tube through only one of said inductances, and one only of said tube circuits including a capacity connected in series with the tube to establish a phase difference between the current waves of the two tube circuits, the values of the starting inductance and parallel connected capacity of each tube circuit being so chosen as to produce respectively therein substantially resonant conditions at different harmonics of the frequency of said source.

2. A circuit arrangement for a pair of glow discharge tubes as defined in claim 1 wherein the inductance capacity starting units of the two tube circuits become substantially resonant respectively at the second and third harmonics of the frequency of said alternating current source.

3. In combination with a single phase source of alternating current of a predetermined frequency, a circuit arrangement for starting and feeding first and second glow discharge tubes connected to said source via parallel circuits, the circuit to said first tube from said source including a starting inductance and a stabilizing inductance connected in series with the tube, and the circuit to said second tube from said source including a starting inductance and a stabilizing inductance and also the starting inductance only included in said first tube circuit connected in series with the second tube, and a capacity connected in parallel with the second tube through only one of the said inductances series connected with said second tube, the capacity and starting inductances in the circuit of said second tube having such a value as to establish in said circuit a substantially resonant condition, and one only of said tube circuits also including a second capacity connected in series with the tube to establish a phase difference between the current waves of the two tube circuits.

4. A circuit arrangement for a pair of glow discharge tubes as defined in claim 3 wherein the circuit of said first tube includes only said starting and stabilizing inductances.

5. A circuit arrangement for a pair of glow discharge tubes as defined in claim 3 wherein all the said inductances are constituted respectively by windings distributed on two columns of a common choke, the winding appertaining to the starting inductance in the circuit of said first tube being arranged on one of said columns, and the three windings appertaining respectively to the remaining three inductances are arranged on the other of said columns.

6. An arrangement for two pairs of glow discharge tube circuits with the tube circuits of each

pair arranged in accordance with claim 3 wherein all of the said inductances of the four lamp circuits are constituted respectively by windings distributed on two columns of a common choke, the ends of said columns being magnetically connected by end yokes and their mid-parts being magnetically connected by a middle yoke, the two windings appertaining respectively to the starting inductances in the said first tube circuit of each pair being arranged on one of said columns at opposite sides of said middle yoke, and the three windings appertaining respectively to the remaining three inductances in the tube circuits of each pair being arranged on the other of said columns at opposite sides of said middle yoke.

7. A circuit arrangement for two pairs of glow discharge tubes as defined in claim 6 wherein the windings appertaining to the series connected starting inductances for one tube circuit of a pair of tubes are arranged in part also on the said other column of the choke.



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