

[54] **BALLAST UNIT FOR GAS DISCHARGE LAMPS**

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[57] **ABSTRACT**

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A ballast unit system for various types of gas discharge lamps, in particular for fluorescent tubes, mercury and sodium vapor lamps, comprising a ballast choke. The lamp circuit is arranged in parallel with at least one semiconductor switching means or a triggering means which are designed to operate at the magnetic saturation bend for the purpose of developing the firing voltage required for lamp starting. In cases where heated lamps are used the switching or triggering means are designed for brief preheating of the lamps with increased rated current. The starter has no mechanical or moving parts, thereby minimizing wear and maximizing dependability.

[52] **U.S. Cl.** ..... **315/97; 315/101; 315/103;**  
315/105; 315/DIG. 5

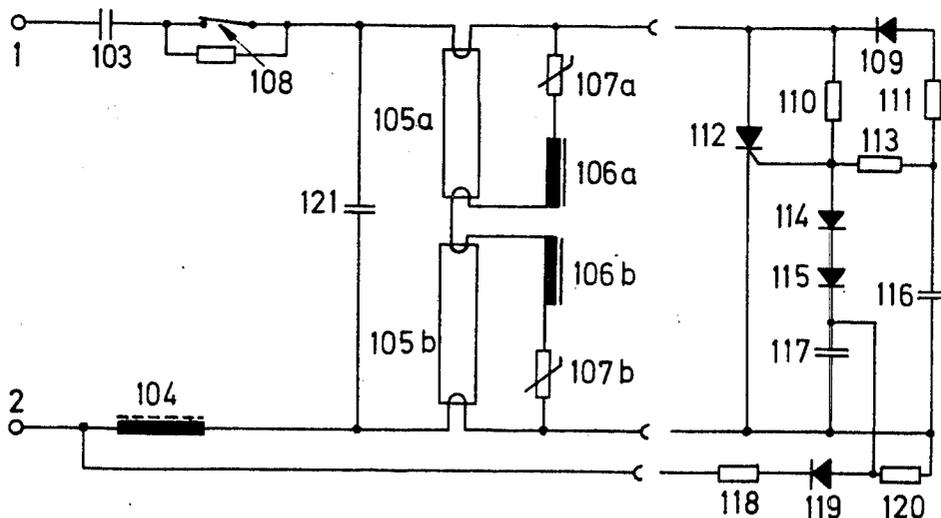
[51] **Int. Cl.<sup>2</sup>** ..... **H05B 41/14**

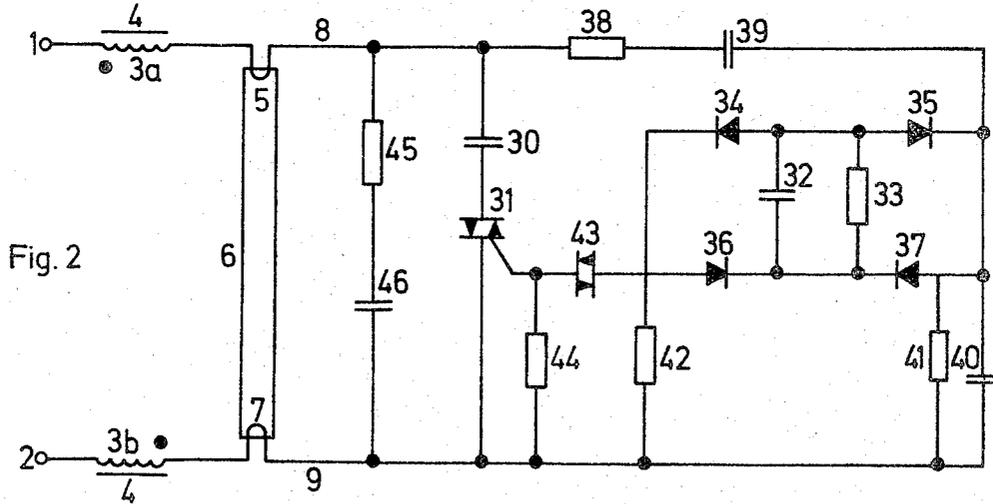
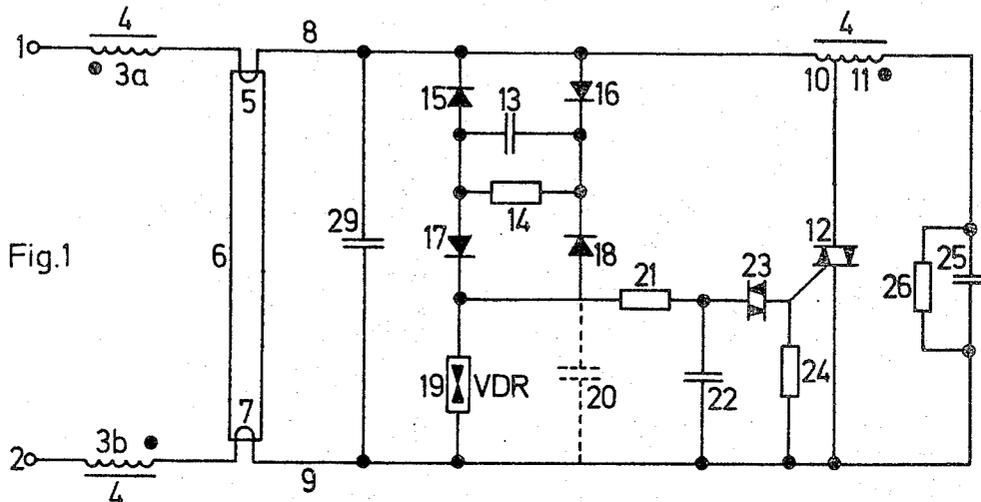
[58] **Field of Search**..... 315/DIG. 2, DIG. 5, DIG. 7,  
315/94-101, 103, 105

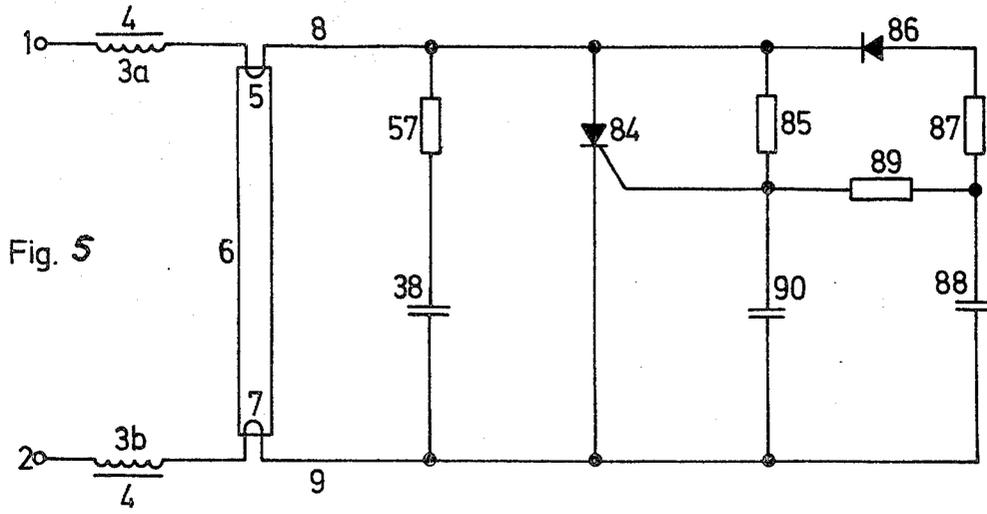
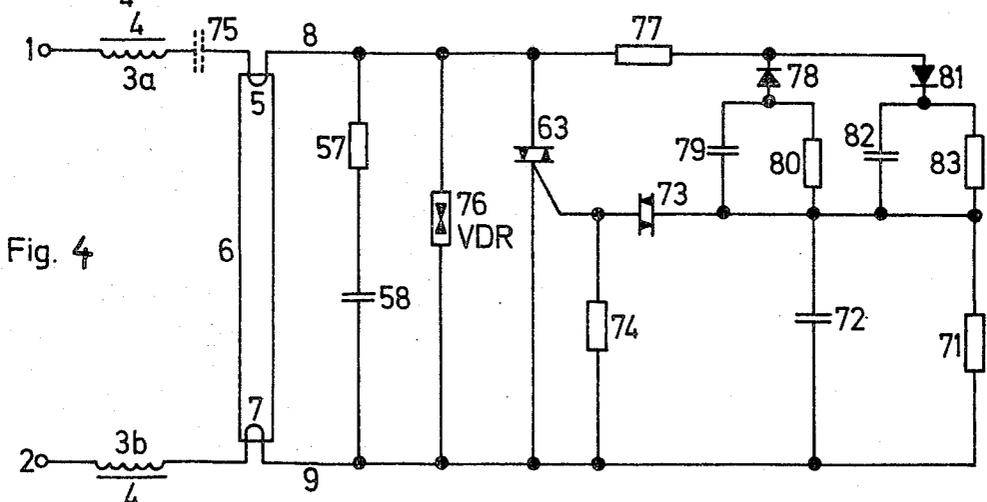
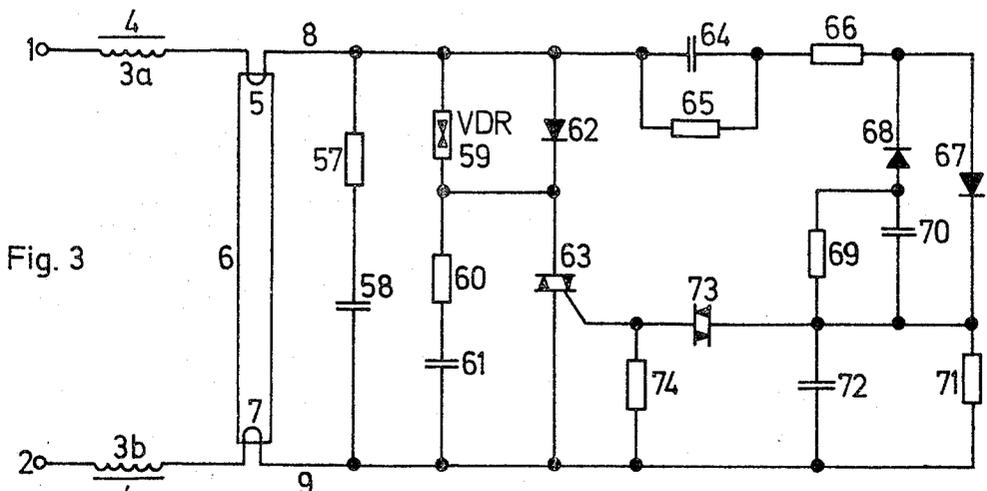
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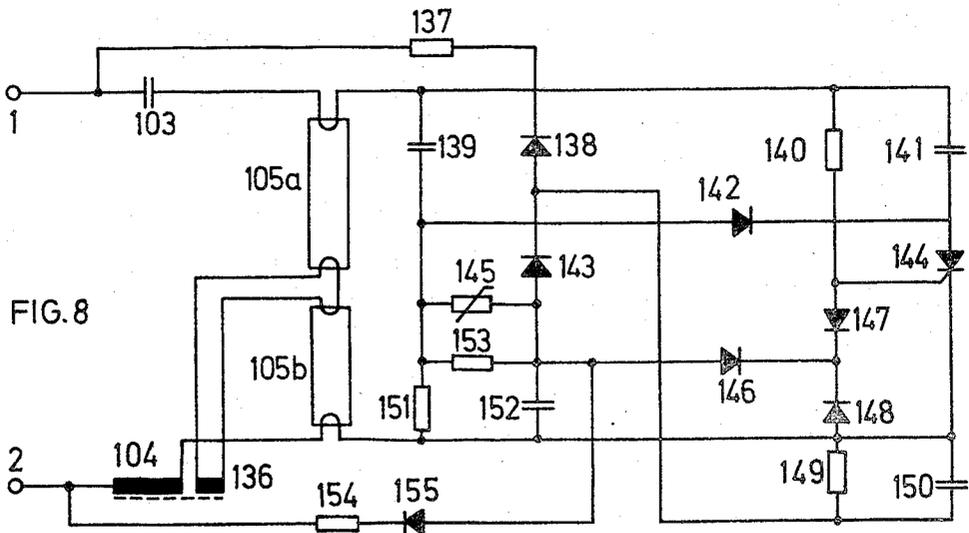
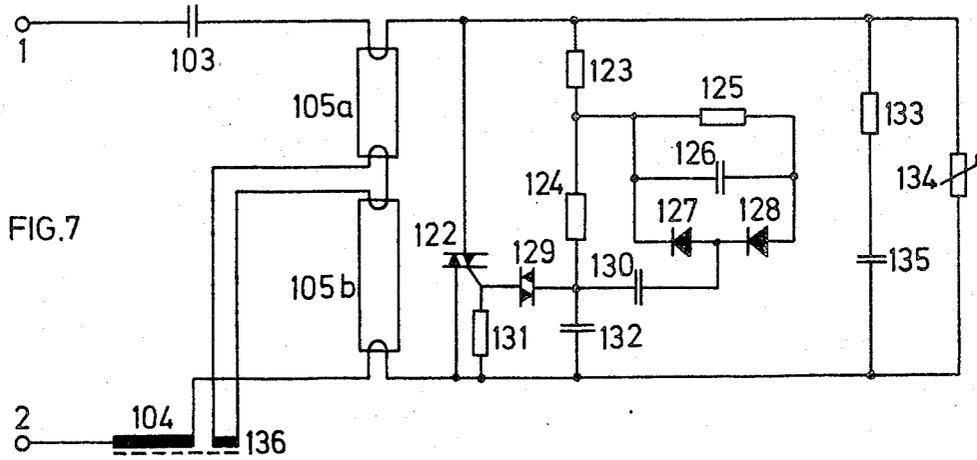
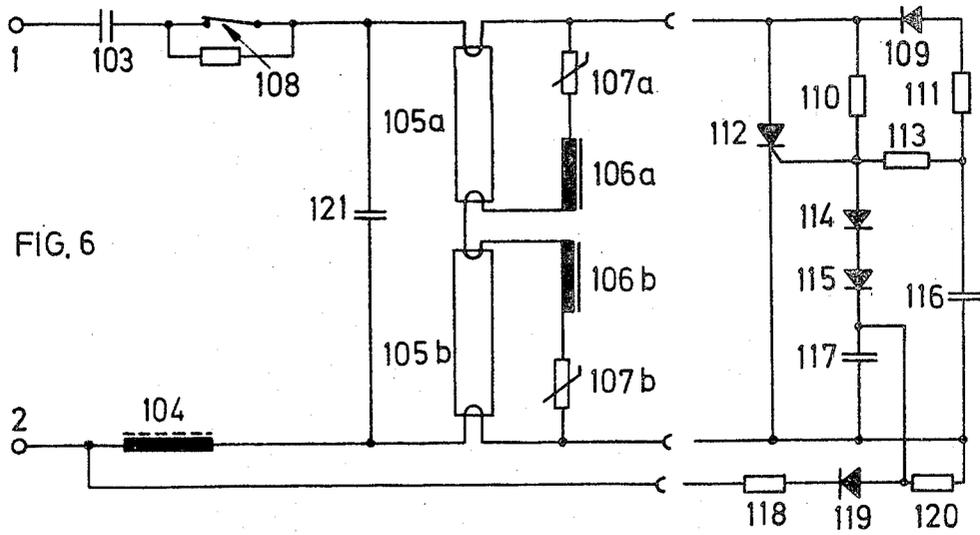
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**21 Claims, 13 Drawing Figures**









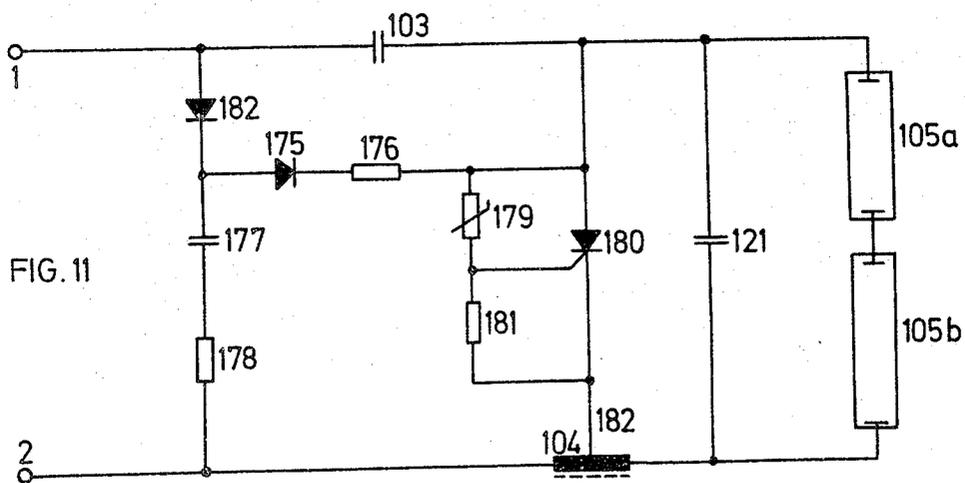
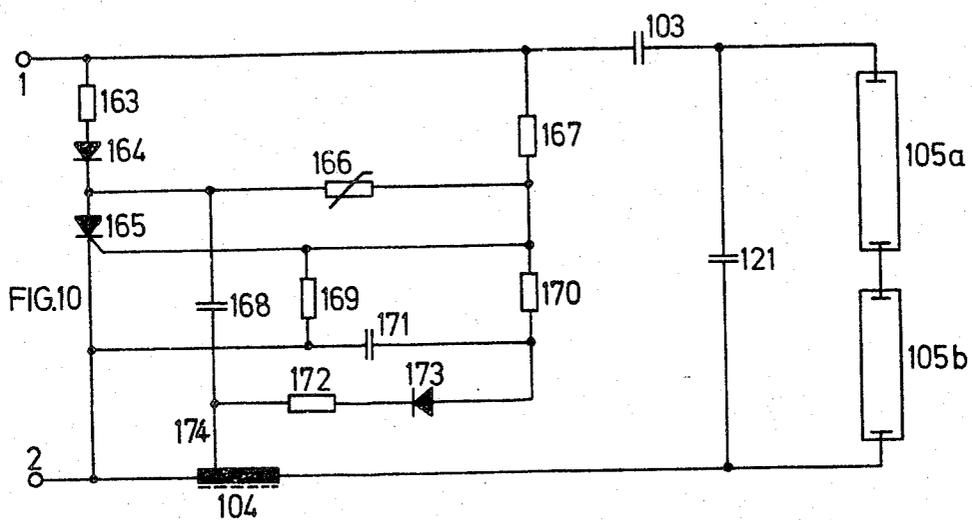
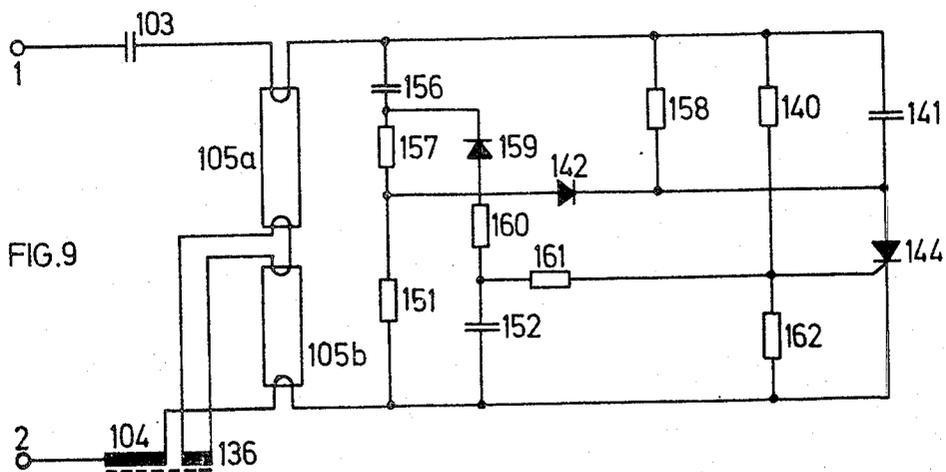


FIG. 12

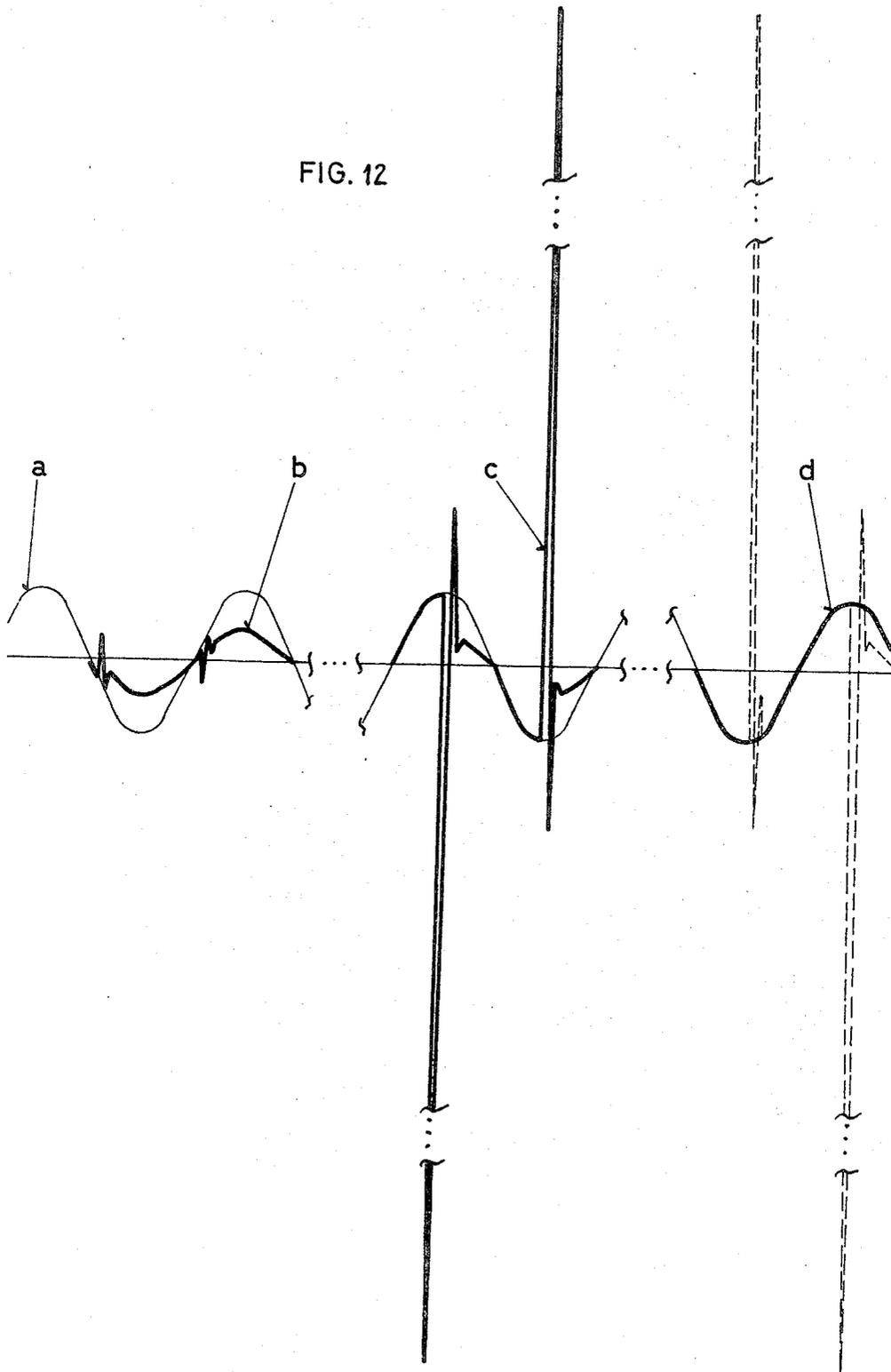
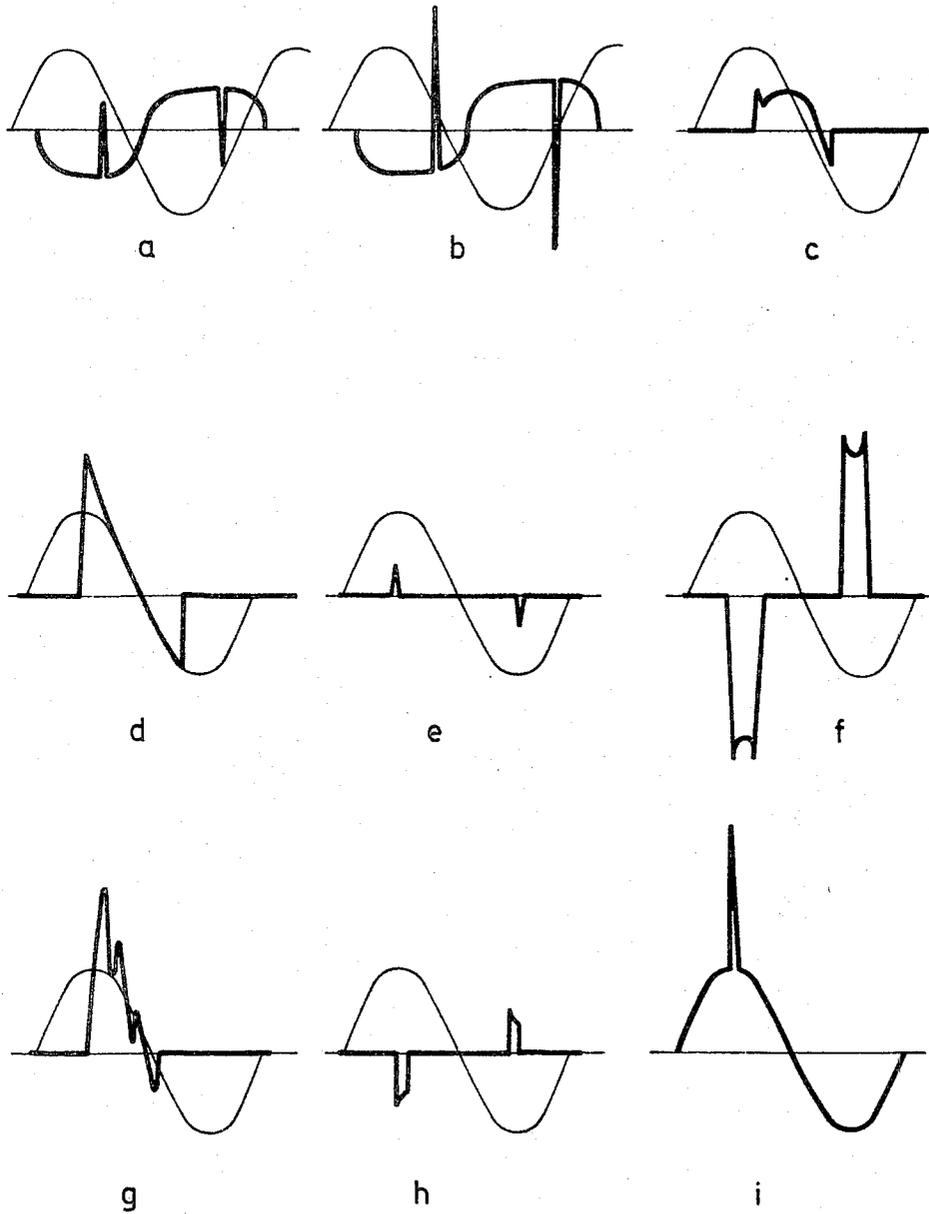


Fig. 13



**BALLAST UNIT FOR GAS DISCHARGE LAMPS**

The present invention concerns a ballast unit for gas discharge lamps, in particular for fluorescent tubes, mercury and sodium vapor lamps, comprising a ballast choke.

The Swiss Pat. No. 431.716, 431.717 and 446.524 have disclosed quick-heating ballast units which, however, have not been approved for trade or installation because, on a fault arising, i.e., when the tube is deactivated or the gas fill is disturbed, the system has no quick-acting cut-off protection against the continually overdosed current and is therefore liable to burn-out, i.e., destruction of tube and choke. Nor do those circuits provide for wattless current compensation or gradual increase of the firing current to prevent cold starting. The German Pat. Nos. 837.419 and 949.419 have disclosed circuits which, however, have neither any feedback quick-heating systems nor any protection against early firing and which therefore have similar disadvantages as have the starterless systems.

The object of the present invention is to provide ballast unit systems for the various types of gas discharge lamp which are technologically better and/or less expensive than known systems. In particular

a. the starter part is not to have any mechanical or moving parts and is thus to minimize wear and maximize dependability;

b. the system is not to have any additional transformers, iron cores and coils other than the copper and iron core required for the choke, in order not to increase weight, size and copper/iron losses needlessly;

c. the system is to use an increased preheating current higher than the rated current of the lamp in order to ensure pleasant, flicker-free starting of the preheated lamp;

d. cut-off of the preheating is not to depend on static conditions, such as a favorable ambient temperature which may trigger a cold start, but instead a certain minimum safety quantity of preheating energy is to ensure the filament flow temperature in any conditions;

e. the system is to rule out any overheating or burn-out of the system in the event of a fault arising, i.e. in the event of de-activated filaments, disturbed gas fill, etc.;

f. the firing voltages are to be higher than the mains voltage to the extent that, at a normal ambient temperature, no special lamps (such as tubes with ignition strips) are required.

The systems disclosed by the patents cited each only fill the above requirements in part, in particular:

Swiss Pat. No. 431.716 fails to meet points (b), (d), (e);

Swiss Pat. No. 431.717 fails to meet points (b), (c);

Swiss Pat. No. 446.524 fails to meet points (b), (e);

German Pat. No. 837.419 fails to meet points (c), (d);

German Pat. No. 949.419 fails to meet points (c), (d), (f);

French Pat. No. 582.392 fails to meet points (d), (e).

The present invention provides for a ballast unit which fills all the requirements together. It achieves its object in that there is connected in parallel to the lamp circuit at least one semiconductor switching means or a triggering means operating at the magnetic saturation bend for developing the firing voltage required to start the lamp, which means is designed for increased rated

current for brief preheating in the case of heated lamps being used.

While in known circuits it is usually the short-circuit current of the choke or a separate heating transformer which preheats the filaments of the lamp in starting, in the system claimed hereunder the series impedance merely serves current-limiting of the tube firing voltage. The high a.c. impedance of the choke, which is also in the preheating circuit, is at all times fully effective on the tube discharge path and is subsequently compensated again by suitable means. Its compensation leaves a sufficiently small residual internal resistance for the purpose of increasing the filament heat-up rate by the much heavier current to the level desired. This much heavier preheating current, which passes through the filaments and the series inductance, but never through the discharge path, would be far too high to be sustained as an effective current by the choke winding and the filaments. It only keeps within the time-safe limits owing to its being a current surge which is exactly time-dosed and controlled and monitored by the lamp itself. Its magnitude is only little below the zone in which an emission-damaging cross-firing across the filament could arise. This dangerous zone begins at about 15 - 20 times the rated current heating power, depending on the type of lamp. The result is a quick-starting, flicker-free ballast unit whose switch-on time approximately corresponds to that of an incandescent bulb.

Several embodiments of the invention are now to be described by way of example with reference to the drawings, in which

FIGS. 1 - 11 show circuit diagrams of several embodiments;

FIG. 12 shows the trend of the tube voltage for various switching phases of the ballast unit;

FIG. 13 (a-i) shows the trend of the tube voltage for the various embodiments.

The embodiments shown in FIGS. 1 - 5 comprise a choke which is connected to the mains terminals 1 and 2 and which consists of two winding sections 3a and 3b wound on to a common core 4. In asymmetrical chokes, the series inductance would consist of a single winding. Such a series inductance can also be formed by a stray field transformer. The gas discharge lamp 6 is connected on one side by its two filaments 5 and 7 to the choke sections 3a and 3b. The other two filaments 8 and 9, which in known ballast units are carried to a bimetal glow starter, are passed to the electronic starting and firing assembly. In all circuit examples shown, a thyristor or a triac (a.c. thyristor) performs the function of the starting switch.

In FIG. 1, compensation of the series inductance 3a and 3b is effected by an additional winding 10, 11 which is wound onto the same iron core 4 as is the choke. Its winding direction is opposite to that of the choke, but the number of windings is the same. Once the unit is connected to the mains terminals 1 and 2 and the triac 12 is fully activated (conductive), there arises an approximately induction-free low-resistance heating circuit 1, 3a, 5, 8, 10, 12, 9, 7, 3b, 2 which results in a very rapid heat-up of the filaments 5 and 7. The far more resistive a.c. circuit 1, 3a, 5, 6, 7, 3b, 2 across the discharge path remains fully preserved and performs the function of limiting the firing current. The rectifier bridge 15 - 18, which at first has no d.c. potential owing to the capacitor 13, begins to charge, and the voltage drop across the voltage-dependent resistor 19,

which works as a load resistor, becomes continually smaller. The control voltage for the trigger diode 23 passed by the series resistor 21 to the trigger capacitor 22 becomes continually smaller. The firing points in the triac now no longer arise shortly after the zero passage of the main sinusoidal voltage curve (FIG. 12), but shift towards the apex. However, at the firing moment, the triac 12 not only closes the heating circuit, but also connects the mains voltage capacitor 25 to the primary 11 of an autotransformer 10, 11, so that a high-voltage firing peak arises in the secondary 10, causing firing of the lamp. The size of the capacitor 25 is such that it also converts the ballast unit, otherwise inductive, into a wattless-current-compensated unit. The third function of the capacitor 25 is to permit the copper cross-section of the ballast winding to be approximately halved owing to the wattless current gain in the choke. Its fourth function is to cut off any overvoltage peaks which may arise in the mains and damage the triac. The assembly further comprises a safety discharge resistor 26 and a safety diversion resistor 24.

Once the triac fires, the voltage across the tube is approximately halved (FIG. 12b), because all the windings practically operate in short circuit and act on an ohmic voltage divider. A radio interference suppressor 29 does not affect the starting and firing functions. The electronic control assembly 13-24 for the triac 12 serves three different control states, in particular:

1. The switch-on phase:

Immediately after switch-on, the time- and voltage-dependent voltage divider arrangement 13 - 22 controls the trigger diode and, accordingly, the triac in such a manner that the latter remains fully switched on. The tube 6 receives a high heating current, but no firing voltage, and about half the mains voltage.

2. The starting phase:

While the filament temperatures rapidly approach the glow level, the capacitor 13 charges and, through the delayed triac firing, the full mains voltage occasionally reaches the tube across the choke. Owing to the shortened triac switching time, the heating current becomes slightly smaller, and the firing peaks become greater from one halfwave to the next. At the moment when firing begins, the voltage across the tube collapses, and the capacitor 13, now overcharged, causes complete cut-off of the triac 12. The size of the delay capacitor 13 is such that readily heatable lamps are ready for firing towards the end of the switch-on phase. For other lamps, the rapid heating continues as necessary.

3. The protection phase:

If, despite the starting phase being prolonged about fivefold, the tube has still not fired, the capacitor 13 will keep charging because of the persistent firing peaks until there is no longer any triggerable voltage across the capacitor 22. The discharge resistor 14 slowly reduces the charging voltage until isolated firing and heating pulses again become possible (FIG. 12d). The time element 13, 14 begins to swing up and down at the rate of once or twice a second. The resistor 14 can be so adjusted that the tube rated current arises as the effective value, which, even when sustained, cannot burn out the winding and which permits the tube to start after removal of the fault (e.g., too low a mains voltage). Moreover, the resistor 14 in conjunction with the capacitor 13 corresponds to a time element with the same time constant as the cool-down rate of the tube filaments, so that, after a short firing pause, the

system can skip part or all of the starting and switch-on phase and does not incur any needless heating of the filaments.

As each type of lamp requires other winding and R-C values, the examples given below for the calculation of the switching elements are of limited validity:

Resistor 14 about	470 kilohms	Capacitor 13 about	1 $\mu$ F
Resistor 21 about	15 kilohms	Capacitor 22 about	47 nF
Resistor 24 about	1 kilohms	Capacitor 26 about	4 $\mu$ F
Resistor 26 about	100 kilohms	Capacitor 29 about	10 nF
Resistor 28 about	0...47 kilohms		

Number of windings (series inductance = 100%)

3a	about 50%
3b	about 50%
10	about 90%
11	about 10%

FIG. 2 shows a second embodiment which partly compensates the high series impedance 3a and 3b, which hinders accelerated flicker-free filament heat-up, yet without reducing such impedance for the purposes of lamp current limiting. This function is performed by a capacitor 30, which acts in opposition to the series inductance. The apparent resistance of the capacitor 30 must be about 2 - 3 times smaller than that of the series inductance in order to avoid any resonance effect and to keep the initial voltage across the tube as low as possible.

In FIG. 2, the capacitor 30 is in series with a triac 31, which, after the beginning of switch-on, is controlled for full conductivity, because the harmonics-eliminating voltage divider 38-41 almost continually acts on the trigger diode 43 across the bridge rectifier 34-37, which is at first still short-circuited. The collapse of the tube voltage to the firing voltage renders the triac control ineffective. The R-C element 45, 46 constitutes a radio interference suppressor. As in starterless systems, the circuit has no firing voltage and, besides ensuring a much quicker start, it provides better early firing protection due to the reduced initial voltage.

For example, the values of the switching elements for the circuit may be:

Resistor 33 about	3.3 megohms	Capacitor 32 about	1 $\mu$ F
Resistor 38 about	22 kilohms	Capacitor 39 about	47 nF
Resistor 41 about	33 kilohms	Capacitor 40 about	47 nF
Resistor 42 about	470 kilohms	Capacitor 30 about	20 $\mu$ F
Resistor 44 about	1 kilohms	Capacitor 46 about	47 nF
Resistor 45 about	33 kilohms		

FIGS. 3, 4 and 5 show embodiments in which an unequally heavy one-sided halfwave load in the choke results in a high d.c. component and therefore in the heating current increase desired. The circuits shown in FIGS. 3 and 4 also include means designed to rule out early firing especially in short tubes, i.e., tubes especially liable to cold starting.

FIG. 3 shows a circuit in which, apart from the suppressor R-C element 57, 58, a triac 63 is connected in series with a diode 62 across the starter connection points 8 and 9. Also, there is a voltage-limiting voltage-dependent resistor 59 across the diode and there is a damping R-C element 60, 61 across the triac 63, so that, with the triac 63 fully activated, a mains voltage approximately halved by the voltage-dependent resistor arises in the one group of halfwaves across the starter connection points, while a mains voltage short-

circuited by the diode 62 arises in the other half-waves (FIG. 13c). As the diode 67 has to charge the time element 64, 65 across the series resistor 66, but is itself bridged by an opposed diode 68 with a time element 69, 70, the triac control signals diminish in their sequence in such a manner that, with an approximately halved mains voltage across the tube, a high asymmetrical d.c. at first effects preheating. Then, owing to the control shift, the halfwave group passing directly through the diode 62 is interrupted, but not so the half-wave group passing through the voltage-dependent resistor. As a result, a heavy heating current continues to flow, yet at the full mains voltage and at an additional overvoltage oscillation which is rendered firing-aiding by the suppressor element 57, 58 (FIG. 13d). When the tube fires, the control voltage collapses to about  $\frac{1}{3}$  and is no longer capable of being activated.

The circuit shown in FIG. 4 is suitable especially for capacitive (wattless-current-overcompensated) ballast units (series capacitor 75 indicated by broken line). A triac 63 arranged directly across the lamp firing path 8,9 is controlled across the trigger system 71-74 through a series resistor 77 and then through two diode time elements 78, 79, 80 and 81, 82, 83 which are connected in parallel and are unequally dimensioned and whose diodes have opposed directions. A voltage-dependent resistor 76 across the tube discharge path prevents, in the presence of a capacitor 75, any voltage straying in the more weakly controlled halfwaves. The delay capacitors 79 and 82, which are at first still discharged, develop a lamp voltage according to FIG. 7e at the almost fully conductive triac. The weaker, faster-charging time element drives the choke into saturation and develops a heavy heating current. If the tube did not fire, or fired late, the voltage curve shown in FIG. 13g would arise towards the end of the starting process.

FIG. 5 shows a much simplified variant for asymmetrical heating. It is suitable for long lamp types. The d.c. saturation already arises from the fact that only a thyristor 84 acts as switch, so that the negative halfwaves are in any case invariably blocked. A resistor 85 carries a continual control voltage to the thyristor firing electrode. After switch-on, however, a diode 86 begins to charge the capacitor 88 across a series resistor 87. The increasing negative voltage across this capacitor increasingly draws the voltage supplied from the resistor 85 into a negative zone, across the resistor 89. When the tube fires, its feed voltage collapses. Owing to the negative superimposition, the control current is no longer sufficient for further firings in the thyristor. If the tube fires later or not at all, the increasing negative influence will eventually cut off the heating. As the R-C values are such that the filaments glow before the charge of the capacitor 88 has reached its maximum, the self-regulating effect is sufficiently great to dispense with a trigger diode.

The embodiments shown in FIGS. 6 - 11 have a choke with an inductance which is 2 - 3 times smaller than that in known units. While a capacitor arranged in the firing circuit in parallel with the inductance is operated by the mains frequency, the inductance preferably operates on the third harmonic of the mains frequency. As the current or voltage trend of the fired tubes is almost square, an almost ideal wattless current compensation arises when the phase relations are considered. As the series inductance is 2 - 3 times lower than that in known units, the firing voltage at the lamps is higher,

permitting two lamps to be connected in series, each of which formerly required a ballast unit of its own. Thus, the reduced inductance and the possibility of operating two tubes in series with a single ballast unit offer substantial savings.

The ballast unit shown in FIG. 6, which is fully operative even without the control circuit indicated in the right section, comprises a series capacitor 103, a series inductance 104, which may have the form of an air gap choke, for instance, and further comprises two series-connected tubes 105a and 105b. The outer filaments of the series-connected tubes are connected in series with the inner filaments across saturation chokes 106a and 106b. Instead, of course, there may be only one saturation choke 106. The arrangement also includes an interference suppressor 121. To protect the ballast unit from overload, the circuit of the saturation choke is provided with positive temperature coefficient resistors 107a and 107b, while the main circuit includes a thermal switch 108 bridged by a resistor.

The saturation chokes 106a and 106b are so dimensioned that, because of their steeply rising reactance, they at first only present a very low resistance to the heating current. When the tubes are fired, however, only a negligibly small current flows through the chokes.

To improve the firing properties of the arrangement shown in FIG. 6, a thyristor 112 connected in parallel with the chokes takes over an additional current quota in one halfwave and is controlled in a subsequent halfwave under the influence of a previously charged capacitor 116. The charging of the capacitor 116 is effected across a diode 109 and a resistor 111. The resistors 110 and 113 ensure corresponding voltage potentials at the control electrode of the thyristor 112. The limiting diodes 114 and 115, which are controlled across the resistors 118 and 120 and across a diode 119 under the influence of a capacitor 117, act as overload protection for the thyristor 112.

For a 50 c/s mains, the values of the switching components used may be as follows:

103	4 $\mu$ F	116	47 nF
104	Z = 300 ohms	117	330 $\mu$ F
110	1 megohm	118	10 kilohms
111	150 kilohms	120	1 kilohm
113	330 kilohms		

The embodiment shown in FIG. 7 has an electronic firing system instead of the two saturation chokes. The inner filaments of the series-connected tubes 105a and 105b are connected across an auxiliary winding 136 arranged on the inductance 104. Owing to the heavy current which also flows in this unit at first, the winding 136 develops a relatively high heating voltage for the inner filaments.

The electronic control circuit developing the increased heating current required to fire the tubes 105a and 105b comprises a triac 122, a resistor 131 and a trigger diode 129. A time element 125, 126 arranged in a rectifier circuit 127, 128 is connected across a resistance assembly 123, 124, a capacitor 132 and a further capacitor 130. In function, this control circuit largely corresponds to the embodiments shown in FIGS. 1 - 3. An assembly comprising a resistor 133, a capacitor 135 and a parallel-connected voltage-dependent resistor 134 provides overvoltage protection for the triac.

A preferred embodiment presents the following values:

123	68 kilohms	126	1 $\mu$ F
124	1 megohm	130	68 nF
125	2.2 megohms	132	150 nF
131	1 kilohm	135	100 nF
133	33 kilohms		

The embodiment shown in FIG. 8 corresponds in essentials to that shown in FIG. 7, with the difference that the cold-starting protection for heated tubes is improved. Moreover, the automatic starting system is bridged by an additional circuit preventing repeated starting in the event of a fault. A thyristor 144 used as a switch is connected to a capacitor 141 which serves as cold-starting protection and which is connected across a parallel-connected diode 142 to a measuring resistor 151, particularly at the gas discharge path. In cold tubes, no voltage is therefore developed. However, once the thyristor 144 has been cut off by a negative voltage drop at the measuring resistor 151 across components 145, 146, 147, 148, 152 and 153, the lamps can fire, and the voltage across the inductance 104, reduced across a resistor 154 and rectified by a diode 155, is used to maintain this cut-off. In the event of a fault, after several unsuccessful starting attempts, this function is taken over by a safety cut-off, comprising the components 137, 138, 143, 149 and 150. A preferred embodiment presents the following values:

137	47 kilohms	139	10 nF
140	1 megohm	141	64 $\mu$ F
151	10 megohms	150	2000 $\mu$ F
149	3.3 kilohms	152	680 $\mu$ F
153	2.2 kilohms	154	47 kilohms

The embodiment shown in FIG. 9 presents a simplification on the version shown in FIG. 8, in that the additional cut-off means is dispensed with. Also, the automatic trigger and cut-off assembly is simplified in that the harmonic quota contained in the firing current after the firing of the lamps is utilized to cut off the thyristor 144. For this purpose, the arrangement includes a differentiator 156, 157 whose signal is rectified by a diode 159 and is passed to the control electrode of the thyristor 144 across resistors 160 and 161. For a preferred embodiment, the values of the switching components are as follows:

157	47 ohms	156	100 nF
158	100 kilohms	152	330 $\mu$ F
160	3.3 kilohms	161	4.7 kilohms
162	3.3 kilohms		

In the embodiment according to FIG. 10, a trigger voltage of several thousand volts is developed. A capacitor 168 charged to mains voltage level is discharged across a thyristor 165 to the smaller coil section of the inductance 104, designed as an auto-transformer and having a tap 174. These pulses are stepped up by the autotransformer and produce the high-voltage pulses desired. After firing, there arises in the smaller winding section an a.c. voltage, which is rectified for cut-off of the thyristor 165. Such a firing device can also be added as an auxiliary firing in all the other circuits mentioned in order to increase firing dependability. For a preferred embodiment, the values are:

163	3.3 kilohms	167	3.3 megohms
169	3.3 kilohms	168	16 $\mu$ F
170	3.3 kilohms	171	330 $\mu$ F
172	3.3 kilohms		

In the embodiment shown in FIG. 11, the firing voltage developed is less high than in the embodiment according to FIG. 10. The primary of the inductance 104 acting as an autotransformer receives about 1.5 times the mains voltage from a voltage multiplier circuit 182, 175, 176 across a switched-on thyristor 180. This value results from the storage of the voltage developed by the voltage multiplier and stored in the capacitor 103 in conjunction with superimposition with the next mains voltage cycle. The autotransformer, formed by the tap 182 on the inductance 104, steps up these voltage peaks by the double to the threefold mains voltage, for instance. After lamp starting, no further charging of the capacitor 103 arises, as the fired lamps no longer permit any d.c. voltage charging of the capacitor 103. A preferred embodiment presents the following values:

176	100 kilohms	177	330 nF
178	1 kilohm	181	1 kilohm

What is claimed is:

1. A ballast unit for gas discharge lamps having a pair of electrodes, comprising:
  - a choke means, exclusively for limiting the current to the lamp after lamp firing, connected in series with the lamp electrodes;
  - at least one semiconductor switching means, having a control electrode, for brief preheating of the filaments of the lamp at increased rated current, said switching means being connected in parallel with said lamp electrodes; and
  - a control circuit means operating in response to an AC voltage supplied to said lamp electrodes and also connected to said control electrode for initially triggering said semiconductor means for a predetermined switch-on time during each half cycle of said AC voltage, to heat the filaments of the lamp with an effective current greater than normal rated current, as well as reducing the switch-on time during each half cycle until the lamp fires, and further increasing voltage peaks across the lamp for a predetermined preheating period prior to reaching ignition voltage, thereby avoiding cold-starting of the lamp;
  - said control circuit means including:
    - a storage device capable of storing a charge corresponding to the voltage applied to the lamp;
    - a discharge resistor connected to said charge storage device; and
    - an overvoltage peak means to cut off any overvoltage peaks.
2. The ballast unit of claim 1 wherein said control circuit connected to said semiconductor switching means and said lamp electrodes including a limiting resistor connected to one of said lamp electrodes; a bridge rectifier having an R-C component connected between said limiting resistor and the other of said lamp electrodes; a time element including a capacitor and a resistor in parallel connected across said bridge rectifier; and control voltage means connected to said bridge rectifier and said limiting resistor including a series resistor, a control diode connected in series with said re-

sistor, and a control capacitor connecting the junction of said series resistor and said control diode with said one of said lamp electrodes; and having the following control states

- a. switch-on phase with fully triggered control-voltage-independent semiconductor switch;
- b. starting phase with partly triggered lamp-firing-voltage-dependent semiconductor switch;
- c. protection phase with fault-dependent semiconductor switch;

wherein said control circuit concurrently forms a short circuit for increased voltages across the gas discharge path so long as the starting phase has not begun, with said limiting resistor forming the load resistor for said time element and concurrently forming an early firing protection for the tube, said R-C component of said bridge rectifier transferring the limiting voltage to the lamp; and, in conjunction with said control voltage means, concurrently triggers said semiconductor switching means.

3. The ballast unit of claim 2 wherein the charging rate of said time element and the behavior of said limiting resistor correspond to the heat-up rate of said electrodes and the cool-down time of said electrodes coincides with the discharge time constant of said time element for the purpose of skipping part or all of the switch-on and starting process in the case of a short firing pause.

4. The ballast unit of claim 1 further comprising a capacitor means connected in series to said semiconductor switching means for reducing the apparent resistance of said choke by acting in opposition thereto only when said semiconductor means is triggered, a trigger diode connected to said semiconductor switching means; and voltage divider means for fully activating said semiconductor switching means and then, until the beginning of lamp starting, partly activating said semiconductor switching means.

5. The ballast unit of claim 1 comprising means for controlling said semiconductor switching means in such a manner that a d.c. component increased above the shortcircuit current arises for said lamp electrode, and for preventing early starting of the lamp; wherein said increased current arises only until the starting of the lamp.

6. The ballast unit of claim 1 including a capacitor connected in series with said choke means and in parallel with the lamp, said choke means being tuned substantially to the third harmonic of the mains frequency.

7. The ballast unit of claim 6 comprising a saturation choke connected in parallel with the gas discharge lamp.

8. The ballast unit of claim 7 comprising a positive-temperature resistor connected in series with said saturation choke.

9. The ballast unit of claim 7 comprising a thermal cut-out connected in series with the parallel combination of said lamp and said capacitor.

10. The ballast unit of claim 7 comprising triggering means having a predetermined time constant connected in parallel with the gas discharge lamp and said saturation choke for triggering said semiconductor switching means and for supplying thereto a cut-off voltage after the starting of the gas discharge lamp for preventing voltage overload of said semiconductor switching means.

11. The ballast unit of claim 10 comprising d.c. voltage circuit means for developing an additional cut-off

voltage for preventing voltage overload of said semiconductor switching means, said d.c. voltage circuit means having a greater time constant than that of said triggering means.

12. The ballast unit of claim 6 wherein said choke includes a heater winding means for the additional preheating of the electrodes.

13. The ballast unit of claim 12 wherein said control circuit comprises a resistor, and a capacitive apparent resistance circuit connected in parallel with said resistor; wherein said semiconductor switching means is a triac.

14. The ballast unit of claim 12 comprising a capacitor connected in parallel with said semiconductor switching means, said semiconductor switching means having a control electrode, for cold-starting protection, a diode and a resistor bridging said semiconductor switching means, and a cut-off circuit and a safety cut-off circuit both connected to said control electrode of said semiconductor switching means.

15. The ballast unit of claim 12 comprising a differentiator and rectifier means connected to said semiconductor switching means for cutting off said semiconductor switching means.

16. A ballast unit according to claim 1, wherein: said storage device compensates at least in part for the resistance of said choke means,

said storage device operating exclusively in said control circuit during the heating of said filaments of the lamp and being inoperative after the lamp fires.

17. A ballast unit according to claim 1, wherein the apparent resistance of said storage device is approximately 2 - 3 times smaller than said ballast choke means.

18. A ballast unit according to claim 1, wherein said control circuit means further includes a heater circuit; said heater circuit being asymmetrically loaded only until the lamp fires;

said heater circuit including a diode and a VDR connected in parallel, the parallel combination being connected in series with one of the pair of lamp electrodes and with said at least one semiconductor switching means; and

a damping resistor and damping capacitor connected in series with each other and said VDR, and in parallel with said semiconductor switching means, whereby an increased direct current component in excess of short circuit current is produced in said heater circuit.

19. A ballast unit according to claim 1, wherein said control circuit means further includes a heating circuit; said heating circuit being asymmetrically loaded only until the lamp fires;

a storage capacitor connected through a storage capacitor resistor to said control electrode and being chargeable by the lamp voltage;

a further resistor connecting one of said pair of lamp electrodes to said control electrode;

a charging current diode electrically connected to one of said pair of lamp electrodes and to said storage capacitor;

said heating circuit being connected to the lamp such that the cut-off voltage component of said storage capacitor counteracts the cut-off voltage component of the lamp voltage, and the time constant of said storage capacitor being such that the filament of the lamp reaches a glowing state prior to the charge on said storage capacitor reaching maxi-

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mum value.

20. The ballast unit according to claim 1 further comprising an auxiliary winding including a primary and secondary winding serially interconnected in the parallel path of said semiconductor means and said lamp electrodes, said choke means and said auxiliary winding being wound to a same iron core in opposite winding directions, said auxiliary winding having the same number of windings as said choke means.

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21. The ballast unit of claim 20, further comprising a primary firing circuit connected to said primary auxiliary winding having capacitor means for providing the triggering energy, converting the ballast unit into a wattless-current-compensated ballast unit, providing an overvoltage peak protection for said semiconductor switching means and developing the lamp firing voltage in said secondary auxiliary winding; wherein said semiconductor switching means closes said heating circuit and said primary firing circuit.

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