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(54) **Control circuit for gas discharge lamps.**

(57) A ballast circuit for a gas discharge lamp (L) which comprises a series resistance (R1) and a series capacitor (C1), the capacitor serving to store a charge provided by a starter circuit (D1, R1) to attain a starting voltage for the lamp, the capacitor also being assigned to determine the mean operating current for the lamp and its capacitance being selected to barely supply adequate operating current for predetermined lamp illumination, and the resistor being assigned to limit peak currents through said lamp and being of a resistance barely adequate to avoid excessive peak current through said lamp.

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CONTROL CIRCUIT FOR THE GAS DISCHARGE LAMPS

The present invention relates to an improved control circuit for gas discharge lamps.

In the prior art the most common type of gas discharge lamps and circuitry therefor are found in fluorescent lighting. Almost invariably in this type of circuit an inductive ballast is used in conjunction with a starter switch or circuit. These components in combination being connected to a supply voltage to give a momentary surge voltage to ionise the fluorescent lamp, with the ballast then acting, after striking of the lamp as a choke to limit or stabilize the current.

These prior art systems suffer from the following disadvantages:-

1. A need for power factor correction
2. Humming of ballast
3. The weight of fittings
4. The size of the base to house the control equipment
5. Heat generated in the ballast
6. A comparatively high cost

The present invention seeks to eliminate the conventional form of inductive ballast, the replaceable starter switch, the starter socket, and the capacitor used for power factor correction to overcome the lagging effect of the current due to the inductive ballast, and thereby largely avoid the above disadvantages.

A former system that has been used is a series resistor operating in conjunction with a low-voltage striking tube. In this case the peak supply voltage is sufficient to strike the lamp. If the lamp is of 20w type operating at, say 100v running voltage on a 250v supply circuit, the resistor has to drop 150v after lamp striking. This will dissipate approximately 20w at the lamp and 30w in the resistor, so that the arrangement is consuming approximately 50w for the 20w of illuminating power. This excessive power consumption is, of course, undesirable.

Numerous attempts have been made to minimise the waste of power in the ballast and to avoid at least some of the disadvantages listed above. The use of a resistor as the principal component for ballasting is far from ideal as these components are noted for their high watts loss. Inductors have been preferred due to their reduced watts loss compared to the resistor, despite their relative bulk and increasing cost. Hence, the ballast circuit for a gas discharge lamp as presently adopted almost invariably has the form of the circuits disclosed in U.S. Patent Specification Nos. 2,575,001 (Bird) and 3,857,063 (Major et al). In the former specification the operating circuit for the lamp includes a series connection from the applied power through an inductor and a capacitor having a capacitance of about 13µf and a reactance at the line frequency of about twice that of the inductor. The principal function of the capacitor is to increase the starting potential on the lamp. In the latter specification the operating circuit comprises only an inductor for stabilizing the lamp operating current.

It has been generally accepted in the industry that a capacitor is not readily adaptable as the principal component for ballasting in the operating circuit of a gas discharge lamp, regardless of the fact that a capacitor generates in itself very little heat. The basis of this reasoning is the large peak currents readily passed by a capacitor relative to those passed by an inductor. The present invention resides in the realisation that a surprisingly great economy and simplification of circuitry is possible if a series resistor is assigned to the task of limiting the operating current and is associated with a capacitor in the operating circuit whose capacitance is selected solely on the criterion of providing adequate operating current for the lamp.

In accordance with the invention there is provided a control circuit for a gas discharge lamp comprising input terminals for connection to a power supply source and output terminals for connection to a gas discharge lamp, a starting circuit for the lamp at least part of which is connected across the output terminals, and a capacitor and an attenuator connected in series with each other and in series between the input terminals and the output terminals, said capacitor having a capacitance no less than and not substantially more than the minimum value of capacitance necessary to pass adequate operating mean current for said lamp from said power supply, and said attenuator having an impedance no less than and not substantially more than the minimum value of impedance which will eliminate excessive peak current flow through said lamp from said power supply.

This invention, therefore, lies in the suitable selection of a capacitor, i.e. one with a capacitance barely sufficient to ensure adequate tube operating power, together with an attenuator having an impedance barely sufficient to ensure adequate limiting of the peak current through the lamp. This attenuator is required to have as low a value as practical otherwise the watts loss in this unit will approach that of a conventional inductive ballast. If the impedance value is too low, permitting excess peak current in operation, a fall in the light output and damage to the lamp will result. If the capacitor is of too low a value there will be insufficient operating power delivered to the lamp. To have minimum losses, the capacitor reactance has to be as high as practical and the attenuator as small an impedance as possible.

This relationship of values of the series capacitor and attenuator is contrary to the conventional design approach. It has hitherto been considered necessary to choose the value of capacitance as large as possible. As the attenuator has been in the form of an inductor design has followed the assumption that the capacitor and inductor should be regarded as a smoothing filter to eliminate excessive peaks in the operating current. An example of this prior practice occurs in the specification of U.S. Patent 2,134,439 (Dorgelo) where a series capacitor of 30μf and a series choke of 2 to 3 H function as a filter, with the values of both being kept as large as possible if normally undesirable variation in light intensity from the lamp is to be avoided. By approaching the design in the fashion of this invention considerable simplification and miniaturization can be achieved.

The invention will now be described in more detail with reference to the accompanying drawings, in which:-

Fig. 1 is a schematic diagram of an exemplary embodiment of the control circuit of the invention;

Fig. 2 is a graph showing typical operating conditions of an 8 W gas discharge lamp plotted against changes in capacitive and resistive values;

Fig. 3 is a diagrammatic representation of an arrangement to enhance starting in larger lamps incorporating the control circuit of the invention; and,

Fig. 4 shows the assembly in actual size of the components of the circuit of Fig. 1, excepting resistor R_1, accommodated within a housing.

With reference to Fig. 1 the circuit shown is designed for a low wattage fluorescent lamp and has its input terminals A and B connectable to a power supply S which in this case is 220/260 AC volts at 50 Hz. Output terminals C and D are connected to the filaments of a fluorescent lamp L and in series therewith is a capacitor C_1 which, as will be explained hereafter, is designed to determine the mean operating current supplied from the source S to the lamp L to ensure adequate lamp illumination, and is assigned a value commensurate with that task. An attenuator, in this instance a resistor R_1, is also serially connected between the input and output terminals A-B and C-D designed to limit the operating current peaks supplied to the lamp L to protect it against damage, and is assigned a value according to this task. The resistor R_1 may be positioned in any part of the circuit providing it is in series between the lamp L and its supply S. Although many different forms of ignition, or starting, circuits may be employed with the control circuit of this invention, such as an oscillating circuit, for the sake of circuit simplification a conventional series network of a diode D_1 and resistor R_2 is preferably used. By appropriate selection of the resistance of resistor R_2 the positive charge stored in capacitor C_1 during the positive half cycles of the applied AC power from supply S is additive to the voltage at the supply S on appropriate half cycles, thus effectively increasing, and even doubling with the correct choice of resistor R_2, the voltage supplied to the lamp L. The value of resistor R_2 may be between 8,000 ohms and 30,000 ohms and will ensure such a voltage and additionally eliminate flicker from the lamp L, due to the shunt connection of diode D_1, by effectively disconnecting the shunt circuit of network D_1 and C_2 when the lamp L fires. Upon firing a damaging peak current would flow through the lamp L from capacitor C_1 in the absence of the current limiter resistor R_1.

In those instances where a large wattage fluorescent lamp, say 40w lamp, is in use the series attenuator may be composed entirely of an inductor X instead of resistor R_1 or additionally thereto. However, due to the value assigned thereto according to this invention the watt loss, and physical size, of the inductor is considerably less than that of a conventional ballast inductor.

A typical capacitance for capacitor C_1 for the operation of 4w, 6w, 8w and 13w conventional fluorescent lamps is 1μf. Because the lamp characteristics are not identical for each of the above lamps, the value of the peak current limiting resistor R_1 has to be varied and therefore the watts loss therein varies. Typical values for the current limiter resistor R_1 when associated with the 1.0μf capacitor C_1 for a 4w and 6w lamp is in the order of 300 ohms, 2 watts. For an 8w lamp the current limiting resistor R_1 is approximately 500 ohms, 3 watts and in the case of the 13w tube is 500 ohms, 5 watts. If the capacitor C_1 is reduced to 0.8μf the current limiting resistor R_1 can be reduced and the watts loss therein is reduced because the average power through the lamp is reduced. However, the 8w lamp would not have sufficient operating mean current applied to it if an 0.8μf capacitor was in series with the supply S. Therefore, a 1.0μf capacitor having a reactance of about 3,000 ohms at 50 Hz would be used in series with a 300 ohm peak current limiter therefore the peak current limiter R_1 has a value 10% of the value of the capacitor C_1 reactance at 50 Hz.

In the case of a 20w lamp, 4.0μf capacitor C_1

represents a reactance of approximately 800 ohms and this is used in association with an 80 ohm current limiting resistor R_1 once again to produce a 10 to 1 ratio. However, it has been found that this ratio does not hold in all cases. If it were so the following calculation would provide the optimum values:

Assume a supply of 250v at 50 Hz, a drop of 100v across the tube after firing, a drop of 150v across a series resistor, 20w dissipated at the lamp, and 30w dissipated in the resistor

If this resistor R_1 be replaced by a capacitor C_1 and a current limiting resistor R_1 having a 10 to 1 reactance ratio, approximately 10 parts of the voltage will be dropped across the capacitor C_1 and one part across the resistor R_1 for every 11 volts, so that the 30w loss by this method of calculation would give about 3w loss in the current limiter R_1. However, this does not apply because the current limiter R_1 is required to handle excessive peak current and in fact it has been found to dissipate 5 to 6 watts and this could vary between one manufactured tube and another.

On the other hand it has been found that there appears to be consistency when selecting the value of capacitor C_1 in the miniature 15 mm diameter lamps (4w, 6w, 8w and 13w with varying lengths) as they all operate satisfactorily with a capacitor between 0.8 MFD and 1.25 MFD. This is shown by the graphs of Fig. 2 where capacitive values of 1.25μf, 1.1μf and 1μf are plotted against values of resistor R_1 and wattage loss in that resistor. It will be seen that the value of resistor R_1 will be chosen to be within the area defined by the plotted coordinates for high wattage loss and light flicker. The specific part of this area chosen is preferably determined by the light output of the lamp. All fluorescent lamps possess a light output plateau with changing operating current and it has been found that if the value of total impedance to the current flow be chosen at or near the lower end of that plateau (i.e. with decreased current) simplification of circuit component construction and longer lamp life are achieved. The light plateau of an 8w lamp may be plotted on the same coordinate as the wattage on the graph of Fig. 2. Therefore, by reference to Fig. 2 it will be seen that the optimum values for an 8w lamp would be 1μf for capacitor C_1 and 280 to 300 ohms, 2 watts for resistor R_1.

Consideration has been given to the development of a formula for calculation of these values but, whereas values can be obtained through calculation in respect of the lamps within a limited range of classes and ratings, it does not appear possible to derive as a general rule these values by calculation. However, it has been found that very little variation occurs in the optimum values required between lamps of the same rating and class produced by different manufacturers. Therefore, component values may be advised for specific lamps independently of manufacturing source.

The method presently adopted, which has proved to be the most reliable, is by empirical selection. After all, there is a limited variety of fluorescent lamps, or other gas discharge lamps, and values once determined for a class and rating of lamp will not require subsequent change. The following procedure has been employed successfully with laboratory test equipment employing appropriate voltmeters, ammeters, variable capacitance box for C_1 values, variable attenuator (being inductive and/or resistive) for R_1 values, variable resistor for R_2 values, a diode, variable power supply means, and a lightmeter, connected in the manner of Fig. 1 with monitoring facility:

1. What is known to be excessive values for R_1 and C_1 are introduced and power applied to start the lamp.

2. As a coarse adjustment progressively reduce the value of capacitance in C_1, thus increasing its reactance and reducing the operating mean current to the lamp, until the output of light falls below the end of the lamp's light plateau and then marginally increase the capacitive value above the plateau end. Note: this plateau is readily discernible as beyond either end the light output from the lamp decreases rapidly compared with variations on the plateau.

3. As a coarse adjustment progressively reduce

the value of resistance in R_1, if it be assumed to be a resistor instead of an inductor, until discernible flicker from the lamp illumination occurs and then marginally increase said resistance value. A peak current meter will provide an accurate indication of the degree of flicker and with experienced use will ensure that excessive peak currents are not applied to the lamp under test.

4. Repeat steps 2 and 3 as often as necessary with progressively finer adjustment of values until optimum values are determined.

5. Switch off power and then restore to check whether the lamp readily restarts. If it does not start reduce the resistance of R_2 until the D.C. voltage across C_1 rises to effect lamp starting. A compromise in value can be struck between ready starting of the lamp and commencement of flicker in the lamp illumination. Occurrence of the latter under these circumstances is an indication that some operating current is being bypassed through the starter circuit.

6. Vary the supply voltage between pre-set limits simulating possible fluctuations to be experienced in service. If the light output flickers at any of these voltages increase marginally the value of R_1 to reduce the flicker to tolerable limits and then repeat steps 4 and 5 above for compensating alteration of the value of C_1 and correct consequential adjustment of the value of R_2.

The above procedure will also be followed in those instances where gas discharge lamps other than fluorescent lamps are to be used.

The control circuit of the invention enables miniaturisation of components so that the components can be an integral part of a lamp, and also a considerable reduction in the cost of components. Lamps controlled by this circuit are preferably operated near the lower end of their light output plateau and although the illumination is reduced, but not to any marked extent, they, and especially lamps up to 20w rating, operate much more efficiently. The watts loss per lumen output is better than that of the conventional ballast, particularly with the small reduction in light output referred to above. The heat generated by the control circuit is so low as to permit miniaturisation and fittings do not require the contemporary large space for a ballast. If the components of the circuit are in the base of the fitting and not in the holder a reduction in the base to about 13 mm thick, is possible compared with the conventional 50 mm for the ballast. Experimental units have been operating satisfactorily for long periods using the control circuit without deterioration.

This invention permits the majority of the components to be placed in the lamp holder i.e., capacitor and charging circuit. In an integral configuration the components may be formed in an end cap of the lamp, or alternatively be a plug-in attachment, or if a lamp manufacturer desires he may incorporate the components actually in the glass envelope permitting the lamp merely to be plugged directly into the supply. Also, another possibility is that if the resistor R_1 is internally connected to the opposite end of the lamp, the fluorescent lamp could have all its terminals at one end, the other end of the lamp merely having a glass dome, or being otherwise sealed off.

Fig. 4 shows the actual size of a thermoplastic housing H and components C_1, R_2 and D_1 housed therein which are used for fluorescent lamps of 4w, 6w, 8w and 13w rating. The connecting leads Y will be connected to terminals in the lamp fitting. The resistor R_1 will be connected external of the housing H for better heat dissipation and will be in this instance 300 ohms, 2 watt.

Some gas discharge lamps by virtue of their shape are more difficult to start than others and also as they age some tend to become harder to start. Furthermore starting is more difficult with lamps of higher rating than 13w. The higher voltages that would be needed for starting in these cases imposes further requirements on the value of C_1. So as not to detract from its principal function of controlling mean operating current to the lamp an exciting arrangement has been devised for the lamp to avoid the requirement of higher starting voltages.

Fig. 3 shows the exciting arrangement comprising a piece of electrically conducting material 1 is placed in casual contact with the outer glass envelope of the lamp L at a position approximately 80% of the way along the length of the lamp and is electrically connected to the more remote lamp terminal socket D. This arrangement may be duplicated by having a second contact 1A also positioned 80% of the way along the lamp L in relation to the other lamp terminal socket C and electrically connected thereto. As the conducting contacts 1 and 1A are accessible, that is not enclosed, it is necessary to meet local and/or International standards by inserting one or more resistors 2, in the connections between the contacts 1 and 1A and the end terminals D and C. This arrangement does not require an earth and its starting efficiency is such that full preheating of the lamps filaments is not necessary.

An alternative arrangement (not shown) is applicable where the base support or socket holder of the gas discharge lamp is earthed. The alternative arrangement comprises a generally dome-shaped conducting rubber grommet, or the like, which is attached to the earthed metal lamp support with the tip of the dome just touching the outer surface of the discharge lamp. However, in this case it is necessary to place a conducting rubber contact approximately 20% of the way from each end of the lamp as there is a possibility that the supply voltage polarity may not be known. Both these arrangement are effective for use with those lamps that are known to be more difficult to strike, such as the 13 watt long lamp and the 40 watt 4 ft. lamp, and for prolonging the useful life of older lamps.

Specific representative embodiments and refinements thereto have been discussed in the foregoing passages for the purpose of illustrations, but it will be apparent to one skilled in the art that various changes and modifications may be made thereto without departing from the spirit and scope of this invention.

Claims

CONTROL CIRCUIT FOR THE GAS DISCHARGE LAMPS

1. A control circuit for a gas discharge lamp comprising input terminals for connection to a power supply source and output terminals for connection to a gas discharge lamp, a starting circuit for the lamp at least part of which is connected across the output terminals, and a capacitor and an attenuator connected in series with each other and in series between the input terminals and the output terminals, and being characterized in that said capacitor has a capacitance no less than and not substantially more than the minimum value of capacitance necessary to pass adequate operating mean current for said lamp from said power supply, and said attenuator has an impedance no less than and not substantially more than the minimum value of impedance which will eliminate excessive peak current flow through said lamp from said power supply.

2. A control circuit according to claim 1, in which the power supply from the source is AC and being characterised in that at the frequency of said power supply the reactance of the capacitor is substantially ten times the impedance of the attenuator.

3. A control circuit according to claim 1 or 2, in which the power supply source is AC, and the capacitor is connected in series with both the starting circuit and the lamp and serves a dual function, and being characterized in that the voltage across said capacitor facilitates starting of the lamp and the current through said capacitor determines the operating mean current for the lamp.

4. A control circuit according to claim 3, in which said starting circuit comprises a current rectifying device for supplying a charge to said capacitor on each cycle of the supplied power in series with a charging resistor whose value determines the level of charge supplied to said capacitor.

5. A control circuit according to any one of the preceding claims, characterized in that said attenuator is located between the lamp and said starting circuit.

6. A control circuit according to any one of the preceding claims, characterized in that said attenuator is a resistor.

7. A control circuit according to any one of the preceding claims, characterized in that the capacitance of said capacitor is between .8μf and 4.5μf while the impedance of said attenuator is between 80 ohms and 500 ohms.

8. A control circuit according to any one of the preceding claims, characterized in that said capacitor and said starting circuit are housed together within a housing separate from said attenuator.

9. A method for determining the values of components for constructing a control circuit for a gas discharge tube with the use of laboratory equipment for the monitoring of voltages and currents and the use of variable capacitance and attenuation boxes connected into an operative circuit as claimed in claim 1, characterized in that larger than anticipated values of said capacitor and said attenuator are introduced by said boxes, the capacitance being then progressively reduced until light output from said lamp falls below the light plateau of the lamp as an indication than an excessively low operating current is flowing through the lamp and then marginally increasing said capacitance, and the impedance of said attenuator being then progressively reduced until flicker in the light output occurs as an indication of excessively high current peaks flowing through the lamp and then marginally increasing said impedance.

10. A gas discharge lamp fitting comprising a lamp with means for connection to a power supply, an electrical starter circuit therefore, and a ballast circuit for determining the operating current flow through said lamp, the ballast circuit comprising a capacitor and an attenuator connected in series with each other and in series between said lamp and its power supply, and being characterized in that said capacitor has a capacitance not less than or substantially more than the minimum value of capacitance necessary to pass adequate operating mean current from said supply to ensure a predetermined light output from said lamp, and said attenuator has an impedance not less than or substantially more than the minimum value of impedance which will limit peak currents from said supply flowing through said lamp which would otherwise substantially detract from the light output from said lamp.

11. A gas discharge lamp fitting according to claim 10, characterized in that said starting circuit and said

capacitor and said attenuator are housed within a holder for the lamp on said fitting.

12. A gas discharge lamp fitting according to claim 10 characterized in that said starting circuit and said capacitor are housed within the glass envelope of said lamp.

13. A gas discharge lamp fitting according to any one of claims 10 to 12, characterized in that opposite terminals of said lamp are electrically connected to respective conducting contacts positioned adjacent the glass envelope of said lamp spaced more than half way down the length of said lamp from their connecting terminals effectively to shorten the length of said lamp between opposite polarities of the power applied to said terminals to facilitate ready starting of said lamp.

14. A gas discharge lamp fitting according to claim 13, characterized in that the connections between said contacts and their respective lamp terminals include resistors.

15. A gas discharge lamp fitting according to claim 13 or 14, characterized in that the spacing between said contacts and their connecting lamp terminals is about 80% of the length of said lamp.

16. A control circuit for a gas discharge lamp substantially as herein described with reference to the accompanying drawings.

17. A gas discharge lamp fitting including a control circuit substantially as herein described with reference to the accompanying drawings.

Claim(s) Nr 16 / 17 deemed to be abandoned

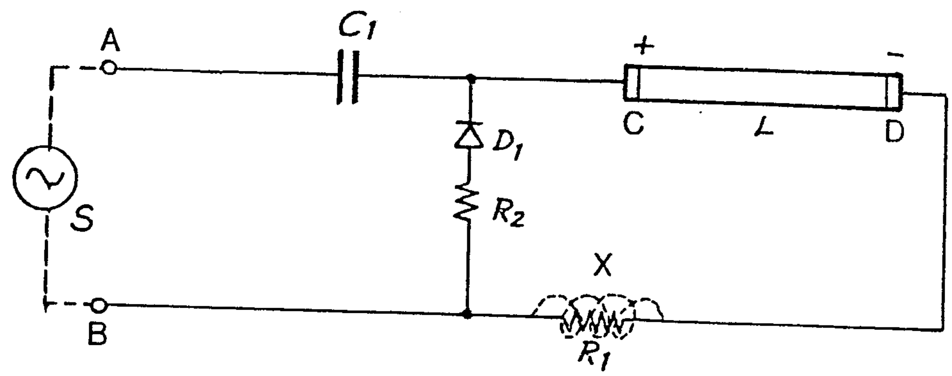
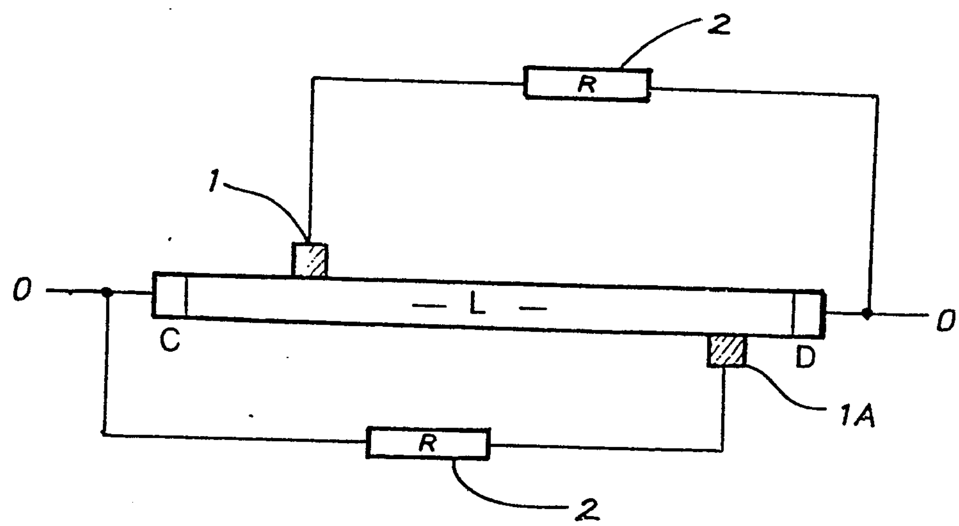


FIG. 1

FIG. 3



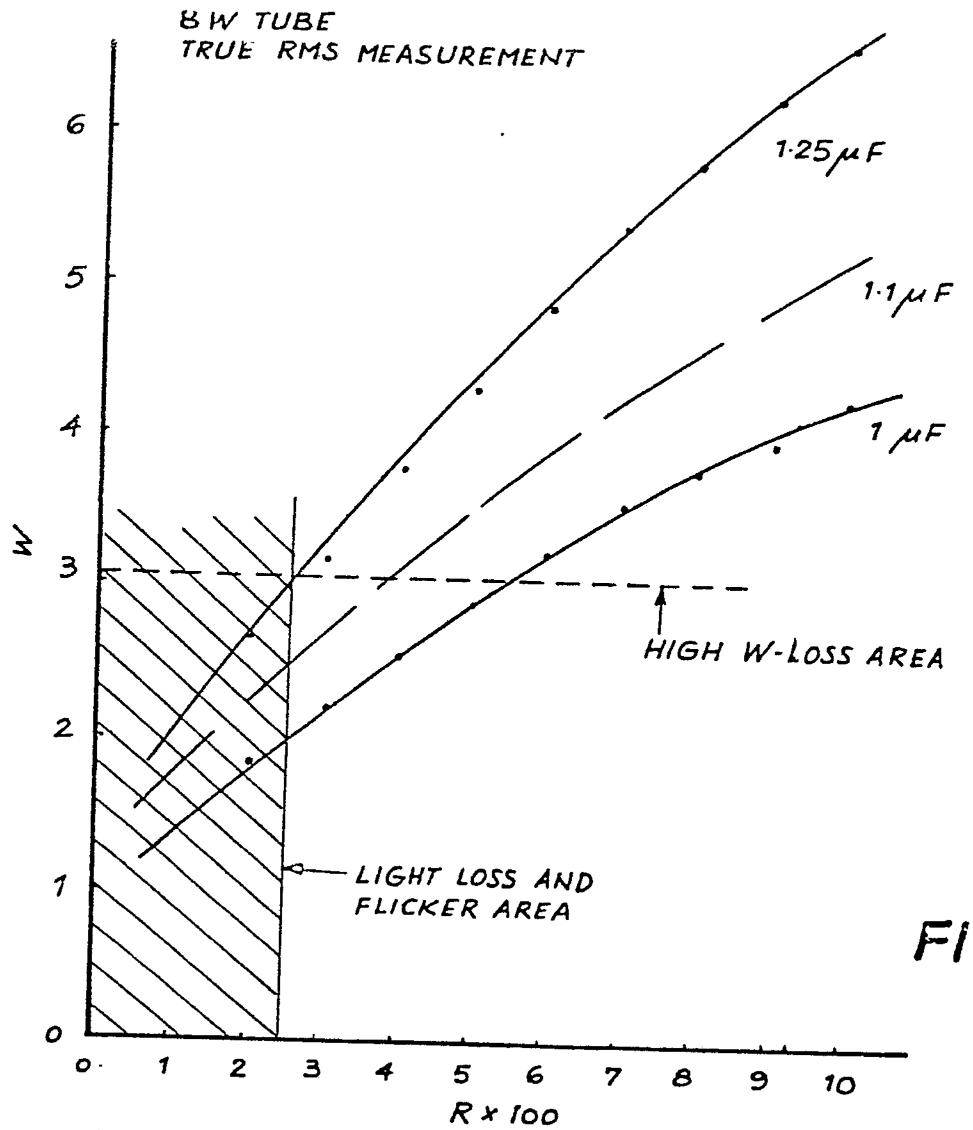

8W TUBE
TRUE RMS MEASUREMENT
1·25μF
1·1μF
1μF
W
HIGH W-LOSS AREA
LIGHT LOSS AND
FLICKER AREA
R x 100
0
1
2
3
4
5
6
7
8
9
10

FIG. 2

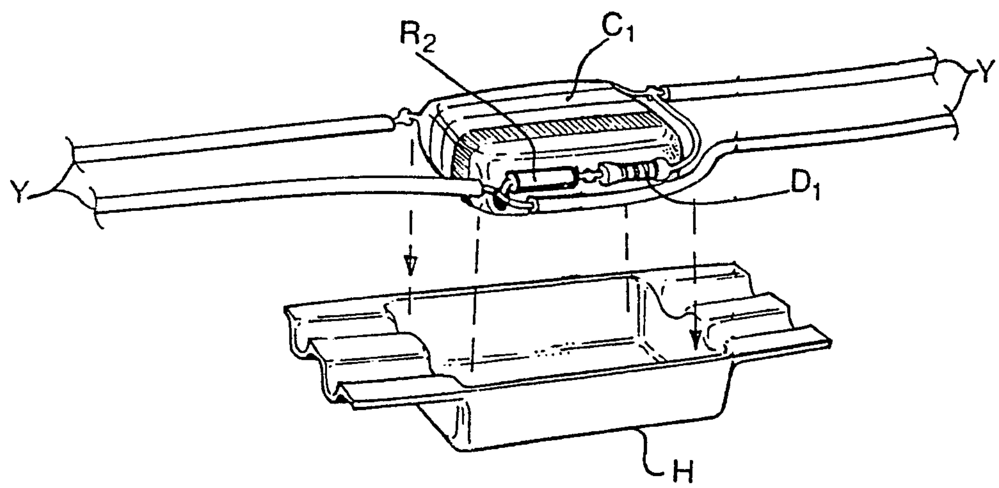

R2
C1
Y
Y
D1
H

FIG. 4

European Patent Office

EUROPEAN SEARCH REPORT

0011508

Application number

EP 79 30 2625

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	US - A - 3 983 449 (THORN ELECTRICAL INDUSTRIES LTD.) * Abstract; column 2, lines 25-46; table 1; figure 1 *	1-3,7, 14
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	DE - A - 2 321 063 (WALZ) * Page 3, lines 3-23; figure 1 *	1,4
	--	
	FR - A - 1 557 851 (TRANSFORMATEUR UNION) * Abstract; figure 1 *	1,4
	--	
	CH - A - 492 378 (GENERAL ELECTRIC) * Column 4, line 59 to column 6, line 10; figure 3 *	11,12
	--	
	FR - A - 958 142 (TESLA) * Page 2, lines 60-72; figure 1 *	13
	--	
	FR - A - 963 793 (CLAUDE PAZ & SILVA) * Page 3, lines 38-50; figure *	14

CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)

H 05 B 41/16
H 01 J 61/70

TECHNICAL FIELDS SEARCHED (Int.Cl. 3)

H 05 B 41/14
41/16
41/18
41/19
41/22
41/23

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	21-02-1980	DUCHEYNE