

# PATENT SPECIFICATION

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## (54) A NEW OR IMPROVED ALTERNATING CURRENT CONTROL DEVICE

(71) We, CRABTREE ELECTRICAL INDUSTRIES LIMITED, a British Company of Crabtree House, Aldridge, Walsall WS9 8LT, England formerly known as J. A. Crabtree & Company Limited, Lincoln Works, Walsall, West Midlands, WS1 2DN do hereby declare the invention for which we pray that a Patent may be granted to us and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates to devices for controlling the supply of alternating electric current to a load, being of the kind comprising a front cover, at the front of which is disposed one or more manually movable control members, a circuit mounting member disposed at the rear of said front cover, input and output terminals for connection respectively to an alternating current source and to the load, and a control circuit connected between the input and output terminals including means for cutting off the current to the output terminals for a proportion of each cycle of the alternating current supply, and means for varying the value of said proportion, this last said means being operatively connected with at least one of said control members. Such devices are herein referred to as being of the kind specified.

One form of device of the kind specified for which the present invention has been primarily developed is that known generally as a dimmer switch intended to be utilised for controlling the current supplied to, and hence the light furnished by, one or more electric lamps.

Such dimmer switches are often required to be mounted so that the cover is flush with, or projects only to a slight extent outwardly of, a wall surface or other panel surface in a room in which the lamps to be controlled are situated. Moreover, when the mounting is on a wall surface there is often a limited depth of plaster or equivalent material covering brickwork which forms the wall and typically the components of the device have to be accommodated in a depth measured perpendicular to the wall surface of not more than 16 millimeters. Often wall boxes of metal or other material having a depth dimension not exceeding this value are provided for accommodating the components of such dimmer switch, the latter being themselves supported on the circuit mounting member while the front cover acts as a closure to the forwardly presented open mouth of the wall box and may overlap with the margin of the wall surface surrounding an opening formed therein to receive the wall box.

The cutting off of the current from the input terminals to the output terminals in the control circuit in each cycle necessarily generates a wave form which contains high harmonics of the supply frequency at an amplitude such as to be liable to cause interference to communication apparatus such as radio receivers and television receivers, and regulations to minimise such interference are becoming more stringent. It is common practice to provide an interference suppression branch in the control circuit to attenuate high frequency components which would otherwise be fed into the supply mains, and the requirement for attenuation is becoming increasingly stringent in respect of the range of frequency and the level of attenuation required in each band of this frequency range.

There is a conflict between this requirement and the requirement to accommodate the components of the device in a relatively shallow space (perpendicular to the wall surface) because inductances providing the requisite inductance value in each frequency band of the range over which suppression is

required and which are commercially available at a cost compatible with the overall cost at which such device requires to be marketed (more especially for the dimmer switch application) tend to be bulky.

The object of the present invention is to obviate or reduce these conflicting requirements.

According to one aspect of the invention, a device of the kind specified is provided wherein the circuit mounting means comprises a circuit mounting board arranged generally parallel to the front cover and at the rear thereof and some of the components of the control circuit are mounted on the rearward face of the circuit mounting member, and wherein the control circuit comprises an interference suppression branch, which includes an inductance having a magnetically conductive core in the form of a ring or frame and of which the thickness dimensions (measured perpendicular to the plane of the front cover) is small compared with its outer diameter or equivalent dimensions in the case of a frame, such core carrying a winding and being mounted flatwise in front of the circuit mounting board, at least one, variable component of the device being mounted on a part of the circuit mounting board which is in alignment with the aperture afforded by the ring or one of the apertures afforded by the frame of the inductance component, and is operated along a line extending through the aperture afforded by the ring or said one of the apertures afforded by the frame.

With this arrangement it is possible to comply with a fairly stringent limit of depthwise dimension, at the same time effectively to utilise the space available on the circuit mounting board, and provide efficient coupling between the winding of the inductance and its magnetically conductive core for effective interference suppression.

Said variable component may be mounted on the rearward face of said mounting board, being operated by means of a part extending through the circuit mounting board, or may be mounted on the front face of the circuit mounting board. In either case, said component may be mounted on the same side of the circuit mounting board on which the inductance is mounted, being mounted on a part of the circuit mounting board which is exposed by the aperture afforded by the ring or said one of the apertures afforded by the frame.

Advantageously however the inductance has at least part of its thickness projecting into or through an opening in the front cover. Conveniently, however, the inductance is enclosed by the front cover, or by the front cover in combination with one of the control members. Conveniently said control member is of shallow cup-shaped form.

Most conveniently said one of the components is a variable potentiometer and is operated, along a line extending through the aperture, by a drive member extending between said control member and said component.

The preferred form of the invention is one which utilises an inductance component which has a core in the form of a ring or frame comprising ring or frame-like components of magnetically conductive materials respectively of different magnetic permeabilities collectively providing an effective value of inductance for suppressing interference over the whole of the suppression band required.

According to a further aspect of the invention, we provide a device of the kind specified wherein some of the components of the control circuit are mounted rearwardly of the circuit mounting member and the control circuit comprises an interference suppression branch, which includes an inductance having a magnetically conductive core in the form of a ring or frame, of which the thickness dimension is small compared with its outer diameter or equivalent dimension, such core carrying a winding the inductance being mounted forwardly of the circuit mounting member and having at least part of its thickness projecting into or through an opening in the front cover but nevertheless being enclosed by either the front cover or the front cover in combination with one of the control members.

Preferably said one control member is of shallow cup-shaped form having its open side presented rearwardly and having a peripheral flange extending around the outer boundary of the inductance component.

Preferably the ratio of the thickness dimension to the outer diameter or equivalent dimension is no less than  $1/1.5$  and/or no more than  $1/5$ .

The invention will now be described, by way of example, with reference to the accompanying drawings wherein:—

Figure 1 is a view in front perspective view of one embodiment of device of the kind specified in accordance with the invention;

Figure 2 is a view looking at the side elevation with the control member, front cover and circuit mounting member in "exploded" relation;

Figure 3 is a view in front elevation of the circuit mounting member of the device of Figure 1 but shown on an enlarged scale; and

Figure 4 is a circuit diagram of the device.

The device shown is intended to be used as a dimmer switch for lighting and mounted on a vertical wall surface.

The device comprises a front cover 10 having an outer peripheral boundary of plate-like form, which may be of any desired shape, for example square as shown, and having a relatively large sized opening 11 conveniently of circular form at the rear.

The thickness or depth measure perpendicular to the front face of the cover is greater at its lower boundary 13 than at its upper boundary 14 as seen more particularly in Figure 1. Between these two boundaries the front face has a shallow convex form as seen at 15 over that part of the front face incorporating the opening 11. Over the opening 11 is mounted an operating member 16 having a circular peripheral boundary and of shallow cup-shaped form incorporating a front wall 17 (Figures 1 and 2) and a peripheral flange 18, the latter being of a depth such that the outer surface of the front wall is approximately coplanar with the raised or higher part of the front cover adjacent its lower boundary 13.

This raised part has an aperture 19 in which is mounted a further operating member in the form of a rocker 20 (omitted from Figure 2) for switching off the current entirely between the input terminals and the output terminals of the device.

In the rear of (viz, behind, as viewed from the front) the front cover is disposed a circuit mounting member in the form of a printed circuit board 21 which is secured in any suitable manner to the front cover and which, on its front face, carries an inductance assembly comprising an inductance proper 21a and a backing member 22 of resilient material to counteract the transmission of any vibrations from the core 23 of the inductance to the printed circuit board 21 and hence to the device as a whole.

The core is of ring-like form, e.g. circular as shown, and may be of square cross-section. The core carries a winding 24 which is thus toroidal.

As a whole the inductance presents a central aperture 25 through which a part 26 of the printed circuit board is exposed, and on this part is mounted one of the components of the control circuit, namely a variable resistor or potentiometer 27.

The component 27 is thus accommodated in a cylindrical space defined by the inductance proper and the backing member 22 in combination and makes use of a part of the printed circuit board which would otherwise be wasted.

The variable resistor or potentiometer 27 has a radial wiper arm which can be moved over a circular or part-circular resistance element and is operable by a boss 28 which can be coupled through a drive member in the form of a bush or spindle 29 to a drive boss 30 at the rearward side of the operating member 16.

The remaining components of the control circuit are mounted on the printed circuit board 21 as indicated respectively at 31 to 34, certain of these being disposed at the rearward side of the board and certain of them at the front of the board.

The board also carries input and output terminals, of which the former are seen at 35 and one of the latter at 36, appropriate connections being made by way of the conducting network on the board between the various components.

By the use of a toroidal inductance, of which the core is a ring or possibly a frame, the requisite value of inductance can be attained while preserving relatively slim dimensions from front to rear compared with the outer diameter or the equivalent frame dimension of the inductance.

Consequently it is possible largely to accommodate the inductance within the depth of the front cover, it being noted that for partial enclosure of the inductance the front cover includes at its front side a part circular web 37 which in combination with the opening 11 forms a housing 38 which is just a little larger diameter than the inductance 21a. Were, however, the web 37 to be omitted, closure of the inductance could be effected entirely by the control member 16, or by the control member in combination with the walls bounding the opening 11.

Referring to the circuit diagram a lamp 1 through which the current is required to be controlled is connected by one wire 10 to one mains terminal (not shown), e.g. the neutral terminal, and the other terminal of the lamp is connected via a wire 11 to terminal t4 of the device. The latter incorporates a switch S1 (of which the operating rocker 20 forms part) which provides connection from terminal t3 to

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either of terminals t2, t1 of which the former is connected to the (e.g. live) side of the mains supply via wire 12 of which the latter t1 is connected by a wire 13 to an alternative live supply.

- 5 With the switch in the "on" position as shown, capacitor C1 charges at a rate determined by the values of R1, TR1, VR1 and through an asymmetrical trigger circuit AT1 causes triac T1 to conduct at a predetermined point in each cycle of the AC supply. Of the variable resistors TR1 and VR1, one is a preset resistor and the other is adjustable by means of the operating member 16 already referred to at 27. The inductance L1 is that designated 21a in Figures 2 and 3. The inductance has inductive values over a frequency range typically 150KHz to 30 MHz effective to provide suppression of noise signals which would otherwise be injected into the mains supply circuit. The suppression preferably is represented by an attenuation of from 60 to 66 decibels. For this purpose the inductance employed includes a core composed of two or more components (each comprising a ring or frame) of different materials providing the requisite values of magnetic permeability in respective frequency bands collectively covering the range. Thus a core having components of nickel iron alloy, and high purity iron would be suitable. To obtain maximum efficiency the winding is distributed over the whole length of the core, preferably substantially uniformly.
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- 15
- 20 The following table of values for the components of the circuit provides satisfactory control as to the mean value of current and as to attenuation of frequencies which would cause interference in radio, television and the like apparatus operating in the vicinity and/or connected to the same mains supply circuit.

| Component | Value        | Tolerance  | Rating     | Possible Type                    | Notes                            |
|-----------|--------------|------------|------------|----------------------------------|----------------------------------|
| R1        | 33K          | ±5%        | 0.25w      | Erie 00121-003                   |                                  |
| C1        | 0.22μF       | ±5%        | 250 v.d.c. | Siemens B32541                   |                                  |
| TR1       | 5M           | ±30%       | 0.1 W      | Iscra-PN 11C                     | 2M5 possible if VR1 is ±20%.     |
| VR1       | 1M           | ±30%       | 0.25 W     | Erie 80P                         | ± 20% preferable                 |
| AT1       | Asymmetrical | AC Trigger | Circuit    | G.E.ST4                          |                                  |
| T1        | 8A           |            | 400 v.a.c. | G.E.SC142D                       | Isolated TAB if Heatsink Exposed |
| L1        | RFI Choke    |            | 240 v.a.c  | Siemens B82603 V-B101            |                                  |
| C2        | 0.15 μF      | ±20%       | 240 v.a.c  | RIFA PME 271 or S.E.L. capacitor | 0.22μF may be required           |

- 45 The value of the inductance would be determined by measuring the attenuation produced over the frequency range within which suppression is required e.g. 150 KHz to 30 MHz. A typical specification would call for attenuation of 60—66 dB in the low frequency bands at the end of this range and 55—60 dB in the high frequency band. Using a core of ring form and incorporating ring components of different permeability materials such as those aforesaid, the required characteristics can be attained with overall dimensions such that ratio of the thickness dimensions to the diametral dimension is not less than 1.1/5 and is preferably no more than 1/5.
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#### WHAT WE CLAIM IS:—

1. A device of the kind specified wherein the circuit mounting means comprises a circuit mounting board arranged generally parallel to the front cover

either of terminals t2, t1 of which the former is connected to the (e.g. live) side of the mains supply via wire 12 of which the latter t1 is connected by a wire 13 to an alternative live supply.

5 With the switch in the "on" position as shown, capacitor C1 charges at a rate determined by the values of R1, TR1, VR1 and through an asymmetrical trigger circuit AT1 causes triac T1 to conduct at a predetermined point in each cycle of the AC supply. Of the variable resistors TR1 and VR1, one is a preset resistor and the other is adjustable by means of the operating member 16 already referred to at 10 27. The inductance L1 is that designated 21a in Figures 2 and 3. The inductance has inductive values over a frequency range typically 150KHz to 30 MHz effective to provide suppression of noise signals which would otherwise be injected into the mains supply circuit. The suppression preferably is represented by an attenuation of from 60 to 66 decibels. For this purpose the inductance employed includes a core composed of two or more components (each comprising a ring or frame) of different materials providing the requisite values of magnetic permeability in 15 respective frequency bands collectively covering the range. Thus a core having components of nickel iron alloy, and high purity iron would be suitable. To obtain maximum efficiency the winding is distributed over the whole length of the core, preferably substantially uniformly.

20 The following table of values for the components of the circuit provides satisfactory control as to the mean value of current and as to attenuation of frequencies which would cause interference in radio, television and the like apparatus operating in the vicinity and/or connected to the same mains supply circuit.

| Component | Value        | Tolerance  | Rating     | Possible Type                    | Notes                            |
|-----------|--------------|------------|------------|----------------------------------|----------------------------------|
| R1        | 33K          | ±5%        | 0.25w      | Erie 00121-003                   |                                  |
| C1        | 0.22μF       | ±5%        | 250 v.d.c. | Siemens B32541                   |                                  |
| TR1       | 5M           | ±30%       | 0.1 W      | Iscra PN 11C                     | 2M5 possible if VR1 is ±20%      |
| VR1       | 1M           | ±30%       | 0.25 W     | Erie 80P                         | ± 20% preferable                 |
| AT1       | Asymmetrical | AC Trigger | Circuit    | G.E.ST4                          |                                  |
| T1        | 8A           |            | 400 v.a.c. | G.E.SCI42D                       | Isolated TAB if Heatsink Exposed |
| L1        | RFI Choke    |            | 240 v.a.c  | Siemens B82603 V-B101            |                                  |
| C2        | 0.15 μF      | ±20%       | 240 v.a.c  | RIFA PME 271 or S.E.L. capacitor | 0.22μF may be required           |

45 The value of the inductance would be determined by measuring the attenuation produced over the frequency range within which suppression is required e.g. 150 KHz to 30 MHz. A typical specification would call for attenuation of 60—66 dB in the low frequency bands at the end of this range and 55—60 dB in the high frequency band. Using a core of ring form and incorporating ring components of different permeability materials such as those aforesaid, the required characteristics can be attained with overall dimensions such that ratio of the thickness dimensions to the diametral dimension is not less than 1.1/5 and is 50 preferably no more than 1/5.

#### WHAT WE CLAIM IS:—

1. A device of the kind specified wherein the circuit mounting means comprises a circuit mounting board arranged generally parallel to the front cover



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Notes

2M5 possible if VRI is  $\pm 20\%$

$\pm 20\%$  preferable

Isolated TAB if Heatsink Exposed

0.22 $\mu$ F may be required

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means at cover

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and at the rear thereof and some of the components of the control circuit are mounted on the rearward face of the circuit mounting member and wherein the control circuit comprises an interference suppression branch which includes an inductance having a magnetically conductive core in the form of a ring or frame and of which the thickness dimensions (measured perpendicular to the plane of the front cover) is small compared with its outer diameter or equivalent dimensions in the case of a frame, such core carrying a winding and being mounted flatwise in front of the circuit mounting board, and wherein at least one, variable component of the device being mounted on a part of the circuit mounting board which is in alignment with the aperture afforded by the ring or one of the apertures afforded by the frame of the inductance component, and is operated along a line extending through the aperture afforded by the ring or said one of the apertures afforded by the frame.

2. A device according to claim 1 wherein said variable component is mounted on the rearward face of the circuit mounting board, and is operated by means of a part extending through the circuit mounting board.

3. A device according to claim 1 wherein the inductance component is mounted on the front face of the circuit mounting board.

4. A device according to any one of the preceding claims wherein said variable component is mounted on a part of the circuit mounting board which is exposed by the aperture afforded by the ring or said one of the apertures afforded by the frame.

5. A device according to claim 1 wherein the inductance is mounted on the front face of the circuit mounting board and has at least part of its thickness projecting into or through an opening in the front cover.

6. A device according to claim 5 wherein the said part of the inductance is enclosed by the front cover or by the front cover in combination with one of the control members.

7. A device according to claim 6 wherein said one of the control members is of shallow cup-shaped form having its open side presented rearwardly and having a peripheral flange extending around the outer boundary of the inductance component.

8. A device according to one of claims 6 and 7 wherein said variable component is a variable potentiometer and is operated along a line extending through the aperture afforded by the ring or said one of the apertures afforded by the frame by a drive member extending between the said control member and said component.

9. A device according to any one of the preceding claims wherein the inductance component has a core in the form of a ring or frame comprising ring or frame like components of magnetically conductive materials respectively of different magnetic permeabilities collectively providing an effective value of inductance for suppressing interference over the whole of the suppression band required.

10. A device according to claim 9 wherein the inductance component produces an attenuation of at least 55 to 66 dB over the frequency range from 150 KHz to 30 MHz.

11. A device of the kind specified wherein some of the components of the control circuit are mounted rearwardly of the circuit mounting member, and the control circuit comprises an interference suppression branch which includes an inductance having a magnetically conductive core in the form of a ring or frame, of which the thickness dimensions is small compared with its outer diameter or equivalent dimension, such core carrying a winding, the inductance being mounted forwardly of the circuit mounting member and having at least part of its thickness projecting into or through an opening in the front cover but nevertheless being enclosed by either the front cover or the front cover in combination with one of the control members.

12. A device according to claim 11 wherein said one control member is of shallow cup-shaped form and having its open side presented rearwardly and having a peripheral flange extending around the outer boundary of the inductance component.

13. A device according to any one of the preceding claims wherein the ratio of the thickness dimension to the outer diameter or equivalent dimension is no less than 1/1.5.

14. A device according to any one of the preceding wherein the ratio of the thickness dimension to the outer diameter or equivalent dimension is no more than 1/5.



15. A device according to any one of the preceding claims, being a dimmer switch.

16. A device of the kind specified, constructed and arranged substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

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