

[54] CONTROL CIRCUIT HAVING LOAD AND POWER SOURCE ISOLATION

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[52] U.S. Cl. 307/12; 307/41; 307/51; 307/80; 323/24

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[58] Field of Search 307/11, 12, 18, 29, 30, 307/38, 39, 41, 42, 43, 51, 64, 65, 70, 80, 81, 85, 146, 147, 317; 315/149; 323/17, 22 SC, 24, 63, 66, 80; 340/40

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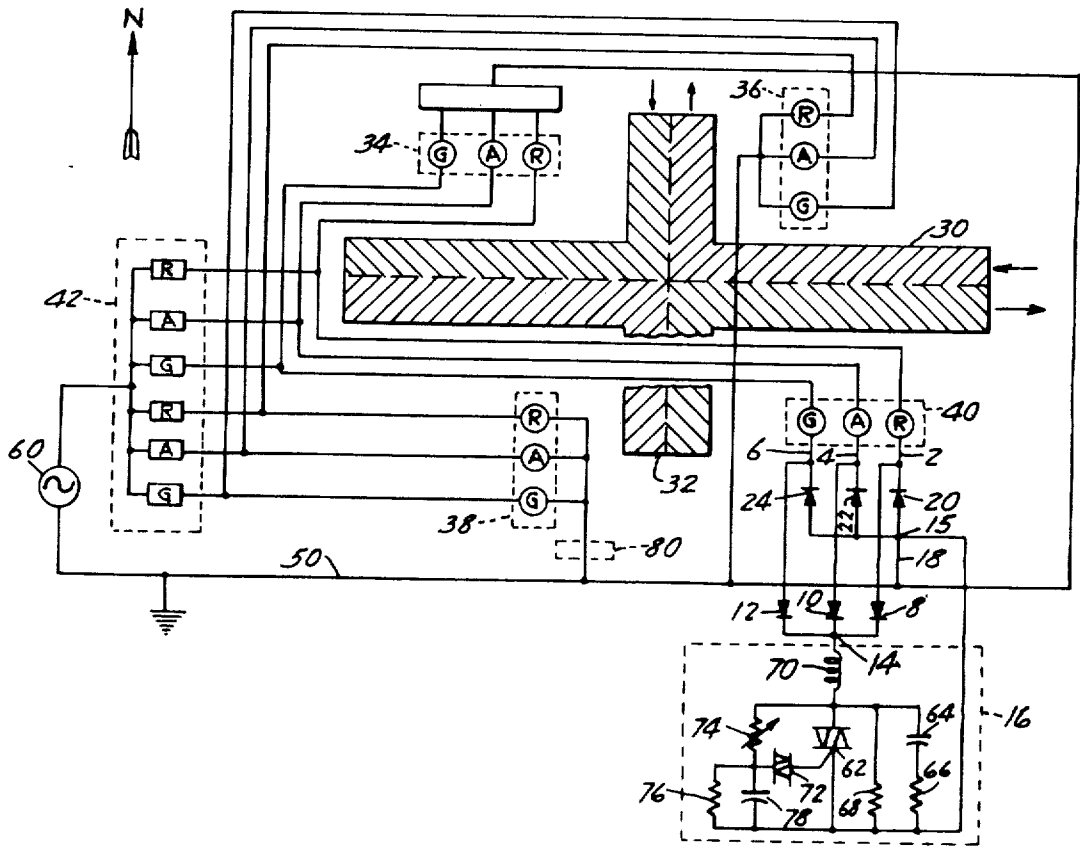
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[57] ABSTRACT

A single proportional type control unit having a gated semiconductor switching device controlled by a single condition responsive impedance can be connected to one or more loads or to one or more power sources. Diodes are arranged to provide load and power source isolation. The circuit, for example, is connected in a traffic light control system to control the intensity of more than one lamp in a single traffic signal face for a traffic phase having more than one traffic signal face. One circuit provides control of the intensity of the lamps for one-half of each cycle of the A.C. source connected to the control circuit. A modified circuit provides full cycle control of the lamps connected to the control circuit. The condition responsive impedance for such use is light responsive.

3 Claims, 5 Drawing Figures



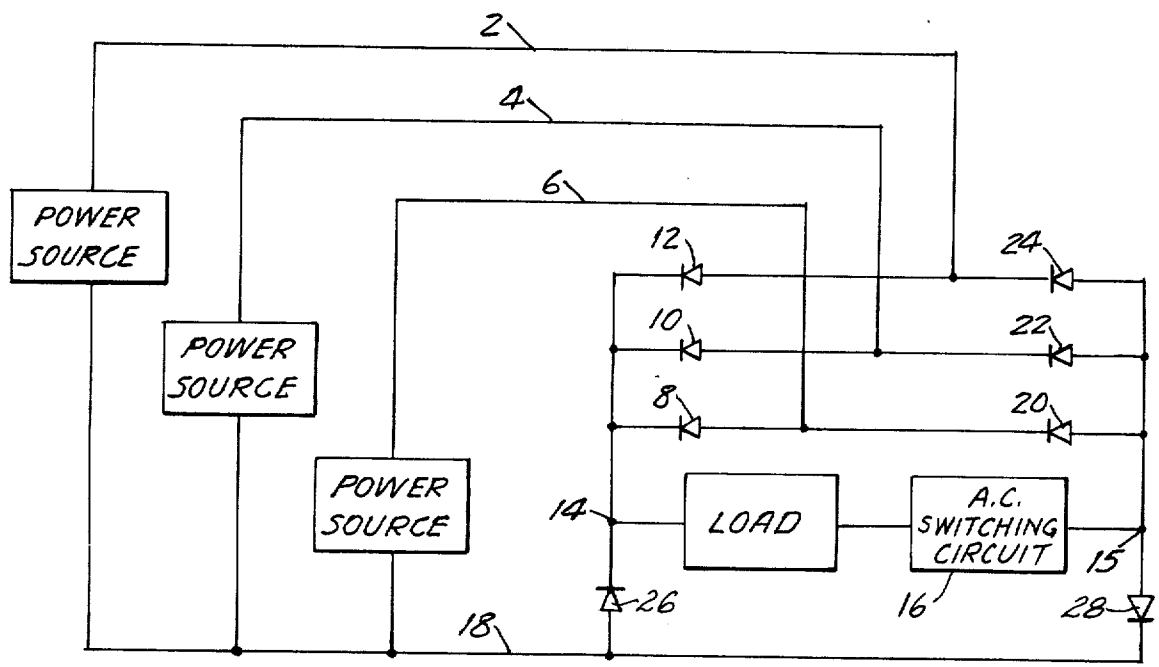


FIG. 5

CONTROL CIRCUIT HAVING LOAD AND POWER SOURCE ISOLATION

This is a division of application Ser. No. 289,444, filed Sept. 15, 1972, now U.S. Pat. No. 3,800,185.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention presented herein relates to a single control circuit for controlling current flow to a plurality of loads in response to a single condition responsive impedance and in particular to circuits of this type which can be connected in a traffic control system to control the intensity of more than one lamp in a traffic signal face. Another aspect of the invention pertains to a similar circuit for controlling current flow to a single load from a number of power sources with a common neutral.

2. Description of the Prior Art

The advantages of providing control of the intensity of one or more of the lamps in a traffic signal face between a high intensity level and a low intensity level as a function of background illumination is explained at length in U.S. Pat. No. 3,500,455. The circuitry disclosed in U.S. Pat. No. 3,500,455 presents a solution to intensity control of traffic lights for a number of situations. However, when intensity control is sought for only one traffic signal face for a traffic phase having more than one traffic signal face, it is not possible to use a single intensity control circuit of the type disclosed in the patent to control all the lamps of the signal face. It is necessary to connect a separate intensity control circuit to each lamp to be controlled. As will be explained later in connection with the drawings used to describe the invention presented herein, use of a single control circuit of the type disclosed in the patent to control more than one lamp establishes ground loops which cause undesirable traffic indications to be presented.

SUMMARY OF THE INVENTION

The invention presented herein provides a single control circuit which can be connected to provide control of the intensity of one or more lamps of a traffic signal face for a traffic phase having more than one traffic signal face. Control of the lamps for the one traffic signal face is obtained without causing undesirable indications to be presented at the same or other traffic signal faces in the traffic phase. In addition, an economic gain over the prior arrangements which required a separate control circuit for each lamp is realized. The use of a single control circuit for such an application reduces the maintenance problem and enhances the reliability of a traffic light control system since fewer components are used.

A single, gate controlled semiconductor switching device controlled by a single variable impedance with the circuit portion is connected to the lamps in the traffic face via unidirectional devices connected to isolate the lamps in the face. In one form, full cycle control is provided and in another, control of only one-half of each cycle is provided. Either form of the circuit can be mounted with ease in the housing of the traffic face to be controlled and can be installed in existing installations.

In a broader sense, the control circuits can be used to control the current flow to a number of loads and to

control the current flow to a single load from a number of power sources which have a common neutral.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic control circuit embodying the invention which provides control for one-half of each cycle of an AC source;

FIG. 2 shows the control circuit of FIG. 1 modified to provide full cycle control;

FIG. 3 is a schematic diagram showing the use of the control circuit of FIG. 1 to control the lamps in a traffic face of a traffic signal system for an intersection; and

FIG. 4 shows how the control circuit of FIG. 2 can be applied to the traffic signal system depicted in FIG. 3.

FIG. 5 shows how the control circuit of FIGS. 2 and 4 can be applied to control the current through a load from a plurality of power sources having a common neutral.

DESCRIPTION

Referring to the drawing, the circuit shown in FIG. 1 includes three sets of two, like poled, series connected unidirectional devices, which may be diodes, connected in parallel across a circuit portion 16. The first set includes diodes 8 and 20, the second set includes diodes 10 and 22 and the third set includes diodes 12 and 24. The cathodes of unidirectional devices 8, 10 and 12 are connected to one side of the circuit portion 16 at connection 14. The anodes of the unidirectional devices 20, 22 and 24 are connected to the other side of circuit portion 16 at connection 15 to which common conductor 18 is also connected. Conductors 2, 4 and 6 are provided for connection to one side of three separate loads (not shown). Conductor 2 connects with a point intermediate the diodes 8 and 20, while conductor 4 connects to a point intermediate the diodes 10 and 22. Conductor 6 is similarly connected to a point intermediate diodes 12 and 24.

Details for the circuit portion 16 are not shown in FIG. 1 since it may take on a number of forms. Broadly, the circuit portion 16 may be any circuit which can be made conductive for one-half of each cycle of an A.C. source or a portion thereof in response to a condition responsive impedance. Circuit portion 16 need not be capable of conducting for more than one-half of each cycle of AC since diodes 20, 22 and 24 effectively short out circuit portion 16 for the other half cycle.

FIG. 2 is a modification of the circuit of FIG. 1 and components in the circuit of FIG. 2 corresponding to those in FIG. 1 are identified using the same reference numerals used for the components in FIG. 1. The circuit of FIG. 2 is the same as that of FIG. 1 except that another set of two, like poled, series connected diodes 26 and 28 is connected across the circuit portion 16. In addition, the common or neutral conductor 18, instead of connecting with the circuit portion 16 at connection 15, is connected to a point intermediate the diodes 26 and 28. The set of diodes 26 and 28 is connected across the circuit portion 16 in the same manner in which the three other diode sets are connected. Thus, the cathode of diode 26 is connected to the cathodes of diodes 8, 10 and 12 and one side of circuit portion 16 at connection 14 while the anode of diode 28 is connected to the anodes of diodes 20, 22 and 24 and the other side of circuit portion 16 at connection 15.

The invention can be best understood by considering its use for controlling current flow to a plurality of

lamps in a single traffic face of a traffic control system for an intersection.

FIG. 3 diagrammatically illustrates a typical intersection of two highways 30 and 32 which are serviced by a traffic signal system. The traffic signaling system may, for example, have four traffic signal faces 34, 36, 38, 40 controlled for on-off operation by a traffic signal controller 42. The traffic signal controller 42 electrically connects one side of the A.C. power source 60 to the four traffic signal faces 34, 36, 38 and 40. Each traffic signal face is shown having lamps for the three usual indications, red, amber and green identified by the letters R, A and G, respectively.

Control of traffic flow along one street or highway is generally referred to as traffic movement. The term, "phase", refers to the group of indications used for controlling traffic movement in one programmed sequence. A simple controlled intersection, such as the one shown in FIG. 3, can have two phases. With north as indicated in FIG. 3, one phase includes traffic signal faces 36 and 38 for control of traffic movement in the northbound and southbound directions of highway 32 and a second phase includes traffic faces 34 and 40 for control of traffic movement in the eastbound and westbound directions of highway 30.

The traffic signal controller 42 for the system is shown in FIG. 3 only to the extent necessary for an understanding of the invention presented herein. The blocks within the traffic controller 42 represent switches which may be of the mechanical or semiconductor type, which in response to appropriate signals provided by the controller 42, complete the current paths from a grounded AC power source 60 to the various lamps of the traffic faces. As is apparent, the traffic signal faces 36 and 38 are connected without any provision made for any control of intensity of any of the lamps in the faces. Each of the traffic faces 36 and 38 have a return or neutral side for the lamps which is connected to a common neutral 50 for the control system which connects to ground at the AC power source 60.

The single control circuit of FIG. 1 is connected between the neutral side of the lamps for traffic signal face 40 and the common neutral 50 for control of the degree of current flow in accordance with the level of background illumination to the lamps of traffic signal face 40 for the traffic phase which also includes traffic signal face 34. In addition, details are set forth for a suitable circuit portion 16. The load conductors 2, 4 and 6 are connected to the red, amber and green lamps of the traffic face 40, respectively. The neutral conductor 18 for the control circuit of FIG. 1 is connected to the common neutral 50.

A suitable circuit portion 16, as shown in FIG. 3, includes a gate controlled semiconductor switching device which may be a bidirectional or unidirectional conducting type. In the circuit shown, a triac 62, which is a bidirectional conductive type, is used. A silicon controlled rectifier, which is unidirectionally conductive, can be used, but the triac type device is preferred since it has more desirable electrical characteristics. In keeping with recommended practice, a dv/dt circuit provided by capacitor 64 and resistor 66 is used with the triac 62. A resistor 68 is connected in parallel with the triac 62 so the circuit portion 16 will not appear as an open circuit to the system when triac 62 is not conducting. Resistor 68 makes the circuit of FIG. 1, as applied to a traffic face, compatible with traffic signal sys-

tems having a traffic controller 42 using gated solid state switching units which are turned on by the use of a single gating pulse. The resistor 68, when triac 62 is not conducting, permits a small current flow which serves as holding current for the gated solid state switching units.

The inductive coil 70 connected between the connection 14 and the triac 62 is provided to repress any high frequency signals. Other elements of the circuit portion 16 are arranged to provide a triggering signal circuit which is connected to the gate of triac 62 via a coupling device 72 such as a bidirectional triggering diode of a type commonly used to couple a triggering signal circuit to the gate electrode of a triac. The triggering signal circuit includes a condition responsive device 74 which for this application is light responsive. The device 74 is connected in series with a resistor 76, with such series circuit connected across the triac 62. A capacitor 78 is connected across resistor 76. The triggering diode 72 is connected between the gate of triac 62 and the connection common to device 74 and resistor 76. The capacitor 78 is charged to the voltage level provided by the device 74 and resistor 76. When the charge on capacitor 78 reaches the breakover voltage of the triggering diode 72, the capacitor 78 is partially discharged into the gate of triac 62 via the triggering diode 72.

The light responsive device 74 may be the same type used in the circuits shown in U.S. Pat. No. 3,500,455, which includes a photocell and a light reducing means and is described in detail in the patent. Using a device of this type, the light directed to the photocell of the unit varies as a function of the changes in background illumination in the vicinity of the traffic face and in turn varies the resistance of the photocell in the unit to provide a substantially linear change in the degree of conduction of the triac in proportion to sensed changes in background illumination.

Before giving further consideration to the operation of the circuit of FIG. 1 as applied in the traffic control system of FIG. 3, the invention presented herein will be better appreciated by considering the ground loop problem that would be presented if the single control circuit as disclosed in FIGS. 7 and 8 of the U.S. Pat. No. 3,500,455, mentioned earlier, were connected between the neutral side of one of the traffic signal faces of FIG. 3 and the common neutral 50. Such an arrangement is represented by the block 80 connected between the traffic signal face 38 and the common neutral 50. Consider, for example, the condition established when the circuit path to the green indication for traffic signal faces 36 and 38 is completed by the controller 42. During each portion of a cycle of the AC power source 60 when the control circuit 80 is not conducting, a conducting path would be provided from the neutral side of the lamp for the green indication of traffic signal face 38 via the amber lamp of face 38 and the lamp for the amber indication in traffic signal face 36 to the common neutral 50. A similar ground loop would be completed via the lamps for the red indications for traffic signal faces 36 and 38. Thus, though only the green indication for the traffic signal faces 36 and 38 is intended to be energized, the amber and red indicating lamps would be energized for those periods of each cycle of the AC power source 60 when the semiconductor switching device of control 80 is not conducting. This ground loop problem is eliminated when using

a control circuit 80, as disclosed in FIGS. 7 and 8 of U.S. Pat. No. 3,500,455, by providing a separate control circuit 80 for each lamp in the traffic signal face 38.

The control circuit of FIG. 1 applied to the traffic intersection control system of FIG. 3 permits the use of a single control circuit for the lamps of a traffic signal face since each load line is isolated from the other load lines by the diodes 8, 10, 12, 20, 22 and 24. This prevents the formation of any ground loops as just described. Assuming the traffic controller 42 operates to apply the AC power source 60 to the lamp for the green indication for traffic face 40 and the triac 62 is gated to conduct for at least a portion of the positive half cycle of the A.C. power, current flow is via the lamp for the green indication, thence via diode 12 to the common neutral 50 via the triac 62 for the time it is conducting. For the portion of the half cycle when the triac 62 is not conducting ground loops are not completed from diode 12 via the lamps for the red and amber indications of traffic face 40 since diodes 8 and 10 are poled to prevent this. Diodes 20, 22 and 24, of course, are poled so there is no current flow to the common neutral 50 via such diodes during any positive half cycle. During each negative half cycle, the diodes 20, 22, 24 do, however, permit current flow from the common neutral 50 to the other side of the power source 60 via the particular indicating lamp that may be connected by the traffic controller 42. The diodes 8, 10 and 12 during a negative half cycle prevent any current flow through the remaining indicating lamps. The diodes 8, 10 and 12 also prevent any current flow through triac 62 during each negative half cycle.

FIG. 4 is the circuit of FIG. 2 drawn in a manner to show how it would connect with a traffic signal face in much the same manner as the circuit of FIG. 1 is shown connected in FIG. 3. The circuits of FIGS. 2 and 4 provide full cycle control of the current to a traffic signal face. With the diodes as connected, current flow through the circuit portion 16 for each half cycle is in the same direction allowing use of either a gated bidirectional semiconductor switching device such as a triac or a gated unidirectional device such as a silicon controlled rectifier. The specific circuitry set forth for the circuit portion 16 in FIG. 3 can also be used for the control circuit portion 16 of FIGS. 2 and 4. It is necessary, however, that a resistor be placed in parallel with the light responsive device 74 when the circuit is used in a traffic control system. The lamps controlled by circuit 16 would then have a minimum low intensity to which they can be dimmed which is determined by the value of the resistor connected across the device 74. Such a resistor was not required by the circuit in FIG. 3 since it always conducts for at least one half of each cycle of the power source.

It should be noted that the single control circuit of FIG. 1 and FIG. 3 need not be connected to control all of the lamps in a traffic signal face. For example, if it were desired to control only the green and amber lamps in accordance with the background illumination, diodes 8 and 20 would not be connected to the lamp for the red indication. The lamp for the red indication would connect directly with the common neutral 50.

Listed below are typical values and types for the various components used in the circuitry of FIG. 2 and the details for the circuit portion 16 shown in FIG. 3.

All diodes	3 amp. 200 volt
Triggering diode 72	43v diac
Triac 62	4.5 amp. 200 volt
Capacitor 64	.015 microfarad
Capacitor 78	.15 microfarad
Resistor 68	1500 ohms
Resistor 66	100 ohms
Resistor 76	47K ohms
Light sensor 74	Cadmium sulphide photocell
	330K ohms at 2 FC
Inductive coil 70	33 microhenries

The circuits of FIGS. 1 and 2 are particularly useful in traffic control systems since they can be assembled as a circuit module which is easily mounted at the housing for a traffic face with a minimum of connections. In the case of new equipment, the circuits can be manufactured as plug-in type modules which is, of course, desirable with regard to assembly and maintenance. In view of the ease with which the preassembled circuits can be installed, existing traffic signal systems can be easily upgraded and with little effort can be adapted to accept a plug-in type circuit module.

While the circuits of FIGS. 1 and 2 have been shown used in a traffic control system, it is possible to use the circuits for other uses. In view of the isolation provided by the diodes in the circuits it is possible to have the circuits of FIGS. 1 and 2 operate from different power sources having a common neutral. FIG. 5 shows how the circuit of FIGS. 2 and 4 can have different power sources with a common neutral connected to conductors 2, 4 and 6 with a single load connected in series with the circuit portion 16.

What is claimed is:

1. An alternating current control circuit for connection in series with each of a plurality of loads and a common circuit neutral to control current flow to the plurality of loads comprising:

a circuit portion including a gated semiconductor switching device and a gating circuit having a variable impedance connected to gate said switching device for controlling current flow through said circuit portion; and

a plurality of sets of two, like poled, series connected unidirectional devices, one set for each load, said sets poled in the same direction and connected in parallel across said circuit portion, each of said sets providing a separate load connecting point for the control circuit, said connecting point being intermediate the two unidirectional devices of the set.

2. An alternating current control circuit for connection in series with each of a plurality of loads for controlling current flow to the plurality of loads comprising:

a circuit portion including a gated semiconductor switching device and a gating circuit having a variable impedance connected to gate said switching device for controlling current flow through said circuit portion; and

a plurality of sets of two, like poled, series connected unidirectional devices, one set for each load plus another set, said sets poled in the same direction and connected in parallel across said circuit portion, each of said sets providing a separate connecting point, said connecting point for each set being intermediate the two unidirectional devices of the set, said connecting point of said another set pro-

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viding a common connection for the control circuit with the remaining connecting points providing load connecting points for the control circuit.

3. A control circuit for controlling current flow to a load from a plurality of power sources having a common neutral comprising:

- a circuit portion for connection in series with the load including a gated semiconductor switching device for controlling the current flow through the circuit portion and a gating circuit having a variable impedance connected to gate said semiconductor switching device; and
- a plurality of sets of two, like poled, series connected,

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unidirectional devices one set for each power source, plus another set, said sets poled in the same direction and connected in parallel across said circuit portion and the series connected load, each of said sets providing a separate connecting point for the control circuit, said connecting point for each set being intermediate the two unidirectional devices of the set, said connecting points of said another set provided for connection to the common neutral of the power sources with the remaining connecting points so provided being power source connecting points.

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