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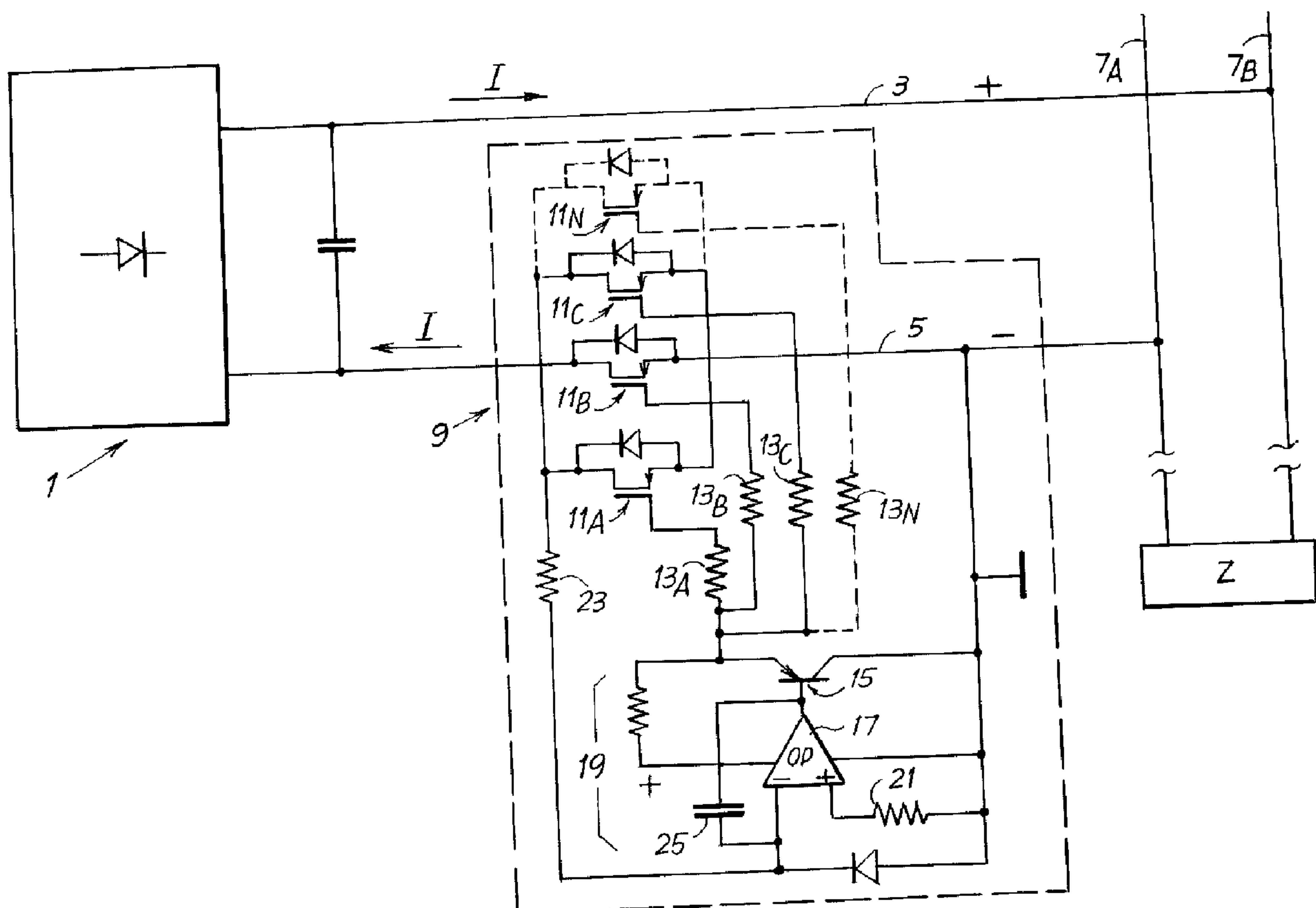
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(54) Title: POWER RECTIFIER WITH POWER SUPPLY CUT-OFF MEANS



(57) Abrégé/Abstract:

A description is given of a power rectifier comprising an output (3, 5) for connection to a supply line (7A, 7B) leading to a load (Z), a cut-off device (9) being connected to said output to break the connection between said rectifier and said supply line. The cut-off device comprises a plurality of MOSFETs (11A-11B) in parallel and a control circuit (19) to make said MOSFETs non-conducting when the output current of said rectifier tends to become inverted.

ABSTRACT

A description is given of a power rectifier comprising an output (3, 5) for connection to a supply line (7A, 7B) leading to a load (Z), a cut-off device (9) being connected to said output to break the connection between said rectifier and said supply line. The cut-off device comprises a plurality of MOSFETs (11A-11B) in parallel and a control circuit (19) to make said MOSFETs non-conducting when the output current of said rectifier tends to become inverted.

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Power rectifier with power supply cut-off means

DESCRIPTION

FIELD OF THE INVENTION

5 The present invention relates to a power rectifier of the type comprising an output for connection to a supply line leading to a load, in which line there is a cut-off device for breaking the connection between the rectifier and the supply line in case of a malfunction of the rectifier.

BACKGROUND

10 There are known devices of this type. These are used when a plurality of power rectifiers is connected in parallel to a single supply line leading to a load, which has a considerable current requirement. In this situation, if a fault occurs in one of these rectifiers, it is necessary to prevent the current flowing in the supply line from entering the faulty rectifier, as this would cause a severe disturbance in the common supply voltage (bus output).

15 At the present time, an arrangement of diodes is provided at the output of the rectifier (on either the positive or the negative terminal) to prevent such an occurrence, these diodes entering the cut-off state when the current at the output of the rectifier tends to be inverted as a result of a fault in the rectifier.

20 These known devices have the advantage of a rapid response speed, but have high dissipation when high currents are present. This not only reduces efficiency, but also makes it necessary to provide efficient heat sinks, in thermal contact with the diodes, to remove the heat generated by the Joule effect in the diodes during the normal operation of the rectifier.

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SUMMARY

The object of some embodiments of the present invention is to provide a power rectifier of the type described above which does not have the drawbacks of the conventional devices.

5 According to an aspect of the present invention, there is provided a power supply cut-off circuit for a power rectifier adapted to be connected to a power supply line leading to a load, comprising: a switching circuit adapted to be connected between the rectifier and the power supply line; a control circuit connected to the switching circuit, the control circuit including an operational amplifier having inputs
10 connected across the switching circuit and a switching control element connected between an output of the operational amplifier and the switching circuit; and wherein, when the switching circuit has been connected between the rectifier and the power supply line, the control circuit is operable to disconnect the rectifier from the power supply line using the switching circuit when the control circuit senses that the rectifier
15 has malfunctioned; and the operational amplifier is operable to apply a first signal indicative of a rectifier malfunction to the switching element that causes the switching control element to generate a second signal that causes the switching circuit to become nonconducting and disconnects the rectifier from the power supply line.

 According to another aspect of the present invention, there is provided
20 a power rectifier having a power supply cut-off circuit and a rectifier output adapted to be connected to a power supply line for a load, the power supply cut-off circuit, comprising: a switching circuit adapted to be connected between the rectifier and the power supply line, the switching circuit including a plurality of switching elements connected in parallel with one another; a control circuit connected to the switching
25 circuit, the control circuit including an operational amplifier having inputs connected across the switching circuit and a switching control element connected between an output of the operational amplifier and the switching circuit; and wherein, when the switching circuit has been connected between the rectifier and the power supply line, the control circuit is operable to disconnect the rectifier from the power supply line by

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causing the switching circuit to become nonconductive when the control circuit senses that the rectifier has malfunctioned; and the operational amplifier is operable to apply a first signal indicative of a rectifier malfunction to the switching control element that causes the switching control element to generate a second signal that
5 causes the switching circuit to become nonconductive and disconnects from the power supply line.

According to another aspect of the present invention, there is provided the power rectifier as described above, wherein the control circuit is operable to sense a current flowing through the switching circuit that is indicative of a rectifier
10 malfunction; and disconnect the rectifier from the power supply line if the current flowing through the switching circuit indicates that the rectifier has malfunctioned.

According to another aspect of the present invention, there is provided a power supply cut-off circuit for a power rectifier having a rectifier output adapted to be connected to a power supply line for a load, comprising: a plurality of MOSFETs
15 connected in parallel and adapted to be connected to the rectifier output so that current flowing between the rectifier and the power supply line is distributed among the MOSFETs, a source-drain voltage existing across the MOSFETs; an operational amplifier with an inverting input and a non-inverting input, a voltage proportional to the source-drain voltage across the MOSFETs being applied across the inverting and
20 non-inverting inputs of the operational amplifier; and wherein, the operational amplifier is operable to generate a first signal indicative of a rectifier malfunctioning that can be used to make the MOSFETs non-conducting.

In some embodiments, the switching circuit or cut-off device comprises, instead of a set of diodes, a plurality of MOSFETs in parallel and a control circuit
25 which makes the MOSFETs non-conducting when the output current from the rectifier tends to become inverted.

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In a particularly advantageous possible embodiment of the invention, the control circuit comprises an operational amplifier to whose inputs are applied voltages proportional to the source and drain voltages of the MOSFET. A reactive circuit with a capacitor is advantageously provided between the inverting terminal and
5 the output of the operational amplifier, to prevent oscillation of the output of the operational amplifier in the proximity of the trigger threshold at which the MOSFET becomes non-conducting.

Further advantageous characteristics and embodiments of the device according to the invention are indicated in the attached dependent claims.

10 The invention will be more clearly understood from the description and the attached drawing.

BRIEF DESCRIPTION OF THE DRAWING

Figure 1 shows, in the single figure, an electrical circuit diagram of the device according to a non-limiting example of an embodiment of the invention.

DESCRIPTION OF EMBODIMENTS

With reference to the drawing, the number 1 indicates in a general and schematic way a power rectifier, whose internal structure is known to those skilled in the art and will not be described in detail in this document. The rectifier typically operates over a power range from hundreds to thousands of watts, for example at
20 levels above 100 watts, and in particular above 400 watts, and with an output voltage which is typically of the order of several tens to several hundreds of volts.

The positive and negative terminals, indicated by 3 and 5 respectively, of the rectifier 1 are connected to a power supply line 7A, 7B to which are connected in parallel other rectifiers which are similar to that illustrated in the figure and which
25 are not shown. The supply line 7A, 7B is connected to a load indicated in a general and schematic way by Z.

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The cut-off device associated with the power rectifier 1 can be connected to the positive output terminal 3 or to the negative output terminal 5 of the rectifier. In the example illustrated in the figure, it is connected to the negative terminal, and is indicated in a general way by 9. The cut-off device 9 comprises a plurality of MOSFETs, indicated by 11A, 11B, 11C ... 11N. The MOSFETs 11A-11N are connected in parallel with each other and are connected to the negative output terminal 5 of the rectifier in such a way that the current supplied by the latter is distributed among the various MOSFETs and flows between the source and drain of each of them.

10 The gates of all the MOSFETs are connected, via corresponding resistors 13A, 13B, 13C, 13N to the emitter of a transistor 15. The collector of the transistor 15 is connected to the negative output terminal of the rectifier 1 before the group of MOSFETs 11A-11N, while the base of the transistor 15 is

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connected to the output of an operational amplifier 17 forming the main element of the control circuit, indicated as a whole by 19, associated with the MOSFETs 11A-11N.

The non-inverting input of the operational amplifier 17 is connected, via a resistor 21, to the negative output terminal of the rectifier 1, before the MOSFETs 11A-11N according to the conventional direction of flow of the current supplied by the rectifier, while the inverting terminal of the operational amplifier 17 is connected, via a resistor 23, to the negative output terminal 5 of the rectifier 1 after the MOSFETs 11A-11N.

A reactive filter containing a capacitor 25 is provided between the inverting terminal and the output of the operational amplifier 17, to prevent oscillations of the output of the operational amplifier 17 in the proximity of the trigger threshold.

The operation of the circuit described above is as follows. In normal operating conditions, the rectifier 1 provides the supply line 7A, 7B with a current I , which is added to the current supplied to the other rectifiers connected to the supply line 7A, 7B, to supply the load Z . In these conditions, a limited voltage drop is established between the source and drain of each MOSFET 11A-11N, and is kept approximately constant until the value of the current tends toward zero, for example if the rectifier 1 suffers an internal fault, which could lead to an inversion of the current at the output of said rectifier, a situation which must be avoided.

When this type of fault situation arises, the voltage drop between the sources and drains of the various MOSFETs 11A-11N causes a reduction of the output voltage of the operational amplifier 17. The reduction of the output voltage of the operational amplifier causes the transistor 15 to conduct. Since the transistor 15 is connected via the resistors 13A-13N to the gates of the MOSFETs 11A-11N, its switching to the conducting state rapidly makes all the MOSFETs non-conducting. Thus the connection between the supply line 7A-7B and the power rectifier 1 is rapidly broken. The reactive filter formed by the capacitor 25 prevents any possible oscillations of the output of the operational amplifier 17 in the proximity of the intervention threshold.

It is to be understood that the drawing shows only an example provided

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solely as a practical demonstration of the invention, which can be varied in respect of its forms and arrangements without departure from the scope of the guiding principle of the invention.

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CLAIMS:

1. A power supply cut-off circuit for a power rectifier adapted to be connected to a power supply line leading to a load, comprising:

5 a switching circuit adapted to be connected between the rectifier and the power supply line;

a control circuit connected to the switching circuit, the control circuit including an operational amplifier having inputs connected across the switching circuit and a switching control element connected between an output of the operational amplifier and the switching circuit; and

10 wherein, when the switching circuit has been connected between the rectifier and the power supply line,

the control circuit is operable to disconnect the rectifier from the power supply line using the switching circuit when the control circuit senses that the rectifier has malfunctioned; and

15 the operational amplifier is operable to apply a first signal indicative of a rectifier malfunction to the switching element that causes the switching control element to generate a second signal that causes the switching circuit to become nonconducting and disconnects the rectifier from the power supply line.

20 2. The cut-off of claim 1, wherein the switching circuit includes a plurality of switching elements connected in parallel with one another.

3. The cut-off of claim 2, wherein the switching circuit further includes a plurality of diodes connected in parallel with the plurality of switching elements.

4. The cut-off of claim 2, wherein the switching elements are MOSFETs.

5. The cut-off of claim 1, wherein the control circuit is operable to:

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sense a voltage across the switching circuit that is indicative of a rectifier malfunction; and

disconnect the rectifier from the power supply line if the voltage across the switching circuit indicates that the rectifier has malfunctioned.

5 6. The cut-off of claim 5, wherein the control circuit determines that the rectifier has malfunctioned if the voltage across the switching circuit falls below a predetermined voltage level.

7. The cut-off of claim 1, wherein:

10 the control circuit further includes a reactive filter connected to the operational amplifier; and

the reactive filter is operable to prevent oscillations of the operational amplifier.

8. The cut-off of claim 7, wherein the switching control element is a transistor and the reactive filter is a capacitor.

15 9. A power rectifier having a power supply cut-off circuit and a rectifier output adapted to be connected to a power supply line for a load, the power supply cut-off circuit, comprising:

20 a switching circuit adapted to be connected between the rectifier and the power supply line, the switching circuit including a plurality of switching elements connected in parallel with one another;

a control circuit connected to the switching circuit, the control circuit including an operational amplifier having inputs connected across the switching circuit and a switching control element connected between an output of the operational amplifier and the switching circuit; and

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wherein, when the switching circuit has been connected between the rectifier and the power supply line,

the control circuit is operable to disconnect the rectifier from the power supply line by causing the switching circuit to become nonconductive when the
5 control circuit senses that the rectifier has malfunctioned; and

the operational amplifier is operable to apply a first signal indicative of a rectifier malfunction to the switching control element that causes the switching control element to generate a second signal that causes the switching circuit to become nonconductive and disconnects from the power supply line.

10 10. The power rectifier of claim 9, wherein the control circuit is operable to sense a current flowing through the switching circuit that is indicative of a rectifier malfunction; and

disconnect the rectifier from the power supply line if the current flowing through the switching circuit indicates that the rectifier has malfunctioned.

15 11. The power rectifier of claim 9, wherein the control circuit determines that the rectifier has malfunctioned if the current flowing through the switching circuit becomes inverted.

12. The power rectifier of claim 9, wherein the control circuit determines that the rectifier has malfunctioned if the current flowing through the switching circuit
20 falls below a predetermined current level.

13. The power rectifier of claim 9, wherein the control circuit disconnects the rectifier from the power supply line by causing the switching circuit to block current flowing through the switching circuit.

14. A power supply cut-off circuit for a power rectifier having a rectifier
25 output adapted to be connected to a power supply line for a load, comprising:

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a plurality of MOSFETs connected in parallel and adapted to be connected to the rectifier output so that current flowing between the rectifier and the power supply line is distributed among the MOSFETs, each MOSFET having a gate;

a transistor having an emitter connected to each of the MOSFET gates,
5 a collector adapted to be connected to the rectifier output between the plurality of MOSFETs and the power supply line, and a base; and

an operational amplifier having an amplifier output connected to the base of the transistor, a non-inverting input adapted to be connected to the rectifier output between the plurality of MOSFETs and the power supply line, and an inverting
10 input adapted to be connected to the rectifier output between the rectifier and the plurality of MOSFETs.

15. The power rectifier of claim 9, wherein the switching circuit includes a plurality of diodes connected in parallel with the plurality of switching elements.

16. The power rectifier of claim 15, wherein the switching elements are
15 MOSFETs.

17. A power supply cut-off circuit for a power rectifier having a rectifier output adapted to be connected to a power supply line for a load, comprising:

a plurality of MOSFETs connected in parallel and adapted to be connected to the rectifier output so that current flowing between the rectifier and the
20 power supply line is distributed among the MOSFETs, a source-drain voltage existing across the MOSFETs;

an operational amplifier with an inverting input and a non-inverting input, a voltage proportional to the source-drain voltage across the MOSFETs being applied across the inverting and non-inverting inputs of the operational amplifier; and

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wherein, the operational amplifier is operable to generate a first signal indicative of a rectifier malfunctioning that can be used to make the MOSFETs non-conducting.

18. The power rectifier of claim 17, wherein:

5 a switching control element is connected between an output of the operational amplifier and the switching circuit; and

the operational amplifier is operable to apply the first signal indicative of a rectifier malfunctioning to the switching control element; and

10 the first signal indicative of a rectifier malfunction causes the switching control element to generate a second signal that causes the switching circuit to become nonconducting and disconnects the rectifier from the power supply line.

19. The power supply cut-off circuit of claim 18, wherein:

each one of the plurality of MOSFETs includes a gate;

15 the switching control element is a transistor and the transistor is connected to the gates of the MOSFETs;

the transistor becomes conducting in response to the first signal indicative of a rectifier malfunctioning generated by the operational amplifier, generates the second signal, and applies the second signal to the gates of the MOSFETs; and

20 the MOSFETs become nonconducting in response to the second signal being applied to the gates of the MOSFETs by the transistor.

