

[54] **METHOD AND APPARATUS FOR THE UNINTERRUPTED SWITCHING OF AT LEAST ONE ALTERNATING-CURRENT CONSUMER OF A VOLTAGE SUPPLY SOURCE OR CURRENT SUPPLY SOURCE TO A DIFFERENT VOLTAGE SUPPLY SOURCE OR CURRENT SUPPLY SOURCE**

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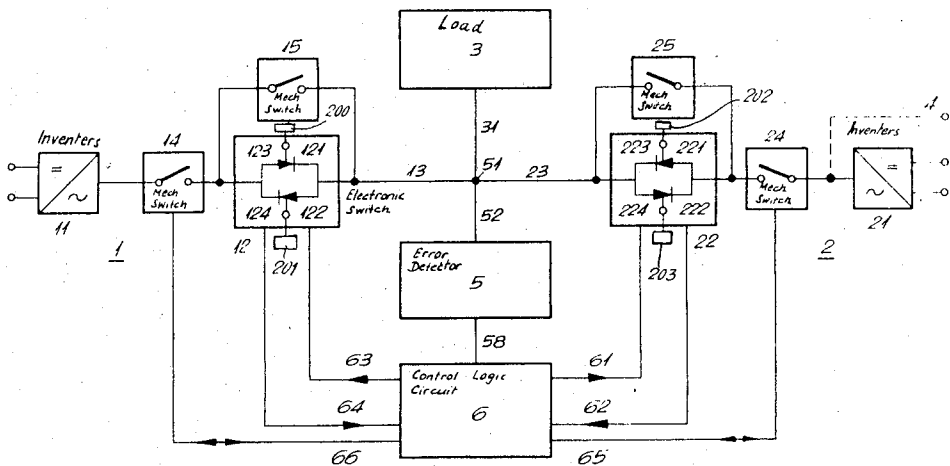
[51] Int. Cl.H02j 7/00

[58] **Field of Search**.....307/64, 66, 85, 86, 87, 43, 307/112, 116, 125, 126, 127, 128

[56] **References Cited**
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[57] **ABSTRACT**
A method and apparatus for switching at least one alternating-current load from one power supply, such as a voltage supply or current supply, to another power supply, such as a voltage supply or current supply, upon the appearance of an error in the power supply coupled with the load. Each power supply possesses electronic switch means at the connection conductors to the load. An error detector determines the deviations of the waveshape of the load voltage from a predetermined waveshape of a reference voltage for a successive time interval, and upon exceeding an adjustable maximum deviation value, the electronic switch means are actuated for coupling the first-mentioned power supply to the other power supply.

10 Claims, 4 Drawing Figures



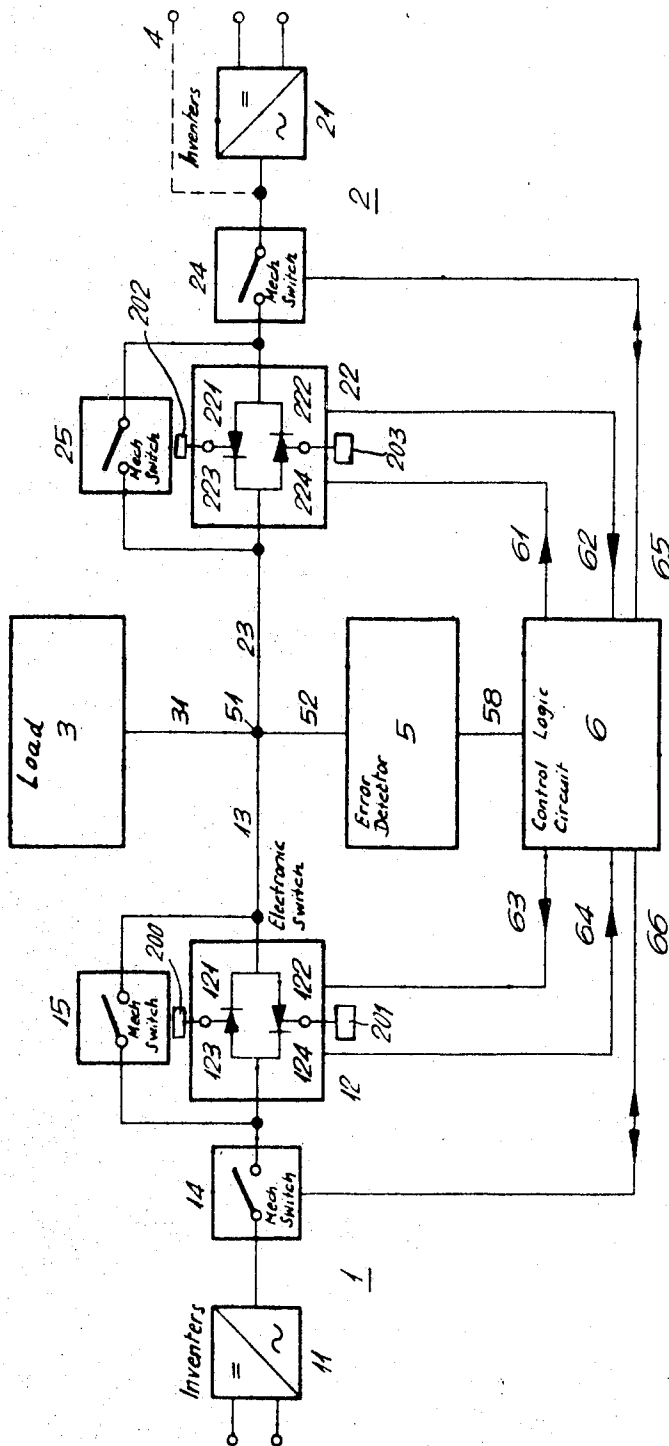


FIG. 1

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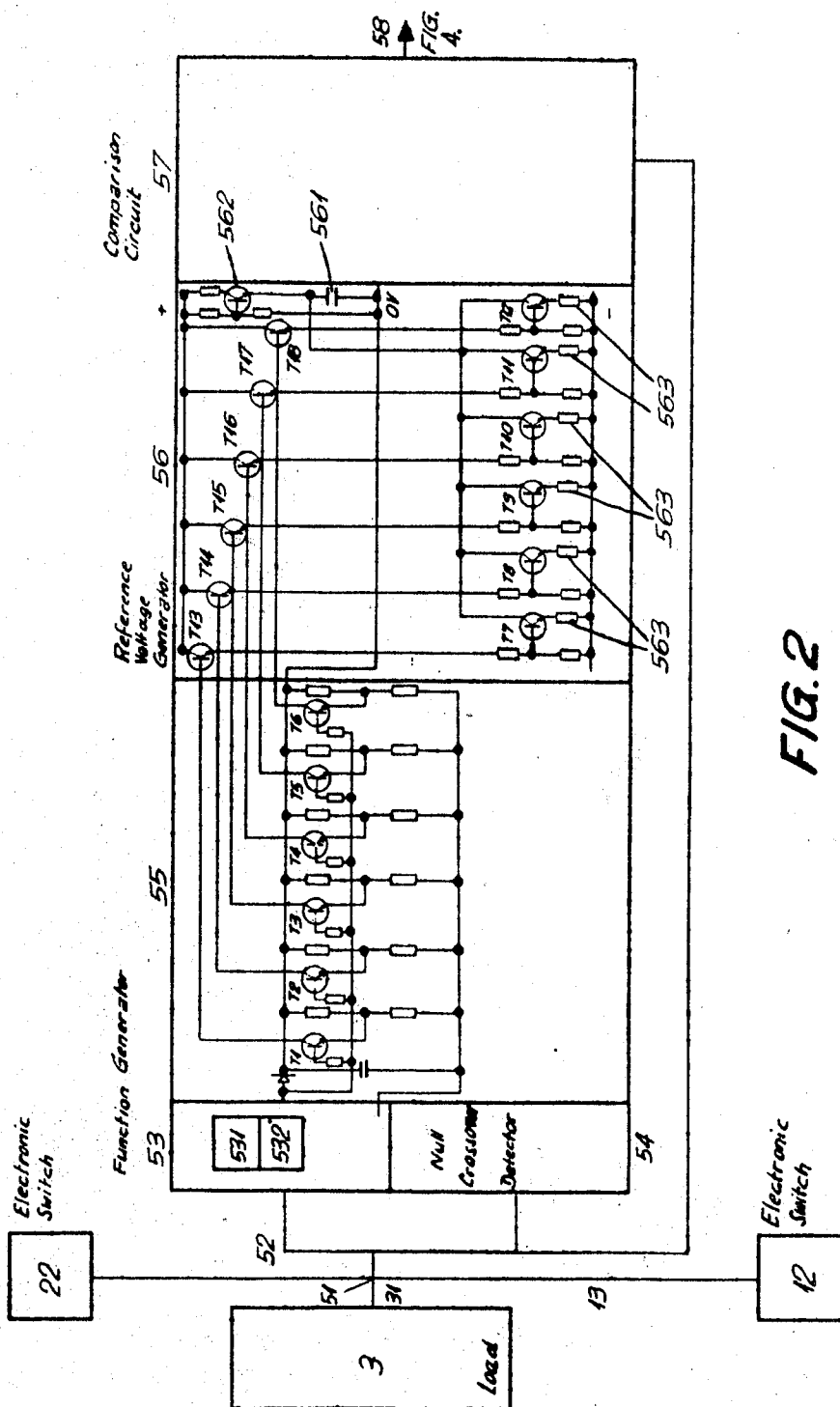


FIG. 2

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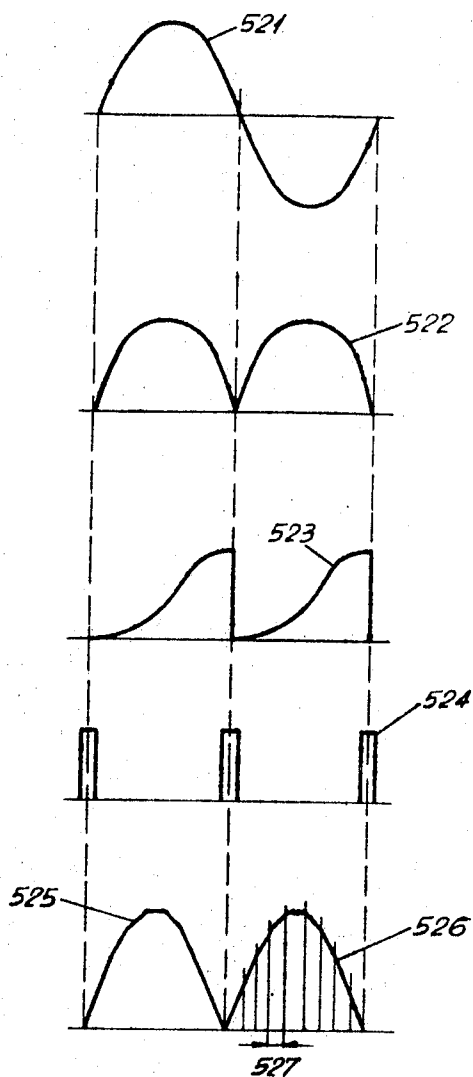


FIG. 3

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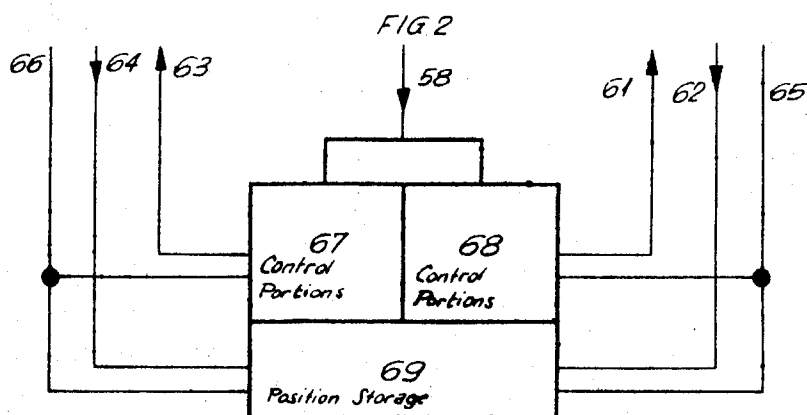


FIG. 4

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BACKGROUND OF THE INVENTION

The present invention relates to an improved method and apparatus for switching at least one alternating-current consumer from a voltage source or current source to a different voltage source or current source upon the appearance of a defect in the source coupled with the consumer or load, wherein each source possesses electronic switches at the connection conductor to the consumer.

Complicated consumers or loads, for instance radar devices, electrical laboratory instruments or large data processing installations or computers which are coupled by a single- or multi-conductor-transmission system with the voltage or current source, possess great susceptibility to short-duration defects or irregularities of the current supply. Consequently, these consumers are equipped with a reserve or auxiliary power or current supply which can be switched in for a very brief period of time. However, since switching requires a certain amount of time, for instance, a full period of the alternating-current voltage or the alternating-current, practice has shown that disturbances arise within the consumer or load.

SUMMARY OF THE INVENTION

Therefore, there is a real need in the art for an improved method and apparatus for the uninterrupted switching of at least one alternating-current load or consumer from a voltage source or a current source to a different voltage source or current source, in a manner avoiding the aforementioned drawbacks of the prior art constructions. It is therefore a paramount object of the present invention to provide a system which capably fulfills this need and overcomes the aforementioned drawbacks of the prior art.

Another, specific object of the present invention is to devise a system which minimizes the time required for switching, thereby eliminating the aforementioned disadvantages experienced in the prior art.

Now, in order to implement these and still further objects of the invention, which will become more readily apparent as the description proceeds, the inventive method is manifested by the features that an error detector is used to determine deviations of waveshape of the consumer voltage from the waveshape of a reference voltage, which waveshape has been predetermined for a successive period of time, and upon exceeding an adjustable maximum deviation value, can be switched to the other voltage source or current source by actuating the electronic switch.

As far as the apparatus structure of the invention is concerned, it is manifested by the features of the arrangement of the error detector and a control logic circuit between the connection conductors of the individual voltage sources or current sources to the consumer and the electronic switches. The control logic circuit influences the ignition circuits associated with the individual electronic switches in such a manner that the defective voltage source or current source, conveniently generally referred to herein as power source, is switched-out and the reserve power source, i.e., voltage source or current source is switched in.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood and objects other than those set forth above will become apparent when consideration is given to the following detailed description thereof. Such description makes reference to the annexed drawings wherein:

FIG. 1 is a block diagram of the entire installation of the present invention;

FIG. 2 is a circuit diagram showing details of the error detector circuit;

FIG. 3 graphically illustrates voltage curves for the error detector; and

FIG. 4 is a block circuit diagram of the control logic circuit.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Describing now the drawings, in the exemplary embodiment given hereinafter, there will be described switching of the load or consumer from a first current supply to a different current supply. According to FIG. 1, both of the current supplies 1 and 2, consisting of d.c.-a.c. inverters 11 and 21, are electrically coupled via electronic switches 12, 22 and the connection conductors 13, 23 to the consumer or load 3. Dashed line 4 indicates that in place of the inverter 21 the normal current supply network 4 can also be connected via the electronic switch 22 with the consumer 3. The error detector 5 is coupled at the junction point 51 of the connection conductors 13, 23 and 31 and influences the control logic circuit 6, the terminals or outputs of which are electrically coupled via the conductors 61, 62, 63 and 64 with the electronic switches 12 and 22. Mechanical switches 14 and 24, disposed at the junction line of the current supplies 1 and 2, are coupled via the conductors 65 and 66 likewise with the control logic circuit 6, as shown.

It is assumed that the current supply 1 acts upon the consumer or load 3, whereas the current supply 2 is switched off. The mechanical switch 14 is closed. The electronic switch 12, which, as known, can consist of a bridge circuit formed of a plurality of silicon controlled rectifiers (SCR) 121 and 122, are conductive. The control electrodes 123 and 124 receive their ignition voltage from suitable ignition circuits, only schematically indicated at 200 and 201 respectively. The electronic switch 22 associated with the other current supply 2 or 4, respectively, likewise consisting of, for instance, silicon controlled rectifiers 221, 222 possessing the associated control electrodes 223, 224, these rectifiers being in their non-conductive state, since their associated ignition circuits, only schematically indicated at 202 and 203 respectively, do not deliver any ignition voltage to the control electrodes. The mechanical switch 24 is likewise closed.

In the electronic error detector 5, which will be described in greater detail in conjunction with the circuitry of FIG. 2, there is formed the desired waveshape or reference-voltage from the individual components of the wave envelope which follow one another in time. These individual wave components can be linear or in the form of a curve. If linear components are employed, then their length must be chosen to be so small that a sufficient approximation to the desired waveshape, for instance sinusoidal, can be achieved. If curve-shaped components, for instance quadratic parabolic segments, are employed, then their length likewise cannot exceed a certain dimension, so that, in the same manner, it is possible to obtain a sufficient approximation to the waveshape of the reference-voltage. The generation of these wave components by switching means will be explained in greater detail hereinafter. At this time there is merely stated that these components possess a certain location or position, and therefore fix for the next successive time-interval the voltage conditions without influence by other effects.

Each component or portion of the reference-voltage curve or reference-voltage shape is compared in the error detector 5 with the curve portion associated with the same time period of the actual-voltage curve or actual-voltage shape applied to the consumer 3. The smaller the time interval is chosen, that much more exact is the comparison. Upon coincidence of the reference-voltage with the actual-voltage per time interval, the error detector 5 does not deliver any signal to the control logic circuit 6. Now, if because of some type of disturbance in the inverter 11 of the current supply 1 the actual-waveshape at the consumer 3 deviates from the, for instance, sinusoidal shape, then, the error detector 5 determines this deviation and delivers a suitable signal to the control logic circuit 6. Since the control logic circuit 6 is informed via the feedback con-

ductor 64 that the electronic switch means 12 are conductive, a signal is delivered via the control conductor 61 to the ignition circuit means of the electronic switch 22. Consequently, the rectifiers 221, 222 of the electronic switch 22 are placed into conductive state, so that the other power supply, for instance designated as the reserve current supply 2, is immediately switched in.

At the same time, the control logic circuit 6 delivers a signal via the control conductor 63 to the electronic switch 12, which immediately is then placed into non-conductive state. The control logic circuit 6 likewise receives via the feedback conductor 62, at the same time, information that the electronic switch 22 is conductive. The mechanical switch 14 is opened via the conductor 66. The mechanical switch 14 can also remain closed. In certain countries, regulations require an additional mechanical separation possibility of the current supply. Apart from this, the arrangement of a mechanical switch 14 or 24 is advantageous during repair of the current supply or the electronic switches. It is for this reason that further mechanical switches 15 and 25 are also coupled parallel to the electronic switches 12 and 22. Mechanical switches 15 and 25 bridging the electronic switches 12 and 22, are, if desired, likewise actuated by the control logic circuit 6. The switching from one alternating-current supply to the other, naturally takes place with sufficient phase coincidence or balance of the voltage curves. To this end, a suitable phase discriminator for such purpose has been conveniently omitted from FIG. 1 since such is generally quite well known to the art. Finally, it is here mentioned that the individual alternating-current supplies can embody single- or multi-conductor-transmission systems. But, to preserve clarity in illustration such have not been depicted. The current supply network 4 can be used instead of the inverter 21. If a defect occurs at the current supply 2, in the same manner, there is undertaken a switch-over to the current supply 1, as described above.

Turning now to the circuit diagram of FIG. 2 depicting details of the electronic error detector 5, such will be seen to incorporate a function generator 53, a null or zero passage detector 54, a circuit arrangement 55 composed of a plurality of transistors T_1 to T_6 , a reference voltage generator 56 with a number of current-stage switches T_7 to T_{12} , as well as a comparator or comparison circuit 57.

For the purpose of explaining the mode of operation of the error detector 5 it is to be assumed that the current supply 1 of FIG. 1 is acting upon the consumer or consumers 3 via the conductive electronic switch 12 and the conductors 13, 31 whereas current supply 2 is switched-off from such consumer or load via the electronic switch 22. The mode of operation will now be described in conjunction with both FIGS. 2 and 3. FIG. 3 graphically illustrates different voltage curves for the error detector 5. The voltage amplitudes are plotted along the ordinate and time along the abscissa. Individual voltage curves are illustrated in superimposed fashion such that they coincide in time. The sinus-shaped alternating-current voltage 521 arriving at the consumer 3 is delivered via the conductor means 52 to the function generator 53, the zero passage detector 54 as well as to the comparison circuit arrangement 57. In the function generator 53 the alternating-current voltage is rectified by a full-wave rectifier bridge 531, whereby each rectified half-wave 522 is integrated. FIG. 3 illustrates such a voltage curve 523. A capacitor can be suitably used as the integration element.

The function generator 52, of course, can also be constructed in such manner that each rectified half-wave 522, instead of being integrated, triggers an ascending voltage curve. The transistors T_1 to T_6 in the circuit or switch arrangement 55 are connected in such a manner that they respond to predetermined values of the ascending voltage curve 523 delivered from the function generator 53, that is to say, these transistors are switched into their conductive state. For instance, transistor T_1 responds to the lowest voltage value and the successive transistors T_2 to T_6 to the next higher voltage values. The respective collectors of the transistors T_1 to T_6 are cou-

pled with the appropriate bases of the further transistors T_{13} to T_{18} serving as amplifier means. When each transistor T_1 to T_6 becomes conductive it causes the associated further transistors T_{13} to T_{18} to also become conductive. These transistors T_{13} to T_{18} control the current-stepping switch means T_7 to T_{12} , likewise composed of transistors, in the reference-voltage generator 56. The emitter-collector path of the transistors T_7 to T_{12} is in parallel with one end or terminal of the capacitor 561. The other terminal of the capacitor 561 is connected via a transistor 562 to a voltage source of, for instance, +15 volts. Each emitter of the transistors T_7 to T_{12} is coupled via an ohmic resistance 563 to a direct-current voltage source of, for instance, -15 volts.

The voltage-zero crossover or throughput detector 54 delivers a signal 524 to the function generator 53 as soon as the rectified half-wave 522 of the alternating-current voltage delivered by the conductor 52 has reached the zero crossover or null point so that the integration element 532 in the function generator 53 is discharged to zero. As a result, transistors T_1 through T_{18} are rendered non-conductive or blocked. At the same time the capacitor 561 in the reference-voltage generator 56, which is situated between +15 volts and the transistors T_7 to T_{12} , discharges. As soon as the integration element 532 in the function generator 53 possesses a voltage ascent 523, the transistors T_1 to T_6 are rendered conductive in series or progression and remain in the conductive state until the next signal 524. The transistors T_{13} to T_{18} are likewise progressively, or in series, rendered conductive. The capacitor 561 in the reference-voltage generator 56 charges whereby, however, the transistors T_7 to T_{12} acting as current stepping or stage switches, are rendered conductive in the same sequence or series by the transistors T_{13} to T_{18} . These current stepping or stage-selector switches cause a current flow from the capacitor, which becomes greater from switch to switch, so that the voltage at the capacitor is diminished in stages. This stepwise reduction is noticeable in that the voltage at the capacitor possesses an almost sinusoidal shape. The transistors T_1 to T_{18} remain conductive for such length of time until the next zero or null signal is delivered by the voltage-zero crossover detector 54. The current stepping switches T_7 to T_{12} , due to their being switched in, provide voltage components 525 which are added together to form the reference voltage 526. In FIG. 2 there have only been illustrated six current-stepping switches. Hence, FIG. 3 thus shows also six components 525 which have been composed together to provide a half-wave 526 of the reference-voltage curve. Each component 525 corresponds to a time interval 527 of the half-wave 526. Each component possesses at the beginning of its time interval, by switching in the corresponding current stepping switch T_7 to T_{12} , a predetermined position or inclination. This position or inclination is fixed for the entire time-interval. If the subdivision of the reference voltage curve 526 is still to be further improved, then a greater number of current stepping switches T_7 to T_{12} and transistors T_1 to T_6 or T_{13} to T_{18} must be provided.

Since the emitters of the current stepping switches T_7 to T_{12} are coupled by linear, ohmic resistances 563 with a -15 volt direct-current voltage supply, there also thus result linear wave components 525. Instead of using these ohmic resistances, it is possible, of course, to also use non-linear resistances. In this case, there would appear curve-shaped wave components, which likewise can be assembled together in a random number to form the reference-voltage curve 526. The reference-voltage curve now appears at the comparison circuit arrangement 57 in which it is compared with the likewise rectified half-wave 522 of the actual-voltage 521 for each time interval. As soon as there has been determined within a time period or interval for a component 525 of the reference-voltage curve a deviation with respect to the actual-voltage curve 521, then, the comparison circuit arrangement or comparator 57 delivers a signal via the output 58 to the control logic circuit 6.

As best recognized by referring to FIG. 4, control logic circuit 6 consists of both control sections or portions 67 and 68

and the position storage 69. The control section or portion 67 is coupled via the conductor 63 at the ignition circuit means 200, 201 of the electronic switch 12 of the current supply 1. The control portion or section 68 is coupled via the conductor 61 with the ignition circuit means 202, 203 of the electronic switch 22 of the current supply 2. The feedback conductors 64, 62 of the electronic switches 12, 22 lead to the position storage 69.

If, in any case, mechanical switches, such as for instance components 14, 24 and 15, 25 are provided as in FIG. 1, then these mechanical switches are connected via the control and feedback conductors 65, 66 with the control logic circuit 6. In this manner the position storage 69 is informed at any moment of time about the switching condition of the electronic switches 12 and 22 as well as the mechanical switches 14, 15, 24 and 25. The control electronic logic circuit means actuates in the case, where mechanical switches are provided, via the control conductors 65, 66 these mechanical switches.

For the purpose of explaining the mode of operation of the electronic control logic circuit means, it is to be assumed that the current supply 1 is coupled with the consumer 3 and the error detector 5 has determined within a very short period of time 527 a deviation of the actual-voltage 521 from the reference-voltage 526. A signal is transmitted via the conductor 58 to both control sections or portions 67 and 68 of the control logic circuit 6. In each control section there is provided a current circuit which influences the relevant ignition circuit means of the electronic switches 12, 22 via the control conductors 63, 61. Each of the control circuits can, however, first then deliver a control signal to the conductors 63, 61 when the information signal from the position storage 69 about the momentary switching conditions of the electronic switches 12, 22 has been transmitted to each of these control or current circuits. This information signal serves to determine polarity, so that in the assumed example the ignition circuit of the electronic switch 22 is actuated or switched in via the control portion 68 and the ignition circuit of the electronic switch 12 is switched out via the control section 67. The mechanical switch 14 is opened via the conductor 66, if this is required by special regulations. It is once again emphasized that the mechanical switches 14, 24 normally need not be opened. As already mentioned, both of the other mechanical switches 15 and 25, depending upon requirements, can also likewise be actuated by the control logic circuit 6, or manually. The installation of the mechanical switches and their actuation is dependent only upon the electro-technical prerequisites or requirements for current supply, or in accordance with special desires of the customer.

Switching from one current supply to the other current supply has been previously described as an exemplary embodiment. In so doing, one was essentially concerned with the sinusoidal shaped voltage curves. The inventive technique or method is also usable for remote-controlled transmitters. Conceptually, then, one need only conceive of both of the current supplies 1 and 2 of FIG. 1 being replaced by the transmitter installations of two similar remote-controlled transmitters. Now, in order to ensure that in each instance the control pulses from the remote-controlled transmitter 1 can be transmitted to the load or consumer 3 which is to be controlled, there is provided the reserve transmitter 2 which is immediately switched in as soon as the transmitter 1 does not operate properly.

While there is shown and described present preferred embodiments of the invention, it is to be distinctly understood that the invention is not limited thereto but may be otherwise variously embodied and practiced within the scope of the following claims.

What is claimed is:

1. A method for switching at least one alternating-current load from one power supply, such as a voltage supply or current supply, to another power supply, such as a voltage supply or current supply, upon the appearance of an error in any one of the power supplies coupled with the load, wherein each supply possesses electronic switch means at the connection

conductors to the load, comprising the steps of determining the deviations of the waveshape of the load voltage from the predetermined waveshape of a reference voltage for a successive time interval, and upon exceeding an adjustable maximum deviation value switching the load from the first-mentioned power supply to the other power supply by actuating the electronic switches.

2. The method as defined in claim 1, further including the steps of forming the waveshape of the reference voltage from separate linear-wave components successively following one another in time, and determining the position of a wave component at the beginning of the time interval associated with it.

3. The method as defined in claim 1 further including the steps of forming the waveshape of the reference voltage from separate curved-wave components successively following one another in time, and determining the position of a wave component at the beginning of the time interval associated with it.

4. An apparatus for switching at least one alternating current load from one power supply, that is a voltage supply or current supply, to another power supply, that is another voltage supply or power supply, upon the appearance of an error in any one of the power supplies coupled with the load, comprising connection conductor means for the individual power supplies leading to the load, electronic switch means provided for each power supply at said connection conductor means leading to said load, error detector circuit means and control logic circuit means coupled between said connection conductors and said electronic switch means, ignition circuit means associated with said individual electronic switch means, said control logic circuit means acting upon said ignition circuit means associated with the individual electronic switch means such that any of the defective power sources is switched-off and the other power source is switched-in.

5. The apparatus defined in claim 4, wherein said error detector circuit means comprises:

- a. a function generator for forming from rectified half-waves of the actual load voltage an ascending voltage curve;
- b. switch means;
- c. detector means which upon zero crossover of the actual-voltage delivers a signal to said switch means;
- d. said switch means comprising a circuit arrangement having a first group of transistors which respond to a predetermined value of the ascending voltage curve generated in the function generator, and a second group of transistors which deliver signals from said first group of transistors to a current-stepping circuit of a reference voltage generator means;
- e. a reference voltage generator means including said current-stepping circuit possessing transistors disposed parallel to a storage element and being rendered conductive in a preselected sequence, so that charging of said storage element can be influenced during predetermined time intervals, and the thus produced wave components are combined into a reference-voltage curve; and
- f. a comparison circuit for comparing each component of the reference-voltage curve with the rectified half-wave of the actual-voltage curve at the time interval associated with both such voltage curves.

6. The apparatus as defined in claim 4, further including means for delivering a signal via a conductor to said control logic circuit means arranged after said error detector circuit means upon exceeding a predetermined maximum deviation error of the actual-voltage curve from the reference-voltage curve.

7. The apparatus as defined in claim 4, wherein said control logic circuit means is composed of control portions for controlling said electronic switch means and position storage means for information concerning the momentary condition of said electronic switch means.

8. The method as defined in claim 1, further including the step of switching the load from said other power supply back to said first-mentioned power supply when there is again

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determined that the waveshape of the load voltage from the predetermined waveshape of a reference voltage for a successive time interval has exceeded an adjustable maximum deviation value.

9. The method as defined in claim 1, including the step of

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forming the reference voltage from the load voltage.

10. The method as defined in claim 1, including the step of carrying out load switching from any one power source to the other without any loss in time.

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