United States Patent

[11] 3,584,152

[72] Inventor **Akihisa Suzuki**
Hamana-gun, Japan

[21] Appl. No. **792,950**
[22] Filed **Jan. 22, 1969**
[45] Patented **June 8, 1971**
[73] Assignee **Nippon Gakki Seizo Kabushiki Kaisha**
Hamamatsu-shi, Japan
[32] Priority **Mar. 15, 1968**
[33] **Japan**
[31] **17003/68**

[54] **ROTATABLE SPEAKER APPARATUS**
6 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **179/1J,** 318/227
[51] **Int. Cl.** **H02p 5/00,** H04r 3/00
[50] **Field of Search** ..... 318/227; 328/146; 331/25, 26; 330/69; 321/46, 43; 323/75 F; 179/1 J

[56] **References Cited**

UNITED STATES PATENTS

2,919,391	12/1959	Charbonneaux	318/227
3,219,140	11/1965	Mizrahi	179/1
3,470,436	9/1969	Steele	318/345

OTHER REFERENCES

D. A. Paice, " Voltage Control for Small Induction Motors" Control Engineer Oct. 1967, Pages 73— 75 (318-227)

Primary Examiner—Kathleen H. Claffy
Assistant Examiner—Douglas W. Olms
Attorney—Flynn & Frishauf

ABSTRACT: A rotatable speaker apparatus is provided with an electrical means to control the rotary speed of a speaker-rotating motor. The electrical means detects the actual speed of rotation of the motor, converts the speed into a voltage signal, compares the signal with a reference voltage representing a desired speed of rotation of the motor, said reference voltage being continuously variable, amplifies a difference voltage between the two voltages and regulates the driving power for the motor, whereby the speed of tremolo is continuously variable over a wide range.

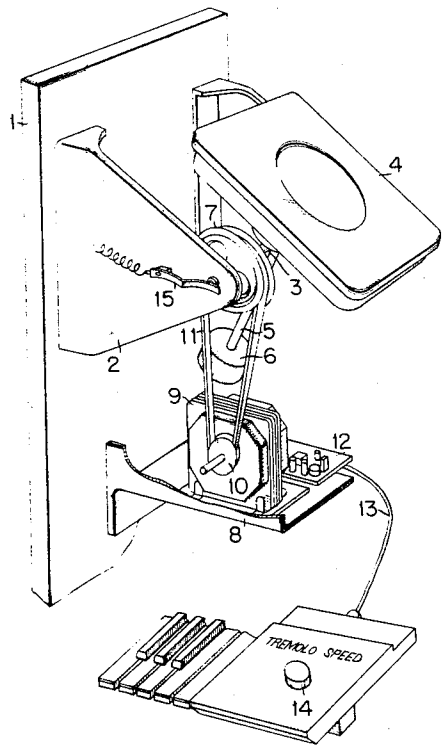


FIG. 1

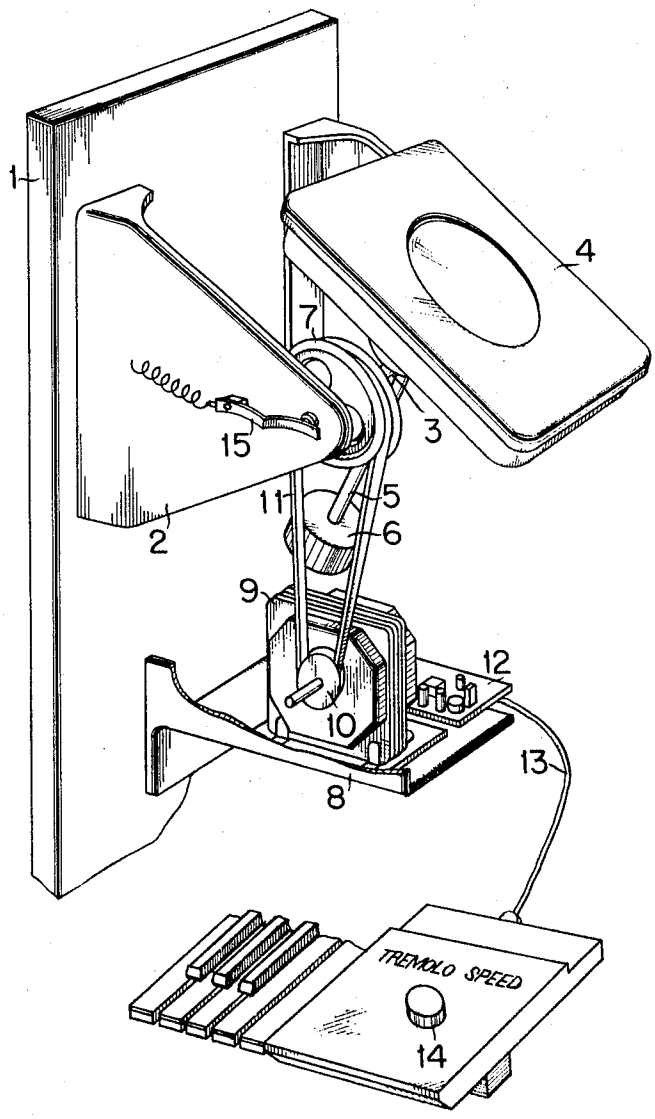
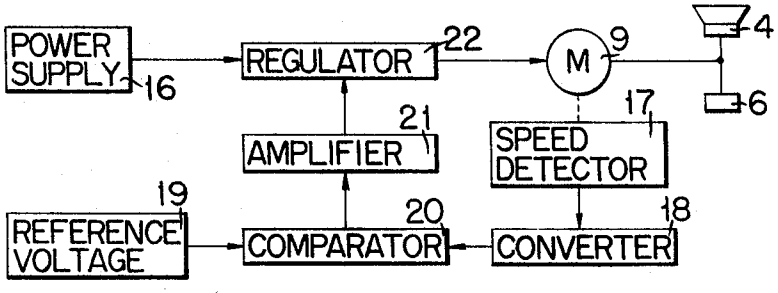


FIG. 2



AKIHISA SUZUKI,

INVENTOR.

BY Fleyan & Fleyan Attys

FIG. 3

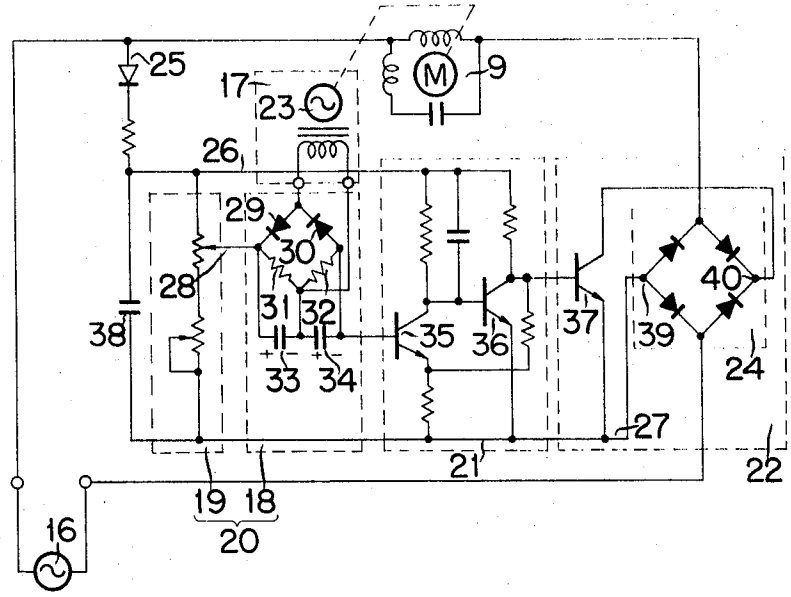
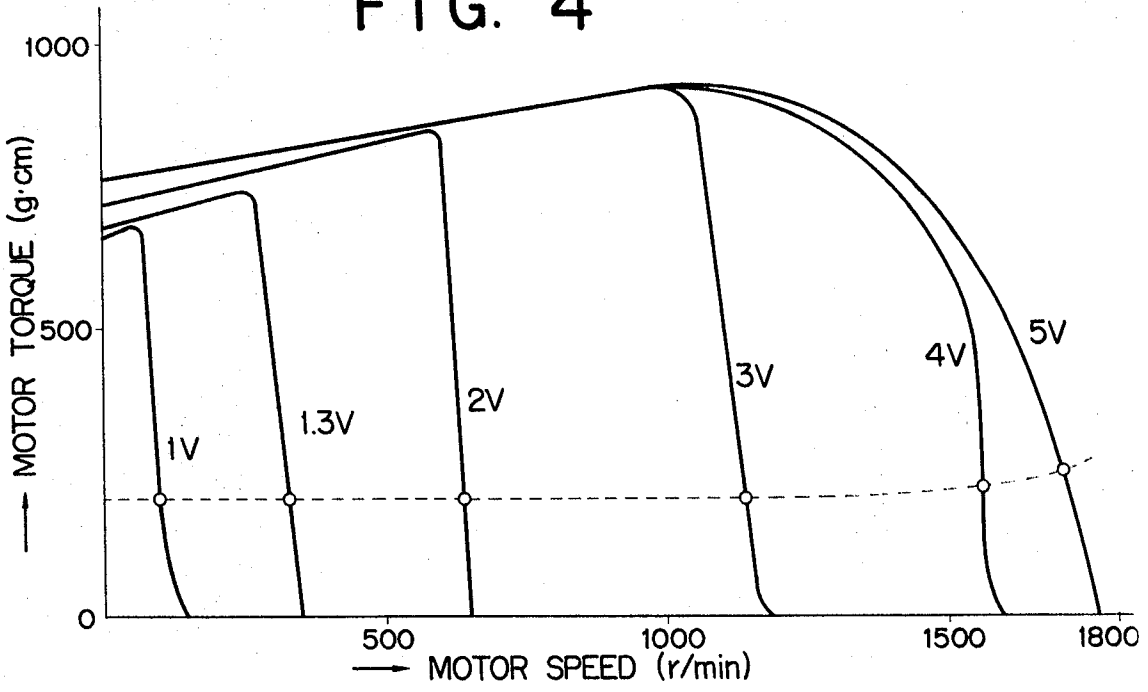


FIG. 4



INVENTOR.

BY

ROTATABLE SPEAKER APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to tremulant sound-producing apparatus, and more particularly to rotatable speaker apparatus capable of continuously varying the tremolo speed over a wide range.

In playing a musical instrument, the tremulant effect is produced to enhance the pleasing quality. As is known in the art, the effect is achieved by mechanically rotating a speaker which gives forth the periodical rotation of the radiation direction of reproduced musical sounds.

A prior art rotatable speaker apparatus includes a single electric motor by means of which a speaker is rotated. This apparatus is provided with a mechanism including a plurality of pulleys for transmission of the motor speed to the speaker, since the rotational speed of the motor can hardly be widely changed by, for example, a variable resistor connected in series with the motor. Thus, the known apparatus merely can change the tremolo speed in dependence upon a predetermined number of revolutions of the motor and upon the rotation transmission mechanism.

Another prior art rotatable speaker apparatus includes a plurality of electric motors having different predetermined speeds of revolution from each other. This apparatus selectively operates the motors and/or mechanically changes the transmission ratio of a rotation-transmitting means thereof to alter the speed of rotation of the speaker. With this apparatus, it is impossible to continuously and widely vary the rotary speed of the speaker. Furthermore, the apparatus is complicated in construction, and is expensive in fabrication.

As stated above, the prior art apparatus will not be applicable when a continuously variable tremolo speed is desired.

SUMMARY OF THE INVENTION

Accordingly, the present invention has its object in the provision of an improved rotatable speaker apparatus which can vary the speed of the tremulant effect continuously over a wide range.

In accordance with this invention, a speaker is rotated by an electric motor such that the direction in which musical tones are emitted is rotary. The actual speed of revolution of the motor is converted into an electrical signal to be detected. The detected signal is compared with a reference voltage for setting a desired motor speed. A difference voltage obtained as a result of the comparison is fed to a regulator circuit for controlling the power supply to the motor. The speed-setting reference voltage is continuously variable, and thus a wide and continuous variation of the speaker-rotating speed is easily effected.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic perspective view of a rotatable speaker apparatus embodying this invention;

FIG. 2 is a block circuit diagram for explanation of a motor drive and control device provided in the embodiment of FIG. 1;

FIG. 3 is a circuit connection diagram showing a concrete example of the circuit arrangement in FIG. 2; and

FIG. 4 is a graph illustrating the relation between the rotational speed and torque of the motor in the embodiment.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. 1, the reference numeral 1 designates a base plate, to which are attached a pair of frames 2. A shaft 3 is rotatably supported on and across the frames 2, and is attached with a loudspeaker 4 in such a manner that the reproduced sounds emitted by said speaker is rotated about the rotary shaft 3. The shaft 3 is made hollow so that the speaker 4 may be supplied with inputs through lead wires in said shaft. The speaker 4 is relatively heavy, so that a support rod 5 is protruded from the rear surface of the speaker 4 to

mount a balance weight 6 at its end remote from the speaker 4. The shaft 3 is coaxially provided with a pulley 7.

The base plate 1 has a support plate 8 attached below the frames 2. On the support plate 8 is mounted an electric motor 9. The motor may preferably be of single-phase induction type, since it exhibits lessened vibratory motions and noises. Over both a driving pulley 10 of the motor 9 and the above-mentioned pulley 7 is extended an endless belt 11, in order that the pulley 7 and accordingly the speaker 4 may be rotated by the induction motor 9. Although not seen in the FIGURE, a generator is arranged such that a rotary shaft of the generator is coaxially rotated with the shaft of the motor 9.

On the support plate 8 is also mounted a circuit plate 12. This plate is coupled through a lead wire 13 to a tremolo speed selector, which includes a turnable knob 14 and is juxtaposed with, for example, the keyboard section of an electronic musical instrument. The circuit arrangement on the plate 12, the wire conductor 13 and the speed selector constitute a motor drive and control device, as hereinbelow described, for continuously and controllably vary the speed of revolution of the motor 9 or the speaker 4.

The reference numeral 15 indicates a pivot type of feed terminal consisting of a metal strip one end of which is suitably supported with an insulator on the frame 2 and a semispheric conductive member protruding from the internal hollow of the rotary shaft 3 and held in contact with the metal strip. Although not seen in the FIGURE, another feed terminal of the same construction as of the terminal 15 is disposed at the other end of the shaft 3. The two feed terminals 15 are respectively connected through leads to an aural circuit (not shown), and are adapted to supply musical sound signals to the speaker 4.

In the embodiment, the loudspeaker 4 is capable of reproducing overall musical sounds. When it is desired to reproduce only some parts of the sounds, a loudspeaker exclusively used for said parts or the corresponding frequency range of tones may be employed instead. FIG. 2 shows in block the motor drive and control device, together with the speaker 4 and the motor 9. The drive and control device comprises a power supply 16, a speed detector 17, a voltage converter 18, a reference voltage source 19, a comparator 20, a voltage amplifier 21 and a regulator circuit 22. The power supply 16 drives the motor 9 for rotation of the loudspeaker 4. The speed-detecting circuit 17 detects the speed of rotation of the motor 9 or the speaker 4. The detected signal is converted into a corresponding voltage by the converter 18. The reference voltage source 19 is for setting a desired speed of tremolo, and is required to be capable of providing a continuously variable voltage. A reference voltage set by the source 19 and the voltage signal from the converter 18 are compared by the comparing circuit 20. A difference voltage obtained through the comparison is supplied to the amplifier 21 to be therein amplified. The amplified voltage signal is fed to the regulator circuit 22, which by the supplied voltage signal effects control of the power supply 16.

The motor 9 is coupled with the loudspeaker 4 as in the previous description with reference to FIG. 1. The loudspeaker 4 is of course connected with an aural circuit which is not shown in FIG. 2.

FIG. 3 concretely illustrates a circuit diagram which puts into practice the concept pictured in FIG. 2.

In FIG. 3, the single-phase induction motor 9 and a regulator 22 (a bridge 24 consisting of four diodes together with an across-connected transistor 37) are connected in series between two terminals of an AC source 16 of power supply. To one of the source terminals is connected a diode 25 in polarities as shown. The diode 25 is connected through a resistor to a bus line 26. Another bus line 27 is connected to the anode-anode junction point 39 of the diode bridge 24, which means that the bus line 27 is connected to the other of the source terminals through the left down one of the diodes of the bridge 24. Between the bus lines 26 and 27 is connected a capacitor 38 as a DC source, the bus line 26 being the plus

side line and the bus line 27 being the minus side line, which supply DC power to the reference voltage source 19 and the voltage amplifier 21.

The reference voltage source 19 comprises a variable resistor, which can provide at point 28 a continuously variable voltage easily by turning the knob 14 in FIG. 1.

Reference numeral 23 designates a generator the rotary shaft of which is coaxially rotated with the shaft of the motor 9 and which serves as the speed detector 17 in FIG. 2. Of course, the electric motor 9 and the generator 23 may well be a so-called motor-generator constructed in one unit.

The converter 18 comprises a bridge circuit consisting of diodes 29, 30 and resistors 31, 32 and capacitors 33, 34 respectively connected between a junction point between the diode 29 and the resistor 31 and a junction point between the resistors 31 and 32 and between the last-mentioned junction point and a junction point between the diode 30 and the resistor 32. A junction point between the diodes 29 and 30 and the junction point between the resistors 31 and 32 are respectively connected to either one of output terminals of the generator 23. The junction point between the diode 29 and the resistor 31 is directly coupled to the above-said point 28.

The voltage amplifier 21 includes a first transistor 35 and a second transistor 36 and is connected as shown across the bus lines 26 and 27. A base electrode of the first transistor 35 is connected to the junction point between the diode 30 and the resistor 32. A collector electrode of the second transistor 36 is connected to a base electrode of the transistor 37.

The operation of the motor drive and control circuit in FIG. 3 is as follows:

An output voltage of the generator 23, which is an AC voltage proportional to the rotation speed of the motor 9, charges the capacitors 33 and 34 in polarities as shown by + and = in the FIGURE, the capacitor 33 being charged with the current through the diode 29 during the positive half cycles and the capacitor 34 with the current through the diode 30 during the negative half-cycles. When the output voltage of the generator 23 goes high, the voltage charged in the capacitors 33 and 34 becomes high, and when the output voltage goes low, the voltage charged in the capacitors becomes low discharging through the resistors 31 and 32, thus will appear across the capacitors 33 and 34 a DC voltage which is determined by the motor speed. The potential at the point 28 is positive with respect to the bus line 27, said potential representing a desired motor speed, and the charged potential of the serially connected capacitors 33 and 34 is positive on the point 28 side and negative on the side of the base electrode of the transistor 35. Accordingly, a difference potential between the potential at 28 set by the variable resistor 19 and the total potential charged in the capacitors 33 and 34 is detected as a voltage between the base electrode of the transistor 35 and the lower potential bus line 27. This connection constitutes the comparator 20.

Now it is assumed that the motor speed is too low, which means the detected difference voltage is positive. The difference voltage is amplified by the transistor 35 thereby to lower the potential of the base electrode of the second transistor 36 and in turn to raise the potential of the base electrode of the transistor 37 of the control circuit 22. When the base potential of the transistor 37 is raised, the collector current of the transistor 37 which acts as a variable conductor connected across the junction points 39 and 40 of the bridge 24, and as a result current flowing through the induction motor 9 will be increased to speed up the rotation. It will be apparent that in case the motor speed is too high, which means the detected difference voltage is negative, the base potential of the transistor 37 is lowered whereby the motor current is decreased to speed down the rotation.

FIG. 4 illustrates the relationship between the number of revolution and the rotational torque of the single-phase induction motor 9, with parameters of reference voltages 1 V., 1.3 V., 2 V., 3 V., 4 V. and 5 V set by the variable resistor 19. In the FIGURE, the dotted curve shows the load characteristic of the rotatable speaker 4. As seen in the FIGURE, a larger difference voltage from the comparator 20 will drive the induction motor 9 with a larger rotational torque to cause the rotational speed of the motor 9 to rapidly approach a desired speed.

According to this invention when the motor speed is low, the conductance of the transistor 37 connected across the junction points 39 and 40 of the diode bridge 24 will be very high. When the rotational speed of the motor 9 comes near to a desired set speed, the conductance of the transistor 37 will begin to become low. As a result, when the motor 9 is started, it will be applied, irrespective of the magnitude of a set reference voltage, with a nearly full voltage of the power supply voltage, whereby the motor torque is large and an easy start of the motor 9 is always assured.

Furthermore, insofar as the reference voltage is set for a motor speed below a normal full speed of rotation at 50 Hz. power supply of the induction motor 9, said motor can be rotated by a power supply of 60 Hz. at the same determined number of rotations as by a 50 Hz. source of power.

With the embodiment of this invention, the tremolo speed is continuously variable over a wide range of from nearly zero up to normal full speed of the motor.

What I claim is:

1. A rotatable speaker apparatus comprising:
a rotatable loudspeaker;
an electric motor;
means coupling said motor to said loudspeaker to rotate said loudspeaker;
means to supply audio signals to said loudspeaker which are to be reproduced by said loudspeaker; and
electrical means connected to said motor and including:
a power supply for driving said motor;
a detector for detecting the actual rotary speed of said motor;
a converter coupled to said detector for generating a voltage which is a function of the detected rotary speed of said motor;
a reference voltage source for providing a voltage representing a desired speed of revolution of said motor;
a comparator for comparing the voltage generated by said converter with the reference voltage to produce a difference voltage;
an amplifier to amplify said difference voltage; and
a regulator circuit coupled to the output of the amplifier for continuously controlling the voltage supplied to the motor from the power supply, said regulator circuit including a four-diode bridge circuit and a transistor, the transistor having a base electrode thereof connected to an output terminal of said amplifier, the internal impedance of said transistor being continuously variable in response to said amplified difference voltage from said amplifier output, the emitter and collector electrodes of said transistor being respectively connected to a cathode-cathode junction point of said diode bridge circuit and to an anode-anode junction point of said diode bridge circuit.

2. Apparatus according to claim 1 wherein said detector has two output terminals and wherein said converter comprises a bridge circuit including two serially connected diodes and two serially connected resistors, the junction point between the diodes being connected to one output terminal of said detector and the junction point between the resistors being connected to the other output terminal of said detector; and two serially connected capacitors, one capacitor being connected between the resistor junction point and a junction point between the cathode terminal of one of said diodes and one of said resistors, and the other capacitor being connected between said resistor junction point and a junction point between the anode terminal of the other of said diodes and the other of said resistors.

3. A rotatable speaker apparatus comprising:
a rotatable loudspeaker;

an electric motor;

means coupling said motor to said loudspeaker to rotate said loudspeaker;

means to supply audio signals to said loudspeaker which are to be reproduced by said loudspeaker; and

electrical means connected to said motor and including:

a power supply for driving said motor;

a detector for detecting the actual rotary speed of said motor, said detector having two output terminals;

a converter coupled to said detector for generating a voltage which is a function of the detected rotary speed of said motor, said converter comprising a bridge circuit including two serially connected diodes and two serially connected resistors, the junction point between the diodes being connected to one output terminal of said detector and the junction point between the resistors being connected to the other output terminal of said detector; and two serially connected capacitors, one capacitor being connected between the resistor junction point and a junction point between the cathode terminal of one of said diodes and one of said resistors, and the other capacitor being connected between said resistor junction point and a junction point between the anode terminal of the other of said diodes and the other of said resistors;

a reference voltage source for providing a voltage representing a desired speed of revolution of said motor;

a comparator for comparing the voltage generated by said converter with the reference voltage to produce a difference voltage;

an amplifier to amplify said difference voltage; and

a regulator circuit coupled to the output of the amplifier for controlling the voltage supplied to the motor from the power supply.

4. Apparatus according to claim 3 wherein said regulator circuit includes a four diode bridge circuit and a transistor, the transistor having a base electrode thereof connected to an output terminal of said amplifier, and an emitter electrode and collector electrode thereof respectively connected to a cathode-cathode junction point of said four-diode bridge circuit and to an anode-anode junction point of said four-diode bridge circuit.

5. Apparatus according to claim 3 wherein the junction point between the cathode terminal of one of said diodes and one of said resistors of said converter bridge circuit is connected to said reference voltage source, and wherein said amplifier includes first and second transistors, a base electrode of said first transistor being connected to the junction point between the anode terminal of the other of said diodes and the other of said resistors of said converter bridge circuit, thereby receiving the difference voltage.

6. Apparatus according to claim 4 wherein the junction point between the cathode terminal of one of said diodes and one of said resistors of said converter bridge circuit is connected to said reference voltage source, and wherein said amplifier includes first and second transistors, a base electrode of said first transistor being connected to the junction point between the anode terminal of the other of said diodes and the other of said resistors of said converter bridge circuit, thereby receiving the difference voltage.