voltage and the stimulation circuit therefore carries out current control. The stimulation circuit includes a circuit section that converts an instruction value as a voltage to a current, and a current mirror circuit that outputs the converted current to the electrodes. This configuration is typical for the electrical stimulation circuit.

[0063] The current mirror circuit is shown in FIG. **9**. This example is configured from a positive power supply and NPN transistors but the discussion described below is exactly the same when a negative power supply and PNP transistors are used. A control current Ic is amplified by a ratio Rc/Rm determined by a resistor Rc and a resistor Rm and is outputted to the electrodes or the switching circuit. When the voltage of a high-voltage generating circuit (DC-DC converter) is Vh and a voltage at an output section of the current mirror circuit is Vs, a voltage drop of Vh−Vs occurs. The voltage drop occurs at the current mirror transistors. This means that a Joule heat of Im×(Vh−Vs) is consumed by the transistors. This heat does not contribute to the stimulation and wastes completely. If the resistance of the skin is high, a voltage Vs required for the same quantity of stimulation current to flow becomes high. The voltage drop Vh−Vs therefore becomes small and unnecessary power consumption is reduced. However, if the resistance of the skin is low, the unnecessary power consumption conversely becomes large. Typical values for the current system are a power supply Vh of 350V, a stimulation current Im of 5 mA, and a stimulation voltage Vs changing in the order of from 200V to 330V depending on the state of the skin. In the worst case scenario, (350−200)×0.005=0.75 W is always unnecessarily consumed.

[0064] In order to resolve this problem, adjustment is always performed where the stimulation voltage Vs is measured, and the power supply voltage Vh is set slightly higher (ten to thirty volts) than the measured stimulation voltage. The time period for adjustment can be in the order of one second because variation of the resistance of the skin is sluggish. The power supply voltage is typically outputted by a DC-DC converter for which it is well-known that voltage regulation is straightforward. This adjustment is carried out using high-speed switching driving. There is therefore theoretically no unnecessary power consumption such as with the current mirror circuit described above. Many stimulation voltage measuring circuits have been introduced in the past in order to optimize the waveform of the stimulation by measuring the impedance of the skin but using this information to adjust the voltage source in order to reduce power consumption has not been tried.

[0065] To summarize, the electrical stimulation circuit includes means for measuring the stimulation voltage (stimulation voltage measuring circuit) and means for adjusting the power supply voltage. The power supply voltage is then set to a voltage a predetermined voltage V (for example, 10 to 30 volts) higher than the measured stimulation voltage by the means for adjusting the power supply voltage. The setting of the power supply voltage by the power supply voltage adjustment means is preferably carried out in a predetermined cycle (for example, one second).

[D] Technique for Converting Environmental Information into Electrical Stimulation Pulse

[D-1] Problems with the Present Series Systems

[0066] According to the stimulation system, with respect to a large number of electrical stimulation points, only one or some out of all electrodes are stimulated at a certain instant and a surface pattern is presented by scanning, or changing the stimulated electrode, like television scanning lines. However, in the case of visual sense-tactile sense conversion, the number of stimulation points is substantially larger than in the related art (for example, sixty-four points for the fingertip electrical stimulation device of the related art, and 512 points for the present forehead-mounted electrical stimulation systems). The time taken to scan also becomes huge as the number of stimulation points increases and the overall stimulation frequency also falls. The time taken for stimulation of one point is currently in the order of 100 microseconds. The time taken for 512 stimuli is therefore 51.2 milliseconds. Namely, the stimulation frequency is approximately 20 Hz.

[0067] It has been considered to make the stimulation pulse itself short but this is impractical because a high voltage is required in order to provide the same amount of energy for a shorter time. It is known that when the stimulation frequency falls below a 30 Hz, a characteristic "coarse feeling" occurs in the stimulation, and a strong feeling of unpleasantness occurs. The idea that the stimulation frequency is kept at a fixed frequency or more is essential. Further, it is difficult to present changes in intensity of sensations by changing the stimulation frequency because of lower stimulation frequency. This means that currently only binary information of 1 (stimulate) or 0 (do not stimulate) can be presented. This means that, for example, only binary values of black and white can be expressed when presenting image information.

[D-2] Resolving Technique of the Related Art: Parallel Stimulation Circuits

[0068] In the related art, resolving means were achieved by putting the stimulation circuits in parallel and increasing the number of points stimulated at the same time. For example, when the number of stimulation points is 512, the stimulation points are divided into eight modules of 64 points. At the same time, the scanning frequency can be increased by a factor of eight by carrying out stimulation at eight locations at the same time. However, eight times the amount of current is required in order to drive eight channels in parallel. The increase in the size of the high voltage power supply is comparatively large in proportion to the increase in the current capacity. Currently, the power supply for driving one channel is of a size that is the permissible limit for existing mobile device. This means that resolution of the problem with parallel stimulation is not possible.

[D-3] Increasing Frequency and Providing Intermediate Gradation by Implementing an Automatic Threshold Value Adjustment

[0069] The number of times of electrical stimulation is adjusted by changing a determination function as to whether or not to carry out stimulation in real time to ensure that a certain maximum number of stimuli is not exceed. The maximum number of stimuli is set so that the time taken in overall stimulation does not exceed a certain time. In particular, when the stimulation frequency is 30 Hz or less (i.e. when a cycle is larger than 33 milliseconds), a strong sensation of unpleasantness occurs as described above. A typical value for the maximum number of stimuli in order to maintain the stimulation frequency at 30 Hz or more is therefore 33 millisec-