

**ELECTRIC TACTILE SENSE PRESENTING
DEVICE AND ELECTRIC TACTILE SENSE
PRESENTING METHOD**

TECHNICAL FIELD

[0001] The present invention relates to an electro-tactile display and an electro-tactile display method.

BACKGROUND ART

[0002] An electro-tactile sense presenting apparatus (an electro-tactile display) is a tactile sense presenting apparatus for directly stimulating tactile nerves under the skin from electrodes on the skin. A basic electrical stimulation procedure using electrodes arranged in a two-dimensional matrix is shown in FIG. 2. Each electrode can be connected to a current source and to ground using two switches in a configuration known as a half-bridge circuit. By switching over these switches, each electrode may be made to operate as a current source (current source electrode) or ground (ground electrode). By making an electrode at a location for stimulate a current source and putting other electrodes to ground, a current path may be formed under the skin in a direction from a current source electrode to ground electrodes so that nerve axons are stimulated.

[0003] The case where the distance between electrodes is small is considered here. At this time, a current path formed below the skin is shallow because the distance between a current source electrode and the ground electrodes is short. A problem therefore occurs where nerve axons that are at deep sections cannot be sufficiently stimulated. Specifically, in the case of the skin of a fingertip, human tactile resolution is in the order of 1.5 mm and it is therefore wished to arrange electrodes at approximately 1.5 mm. However, an appropriate distance between the current source electrode and ground electrode in order to stimulate nerves underneath the skin is about 2 to 3 mm. The problem described above is therefore extremely important.

[0004] If, at the switching circuit of FIG. 2, a high-impedance mode (a state where the two switches are both open) is possible, by taking electrodes neighboring the current source electrode to be high-impedance electrodes and taking electrodes at locations a little further away to be ground electrodes, it becomes possible to broaden the distance between the current source and ground and this problem no longer occurs (right side of FIG. 3). In non-patent document 1, a switching circuit is disclosed that provides a high-impedance mode where the two switches are open, and a short-circuit mode where the two switches are closed.

[0005] Here, when actually designing a device incorporating the above system, it is necessary to use an integrated circuit having a large number of half-bridge circuits in order to miniaturize the switching circuit portion. However, half-bridge circuits adopted in integrated circuits compatible with high-voltages do not have the high-impedance mode and short-circuit mode. It should also be considered that the main application of a high-voltage half-bridge circuit is to control micro-machines. In this application, these modes are not only unnecessary, but may also be harmful. Integrated circuits that are actually utilized do not have the high-impedance mode and this method therefore cannot be used for solving the problem.

[0006] Non-patent document 1: Takahashi, Kajimoto, Kawakami, Tachi, "Electro Tactile Display with Localized

High-Speed Switching", Proceedings of the Virtual Reality Society of Japan Seventh Annual Conference (Tokyo, September 2002), pp. 145-148, 2002.

[0007] It is therefore an object of the present invention to stimulate nerve axons of deep sections in a superior manner in electrical stimulation using an array of electrodes without deteriorating spatial resolution of the tactile stimulation even in cases where interval between the electrodes is narrow.

DISCLOSURE OF THE INVENTION

[0008] In accordance with one aspect of the present invention, an electro-tactile display comprises: at least one current source; arrayed electrodes; a switching circuit for connecting each electrode to the current source or to ground; and electrode selecting/switching means for selecting an electrode connected to the current source and an electrode connected to ground via the switching circuit and switching over the selected electrodes. The electrode selecting/switching means further comprises: first electrode selecting/switching means for connecting one or a plurality of electrodes at a position or positions for stimulation to the current source to provide one or a plurality of current source electrodes and switching over the current source electrodes at a predetermined time interval to present tactile sensations; and second electrode selecting/switching means for alternately connecting neighboring electrodes in the vicinity of the current source electrodes to the current source and to ground at a time interval shorter than the predetermined time interval.

[0009] In accordance with another aspect of the present invention, an electro-tactile displaying method is characterized by selecting one or a plurality of electrodes from arrayed electrodes and connecting the selected electrodes to a current source to provide one or plurality of current source electrodes; alternately connecting neighboring electrodes in the vicinity of the current source electrodes to the current source and to ground; connecting a plurality of remaining electrodes other than the neighboring electrodes to ground to provide a plurality of ground electrodes; providing electrical stimulation from the current source electrodes, the current source electrodes being spaced apart from the ground electrodes via the neighboring electrodes; and switching over the current source electrodes at a predetermined time interval to present tactile sensations. Switching of the neighboring electrodes of the current source electrodes is carried out at higher speed than the switching for providing electro-tactile sensations.

[0010] According to an electro-tactile display using arrayed electrodes, an electrode (a current source electrode) at a position for stimulation is connected to a current source, and other electrodes are connected to ground. A current path flowing from the current source electrode to ground is therefore formed at nerve axons beneath the skin, and nerve axons are stimulated. In accordance with the present invention, selecting one or a plurality of electrodes from the arrayed electrodes and connecting the selected electrodes to a current source to provide one or plurality of current source electrodes; alternately connecting neighboring electrodes in the vicinity of the current source electrodes to the current source and to ground; connecting a plurality of remaining electrodes other than the neighboring electrodes to ground to provide a plurality of ground electrodes; and providing electrical stimulation from the current source electrodes wherein the current source electrodes are spaced apart from the ground electrodes via the neighboring electrodes.