# Actuation mechanism for high-resolution tactile display


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## Abstract

Braille displays have been used to present symbolic information to blind person's fingertips. However, these displays could not convey schematic information such as figures. For the presentation of schematic information, we need to develop tactile display that consists of a pin array of higher resolution. To attain higher resolution we propose a novel actuation mechanism using low melting point metal. The low melting point metal is used to fix each pin; usually, the pin is clutched because the metal is solid, once a heater melts the metal, the pin is released and pushed up or down using compressed air. We implemented prototype display devices that have 10x10 pin array, with a pin interval of 2mm and a pin diameter of 0.5mm, actuated by the proposed mechanism, to evaluate the characteristics of the devices.



***Keywords:*** *Tactile display, Actuator, Low melting point metal, Compressed air*


## 1. Introduction

Braille displays present tactile information by 6 pins in an array of 2x3 for one ASCII character. This kind of devices require decoding skill, or a skill of reading braille, to users to extract displayed information; users have to train themselves to translate such symbolic codes into characters smoothly and quickly. Another disadvantage of braille display is that it can not present schematic information such as geometric shapes, which is often much more helpful than verbal explanations. For these reasons, we planned to realize a universal device that can present both braille characters and geometric shapes.

For the presentation of schematic information, we need to develop a tactile display that consists of a pin array with higher resolution than braille displays. In this paper, in order to attain higher resolution, we propose a novel actuation mechanism using low melting point metal. We implemented 2 prototype display devices. These have 10x10 pin arrays with pin distance of 2mm, respectively, to evaluate the characteristics of the devices.

## 2. Related works

Some previous studies have employed solenoid and bi-morph type piezo actuators.[1,2] However these

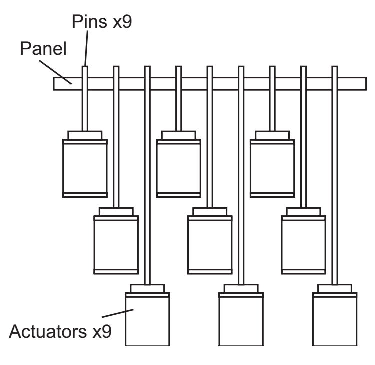


Fig.1 Ordinary structure of tactile displays.

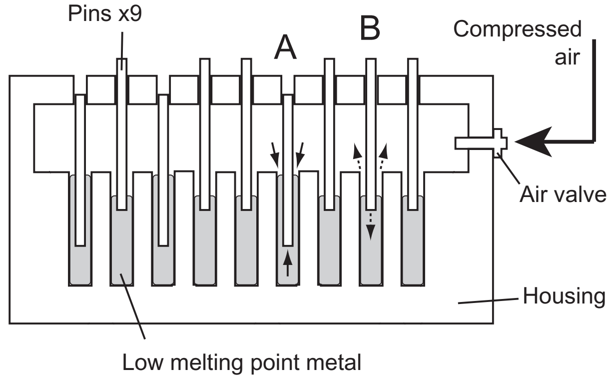


Fig.2 Proposed structure of tactile displays.

actuators are not necessarily suitable for high-density integration because of restrictions of the actuator's own size or form. Most researches on schematic tactile displays are trying to reduce the size of each actuator or to arrange them efficiently in space. Fig.1 shows an example of the structure of the ordinary display system. Since each actuator is too large to put it side by side with the others in an identical pitch as the pins, the actuators are stacked in three layers, which makes the device thick.[3,4] There is also a device that uses stepping motors as the actuator in combination with ball screws. It succeeded to present 3-dimensional information, or the information of height of each pin.[5]. This type of the mechanism has similar difficulties to increase the density of actuators.

## 3. Method

In order to improve the density of tactile pins, a smaller mechanism that can move and hold tactile pins is required. As such mechanism, we propose a structure of actuation mechanism using low melting point metal and compressed air as shown in Fig.2. The low melting point metal is used to fix each pin; usually, the pin is clutched because the metal is solid, once the metal is melted by heat, the pin is released and pushed up or down using compressed air or a vacuum. If you want to make the pin 'A' up, you heat the metal holding pin 'A' and pin 'A' become free to move; the pin is lifted if compressed air is introduced to the housing, because this air pressure is applied also to the bottom of the tactile pin by the principle of Pascal, and similarly, the pin 'B' is pulled down if air is removed from the housing. This structure is so simple that it is easy to assemble a high-density array of pins and to expand the array into larger scale. Another advantage of that mechanism is that the displayed information is held without any other power supply; in normal temperature, all of tactile pins are fixed by the low melting point metal in a solid state.

Two prototypes were implemented using the proposed actuation mechanism. Prototype 1 was used to confirm the feasibility of the actuation mechanism; by using this prototype, we evaluated the thermal and temporal characteristic of the mechanism in operation. Prototype 2 was used to test a heater matrix.

## 4. Prototype 1 -Possibility of an actuation mechanism-

Fig.3 and Fig.4 show the structure and the picture of the prototype 1. This equipment has an array of 10x10

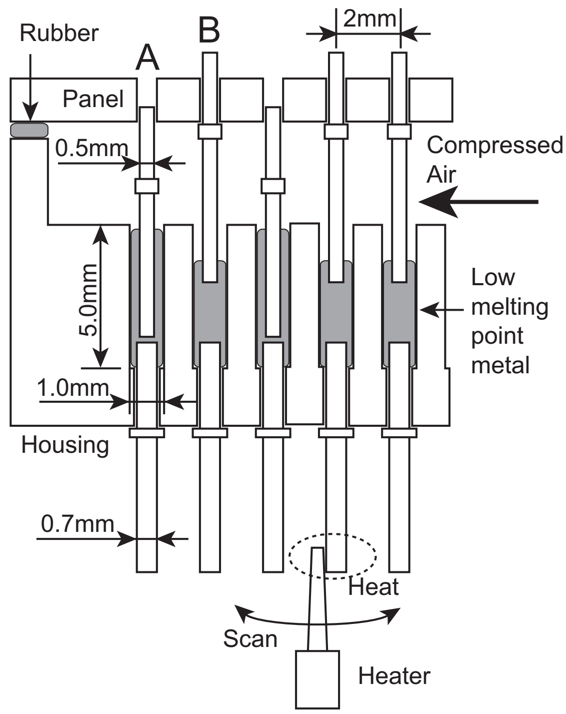


Fig.3 System configuration of prototype display 1.

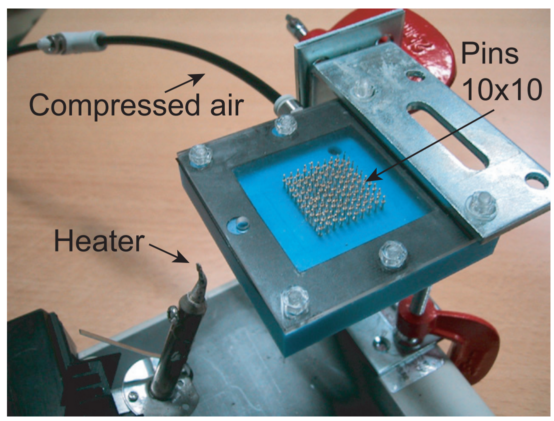


Fig.4 Overview of the prototype display 1.

pins with a distance of 2mm towards their neighbors. The vertical stroke length is up to 0.6mm from surface of the display panel and pin diameter is 0.5mm. We used low melting point metal with a melting point of 47 degrees Celsius (U-alloy 47, Osaka asahi metal). Each reservoir pit contains about 2.4 nano liters of the low melting point metal. Compressed air is delivered into the housing from a filter regulator, and the maximum pressure of the air is 0.1kg/cm$^2$. A ceramic heater with triac controller was used as a heat source, and the heat source can be moved by a X-Y plotter mechanism. The heat from the head source is conducted to a pin on the bottom of each reservoir pit by making directly contact.

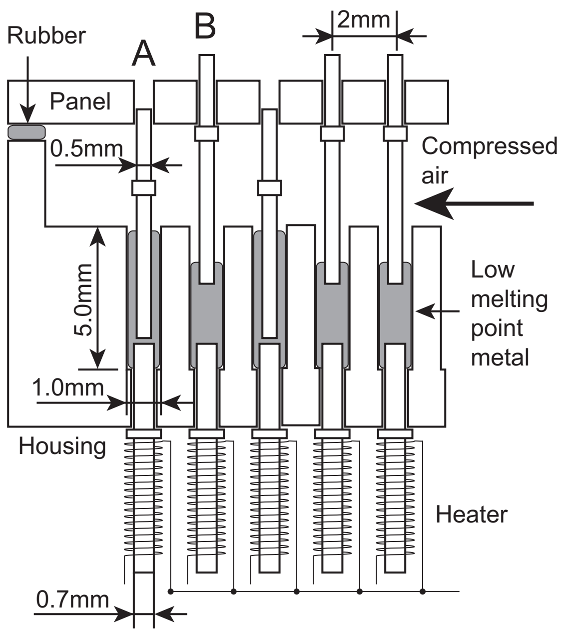


Fig.5 System configuration of prototype display 2.

The motion of the X-Y plotter, power of the heater, and operation of solenoid valves for air supply are controlled by a PC.

According to the measurement by a non-contact thermometer, the temperature of the heater tip part was about 100 degrees Celsius, and each pin was actuated within 5 to 10 seconds after the contact of the heater tip. Also we confirmed that the system can present tactile patters of the image of some Japanese characters by selectively actuating tactile pins.

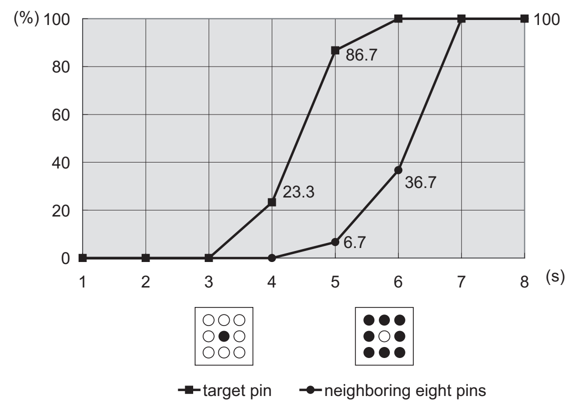


Fig.6 The characteristic actuation when heating target pins and neighboring eight pins.

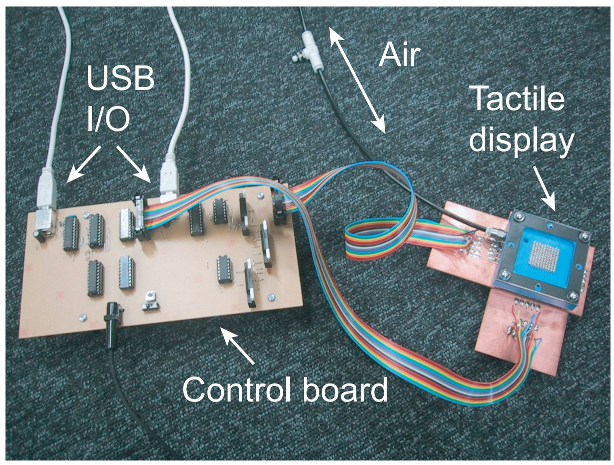


Fig.7 Overview of the prototype display 2.

## 5. Prototype 2 -Pattern presentation by matrix drive-

Fig.5 shows the schematic structure of prototype 2. The fundamental structure of this equipment is almost same as that of the prototype 1 except that each pin has a heater respectively in order to realize parallel operation of tactile pins. The heaters are composed of Ni-Cr wire and are driven by a control circuit that is similar to a controller of a LED matrix; this approach enables the system to operate heaters in a row selectively and at a same time.

Two kinds of experiments were conducted with the structure shown in Fig.5. Experiment equipment which has an array of 3x3 pins with a distance of 1.5mm. It can drive by heating each pin with individual conditions. The electric resistance of the Ni-Cr heater is about 90ohms, and consequently, if a voltage of 13.0V is applied, it is expected to heat with 1.9W. Compressed air was applied to the inside of equipment every 0.5 seconds for 0.1 seconds, and the air pressure was 0.1MPa. Most part of supplied heat is expected to be conveyed to a target pin. However, other part of the heat diffuses to neighborhood via the housing of display. In the experiment 1, only one central pin was heated and heating time required since a pin is driven was measured. The time required to actuate the target tactile pin was about 5 seconds heating. The next experiment, all the 8 pins other than a center was heated. When the 8 heaters were heated about 6 to 7 seconds, it turned out that the central pin begins to move up. Fig.6 shows the result of two experiments. The result suggest that the ideal heating time is about 5 seconds where the target pin is released without causing side effects on the neighboring pins.

The equipment shown in Fig.7 was made based on the experiment result. The heater built of Ni-Cr wire is about 60ohms, and the voltage at both ends of the heater is 7.0V. According to the measurement by a non-contact

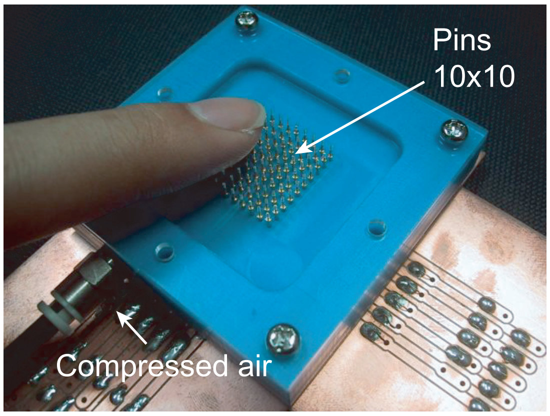


Fig.8 display area of prototype 2.

thermometer, the temperature of the heater tip part was about 100 degrees, and each pin was actuated within 5 seconds after the heating. We confirmed that we could update the information presented by the device within about 60 seconds, which is 60 minutes faster than the prototype 1.

## 6. Conclusion

The speed of the display system we developed is inferior to existing displays. However, there are various advantages derived due to the different structure.

A feature of the proposed mechanism is that all pins share a power source that drive them; all pins are driven by air pressure that affects force on them equally. Each pin has just a clutch mechanism controlled by heat; each pin is selectively actuated by supplying heat. Since the structure of the clutch mechanism is quite simple, it is easy to downsize the mechanisms; by reducing the size of the mechanism (or the volume of low melting point metal in the mechanism), the quantity of heat required for controlling the mechanism is also reduced. This feature of the proposed mechanism is thought to provide a benefit for implementing tactile displays with higher-resolution pin array. Once the size of these elements is reduced further, the heat capacity required to change the state is decreasing markedly, which promises improved response times.

Another advantage of our mechanism is that it can hold pins without power supply, because the low melting point metal is solid at ordinary temperature; since all the tactile pins of a display unit is clutched completely by the low melting point metal, pins are firmly fixed and they hardly move by external forces. This feature is useful if the tactile display with this mechanism is applied to a kind of notice board for blind people where information is not changed so often.

## 7. Future works

In this paper, a possible realization of a high-density tactile display unit was proposed. In our future work, we are going to investigate on reducing the time required for moving pins by improving the efficiency of heat conduction. For this purpose, we are planning to carry out thermal analysis on the mechanism.

Also, we are interested in implementing the device with higher-density and larger-scale pin array, and for this purpose we need to implement heaters for all pins in a more efficient way. One idea is to making a heater array on a print circuit board using surface-mount heating elements and imposing the heater array on the array of the clutch mechanism.

## References

[1] JAMES C. BLISS, MICHAEL H. KATCHER, CHARLES H.ROGERS AND RAYMOND P.SHEPARD: Optical-to-Tactile Image Conversion for the Blind, IEEE TRANSACTIONS ON MAN-MACHINE SYSTEMS, VOL. MMS-11, NO.1, MARCH 1970

[2] D. Stein. The Optacon: Past, Present, and Future. http://www.nfb.org/bm/bm98/bm980506.htm

[3] Yasushi Ikei, Kazufumi Wakamatsu, Shuichi Fukuda; Texture Presentation by Vibratory Tactile Display, Proc. VRAIS '97, IEEE, pp. 199-205, 1997

[4] KGS Corporation Tactile display GD-64X48, Dot View DV-1, Graphic cells SC5, http://www.kgs-jpn.co.jp/

[5] Masami Shinohara, Yutaka Shimizu, and Akira Mochizuki: Three-Dimensional Tactile Display for the Blind, IEEE TRANSACTIONS ON REHABILITATION ENGINEERING, VOL. 6, NO. 3, SEPTEMBER 1998