FIG. 11 shows a schematic of a preferred design for the electrical circuits needed to generate the current pulses selectively into each and any of the shape memory wires, throughout the display area.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

Each dot of a tactile display according to the present invention, is attached to the upper part of a mobile assembly comprising a vertical cylindrical rod **1**, two horizontal circular springs **11** and **14** to lock elastically the mobile assembly in its raised and recessed positions, and two shape memory wires **22** and **28**, to move up and down the whole assembly. The mobile assemblies are mounted perpendicularly to six horizontal plates: a top reading panel **21**, comprising a regular array of holes through which the tactile dots can protrude when the corresponding mobile assemblies are in their raised position, four boards **25**, **4**, **5** and **31** which support the mechanical elements, the electronic parts and the printed electric wires used to supply electric power to the shape memory wires, and a bottom protective plate **34**.

The vertical layout of these display elements is shown on FIG. **1**, **4** and **5**. The vertical rod **1** is allowed to move along its vertical axis through holes provided in the horizontal boards. The circular springs **11** and **14** have one end inserted, from opposite sides, into a small hole drilled into the middle of rod **1** perpendicularly to its axis. The remaining ends of each spring are similarly inserted into small holes drilled in two support rods **6** and **7**, held between the boards **4** and **5**, in such a way that the amplitude of the vertical displacement of the mobile assembly is defined by the distance between the inner boards **4** and **5**, and by the thickness of the locking springs, their ends rotating inside said holes during the displacement.

The springs are mounted in such a way that they are compressed between the mobile rod on one side, and their respective support rods **6** and **7** on the other side. The vertical components of the compression forces keep the ends of the springs pressed against the board **4** in the raised position of the mobile assembly, and against the board **5** in the recessed position of the assembly, thus providing the desired elastic lock-up mechanism for this mobile assembly.

To prevent the user from accidentally moving a dot from its raised to its recessed position by applying an excessive pressure on the tip of the tactile dot, this dot is mounted elastically on the upper end of the mobile assembly, by using a coil spring **19** inserted between the dot **16** and the top of rod **1**, which limits the force which can act downwards upon the mobile assembly if a pressure is applied to the dot protruding above the surface of the reading plate. The spring **19** is designed to insure that this force is lower than the vertical force provided by both lock springs, while insuring an adequate stiffness to the tactile dot.

A shape memory wire **22** made of a nickel-titanium alloy is attached by its ends to the eyelets **23** and **24** clamped across the horizontal boards **25** and **4**, in such a way that its middle part rests in a rests in a horizontally extending portion of a vertical slot **27** cut in the upper part of the rod **1**, the wire being almost horizontal and the shortest when the rod is in its lower position, and assuming an inverted V shape and being the longest when the rod is in its upper position.

Another wire **28** made of a nickel-titanium alloy is attached by its ends to the eyelets **29** and **30** clamped across the boards **31** and **5**, in such a way that its middle part rests in a horizontally extending portion of a vertical slot **33** cut in the lower part of the rod **1**, the wire being almost horizontal and the shortest when the rod **1** is in its upper position, and assuming a V shape and being the longest when the rod is in its lower position.

The shortest size of each wire corresponds to its contracted shape, memorized during its fabrication, and the longest size corresponds to its extended shape, obtained by pulling on the wire by a sufficient elongation force. In order to achieve a large number of extension-contraction cycles without any irrecoverable deformation of the wire, the wire elongation must be kept below a threshold depending upon the properties of the alloy used in the fabrication of the wire, typically less than 3 per cent. This condition, combined with the desired vertical travel of the tactile dot, determines the length of the wire.

The displacement of the mobile assembly from one position to the opposite position is obtained by sending an electrical current pulse through the wire to be contracted, for example the bottom wire if the rod occupies initially its lower position. The wire is quickly heated to its shape recovery temperature and then provides, during its contraction, the vertical force needed to unlock the mobile assembly and move it towards its opposite position.

The diameter of the wire is chosen to provide a force strong enough to overcome at any time during the upward motion, the sum of all the forces involved: the vertical component of the compression force of the locking springs **11** and **14**, the force needed to compress eventually the dot spring **19**, the force needed to elongate the opposite wire and the friction forces. During the second half of the vertical motion, the vertical component of the compression force of the locking springs helps accelerate the rod towards its new position.

The electrical current pulse is controlled by the transistors **40** and **41** respectively for the top and bottom wires. These transistors are mounted between the board supporting the wire and the nearest board supporting the locking springs. Electrical conductors, printed on these boards in directions parallel to both the rows and the columns of dots, provide to every transistor the electrical signals necessary to produce the desired current pulses through either the top or the bottom wire, at any selected dot position. These conductors constitute a network of electrical lines connected to the shape memory wires through their respective eyelets and transistors.

To allow the juxtaposition of any number of dots in parallel rows and colas, the volume available inside the display is divided into **5** horizontal slices. The upper slice, between the reading plate **21** and the board **25**, is devoted to the top wires and the upper section of the rods **1** as shown on FIG. **6**. The next slice, between the board **25** and the board **4**, is devoted to the upper transistors **40**, the upper eyelets and the upper-middle section of the moving assemblies, as shown also on FIG. **6**. The middle slice, between the boards **4** and **5**, is devoted to the locking springs, their supporting rods and to the middle section of the moving assemblies, as shown on FIG. **7**, the springs being imbricated in such a way that they can move up and down without touching their neighbors. Each supporting rod can hold two springs belonging to adjacent assemblies. The two lower slices are used in a way similar to the corresponding upper slices.

The total thickness of such a display can be kept below 0.5 inch with a dot pitch of 0.1 inch. Typical wire dimensions are 0.5 inch long and 3 to 4 mils diameter, for a vertical dot travel of 32 mils.