Pin setting and resetting for the apparatus of this invention utilize approaches that reduce the number of actuators needed by a very large factor compared to heretofore known devices and include a one-dimensional scanned actuator array. Each of the various approaches taught herein has its own advantages and, thus, applications for which it is most effective.

A first embodiment utilizes a one-dimensional scanned array of actuators with spacing matching that of the pins. The array is passed across the display (e.g. contacting the bottom portions **35** of pins **21**) and each actuator sets the selected pins that it encounters. The entire display is written in a single pass, and the number of actuators needed to set the pins is greatly reduced. For example, in a display with an m by n array of pins, and an m×1 actuator array, the number of actuators needed is 1/n of the number needed using the conventional approach of one actuator per pin. The additional time needed to scan the actuator array across the display will not be an issue for many applications, since the tactile reading of two-dimensional images is a relatively slow process. This approach requires precision 1-dimensional tracking of the actuator array and placement to align it with the pins that each actuator must control.

Raster scanning of the display could be utilized. A monochrome CRT (cathode ray tube) monitor uses an electron beam that sweeps across each row of the visual display in turn, until all the rows have been traced, allowing one beam to drive every pixel in the display in sequence. A similar approach can be used in setting pins **21** in the extended array tactile graphic display of this invention, wherein one actuator is moved across all the pins in the display, setting the selected pins to form a pattern. Since there may be many thousands of pins and the mechanical setting process is much slower than the writing process of an electron beam, the process may be speeded by raster scanning using a 1-dimensional array that in length is an integer fraction of one of the dimensions of the pin array. For example, in a display of m rows and n columns, an m/8 by 1 array of actuators can scan ⅛ of the rows at a time, so that the entire display is written in 8 passes. Raster scanning requires precision 2-dimensional guidance of the actuators.

Another approach utilizes vector drawing. Most tactile graphic drawings for accessibility place an emphasis on lines and curves, since these are easier to interpret using the sense of touch than area fills. It is possible to take advantage of this tendency by designing a tactile graphic display that employs vector drawing methods to set pins **21**, with as little as one actuator setting all the pins for the drawing. Rather than systematically scanning all the pins on the display, the drawing is specified in terms of a set of lines and curves (vectors), and the actuator is made to draw out these lines and curves on the display by following the vectors and setting the pins that are encountered. The vectors are followed using a precision 2-dimensional guidance system comparable to that of a 2-dimensional graphic plotter used for making visual plots on paper. Selected pins can be explicitly set by precision placement of the actuator, or the actuator can be made to set all those pins it happens to encounter in its passage. The latter method works especially well if the writing process is performed by pressing against the ends of the pins opposite the ends that the user reads, and facilitates very fast vector writing of the image (since the positioner does not have to pause at each selected pin). It also facilitates scaling of images to larger or smaller sizes, since it is not necessary to calculate in advance a mapping between the vectors needed and the physical placement of the pins in the display (though such calculation may result in an improved tactile graphic image).

When using the vector drawing approach, the time to complete a drawing is no longer a constant: it becomes proportional to the complexity of the drawing. The drawing is a set of straight or curved vectors, each of which is made by positioning the actuator at the starting point, engaging the actuator, following the specified vector, then disengaging the actuator. This approach lends itself very well to incremental drawing (described above), since individual increments that involve a few vectors may take a very short time to write compared to the time needed to scan the entire display. If the source imagery is not in vector form, then the display driving algorithm must include the capability to efficiently transform other image formats to vector form. There are image processing programs currently commercially available that can be adapted to perform this function. Vector conversion may include the introduction of brief delay cycles in the drawing vectors to ensure that the drawing speed does not exceed the speed capability of the display components.

Tactile graphic vector drawing can be conducted using a tracker **93** either hand operated (in the simplest mode of operation) or mounted at a precision 2-dimensional guidance system **94** and having a freely rotating metal ball **95** maintained in the end of tube **97** (similar in structure to the tip of a ballpoint pen) to press against the pins on the back of the display when the actuator is engaged (FIGS. **12** and **13**). The diameter of the ball determines the number of pins that are expected to be set with any arbitrary motion of the tracker, and thus the solidity and thickness of the tactile line to be drawn. A thicker line can be drawn by multiple passes of tracker **93** with a slight offset of ball **95** for each pass.

Alternatives to the roller ball tracker **93** are a precision actuator tip that contacts selected pins individually (provides greater precision, but slower drawing), and a tip that vibrates with sufficient amplitude and sufficiently high frequency that it impacts and sets all the pins along the vectors being drawn.

The section above on pin locking describes the desired mechanical properties of the control for the pin locking mechanism—the need for precision motion control of the locking mechanisms for all the pins, moved all together for a very short distance, with the need for the locking mechanism to remain stable during the reading process. For a powered display, an actuator can provide the needed force to engage and disengage the lock, and can be controlled by the same control system that operates the other components of the display. Because reading may often be a lengthy process and the user may sometimes want a particular image to be displayed for a long period of time, it is desirable for retention of the lock to be performed by the mechanical linkage to the locking mechanism, so that the pins remain locked (and the image is retained) with no additional application of power once the lock is engaged.

When the time comes to reset the display, the pin locking mechanism is disengaged, and all the pins must be reset, possibly requiring force to overcome the effect of the temporary pin holding system. A device that engages all of the set pins of the display and moves them to the reset position is one approach, and could be made as part of the locking mechanism. This can be accomplished by including a plate in the array stack that can move vertically (perpendicular to the plane of the display) as well as horizontally, and has ovoid holes or other mechanism to catch the pins—for reset, the plate would be moved horizontally to catch all the pins that have been set, then vertically to move the pins to the reset position. A simpler approach is a roller