the direction opposite the direction of actuator movement. This would allow a linear display to be built with a total length not much greater than the length of the line of Braille displayed. If the material forming the retention device were even thinner and more flexible, the retention device could be maintained, fed from and reloaded at a spring-loaded roller.

[0108] A linear display would display a line at a time, and the line would be scanned in from one end to the other, unlike the near-simultaneous update possible with the conventional linear displays that use a separate actuator for each dot. However, with fast actuators, the time to write an entire line would be relatively short. Given the savings achievable in cost of the linear device of this invention due to the greatly reduced number of actuators, the time delay is felt to be acceptable.

[0109] Any degree of friction in the display system of this invention increases the amount of energy required to operate the display and increases the potential for wear of parts. A certain amount of friction in the motion of the pins along their shafts may be desirable to prevent the pins from slipping out of position during text or other tactile display cycling (i.e., during the transition from actuator to retaining device, from retaining device to passive positioning device, and from passive positioning device to actuator), thus rendering the device less susceptible to outside influences of gravity and vibration. A certain amount of friction in the system can also reduce the risk of build-up of internal vibrations leading to excessive system noise, timing errors and damage.

[0110] With these factors in mind, production of the display should take into account both the friction and the wear resistance of the components. Some form of lubrication is desirable (for example, a dry powder lubricant such a graphite or, where stiffening of component movement is desired, various known greases). Friction may be introduced into the system in a controlled manner at the transition points in the display cycle by application of a soft, compressible material such as felt, for example.

[0111] Pin shafts with a circular cross-section may have a tendency to rotate in their openings as the wheel rotates. This will not affect readability of the display at the viewing aperture, but may result in a risk of accelerated or uneven wear of the pin or the opening in which the pin moves. Pin rotation can be eliminated by utilization of pin and opening configurations defined by a non-circular cross-section.

[0112] Conventional Braille uses two dot levels, extended (dot) and retracted (no dot). It is possible to generate additional levels, however, for other application utilizing the display device of this invention by employing actuators capable of multi-position extension and multiple position retention devices **219** (as illustrated in **FIG. 24**, replacing the two position devices as shown in **FIGS. 16 and 17**, for example).

[0113] Turning now to **FIGS. 25 through 28**, embodiments of this invention configured to allow extensive actuation of pins no matter direction of travel of the cylinder (or relative direction of travel of actuators and pins in other embodiments) are shown. In these FIGURES, it should be understood that the illustration of the embodiments have been greatly simplified, but that all elements previously discussed (particularly with reference to **FIG. 6**) can be and are applied in the embodiments discussed hereinbelow unless otherwise noted. In particular, the various actuator (at least in part) and pin embodiments discussed are understood to be applicable herein as are the various position retaining devices heretofore discussed. It is desirable, however, for at least some of the embodiments discussed below to eliminate the various passive default pin positioning devices heretofore discussed for reset of the pins.

[0114] A first embodiment of the apparatus and method utilizing bi-directional relative movement for implementation of a refreshable tactile display is illustrated by **FIG. 25**, wherein passive reset of rows **121** of pins **81** in openings **93** as heretofore described (for ease of illustration, none are shown in **FIG. 25** or **26**; refer to **FIG. 6**) is accomplished with a two ramp default positioning device **212** (as discussed with respect to **FIG. 23**). Device **212** is located between assembly **45** and a second set, or assembly, **250** of actuators much like assembly **45**, the two assemblies together comprising an actuator station **255**.

[0115] The arrow shows the direction of normal rotation of cylinder **27** for normal reading and advancement of the Braille text, with pins being set by actuator assembly **45**, assembly **250** being inactive. If the user wishes to re-read text that was displayed at reading, or display, area **39** on surface **33** but which has already passed from display area **39** (effectively reading backward), the direction of rotation of cylinder **27** is reversed by the user at user input **75** of controller **65**, and the second set of actuators **250** sets the pattern of Braille text as far back as the user wishes to read (assembly **45** remains inactive during this period) under the control of properly programmed control implementation **65**/driver **81** (**FIG. 4**). Position retaining device **99** and default positioning device **212** operate as before and are accessible in either direction of cylinder rotation.

[0116] **FIG. 26** shows another implementation of a bi-directionally rotatable cylinder for streaming Braille text in either forward or backward order at display area **39**, with only a single set, or assembly, **260** of actuators at station **262**. In this case actuators that can set or reset pins, regardless of the initial positions of the pins, by contacting and moving a pin in either direction in its opening. This design takes advantage of the fact that the user does not expect any text that has already been read to change, so with no automatic reset, all of the text that is at the bottom of the cylinder (outside of the reading area) is still readable if the direction of the rotation of the cylinder is reversed. The single set of actuators **260** is therefore used for both forward and reverse writing (under the control of properly programmed control implementation **65**/driver **81**), and the user reading the Braille text can thus request movement arbitrarily far forward or backward along the line of text by controlling cylinder rotation at user input **75** of controller **65** (**FIG. 4**). Again, position retaining device **99** operates as before and is accessible in either direction of cylinder rotation.

[0117] **FIG. 27** illustrates one way to implement the array of dual directional actuators **260** to control position of pins **81**. Actuator shafts **265** of individual actuators **266** in assembly **260** (only one of which is shown in **FIG. 27** for ease of illustration) are configured with arms **267** and **269** each having a contact tip **271** and **272**, respectively, thereat. Actuators **266** are positioned so that contact tips **271** and **272** are located to provide the ability for the actuator to push