83 diameter, it may be sufficient to have passive position retention device 99 contact only one side of the pin (head and shaft) thereby eliminating the redundant elements 187 of the device utilized to define slots 185.

For all passive positioning devices 165, 101 and 99 shown hereinabove, pin head 85 configuration is important. The various ramps and elements that provide pin raising, lowering and/or retention must be able to contact underface 183 of pins 81 if they are to be lowered (retracted) or retained, and must be able to slide along the pin edge smoothly if they are to be raised (extended).

In particular, where a pin 81 is so extended as to be in contact with surface 104 of wheel 27, a ramp structure 169 utilized for retracting the pin must be able to be inserted between pin head 85 and surface 104 at its leading edge 175. In addition to the edges of pin heads 85 being well rounded or otherwise sloped, a thin ridge of material 191 is preferably incorporated with pins 81 (a collar as shown in FIG. 18) and/or at openings 93 at surface 104 of wheel 27 (a surrounding lip as shown in FIG. 19) to prevent pin movement to a fully flush position with surface 104 and allow a gap for more ready acceptance of leading edge 175 of ramp structure 169.

In the event of geometric constraints, for example the diameter of each of the actuators 49 being greater than the spacing between adjacent rows 121 in a Braille cell, methods can be used to concentrate the effects of the multiple actuators 49 down into the space required (i.e., to fit the actuators to the available space). Some such methods include use of shaft linkages 195 (mechanical or flexible linkages, for example) as illustrated in FIG. 20, or utilization of different pin and/or actuator shaft 51 lengths (see FIG. 21, for example, wherein actuators 49 are staggered and employ different shaft 51 lengths).

FIG. 22 shows a combination actuator/passive position retention device 200 that includes a flexible or hinged extension 202 positionable by actuator 49 to act as a ramp, guiding pins 81 that contact the ramp from a default position to a non-default position. When extension 202 is raised by actuator shaft 51, pin heads 85 pass underneath it and remain in the default position. The connection between actuator shaft 51 and extension 202 is offset relative to a line defined by a row 121 of pins 81 so that the moving pins do not impact actuator shaft 51. This permits use of a relatively long ramping and, thus, a relatively shallow slope to move pins 81. Changes in position of extension 202 while pins 81 are in transit therealong will cause those pins on the ramp defined by extension 202 to be immediately shifted by some amount but will not effect the final positions of the pins in the reading aperture.

The construction of rotatable outer rim 105 of FIG. 6 can be single piece, with pin shaft openings 93 drilled or molded, or multiple piece, one or two ring layers per row 121 of Braille pins. If assembly 92 is placed in an assembly workstation with drive shaft 109 pointed down, pins 81 may be inserted in openings 93 of outer rim 105 and then rotating assembly 92 lowered down and fitted into place in housing 37. Non-rotating assembly 95 will prevent pins 81 from falling out of outer rim 105 once it is in place.

The techniques described for a wheel-based display could also be applied to a more conventional structure of a line display. As shown in FIG. 23, pins 81 can be placed in a linear, nonmoving matrix 208 at a housing (not shown), and assembly 210 moved underneath pin matrix 208 to set pins 81 and thus the Braille dots as heretofore disclosed. Moving assembly 210 includes a passive pin default positioning device 212 (a two ramp structure generally of the type shown in FIGS. 14 and 15 for lowering pins 81), followed by actuators 49 (one for each row of pins, three or four total for the entire line) and passive pin position retention device 99. Assembly 210 as shown moves from left to right, with establishment of pin default position being assured at forward ramp 214 of device 212, writing and fixing the Braille text as it moves. When the user is finished reading the line of Braille text streamed across reading area 33 and signals for a refresh, moving assembly 210 travels back (from right to left in the FIGURE), with actuator shafts 51 retracted. The reversed ramp 216 of passive default positioning device 212 lowers any pins 81 that were raised to allow passage of passive default positioning device 212 during return.

Passive pin retention device 99 is configured to be as long as the entire line of Braille cells in the display. Thus the entire Braille display assembly in this case will be more than twice as long as the line of Braille displayed. If, however, the passive pin retention device is made of strips of flexible material, supported along the sides away from the pins and of sufficient flexibility to support large-radius curves along its length but sufficiently stiff to prevent lateral flexing(steel tape for example), then the strips may be guided along tracks, grooves and/or wheels to wrap around under the moving assembly and thus extend to at its end in 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.

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.

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.

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.

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