angle of initial contact with pin heads **85**, yet small enough to avoid interference with adjacent pins. This, in turn, depends in part on the relationship among pin spacing, pin head diameter, and the distance the pins must travel.

The solenoid type actuators shown in FIGS. **8** and **9** are designed to be both extendible and retractable on command, for example utilizing a unidirectional solenoid with spring mounted return motion. An active bi-directional solenoid could also be utilized. The distance of travel of actuator shaft **51**, and thus element **137** at the shaft end, is controlled, for example, by stops or other such means to insure conformance to the geometry requirements of the display apparatus **91**.

Alternative actuator designs and implementations are described hereinafter and some are illustrated in FIGS. **10** through **12**. Instead of using solenoid type actuators, electromagnetic actuators **145** could be utilized as shown in FIG. **10**. The default position of pins **81** would be the raised position (retracted, utilizing the device shown in FIG. **14**, for example) and pins **81** would be made of magnetically responsive metal (in other embodiments, the material utilized for the pins is of little consequence so long as they are robust). A bank of electromagnets **145** (the number and arrangement thereof being the same as heretofore discussed) mounted in the nonrotating assembly **95** at station **47** of rotating wheel **27** are selectively activated to cause selected pins **81** to move to the lowered (extended) position. Pins **81** thus function as an element of the actuator in such case. The configuration and strength of electromagnets **145** and the geometry and assembly must be chosen to prevent one electromagnet from shifting unintended pins **81** in the same or adjacent rows **121**. Avoiding inappropriate shifting of pins may be assisted by slightly staggering the switching area and electromagnet placement along the path of motion for the different adjacent rows **121**, with pins **81** only able to shift in one row at each position (pins in other rows held by a passive retention device **99**, for example).

Use of permanent magnets can assist in achieving the goals of maintenance of small actuator size and quick actuator response. Again pin material and geometry are chosen so that pins **81** will not be inappropriately shifted by the electromagnets. Permanent magnets may be incorporated in pin heads **85** and/or shafts **83**, with electromagnetic coils at the various activation positions. Alternatively, permanent magnets **147** may be incorporated in actuator shafts **149** operating against fixed electromagnets **145** in an actuator body (electromagnetic polarity switching controlling movement of the shaft) as shown in FIG. **11** (exactly the opposite arrangement, as well as combinations thereof, could as well be utilized). Moreover, one large permanent magnet **151** as a fixed component of an actuator could be utilized in conjunction with three (or four) adjacent movable electromagnets **153** (at actuator shafts **149**) to control positioning across the three or four rows **121** of pins **81** (FIG. **12**).

Many other actuator configurations may be conceived of without departing from the intended scope of this invention. For example, a sliding spring or Earth's gravity in a lateral shutter arrangement may be used to assist the motion of the pins. In the case of gravity assist, the orientation of the reader in use must be a constant. In the case of spring assist, the pins must be configured with a projection or similar physical feature part of the way along the shaft against which the spring may act. In either case, the actuators are used to operate sliding shutters that move perpendicular to the axes of the pins (i.e., perpendicular to the direction of motion of the pins), opening and closing apertures. When an aperture is closed, a pin moving past is unable to move along its opening and remains in the default position (either raised or lowered depending upon configuration). When an aperture is opened, the spring or gravity assist moves the pin to the non-default position. In either case, the pin is then held in its selected position by a passive position retention device as it moves across the reading aperture.

Another example is similar to the spring-assisted option above, except that the external force to assist or cause motion of pins along their axes is air pressure (i.e., an external source of pressurized air or a source for partial vacuum). A pressurized air source moving the pins to the raised (extended) position would provide the further benefit of cleaning the device and keeping the pin shafts clear of debris.

Other actuator examples utilizable with this invention include rotary actuators (utilizing linkages to convert rotary to linear motion), cam actuators (allowing pins to pass undisturbed on their flat side and rotatable to a position for moving pins relative to their sloped side) and hydraulic actuators. Rotary or cam actuators can be uni-directional or bi-directional in their rotation, should be able to start and stop rotation rapidly, and must be configured for precision positioning. Use of pneumatic or hydraulic actuators may actually provide additional benefits since the bulk of such devices can be physically located at a position other than directly adjacent to the pins. Factors such as compressibility and mass of the working fluid, elasticity of the conduits, and friction should be considered since each will have an effect upon the response time and maximum rate of operation of the apparatus.

Devices for default positioning of pins **81** after reading are shown in FIGS. **13** through **15**. Again, for ease of illustration, FIG. **13** and FIGURES following show a linear implementation of the default positioning and position retaining systems (a curved implementation for use at a segment of wheel **27** would employ the same structure and principles). The collection of pins **81** mounted through openings (or apertures) **93** in a block of material forming the readable surface **33**, are capable of movement back and forth through the block in their respective openings (in FIGURES and **14**, pins **81** that are moved to the right are considered raised, because tips **84** of pins **81** extend beyond reading surface **33** of the block and are thus felt as bumps, or dots, at the surface). The block segment shown in FIGS. **13** and **14** is moving in the direction illustrated by the arrow with respect to a non-moving retaining wall **161** (for example, surface **163** of structure **97** in FIG. **6**) to which the positioning devices are attached and that limits the extent to which pins **81** can be retracted. As they approach the default positioning devices, pins **81** may be in either the raised or lowered positions.

FIG. **13** shows default positioning device **165** including ramp structure **167** affixed at the non-moving portion (i.e., structure **97**). As wheel **27** moves past ramp **167**, pins **81** that were in the lowered position are forced into the raised position. Pins that are already in the raised position are unaffected. The result is that all of the pins are forced into the raised position (extended from the surface) as they pass ramp **167**, and are kept in that position by extending the end of the ramp along the direction of travel as is needed until acted upon by an actuator (external as in FIG. **2** or magnetic as in FIG. **10**, for example). Note that in a Braille display, the passive system that positions and holds pins in the raised position and the length of the pins must be sufficiently tightly controlled to meet the dimensional specifications for a raised Braille dot.