exceeds the air flow out of the chamber **30** through the leak hole. When the air flow into the chamber **30** is reduced to a certain amount or discontinued (as when the MEMS device **16** is closed) the Braille dot **20**, because of its resilient nature, will contract, as described above, and forces the air out of the chamber **30** throught the leak hole. The actuator **28** can be operated electrostatically, thermally, piezoelectrically or using shapememory alloys.

[**0049**] Referring now to **FIG. 7A and 7B** there are shown detail views of a Braille dot with a MEMS device **16** extended and retracted, respectively. The actuator **28** is a sliding element operating between two electrodes (electrostatic), **281***a* and **281***b* depending on to which electrode voltage is applied. In **FIG. 7A** voltage is being applied to electrode **281***b* and the slide element **28** is attracted to it, opening a passage to plenum **32** and closing the passage to the vent path **33**. In this position air flows into the chamber **30** and the chamber **30** is allowed to pressurize and expand the Braille dot **20**. In this the Braille dot **20** is formed by distorting the top surface **46** attached to the frame **24** (which may be part of the housing **22** module **18** and is not shown in **FIG. 7A** or 7B). The Braille dot **20**, is just a dimple in the top surface **46**. Referring now to **FIG. 7**B, voltage is applied to electrode **281***a* and the slide element **28** is attracted to it closing the passage to the plenum **32** and opening the passage to the vent path **33** and allowing the pressure to vent out of the chamber **30**. Without the pressure, the Braille dot **20** contracts, flattening out the Braille dot in the top surface **46**. The voltage to the electrodes **281***a* , **281***b* is controlled by either the microcontroller **40** through lines **44** or the module microcontroller **45** through lines **44** allowing independent extension and retraction of the Braille dots **20**.

[**0050**] **FIG. 8** is a design for a microelectromechanical device that indirectly actuates a Braille dot by opening and closing a valve that allows gas, e.g. air, etc or fluid to exert pressure on a resilient, flexible polymer to form the Braille dot **20**. In **FIGS. 8A and 8B** are shown detail views of a Braille dot **20** with a MEMS device **16** extended and retracted, respectively. The actuators are a pair of MEMS microvalves **284***a* , **284***b* which open or close. The MEMS microvalves **284***a* , **284***b* can be actuated electrostatically, thermally, piezoelectrically or using thin film shape-memory alloys. In **FIG. 8**A, the MEMS microvalve **284***a* is open allowing pressurized gas from the plenum **32** into the chamber **30**, while the MEMS microvalve **284***b* is closed blocking the pressurized gas from leaving the chamber **30**. The pressurized gas in the chamber **30** expands the Braille dot **20**. In this the Braille dot **20** is formed by distorting the surface covering **45** attached to the frame **24** (which may be part of the housing **22** or module **18** and is not shown in **FIG. 8A** or 8B). The Braille dot **20**, is just a dimple in the top surface **46**. Referring now to **FIG. 8**B, the MEMS microvalve **284***a* is now closed blocking the flow of pressurized air from the plenum **32** and the MEMS microvalve **284***b* is now opened allowing the air to evacuate from the chamber **30** to the vent **33**. With the pressure vented, the Braille dot **20** contracts, flattening out the dimple on the top surface **46**. The voltage to the two the MEMS microvalves **284***a* , **284***b* are controlled either directly by the microcontroller **40** or by the module microcontroller **45** to extend and retract Braille dots **20** independent of other Braille dots **20**.

[**0051**] **FIGS. 9 and 10** show directly actuated devices using shape memory alloy or piezoelectric based devices. **FIG. 9** is a design for a microelectromechanical device that directly actuates a Braille dot using a thin film shape memory alloy or piezoelectric element to form the Braille dot **20**. In **FIGS. 9A and 9B**, there is shown a detailed view of a Braille dot **24**) and MEMS device **16** which uses either a thin film shape memory alloy or piezoelectric element **282** as the actuator. A thin film SMA based microelectromechanical actuator is significantly different than traditional bulk shape memory alloy actuators in size, fabrication techniques, and operation. The mechanical properties of a thin film SMA can be precisely tailored by changing the alloy ratios during fabrication while a macro sized bulk SMA actuator may have regions where the alloy ratio changes within the bulk material of the actuator, these regions will increase power consumption, reduce fatigue resistance and limit life. Thin film SMA actuators have greater fatigue life and improved phase transition characteristics then traditional bulk SMA actuators. The thin film SMA also has faster response and lower power consumption than traditional bulk SMA actuators due to their reduced volume and large surface area which allows the actuator to change from one phase state to another faster than the larger bulk SMA actuators. The rapid response of the thin-film SMA actuators allows a user to quickly scroll through a document without having the refreshable Braille display lag behind. The lower power consumption of a thin film SMA actuator reduces the amount of heat that needs to be dissipated from the actuators during operation and can permit battery operation for use with portable electronic devices. Shape Memory Alloys (SMA's) are a unique class of alloys which have the ability to form two different crystalline phases, defined as martensite and austenite, in response to temperature and strain. SMA's are produced by equiatomically combining at least two component metals into a desired shape, which is then annealed. When produced, the SMA is in the austenite phase, having a certain shape and characterized by low ductility, high Young's modulus and high yield stress. Upon cooling the SMA changes to the martensite phase characterized by high ductility, a low Young's modulus and low yield stress. In the martensite phase, the SMA is easily deformed and can take on a different shape from its austenite or original shape by applying an external strain. The SMA will retain this different shape until it is heated to its austenitic transformation temperature. When the SMA is heated to its austenitic transformation temperature the SMA transitions to its austenite phase and transforms back to its original shape. Similarly, piezoelectric elements **282** can be tailored for the application. **FIGS. 9A and 9B** also show the application of a direct actuation of the Braille dot **20** without the need of a pneumatic or hydraulic force.

[**0052**] If a thin film SMA element **282** is used then in **FIG. 9A** the thin film SMA element **282** is in its martensite phase with the Braille dot **20** retracted. Since the martensite phase is characterized by high ductility, low Young's modulus and low yield stress, the thin film SMA element **282** is easily deformed by external stresses like biasing means **283**, shown as a spring in **FIG. 10**. When heated to its austenitic transfer temperature, the thin film SMA element **282** transitions from its martensite phase to its austenite phase transforming to its austenitic or original shape. The force produced by the biasing means **283** is less than the force produced by the thin film SMA element **282** during this transformation. The thin film SMA element **282**, thereby,