possible to construct substrate **130** using multiple layers from the same material or from different suitable materials.

[0020] Membrane **110** can be made from a suitable optically transparent and elastic material including polymers or silicon-based elastomers such as poly-dimethylsiloxane (PDMS) or polyethylene terephthalate (PET). In some embodiments, membrane is a single homogeneous layer less than 1 mm thick (preferably 50 to 200 microns) and can be manufactured using techniques known to one skilled in the art. It is also possible to construct membrane **110** using multiple layers from the same material or from different suitable materials. Membrane **110** can be attached to substrate **130** using a suitable adhesive, ultra-sonic bonding, oxygen plasma surface treatment or any other suitable techniques known to one skilled in the art.

[0021] Enclosed cavity **120**, formed between substrate **130** and membrane **110**, is fluid tight and coupled via a fluid channel **140** to one or more fluid pumps (not shown in FIG. 1A). Note that the pump(s) can either be internal or external with respect to a touch screen assembly incorporating button array **100**.

[0022] A suitable button fluid can be used to inflate exemplary cavity **120**. To minimize optical distortion, the refractive index of the button fluid should be substantially similar to that of substrate **130** and also membrane **110**. Depending on the application, suitable fluids include water and alcohols such isopropanol or methanol. It may also be possible to use an oil-based fluid such as Norland's index matching liquid (IML) **150** available from Norland Products of Cranbury, N.J.

[0023] Referring now to FIG. **1**B, when button array **100** needs to be activated, i.e., raised or in other words inflated, fluid pressure inside cavity **120** is increased thereby causing membrane portion **110***a* to be raised. In this example which is suitable for a handheld device, cavity **120** has a cavity diameter of approximately 5 mm and membrane **110** is approximately 100 micron thick. Conversely, when button array **100** needs to be deactivated, fluid pressure inside cavity **120** is decreased thereby causing cavity **120** to deflate and membrane portion **110***a* to return to its original flat profile. It is contemplated that a button fluid pressure of approximately 0.2 psi and a button fluid displacement of about 0.03 ml should be sufficient to raise membrane (button) portion **110***a* by about 1 mm.

[0024] FIG. **2** shows a cross-sectional view of one embodiment of a touch sensitive display assembly comprising button array **100** of the present invention located on top of a touch display which includes a touch sensing layer **260** and a display screen **280**. In this embodiment, button array **100** includes multiple cavities **220***a*, **220***b*, **220***c* and corresponding membrane portions **210***a*, **210***b*, **210***c*. Button array **100** is located just above touch sensing layer **260**. Although FIG. **2** shows button array **100** in contact with touch sensing layer **260**, it may be possible for a gap to exist between array **100** and sensing layer **260**. The gap may optionally be filled with a suitable flexible solid or fluid material.

[0025] It is also possible for display screen **280** to include sensors that provide input capability thereby eliminating the need for sensing layer **260**. For example, an LCD with embedded optical sensors both touch screen and scanner functions was announced in a 2007 press release by Sharp Electronics of Japan.

[0026] FIG. **3**A is a cross-sectional view of another embodiment of a touch sensitive display assembly of the present invention wherein a touch sensing layer **360** and a display screen **380** of the touch sensitive display are separated. Button array **100** includes multiple cavities **320***a*, **320***b*, **320***c* and corresponding membrane portions **310***a*, **310***b*, **310***c*. In this embodiment, button array **100** is sandwiched between a flexible touch sensing layer **360** and display screen **380**. As a result, raising membrane portions **310***a*, **310***b*, **310***c* results in the raising of sensing layer portions **360***a*, **360***b*, **360***c*, respectively.

[0027] FIG. 3B is a cross-sectional view of a variation of the touch sensitive display assembly of FIG. **3**A wherein two or more cavities are inflated, a contiguous portion of touch sensing layer **360** is raised. In this embodiment, button array **100** is also sandwiched between touch sensing layer **360** and display screen **380**. When cavities **320***d*, **320***e* are inflated, corresponding membrane portions **310***d*, **310***e* are raised, thereby causing the raising of sensing layer portions **360***d*, **360***e*. In addition, raising membrane portions **310***d*, **310***e* also results in the raising of touch sensing layer portion **360***f* located between sensing layer portions **360***d*, **360***e*.

[0028] FIG. **4** is a cross-sectional view illustrating yet another embodiment of a touch sensitive display assembly wherein the entire touch screen is made from flexible material (s). Hence, the touch screen includes a flexible touch sensing layer **460** and a flexible display screen **480**. Button array **100** includes one or more cavities **420***a*, **420***b*, **420***c* and corresponding membrane portions **410***a*, **410***b*, **410***c*. In this embodiment, button array **100** is located below display screen **480**.

[0029] As discussed above, button array **100** and sensing layer **460** may be attached directly to each other or array **100** and layer **460** may be operatively coupled to each other via a suitable intermediate solid or fluid material.

[0030] FIGS. **5** and **6** are top views showing a button array **500** and an exemplary touch screen **600** which can be combined to form an exemplary input and output (I/O) user interface suitable for telecommunication applications. While the following description uses the 14-key telephone-based keypad of FIG. **5**, the present invention is also applicable to many other non-telecommunication applications.

[0031] Button array **500** includes cavities **520***a*, **520***b*, **520***c*, **520***d*, **520***e*, **520***f*, **520***g*, **520***h*, **520***k*, **520***m*, **520***n*, **520***p*, **520***q*, **520***r*, while touch screen **600** is configured to able to display a set of corresponding input keys **620***a*, **620***b*, **620***c*, **620***d*, **620***e*, **620***f*, **620***g*, **620***h*, **620***k*, **620***m*, **620***n*, **620***p*, **620***q*, **620***r*. In this example, cavities **520***a*, **520***b*, **520***c* . . . **520***r* are overlaid on corresponding input keys **620***a*, **620***b*, **620***c* . . . **620***r*, using the exemplary techniques described above for the embodiments of FIGS. **2**, 3A, 3B, **4**.

[0032] As shown in FIG. **5**, button array **500** is coupled to fluid pumps **572**, **576**. A fluid reservoir **574** is located between fluid pumps **572**, **576**. Suitable commercially available fluid pumps include pump #MDP2205 from ThinXXs Microtechnology AG of Zweibrucken, Germany and also pump #mp5 from Bartels Mikrotechnik GmbH of Dortmund, Germany.

[0033] Button array **500** is coupled to inflating fluid pump **572** and deflating fluid pump **576** via inlet fluid channel system **592** and outlet fluid channel system **596**, respectively. In this example, fluid channel systems **592**, **596** vary in width, i.e., wider in width nearer pumps **572**, **576**, in order to ensure fluid pressure and flow uniformity, in a manner similar to a human circulatory system.

[0034] Although the techniques discussed are applicable to many embodiments of the present invention, including the embodiments of FIGS. **2**, 3A, 3B, **4**, for this discussion,