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Eventoff

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(54) **PRE-LOADED FORCE SENSORS**

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This patent is subject to a terminal disclaimer.

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- (60) Provisional application No. 61/794,361, filed on Mar. 15, 2013, provisional application No. 61/565,847, filed on Dec. 1, 2011, provisional application No. 61/541,608, filed on Sep. 30, 2011.

- (51) **Int. Cl.**
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G01L 1/22 (2006.01)
G06F 3/041 (2006.01)
G06F 3/044 (2006.01)
G01L 1/20 (2006.01)

- (52) **U.S. Cl.**
 CPC **G01L 1/2287** (2013.01); **G01L 1/205** (2013.01); **G06F 3/044** (2013.01); **G06F 3/0414** (2013.01)

(58) **Field of Classification Search**

CPC G01L 1/2287; G01L 1/205; G06F 3/0414; G06F 3/044
 USPC 73/760, 780, 862.627
 See application file for complete search history.

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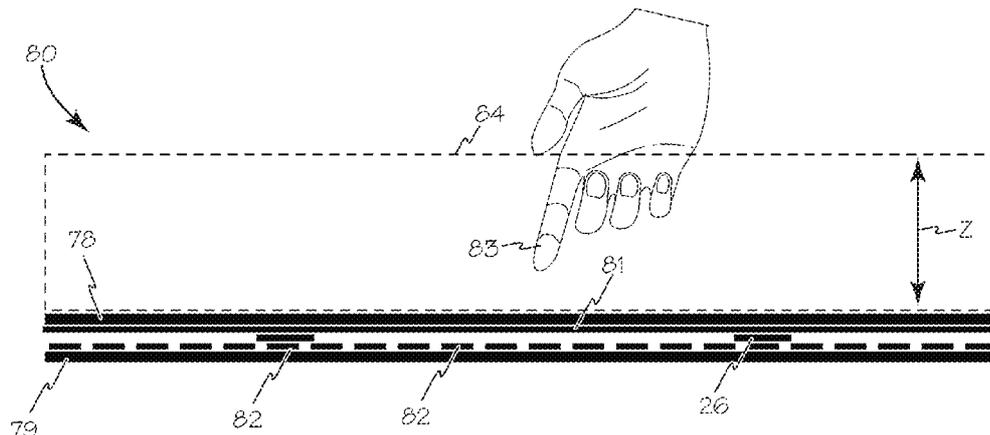
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(57) **ABSTRACT**

Pre-loaded force sensitive input devices, force sensing resistors (FSR), are formed as a multiple membrane assembly that is capable of detecting low intensity pressure inputs and quantifying varying applications of pressure to the sensor surface. Pre-loading the force sensor elements results in controlled amount of force between the two substrates causing a constant state of pre-load and eliminating the low-end or minimal pressure signal noise associated with unloaded sensors. Pre-loading the force sensing resistor sensors also enables the sensor to detect removal of low intensity pressure input such as might occur during theft of light weight articles placed in contact with the pre-loaded force sensor. Using an FSR or FSR Matrix Array will enable any handling of protected retail packaging to be detected and identified. A library of “touches” can be established that will yield cutting, ripping, twisting, etc. making the detection of a theft in progress more accurate.

19 Claims, 5 Drawing Sheets



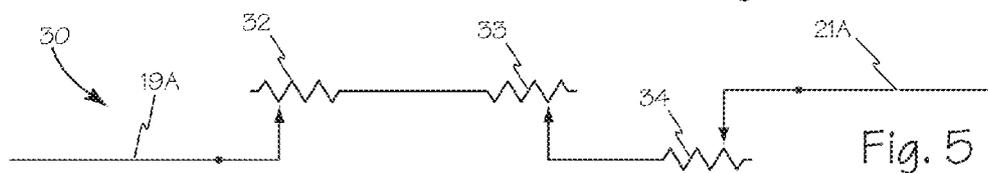
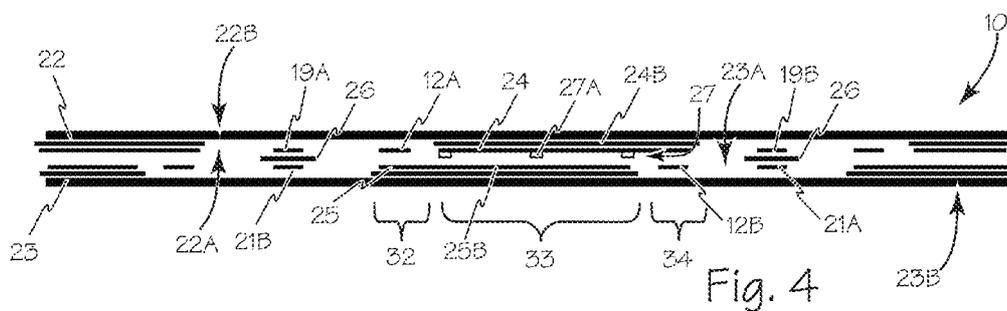
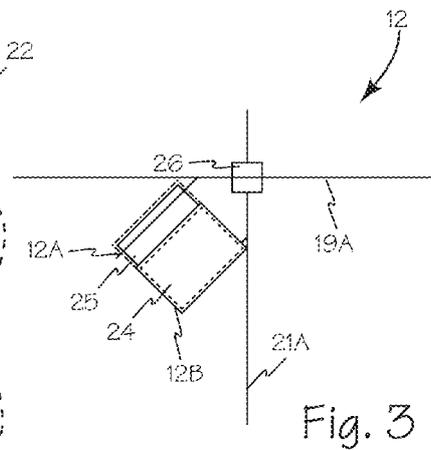
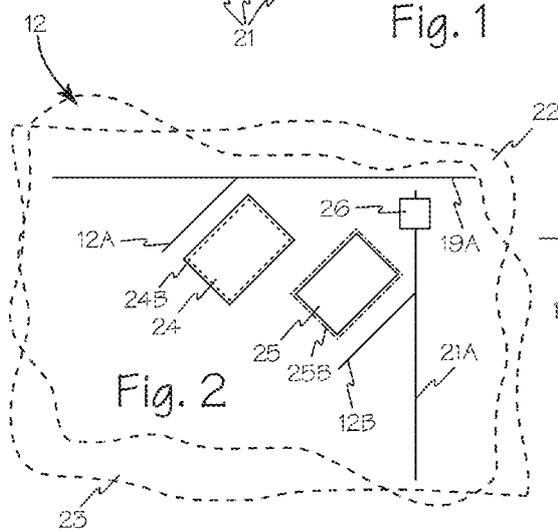
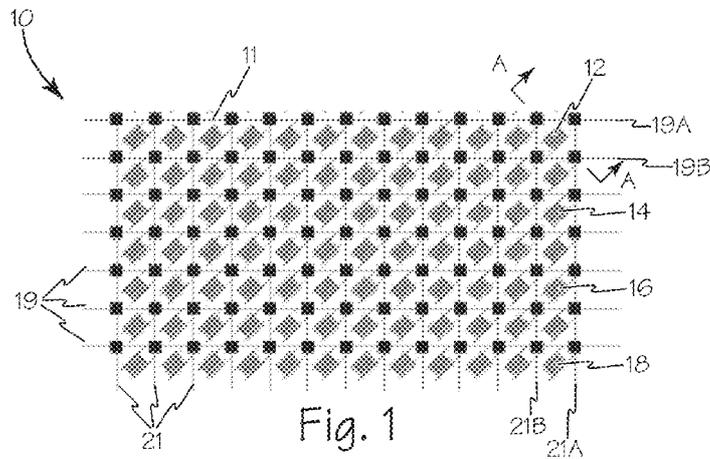
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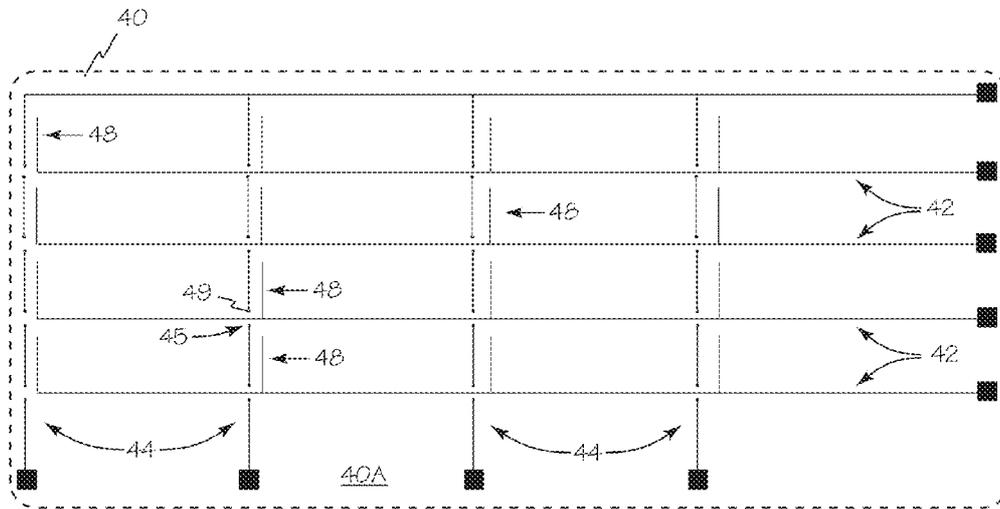


Fig. 6

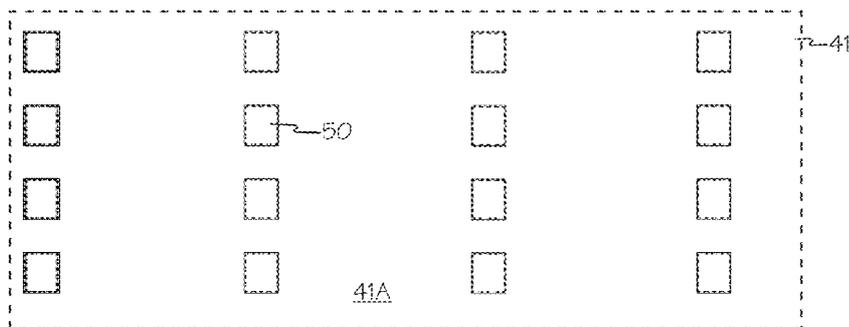


Fig. 7

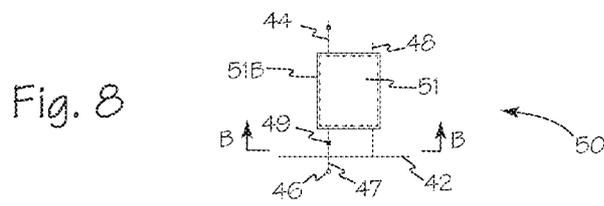


Fig. 8

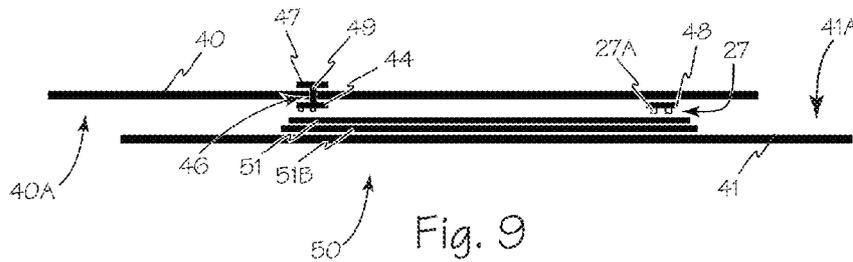
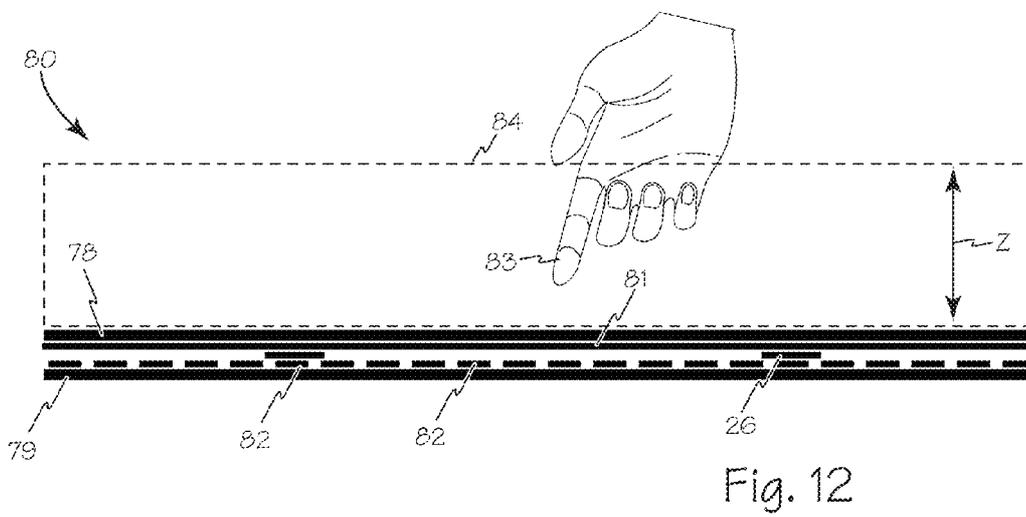
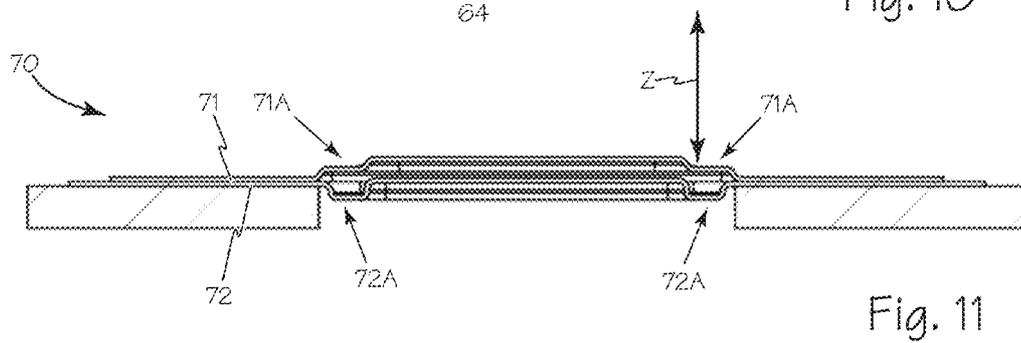
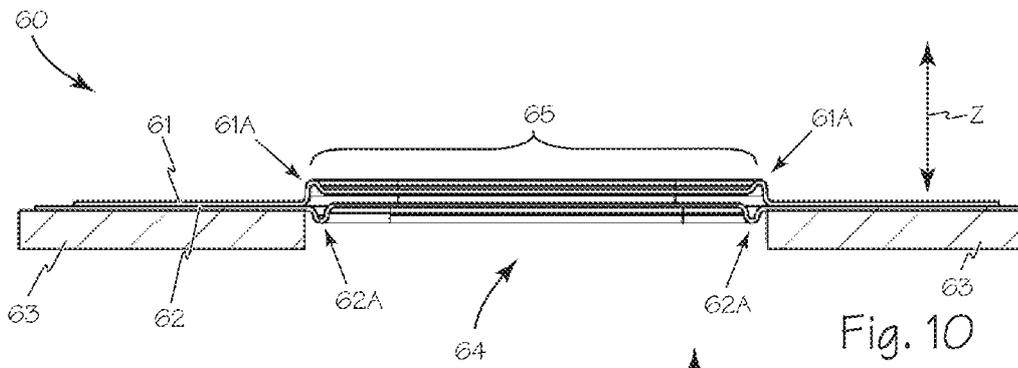


Fig. 9



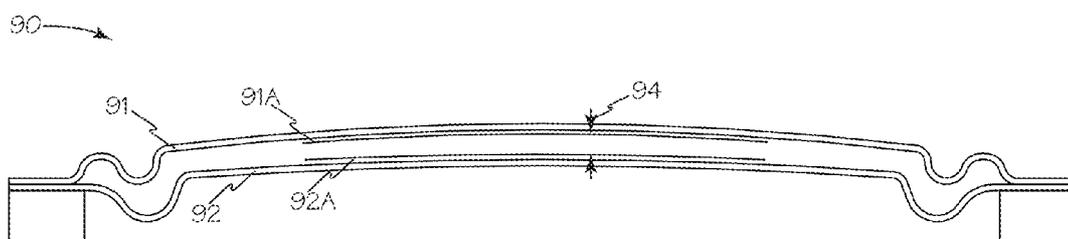


Fig. 13A

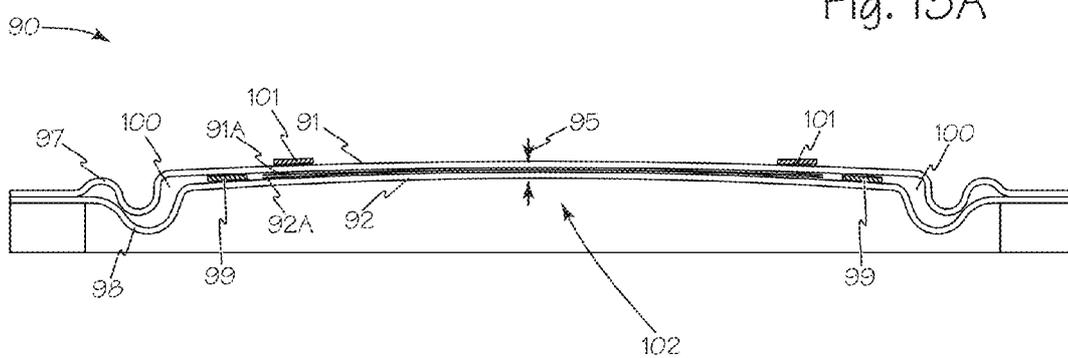


Fig. 13B

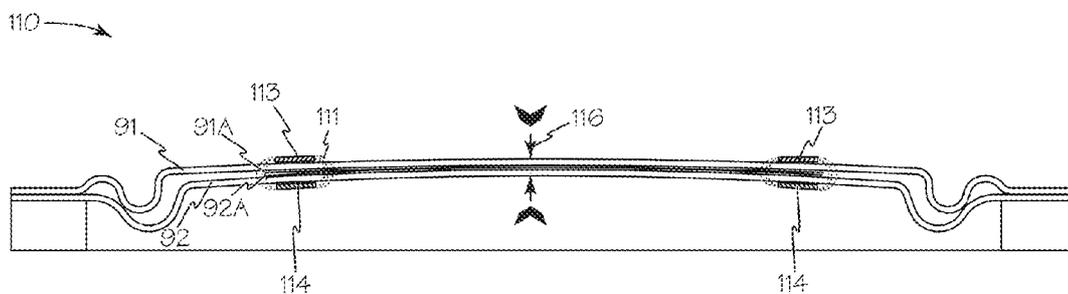


Fig. 14

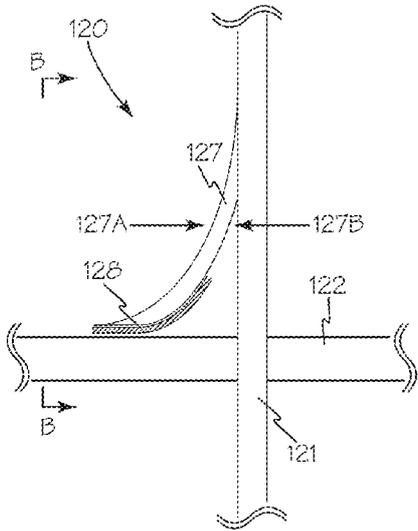


Fig. 15B

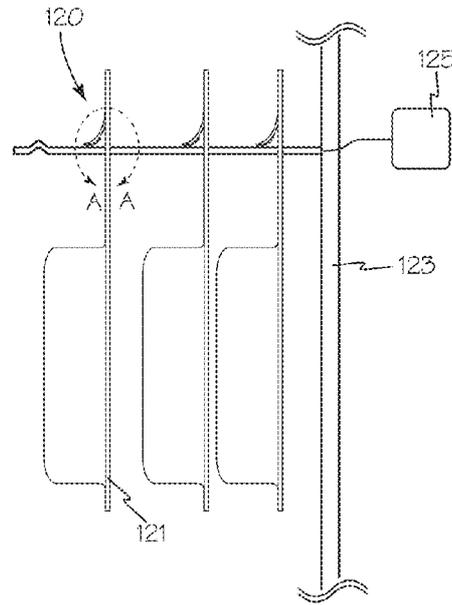


Fig. 15A

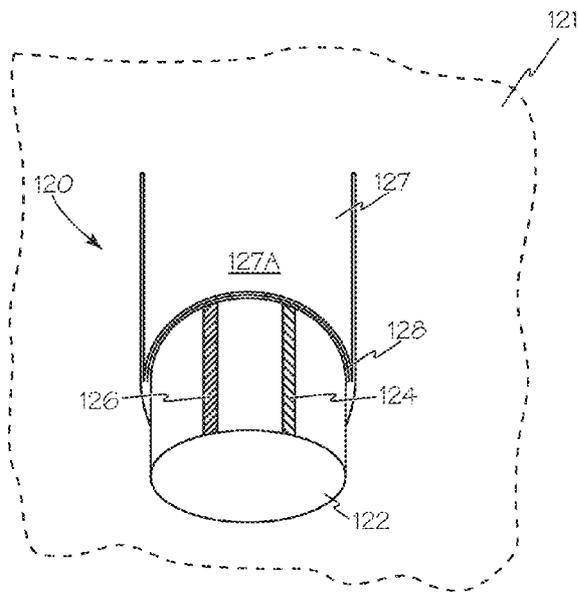


Fig. 16

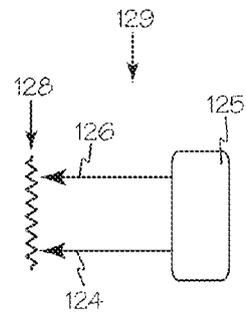


Fig. 17

PRE-LOADED FORCE SENSORS

RELATED APPLICATIONS

This application claims priority from U.S. Provisional Patent Application 61/794,361 filed Mar. 15, 2013. This application is also a continuation-in-part of copending U.S. patent application Ser. No. 13/632,571 filed Oct. 1, 2012 which claims priority to U.S. Provisional Patent Application 61/565,847 filed Dec. 1, 2011 and U.S. Provisional Patent Application 61/541,608 filed Sep. 30, 2011.

FIELD OF THE INVENTIONS

The present invention relates generally to the field of analog input sensors and more specifically to the field of pre-loaded force sensing resistor input sensors electronic devices.

BACKGROUND OF THE INVENTIONS

Modern interface controls are integrating electronic touch sensors to detect inputs. Conventional sensor surfaces based on force sensing resistors generally suffer from relative insensitivity to the application of very light input force or the removal of very light input force due to the materials used and the density of material necessary to achieve a functional sensor. Different sensors are currently being employed to prevent retail theft and many of the sensor configurations provide ambiguous signals or are too slow to be effective in theft prevention.

SUMMARY

The method and apparatus for pre-loaded force sensitive input devices, force sensing resistors (FSR), as disclosed below are formed as a multiple membrane assembly that is capable of detecting low intensity pressure inputs and quantifying varying applications of pressure to the sensor surface. Pre-loading the force sensor elements results in controlled amount of force between the two substrates causing a constant state of pre-load and eliminating the low-end or minimal pressure signal noise associated with unloaded sensors. Pre-loading the force sensing resistor sensors also enables the sensor to detect removal of low intensity pressure input such as might occur during theft of light weight articles placed in contact with the pre-loaded force sensor. Using an FSR or FSR Matrix Array will enable any handling of protected retail packaging to be detected and identified. A library of "touches" can be established that will yield cutting, ripping, twisting, etc. making the detection of a theft in progress more accurate.

A Force Sensing Resistor Smart-Peg may be used to support and display merchandise and identify theft when it is in progress. A FSR Smart-Peg combines a force sensing resistor element printed on cardboard merchandise packaging that may or may not be coated with plastic. The cardboard is stamped to form a curved leaf-spring which is oriented to maintain pre-loaded contact with electrodes of the Smart-Peg as the merchandise is displayed hanging from the Smart-Peg. This pre-loaded state will allow extra time for photographing any person lifting or moving the packaging to assist in identifying thefts in progress because as the product is lifted the sensor will remain in contact with the electrodes.

Force sensing resistor pre-load options include a fixed weight, adhesive, vacuum or differentially embossed upper

and lower substrates causing a pre-load between the substrates. Another alternative for pre-loading FSR sensors is the use of a magnet or magnets on one or both substrates to control the intensity of the pre-load force. When used to generate a pre-load a magnetic field will allow a wide range of options.

A hybrid capacitive force sensing membrane assembly is formed with conductive particles by using two sheets of Mylar (PET) or other clear or any opaque substrate coated with oriented patches of conductive particles on apposing surface of the parallel substrates along with an array of parallel conductors on each substrate. As a capacitive sensor, the electrical charge of a user's hand, finger or other extremity is sensed by the conductive layers of the sensor as a function of the input extremity's location and proximity to the sensor surface. As a force sensor, a user's input contact with the sensor surface is detectable when conductive elements on apposing substrates are forced into contact when the input force is applied. Increasing the applied force increases the area of contact between the substrates increasing conductance and increasing the number of conductive particles in the force sensing resistor elements making contact allowing the electrons to travel from one conductive trace on a first substrate through the contacting FSR element, such as CNT patches, to a perpendicular conductive trace on a second substrate.

The conductive traces and patches discussed below will generally refer to PEDOT or other highly conductive material, generally on the order of less than 50 ohms, as the deposited material. Any suitable conductive material may be used in place of PEDOT in this disclosure such as carbon allotropes such as carbon nanotubes (CNT) and graphene or conductive polymers such as Poly(3,4-ethylenedioxythiophene) or PEDOT (or sometimes PEDT) or metal oxides such as zinc oxide or indium tin oxide (ITO), indium zinc oxide (IZO), aluminum zinc oxide (AZO) or gallium zinc oxide (GZO).

Combining capacitive and force sensing resistor sensors provides a hybrid sensor with a z-axis depth of field sensitivity permitting gesture sensing with capacitance reacting to the approaching finger activator, then the FSR responds to applied force of the finger and capacitive sensing again responds as the activating finger is withdrawn from the sensor surface.

The method and apparatus for force sensitive input devices disclosed below are formed as a membrane that is capable of detecting pressure inputs and varying applications of pressure. A transparent or opaque force sensing membrane is formed with carbon nanotubes, conductive polymers, graphene or other conductive or semi-conductive material by using two sheet of Mylar (PET) or other clear or opaque substrate coated with oriented patches of conductive polymer, micro-particle deposits or carbon nanotubes (CNT).

The coating process includes conductive particles or micro-particles such as zinc oxide, carbon or other suitable materials or carbon nanotubes mixed in an aqueous or other solution and deposited using any suitable technique such as aerosol jet deposition, or suitable printing such as screen, flexo, gravure, offset, litho or other suitable method. The aqueous solution may be an alcohol carrier or other suitable liquid and may also include one or more additives such as a suitable ionomer to bind the CNT to prevent the CNT from passing through human skin or lung membranes. The clarity or light transmission of a transparent force sensing membrane is rated at about 92%, which to the human eye seems like looking through clear glass. Higher resistance of the

conductive particle patches improves the light transmission through the sensor. Alternatively, conductive polymer patches such as PEDOT or other suitably conductive polymer may be used to form force sensing resistor (FSR) patches.

A transparent force sensing membrane is made by depositing conductive particles, such as CNT or other suitable semi-conductive particles, in FSR elements such as oriented patches on apposing surface of parallel substrates. A user's input contact with the sensor surface is detectable when the conductive particles, tubes, wires or polymer elements in apposing patches are forced into contact with each other and with the conductive traces when the input force is applied. The more force, the more conductive elements make contact allowing the electrons to travel from one conductive trace through the contacting FSR CNT patches to a perpendicular conductive trace. Higher force also increases the contact area between the substrates that also increases conductance between conductive elements in contact on each substrate.

A small area of contact between apposing patches and their conductive traces is made when an actuator (the device that touched the sensor surface) such as a human finger makes initial contact with the sensor. As force is increased the area of contact increases bringing more particles into play and thus increasing the conductivity of the device.

A suitable force sensing membrane is made using two parallel substrates. A first substrate has rows and columns of conductive traces formed on a first side of the substrate. Where the column traces intersect the row traces, the column traces are interrupted by forming an electrical connection through the substrate from the first side to the second side and crossing the row trace and then again forming an electrical connection from the second side of the substrate to the first side of the substrate and connecting with the interrupted column trace.

Alternatively, a dielectric or insulating pad can be printed over the row traces allowing an uninterrupted column trace to be deposited perpendicular to the row traces over the dielectric or insulating pads with a top coat of a suitable conductor such as silver. Parallel to the column traces are short conductor leg traces. On the first side of the second substrate are deposited FSR elements such as patches of conductive material such as CNT. When the substrates are oriented parallel with the first sides in apposition, the patches of the conductive material align over a column trace and a short leg trace such that pressure on the membrane causes one or more conductive patches to engage a column trace and a short leg trace forming a force sensitive resistance circuit.

A trampoline sensor as described below provides a hybrid force sensing membrane which is secured along its perimeter over an opening sized and shaped to correspond to the size and shape of the force sensing membrane. A user applying force input to the sensor membrane does not encounter a hard surface beneath the sensor membrane. Instead the sensor membrane operates like a trampoline providing an increased travel when a force is applied with no hard feel at the end of the sensor travel. A trampoline sensor may also include hybrid capacitive input sensing as described below.

Force-sensing resistors date back to Eventoff U.S. Pat. Nos. 4,314,227, 4,314,228, etc. which disclose two basic FSR configurations, the "ShuntMode and ThruMode." Both configurations are constructed with various formulations of force-sensing-resistor inks. Typically the solvent based ink is screen printed and cured on any suitable substrate from glass to PET/Mylar or other compounds to makes a force-

sensing resistor element, however any other suitable methods of deposition or printing may also be used.

These and other features and advantages will become further apparent from the detailed description and accompanying figures that follow. In the figures and description, numerals indicate the various features of the disclosure, like numerals referring to like features throughout both the drawings and the description.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic of a portion of a force sensor array.

FIG. 2 is an exploded block diagram of the elements of a force sensing element of the force sensor array of FIG. 1.

FIG. 3 is an oriented layout diagram of the elements of FIG. 2.

FIG. 4 is a cross section diagram of the force sensor assembly including the force sensing array of FIG. 1 taken along A-A.

FIG. 5 is a schematic circuit diagram of a force sensing assembly.

FIG. 6 is a layout diagram of a portion of a single layer conductive trace arrangement.

FIG. 7 is a layout diagram of conductive FSR patches for use with the conductive trace arrangement of FIG. 6.

FIG. 8 is a top view of a single force sensor conductive patch and its corresponding traces.

FIG. 9 is a cross-section view of the force sensor of FIG. 8.

FIG. 10 is a cross-section view of a trampoline force sensor.

FIG. 11 is a cross-section view of an alternate trampoline force sensor.

FIG. 12 is a cross-section view of a capacitive force sensor.

FIG. 13A is a cross-section view of an FSR sensor before pre-load.

FIG. 13B is a cross-section view of an FSR sensor after pre-load.

FIG. 14 is a cross-section view of an FSR sensor with external pre-load applied.

FIG. 15A is a side view of a conductive peg and cooperating FSR packaging.

FIG. 15B is a close-up view of the pre-loaded FSR sensor of FIG. 15A taken along A-A.

FIG. 16 is a front perspective of the conductive peg and FSR sensor of FIG. 15B.

FIG. 17 is a schematic diagram of the circuit formed using the apparatus of FIG. 15A.

DETAILED DESCRIPTION OF THE INVENTIONS

Referring now to FIG. 1, force sensing assembly 10 includes force sensor array 11 which is formed from one or more force sensing resistor assemblies such as FSR assemblies 12, 14, 16 and 18. Each FSR assembly is oriented between parallel rows of conductor traces on each substrate such as first traces 19 and second traces 21. FSR performance may be improved by including a highly conductive pad or patch between the substrate and each FSR patch.

A force sensing assembly may be formed using two parallel substrates such as first substrate 22 and second substrate 23 as illustrated in FIGS. 2, 3 and 4. First substrate 22 has parallel conductive traces 19 printed along with a conductive leg such as leg 12A for each FSR assembly such as FSR assembly 12. Second substrate 23 has parallel

conductive traces **21** printed along with a conductive leg such as leg **12B** for each FSR assembly such as FSR assembly **12**. When first substrate **22** and second substrate **23** are properly aligned with the deposited traces and patches in apposition, first conductive traces **19** are oriented perpendicular to second perpendicular traces **21**. Near each conductive leg on each substrate, an FSR patch such as patch **24** and patch **25** are deposited. Insulating elements or pads such as insulator pads **26** are deposited on either substrate over the conductive traces at the points where the corresponding conductive trace on the other substrate would be in contact when the substrates are aligned in apposition as illustrated in FIGS. **3** and **4**. Insulating elements **26** separate the first conductors from the second conductors. Optional, highly conductive patches may be deposited between each FSR patch and the substrate that supports it. For example, highly conductive patches **24B** and **25B** may be deposited between FSR patches **24** and **25** and substrates **22** and **23** respectively.

Controlling the dynamic range, the measured resistance of an FSR circuit as a function of applied force on the sensor, is possible by controlling the size and texture of the conductive patches or electrodes as well as the spacing between the electrodes on the sensor substrates as well as the pre-load holding the substrates in contact without user input force. For example, using the aerosol jet deposition method to form the electrodes or patches, such as patches **24** and **25** of FIG. **4** or conductors **44** and **48** of FIG. **9**, a second layer, layer **27**, of small dots or dashes **27A** or other shapes over the base conductor electrode may be applied in an effort to emulate the texture of a thick-film silver and FSR deposition. A thick-film FSR has a better dynamic range when used in conjunction with a thick-film silver electrode with few small conductive peaks or spots as opposed to using a "flat" copper trace. Having too many spots or peaks causes the electrode to behave similar to a smooth flat conductor. In addition, pre-loading or compressing the substrates into a normal state of contact such as illustrated in FIGS. **13B** and **14**. This contact state, or pre-load state may form the lower threshold for switch or sensor closure thus eliminating low contact noise and inconsistencies between sensors. Pre-loading an FSR also reduces the dynamic range of the sensor.

Referring now to FIG. **4**, first substrate **22** has first conductive traces such as traces **19A** and **19B**, conductive leg **12A** and first FSR patch **24** deposited on a first surface such as conductor surface **22A**. Second substrate **23** has second conductive traces such as traces **21A** and **21B**, conductive leg **12B** and second FSR patch **25** deposited on a first surface such as conductor surface **23A**. Each substrate has a corresponding second surface such as second surfaces **22B** and **23B** respectively. When two printed substrates are aligned in parallel, the first surfaces of each substrate are aligned in apposition with the parallel traces on each substrate oriented perpendicular to the conductive traces of the apposing substrate yielding a force sensing assembly such as force sensing assembly **10** with the second surfaces of each substrate operating as a contact surface for the application of force to be detected and measured.

In use, pressure on the second surfaces **22B** or **23B** of either first or second substrate at or near an FSR assembly such as FSR assembly **12** will create a force sensitive circuit such as circuit **30** of FIG. **5** that extends from first conductive trace **19A** to second conductive trace **21A** through the three resistive elements described below. First resistive element **32** is formed by the interaction of a portion of second FSR patch **25** with conductive leg **12A**. Second resistive element **33** is formed by the interaction of a portion

of first FSR patch **24** with second FSR patch **25**. Third resistive element **34** is formed by the interaction of a portion of first FSR patch **24** with conductive leg **12B**. The resistance value of each resistive element is proportional to the pressure applied to the substrate and the location of the pressure.

Referring now to FIGS. **6**, **7**, **8** and **9**, an array of force sensor assemblies may be formed using two parallel substrates, such as substrates **40** and **41**. First substrate **40** has rows and columns of conductive traces such as row traces **42** and column traces **44** formed on first side **40A** of the substrate. Where the column traces intersect the row traces, such as intersection point **45**, the column traces are interrupted by forming an electrical connection through the substrate from first side **40A** to second side **40B** and crossing the row trace with a jumper trace such as jumper trace **47** and then again forming an electrical connection such a connection **49** from second side **40B** of the substrate to first side **40A** of the substrate and reconnecting with interrupted column trace **44**.

Electrical connection **49** may be formed using any suitable technique. A useful technique for forming electrical connection **49** when the majority of conductors are deposited using printing methods is accomplished by adjusting the viscosity of the conductive liquid being deposited to permit the conductive liquid to flow in and through a hole, such as hole **46** formed between first side **40A** to second side **40B**.

Alternatively, a dielectric or insulating pad can be printed over the row traces allowing an uninterrupted column trace to be deposited perpendicular to the row traces over the dielectric or insulating pads with a top coat of a suitable conductor such as silver. Parallel to the column traces are short conductor leg traces. On the first side of the second substrate are deposited FSR elements such as patches of conductive material such as CNT. When the substrates are oriented parallel with the first sides in apposition, the patches of the conductive material align over a column trace and a short leg trace such that pressure on the membrane causes one or more conductive patches to engage a column trace and a short leg trace forming a force sensitive resistance circuit.

Parallel to the column traces are short conductor leg traces such as leg traces **48**. An array of force sensing assemblies such as force sensing assembly **50** is formed with an array of patches such as conductive patch **51** are deposited on first side **41A** of second substrate **41**. Highly conductive backing patches such as patches **51B** may first be deposited on substrate **41** and FSR conductive patches such as patch **51** may be deposited on the highly conductive backing patch to improve FSR performance. FSR elements or patches such as conductive patch **51** include conductive material such as CNT or PEDOT. When substrates **40** and **41** are oriented parallel with first sides **40A** and **41A** in apposition, the conductive patches such as patch **51** align over an interrupted column trace and a short leg trace as illustrated in FIGS. **8** and **9** to form force sensing assemblies such as force sensing assembly **50**. In use, pressure on the membrane causes one or more conductive patches to engage a column trace and a short leg trace forming a force sensitive resistance circuit as discussed above.

Alternatively, substrate **41** may not have a plurality of conductive or semi-conductive patches such as patches **51**, instead having a single flood layer of conductive or semi-conductive material deposited on substrate **41** with the conductive area apposing parallel conductors forming a force sensing assembly.

Force sensing membranes as discussed, and pre-loaded force sensing membranes may also benefit from a trampoline configuration such as illustrated in FIGS. 10, 11, 13A, 13B and 14. Force sensor 60 is formed with two parallel substrates such as first and second substrates 61 and 62 as discussed above. Each substrate may be planar or may be shaped to form a flexible section such as sections 61A and 62A respectively to optimize sensor movement along the z-axis. Each substrate containing one or more FSR elements such as conductive deposits and/or traces to form a force sensing resistor to quantify the location and intensity of force applied to the active area of the sensor. Sensor support 63 includes openings such as opening 64 sized and dimensioned to correspond to active area 65 of force sensor 60.

Force sensor 60 may be formed with the force sensing elements on each substrate oriented to provide one or more different active areas corresponding to each force sensing element. Multiple openings in sensor support 63 are formed with each opening collocated with a force sensing element

Force sensor 70 is formed with two parallel substrates such as first and second substrates 71 and 72 as discussed above. Each substrate is shaped to form a flexible section such as sections 71A and 72A respectively to allow sensor movement along the z-axis. Each substrate containing one or more FSR elements such as conductive deposits and/or traces to form a force sensing resistor when force is applied to the active area of the sensor.

Referring now to FIG. 12, First conductive layer 78 and second conductive layer 79 of force sensing resistor 80 may also be used as elements of a capacitive sensor to sense the presence and location of a user's stylus, hand, finger or other conductive apparatus or appendage along the z-axis. Conductive area 81 is deposited on first conductive layer 78 and conductive traces 82 are deposited on second conductive layer 79 to form a force sensing resistor. A voltage applied across the conductive layers creates a capacitive sensor reactive to a conductive appendage such as finger 83 in sensor space 84.

Referring now to FIGS. 13A and 13B, sensor 90 is a force sensing resistor as described above and includes substrates 91 and 92 with conductive contacts 91A and 92A deposited thereon respectively and optional highly conductive backing contacts as well. Generally, substrates 91 and 92 are oriented with conductive contacts 91A and 92A in apposition with some separation 94 between the conductive contacts as shown. Pre-loading of the substrates as illustrated in FIG. 13B brings conductive contacts 91A and 92A into a pre-determined level of contact which is determined by pre-load force 95. In this configuration, pre-load force 95 is controlled by first and second embossed edges 97 and 98 respectively.

Alternatively, pre-load force 95 between first substrate 91 and second substrate 92 may be generated by an adhesive layer 99 between the substrates, or by drawing a vacuum in space 100, or by installing a fixed weight or weights 101 on first substrate 91 to use gravity to urge the substrates into pre-load position 102. These configurations for achieving FSR pre-load are fixed during manufacture and present little opportunity to change or adjust the intensity of the pre-load force during use.

Referring now to FIG. 14 FSR sensor 110 is pre-loaded using magnetic field 111 between first or upper magnet 113 and any suitably oriented ferrous material such as second or lower magnet 114. The size of the magnets and the strength of field 111 permits control of pre-load force 116. Magnets 113 and 114 may be fixed magnets for providing a fixed pre-load, alternatively, either or both of the magnets may be

electro magnets enabling controllable variation in pre-load force 116. If the electro-magnet may also be configured to create a repulsive force to set a negative pre-load of offset that must be overcome to engage the FSR. Similarly, either first magnet 113 or second magnet 114 may be replaced by suitable ferrous material to interact with the remaining magnet or electro-magnet.

In some FSR configurations, the conductive electrodes deposited on the substrates may be made magnetic to achieve a pre-load between the substrates. Alternatively, the ink used for the FSR conductive patches may be made magnetic to create the pre-load.

Pre-loaded FSR sensors may be incorporated into or on merchandise packaging to assist in minimizing theft. Referring now to FIGS. 15A, 15B and 16, pre-loaded FSR sensor 120 is incorporated into merchandise packaging 121. Merchandise may be displayed and supported by pegs, rods, hooks or other devices such as peg 122 which is supported on a merchandise display rack such as rack 123. Peg 122 includes one or more conductive elements such as electrodes 124 and 126 which are connected to any suitable merchandise security system such as system 125. Merchandise packaging 121 is cut and shaped to form a tab such as tab 127 which functions as a leaf spring which provides elastic support for packaging 121 and any attached merchandise. Tab 127 is configured to enable the weight of packaging 121 and the attached merchandise to preload the FSR. Tab 127 has a first side 127A and a second side 127B. Second side 127B serves as a substrate for conductive FSR patch 128 which may be formed and deposited as discussed above.

When merchandise packaging is displayed as illustrated in FIG. 15A, circuit 129 of FIG. 17 formed by FSR patch 128 and electrodes 124 and 126 is pre-loaded by the spring action of tab 127. The pre-load enables circuit 129 to react to a change in the resistance of the circuit caused by movement of packaging 121 which may or may not be caused by a legitimate purchaser.

Thus, while the preferred embodiments of the devices and methods have been described in reference to the environment in which they were developed, they are merely illustrative of the principles of the inventions. Other embodiments and configurations may be devised without departing from the spirit of the inventions and the scope of the appended claims.

I claim:

1. A force sensing assembly comprising:
 - a generally planar first substrate having a conductor surface and an opposing touch surface;
 - a plurality of parallel conductive traces on the conductive surface of the first substrate;
 - an array of conductive patches oriented between adjacent parallel conductive traces and each patch is electrically connected to the conductive traces on the conductive surface of the first substrate;
 - a generally planar second substrate having a conductor surface and an opposing touch surface;
 - a plurality of parallel conductive traces on the conductive surface of the second substrate;
 - an array of conductive patches oriented between adjacent parallel conductive traces and each patch is electrically connected to the conductive traces on the conductive surface of the second substrate;
- wherein the first substrate and the second substrate are oriented parallel to each other with the conductive surfaces of each substrate in apposition and the plurality of parallel conductive traces on the first substrate

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- oriented perpendicular to the plurality of conductive traces on the second substrate;
- a plurality of insulating pads secured on the conductive traces on the first substrate where the perpendicular traces of the second substrate intersect the traces of the first substrate; and
- means for pre-loading the first and second substrate to create a pre-load force between the first and second substrate.
- 2. The force sensing assembly of claim 1 wherein each conductive patch of the arrays of conductive patches are formed of at least two layers of conductive material.
- 3. The force sensing assembly of claim 2 wherein the arrays of conductive patches are formed of conductive material selected from the group comprising:
carbon allotropes, conductive polymers or metal oxides.
- 4. The force sensing assembly of claim 2 wherein the arrays of conductive patches are formed of graphene.
- 5. The force sensing assembly of claim 2 wherein the arrays of conductive patches are formed of Poly(3,4-ethylenedioxythiophene).
- 6. The force sensing assembly of claim 2 wherein the arrays of conductive patches are formed of indium tin oxide.
- 7. The force sensing assembly of claim 1 wherein the means for pre-loading the substrates is adhesive applied between the first and second substrate.
- 8. The force sensing assembly of claim 1 wherein the means for pre-loading the substrates is a vacuum drawn between the first and second substrate.
- 9. The force sensing assembly of claim 1 wherein the means for pre-loading the substrates is an embossed edge formed on the first substrate and a second embossed edge formed on the second substrate.
- 10. The force sensing assembly of claim 1 wherein the means for pre-loading the substrates is a first magnet secured on the first substrate and a second magnet secured on the second substrate.

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- 11. The force sensing assembly of claim 10 wherein the first magnet is an electro-magnet.
- 12. The force sensing assembly of claim 1 wherein one of the at least two layers of each conductive patch is highly conductive and oriented between the other of the at least two layers of the conductive patch and the substrate.
- 13. An FSR sensor assembly comprising:
two generally planar, flexible substrates oriented parallel to each other;
a conductive patch and conductors deposited between the two substrates forming an FSR force sensor in an active area of the substrates;
means for creating a pre-load force between the conductive patch and the conductors of the FSR sensor;
a support with a hole there thru, the hole sized to correspond to the active area of the substrates; and
wherein the two substrates are secured to the support with the active area collocated on the hole.
- 14. The hybrid force sensor of claim 13 wherein the arrays of conductive patches are formed of at least two layers of conductive material.
- 15. The force sensing assembly of claim 13 wherein the means for pre-loading the substrates is adhesive applied between the first and second substrate.
- 16. The force sensing assembly of claim 13 wherein the means for pre-loading the substrates is a vacuum drawn between the first and second substrate.
- 17. The force sensing assembly of claim 13 wherein the means for pre-loading the substrates is an embossed edge formed on the first substrate and a second embossed edge formed on the second substrate.
- 18. The force sensing assembly of claim 13 wherein the means for pre-loading the substrates is a first magnet secured on the first substrate and a second magnet secured on the second substrate.
- 19. The force sensing assembly of claim 18 wherein the first magnet is an electro-magnet.

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