Title: PRINTED PRESSURE SENSITIVE SENSOR SYSTEM

Abstract: The present invention relates to pressure-sensing fabrics and systems, and particularly comprises a force sensitive sensor system that can be assembled in the form of a mat from conductive ink and resistive ink in various combinations to achieve an electrical response to flexure, compression, and stretch. An electronic circuit measures the properties of the mat and the intersections of multiple layers of the assembly to create a map of the physical conditions present in the assembly.
Title: Printed Pressure Sensitive Sensor System

Reference to Related Application

This application claims benefit of priority from US Provisional Application No. 62/195,742, filed July 22, 2015, the disclosure of which is incorporated by reference herein in its entirety.

Field of the Invention

The present invention relates to pressure-sensing fabrics and systems, and particularly comprises a force sensitive sensor system that can be assembled in the form of a mat from conductive ink and resistive ink in various combinations to achieve an electrical response to flexure, compression, and stretch. An electronic circuit measures the properties of the mat and the intersections of multiple layers of the assembly to create a map of the physical conditions present in the assembly.

Background Art

Various pressure-sensing fabrics and systems are known in the art. For example, US Patent Application No. 20060065060 discloses a pressure-detecting mat which includes a plurality of communication modules that are configured to communicate with each other using the two dimension diffusive signal-transmission technology, a module layer that includes the plurality of communication modules scattered therein, a plurality of conductive layers that electrically interconnect the plurality of communication modules, at least two insulating layers that sandwich the module layer and the plurality of conductive layers, and a plurality of pressure sensors that are arranged in one of all the layers except the farthest layer in a pressure applying direction. Each of the pressure sensors being capable of detecting a pressure and communicating with each of the communication modules to send an output signal according to the detected pressure to each of the communication modules. The total stiffness of the layers that are farther in the pressure applying direction than the layer in which the pressure sensors are arranged is
higher than the total stiffness of the layers that are closer in the pressure applying
direction than the layer in which the pressure sensors are arranged.

Additionally, US Patent No. 7,658,112 discloses a mat for pressure measurement
comprising: a plurality of medium accommodation objects which inside is filled with a
pressure transmission medium; and a connecting pipeline provided in the respective
medium accommodation objects which lead the pressure inputted into the medium
accommodation objects to a pressure detection unit of the pressure transmission medium
and which has a different pressure loss coefficient reciprocally. US Patent No. 6,964,205
discloses a force sensor for measuring a force applied to a surface. The sensor includes
first and second thin, flexible substrate layers, the layers arranged in facing relationship
to each other, and a first plurality of conductive traces formed on the first substrate layer
and a second plurality of conductive traces formed on the second substrate layer, with the
first and the second conductive traces facing each other. The sensor further includes a
plurality of individual force sensor elements disposed between the first and the second
substrate layers, and electrically connected to the first and second conductive traces. The
first and second conductive traces each have a portion that extends from and partially
around the sensor element in a spiral-like pattern. A plurality of slits is formed through
the first and second substrate layers. The slits permit the sensor elements to move,
thereby allowing a sensor element to move relative to adjacent sensor elements.

Further, US Patent No. 6,225,814 discloses apparatus for measuring contact width
between two contacting surfaces. The apparatus includes first and second insulating
substrates having spaced facing inner surfaces and outer surfaces, the substrates being
adapted to be fitted between contacting surfaces to measure contact width. A pattern of
conductive material is formed on each of the facing inner surfaces, the patterns being
spaced from each other and selectively overlapping. US Patent No. 6,032,542 discloses a
pressure sensitive element or array which includes at least one first conductor on a first
substrate and at least one second conductor on a second substrate, with a first conductor
and a second conductor intersecting adjacent to each other at a sensor point and a
pressure sensitive material being between the first and second conductors at each such
sensor point. A mechanism is also provided which applies a predetermined prepressure to the substrates at least at selected ones of the sensor points. US Patent No. 5,756,904 discloses a circuit for facilitating the higher speed scanning of an array of pressure responsive sensor points and a sensor array for use in such circuit. Each sensor or pressure point is at an intersection of a selected drive electrode and a selected sense electrode. In the sensor array, there is pressure sensitive resistance between the electrodes intersecting at each pressure point. US Patent Application No. 2007/0179360 discloses an apparatus for measurement of an individual's body composition includes a pressure mat configured to fully support an adult supine patient and to provide a series of pressure readings at a series of cells over the surface of the pressure mat and then electronically transmits the readings to a computer or the like. The pressure readings along with other relevant clinical information such as the patient's weight are then used to determine the patient's body composition such as percent body fat, body density, total body volume, fat mass and fat-free mass.

Summary of the Invention

The present invention provides a force sensitive sensor system comprising a flexible fabric mat assembly having one or more fabric layers, and having incorporated therein a conductive ink and a resistive ink in effective amounts and suitably situated within at least one of said layers of said fabric, thereby to achieve an electrical response to flexing, compression, and stretching of said fabric, and whereby the electrical response is measured by an associated electronic circuit means to determine the degree of such flexing, compression and stretching of said fabric and correlates therewith the properties of the mat assembly and the intersections of the layers of the assembly to create a map of the physical conditions present in the assembly.

The system provided by the invention, while not limited by the advantages and uses herein described, is more sensitive, accurate and cost effective than previously known systems, and is particularly useful in the assessment by a clinician or other user of human patients having various posture related or mobility disabilities or impairments.
Brief Description of the Drawings

Fig. 1 is an illustration of a preferred embodiment of the present invention, showing a particularly preferred top layer of fabric of a pressure sensing mat of the system of the invention, having an array of electrically active sites which are created by overlapping a pair of conductive printed stripes, printed on fabric layers or pieces of the mat.

Fig. 2 shows a computer display graphic image screen capture of the associated computer processing and analysis means of the system of the present invention, enabling determination of the degree of such flexing, compression and stretching of the fabric layers of the pressure sensing mat, and to correlate therewith the properties of the mat assembly and the intersections of the layers of the assembly, thereby to create and display a map of the physical conditions present in the assembly.

Fig. 3 shows the four sensor fabric layers of a preferred embodiment of a pressure sensing mat in accordance with the invention, illustrating the layout of the printed sensor stripes on each respective layer.

Detailed Description of the Invention

In a preferred embodiment of the present invention, and particularly referring to Fig. 1 of the drawings appended hereto, the invention comprises a pressure sensing mat including an array of electrically active sites which are created by overlapping a pair of conductive printed stripes, printed on fabric layers or pieces of the mat and oriented so that the stripes on one layer or piece of fabric are rotated 90 degrees from the stripes on a second piece of fabric. In this preferred embodiment, the stripes are bendable, stretchable, and breathable, or in another embodiment they may be not breathable, but they are oriented so that when the mat is in use, for example by a human body sitting or lying thereupon, the stripes are able to take the shape of the body that is sitting or lying upon it, and in this shaped or contoured condition respond to pressure between two conductive surfaces, thereby to provide an electrical response capable of being measured by an associated electronic circuit means that determines the degree of such flexing, compression and
stretching of said fabric, and to correlate therewith the properties of the mat assembly and the intersections of the layers of the assembly, thereby to create a map of the physical conditions present in the assembly.

The principles of the present invention are described herein for illustrative purposes by referencing various exemplary, preferred embodiments thereof. Accordingly, although certain embodiments of the invention are specifically described herein, one of ordinary skill in the art will readily recognize that the same principles are equally applicable to, and can be employed in, other apparatuses and methods. Before explaining the disclosed embodiments of the present invention in further detail, it is to be understood that the invention is not limited in its application to details of any particular embodiment shown. The terminology used herein is for the purpose of description and not of limitation.

As previously stated, in a preferred embodiment, the invention comprises a pressure sensing mat, the mat including an array of electrically active sites which are created by overlapping a pair of conductive printed stripes, printed on fabric layers or pieces of the mat and oriented so that the stripes on one layer or piece of fabric are rotated 90 degrees from the stripes on a second layer or piece of fabric. In some embodiments these stripes are bendable, stretchable, and breathable, or in other embodiments they may not be breathable. The stripes are oriented so that, in use, they may take the shape of a body that is sitting or lying upon it and in this shaped or contoured condition respond to pressure between two surfaces in the mat.

It will be appreciated by those skilled in the art that the objects and advantages of the present invention are not limited by the particular configurations of the preferred embodiments described herein. Therefore, such objects and advantages can be conferred merely by following the teachings in this detailed description and the examples. Accordingly, it will be apparent from the descriptions herein of the system how one skilled in the art would construct and use such a system, and no particular drawing figures or graphical representations of the system as set forth herein are, or should be, necessary to teach one skilled in the art the construction and use of the invention.
A particularly preferred example of a suitable fabric for use in the manufacture of the present invention is the Ponte Roma Fabric, commercially available from JoAnn Fabrics, 302 North Marketplace Drive, Centerville, UT 84014 as part number 40085271454. Other suitable fabrics are any commercially available fabric having similar properties to the foregoing, and particularly preferred are those commercially available which consist substantially of 5% Polyester, 44% Rayon, 1% Spandex. One skilled in the art will be readily able to conceive of many other suitable such fabrics for use in the present invention.

The foregoing described conductive stripes can be printed in various patterns onto the fabrics comprising the mat of the system, for example as illustrated in Fig. 1 of the drawings, using any conventional means, such as silkscreening or jet printing, as will be well known to and appreciated by those skilled in the art. The ink can be, and preferably is, a highly conductive ink, on particularly preferred example of which is silver ink, commercially available as part no. CI-1036, from Engineered Conductive Materials, LLC, 132 Johnson Dr., Delaware, OH 43015. One skilled in the art will be readily able to conceive of many other suitable such inks for use in the present invention.

It is to be appreciated that a simple sensor for use in the present invention can be constructed by printing a more conductive layer in stripes to create an array, or in simple layers for a single sensor, then printing a second layer of a higher resistive layer on top of the first sensor, and then printing a third layer similar to the original layer allowing the compression of the assembly to be sensitive to even low levels of forces (compression, tensile, shear) applied to the assembly.

The performance of the system provided by the invention can, in a further preferred embodiment, be made more sensitive over a greater range by adding a third layer that is conductive or of various levels of conductive or resistive properties, to provide the desired responsiveness to loading, as will be appreciated by those skilled in the art. For example, by using a resistive ink printed in a checker board pattern, so that there is a thin gap having non-conductive, insulative or di-electric properties, can function to provide a
clear responsiveness to loading, compression, shear, or combinations of these. This third layer can also be comprised of a simple layer of conductive /resistive material, that is different enough in conductivity from the printed stripes, such that each sensor can be distinguished from another when the output thereof is fed to an associated electronic circuit which interprets or analyzes the output.

Referring now to Fig. 3 of the appending drawings, the four separate layers of a preferred embodiment of the pressure mat provided by the invention is shown, with preferred patterns of printed conductive/resistive stripes on each respective layer to form the sensors of the invention. This embodiment is particularly adapted and advantageous for high resolution pressure mapping of subjects applying pressure of one or more body parts to the mat, in accordance with the invention. The layers shown are comprised of a commercially available "Mylar" material with printed conductive stripes using the printed conductive/resistive inks as described elsewhere herein, and having a suitable dielectric material situated there-between, such dielectric material being selected from those commonly used and known by those skilled in the relevant art. The four layers when placed together, one on top of another, in the manufacture of the pressure mat of the invention, form the finished pressure mat of the invention, with the conductive electrical leads illustrated serving to conduct the signals from the sensors within the layers to the associated computer processing means, as described herein.

One preferred example of such a conductive/resistive graphite ink which is useful in the present invention is a carbon based resin screen printable ink, wherein the resin and carbon are blended to create a resistance of 10-60 kΩ. Such a particularly preferred ink is commercially available as part no. CI-2051 from Engineered Conductive Materials, LLC, 132 Johnson Drive, Delaware, OH 43015. One skilled in the art will be readily able to conceive of many other suitable such inks for use in the present invention.

In a preferred embodiment, in the manufacture of the system of the invention the application of the conductive/resistive material (ink) is accomplished using commercial printing technology well known to those skilled in the art, such as screen printing, to at
least one side of the fabric or substrate so that it soaks in, or to both sides thereof in varying amounts to create a varying conductivity / resistivity in the Z axis of the fabric or substrate. This can enable improved sensitivity of the sensor in that as the assembly is subjected to forces (compression, tensile, shear) the electrical conductivity / resistivity varies due to such factors as the changes in relationship of the individual fibers in the fabric yarn, the shape of the knit or weave, and the orientation of the yarns and fibers in the assembly so that the electrical characteristics (conductivity/ resistivity/ capacitance or impedance of the layers) can be measured and used to generate varying signals useful to the user in identifying the forces experienced by the assembly.

It will be appreciated that this variation in performance of the electrical signals can be generated, in the manufacture of the mat provided by the invention, by multiple production techniques including, but not limited to, ink jet deposition, screen printing, pad or transfer printing, where variations in the screen size or printing pattern controls the amount of ink delivered to the various layers of the assembly. In addition multiple conductivities, or resistivities, can be achieved by printing into a single layer with multiple passes of ink application, or of application and curing and re-application, to rework the performance of an existing assembly or to adjust the sensitivity to changing forces or the rates of force application, when the resulting system is in use.

Preferred characteristics of the sensor:

Range and sensitivity of the sensor. Range can be governed by the variation in deposition of conductive/resistive substrate in the z axis. The strength of the signal can be governed by the area of the sensor and the ratio of the conductance to resistance of the stripes to the sensitivity layer.

Cross talk. Cross talk is controlled by the insulative / di-electric regions or the ratio of the resistance of a single sensor to the cumulative resistance of multiple sensors in geometrical pattern with each other. Further these are in relationship to the electric circuit that is designed to sample or measure the characteristics of the sensor(s). In addition, thickness of the third layer, knit pattern, absorptive nature of the fibers, concomitant treatment of the yarns and the use of fibers with materials that impact
absorption and adhesion of the ink or resistive/conductive substrates applied to the fabric, can be used to govern the strength of the signal, the range of the signal or other parameters that are desired to enhance the sensitivity of the signal.

**Electronic Circuit:** A multiplexing electronic circuit is preferably used in association with the mat incorporating therein the printed sensor stripes, which is capable of addressing each of the intersections of each of the layers of stripes through a multiplexer, so as to allow the measurement of the load at each created sensor intersection for pressure or shear. The circuit may address each layer independently communicating with each stripe sequentially, or randomly in response to existing loading, to allow the updating of the signal from each sensor that is indicating a load greater than a minimum threshold or a series of thresholds governing a series of responsive zones in the accumulated sensors, in the event that it is preferred to know the electric conductivity/resistivity at each sensor that is showing load, rather than those that do not show a load.

In addition, multiple connections, either physical or switched in the electronic circuit, enables the ability to simultaneously measure the signal, as described above, and measure the reduction in signal that is generated by the shear based stretching of the fabric assembly by measuring the conductivity/resistivity from end to end of a single stripe. The sensing of the individual stripes in both layers allow the creation of a composite map of the shear that is experienced between the opposing layers due to elastic deformation or mechanical displacement.

In a particularly preferred embodiment of the invention, it is possible to make the performance of the individual sensors stronger and more accurate employing multiple ink printed layers of different resistances. In addition, in another preferred embodiment, circuit connectors between the fabric or substrate and the electronics circuit can be employed to greatly simplify, during manufacture of the sensor system of the invention, the assembly thereof and improve the feel and performance of the map produced from use of the system, by eliminating wires.
It is to be appreciated that the present invention is also particularly useful in, and can be very important to the manufacturers of, clothing that contains electric circuitry. The following are examples of some applications of the present invention, but it is to be appreciated that the invention is not limited to the list below:

- Health monitoring of vital signs of the wearer such as heart rate, respiration rate, temperature, activity, and posture.
- Sports training data acquisition
- Fire/EMS and first responder lit protective wear for fire and car accident scenes along road (ie. jacket/shirt/vest with warning signs lit up on the back)
- Tote bags, sports bags, and similar items
- Anti-theft (alarms when fabric is cut) for vehicle/convertible covers, motorcycle covers, etc.
- Theater and broadway shows (changing the backdrop of a scene in seconds)
- Coal mine protective gear (identifying problem vitals in workers)
- Clothing for joggers/night walkers (light up gear)
- Adjustable/interactive camouflage for the military (changes appearance with environment)
- Military, military, military something!
- Halloween/costumes, outdoor decorations, holiday decor
- Sports marketing (ie. shirt with light up team name/logo on it)
- Fire/EMS training (monitoring of heart rate, respiratory rate)
- Shoe insert for weight bearing monitoring after surgery (hardware placement)
- "activity trackers" - wearable devices that monitor and record a person's fitness activity
- Monitoring personnel handling hazardous materials
- Tracking the position and status of soldiers in action, or hikers, wilderness adventurers, etc.
- Monitoring pilot or truck driver fatigue
- Fashion of various kinds
- Interior design (changeable drapes, wall "paper" fabric, etc)
Helping patients to regain sensory perception that was previously lost by accident or birth
- Sound shirts or sleeves with speakers incorporated in apparel
- Stuffed animals (for example, to change "Stuffy's" appearance, "clothes", make "Stuffy's" outfit match yours, etc.)

In a preferred example of an embodiment of the present invention, a system provided by the invention comprises the following:

1. A mat assembly that can be placed between a person and a support surface (for example a mattress or chair cushion) to measure the forces applied to the body of the person by the surface that it is seated or lying thereupon.
2. An associated data processing system such as a personal computer, having a computer software generated representation of the forces measured between the body and the support surface, showing location and magnitude of the forces, such as is illustrated in Fig. 2 of the drawings appended hereto.

Additional features of a particularly preferred embodiment of the invention can include:

1. 16" by 16" sensing area, with an 18" by 18" over-all size, is preferable.
2. Between 100 and 256 sensors, covering as much of the sensing surface as physically possible.
3. A conventional computing means, such as a personal computer, running software to calibrate or validate performance of the output of the system.
4. Weight validation based on entering the weight of the person being pressure mapped.
5. Pressure scale indicated by display of color or other suitable indicator on the computing means display and associated peak pressure display.
6. On/Off toggle showing the center of gravity or center of mass.
7. The ability of the user to toggle a control to display:
   a. Cell pressure
   b. Cell ID
c. Raw data

d. Image home button

8. Means to export pressure values into data recording/logging function and to provide a recordable "snapshot" of the resulting data.

9. Peak pressure measurement tool, defaulting to the ISO Peak pressure definition, but which is modifiable to resize the measurement area.

10. Average pressure indication.

11. Contact area indication, which correlates with the number of sensors that are actively sensing pressure over a predetermined pressure setting (settable by the user), and which reports in square inches and square cm.

12. Interpolation, which is averaging between adjacent sensors and creating an assumed gradient between actual readings, thereby to increase apparent resolution.

13. Associated analysis and data logging software operating on a conventional computer system such as a personal computer, that will handle all of the above data inputs and operates on the conventional computer system provided by the user, including controls for Subject Information fields, Subject Id, Date, Record and play controls:
   a. Record
   b. Play
   c. Pause
   d. Stop
   e. Frame ID
   f. Screen capture.

30. Graphic Display (in particular reference to Fig. 2 of the drawings):

1. Rotating graph of the pressure image

2. Reversible image of the graphic image, top for bottom, and side for side, etc.

3. Color scale with 16 different colors in the sliding scale adjustable by the user.

4. Field to record subjects name or other identifier.
Sensor interpolation, providing the image of the interpolated value to increase visual resolution.

Preferred physical components of the pressure sensing system and electronics:

1. Two gridline circuits with conductive traces evenly spaced so as to create sensors when one is rotated 90° in relation to the other, providing sensors equally spaced in X and Y axis over the entire surface of the fabric layers (mat) of the system.

2. Robust connectors to allow multiplexing of the sensors with X-Y addresses across the surface of the fabric layers (mat) of the system.

3. Between 100 and 256 sensors, providing the highest number of sensors that enables reasonable precision in the sensor data interpretation.


5. Fabric cover for the sensors, to make robust and improve handling and appearance.

6. Strain relief cover on a ribbon cable for communication with a multiplexer.

circuit capable of collecting a pressure reading from each sensor in the grid multiple times per second and provide at least approximately one data update per second.

7. Each data point preferably consists of the average of three samplings of sensor readings.

8. Data is preferably communicated to a Laptop or other conventional computer via USB.

9. The Multiplexer will respond to logic commands to facilitate the collection and manipulation of data by the computer resident software.

10. The communication protocol of the system is to be defined by the user based on both the hardware and software operating system environments.

11. The preferred system also supports, either in software or in the hardware, one or more of the following features:

   a. Zero offset adjust
   b. Span adjust
   c. Calibration process.
d. Creep Correction.
e. Drift Correction.
f. Hysteresis Correction.

12. The preferred software configuration of the system supports:
   a. Send command for data response
   b. Send command for continuous data feed until stopped.
   c. Log data and save to disk.
   d. Manipulation of data to display as graph, table of numbers and satisfy the display requirements above-mentioned.
   e. Printing function, if desired, for the pressure mapping session data set.
   f. Send command for calibration of A to D gain setting.

In use of the system provided by the invention, for example by a clinician to assess the status of a subject patient, such as a person lying upon the mat provided by the system of the invention, the invention has, without limitation, the following features and advantages over previously known systems, such as, for example:

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**Gauge pressure under the subject's contact areas**

- Thoroughly evaluate static or dynamic pressure distribution through the use of real time pressure mapping and imaging system. Immediate feedback and continual, live updates, including peak pressure measurements and high resolution graphics provide the user with greater accuracy of measurement and greater affordability by comparison with existing conventional systems.

**Measure anatomical landmarks**

- A linear measurement feature functions to incorporate precision measurements of the subject's contact area width or the distance between ischial tuberosities, to ensure optimum seat selection. Pressure areas can be traced within the seating system, or the severity of pelvic rotation can be determined.
• The presence of pelvic obliquities, pelvic rotation, scoliosis, anterior or posterior pelvic tilt, sacral sitting, lordosis or any number of postural or positioning concerns can be more easily identified.

Record, freeze, save and print any and all images
• The preferred system has the capability to record up to ten minutes of video images, enabling the clinician to achieve proper assessment of self-propulsion capabilities and settle analysis.

Examine peak pressures
• Fully adjustable, repositionable peak pressure margins provide the user with immediate and continual visualization of the peak pressures, which are modifiable and able to be repositioned and resized accordingly.

Locate the subject's center of gravity
• The invention can be useful in the discovery and correction of asymmetries and obliquities, and can show the user, in real time, the center of gravity of the subject and aids the user in verifying proper positioning during evaluation or after implementing a seating solution.

Evaluate drive wheel placement
• Through the use of center of gravity feature, clinicians may easily identify discrepancies in drive wheel placement, which can affect the subject's ability to successfully self-propel a wheelchair or other wheeled assist device.

Track center of force trajectory
The force tracer feature of the system of the invention can be used to track the subject's center of gravity during self-propulsion, transfers or pressure shifts to ensure the subject is performing such tasks as efficiently as possible.

Although the foregoing description and appended drawing figures describe preferred embodiments of the invention and the advantages and various features thereof, one skilled in the art will readily ascertain that many possible variations and modifications to the specific teachings herein can be made, and that all such variations and modifications are intended to be within the scope of the invention, given the teaching of the principles of the invention contained herein.

Accordingly, the examples of preferred embodiments of the invention herein have been presented only for the purposes of illustration and description, and are not to be construed as limiting the scope of the present invention in any way. Such scope is intended to be solely defined in the claims appended hereto.
What is claimed is:

1. A force sensitive sensor system comprising a flexible mat assembly having one or more fabric or substrate layers, and having incorporated therein a conductive ink and a resistive ink in effective amounts and suitably situated within at least one of said layers, thereby to achieve an electrical response to flexing, compression, and stretching of said layer, and whereby the electrical response is measured by an associated electronic circuit means to determine the degree of such flexing, compression and stretching and correlates therewith the properties of the mat assembly and the intersections of the layers of the assembly to create a map of the physical conditions present in the assembly.

2. The sensor system of claim 1, wherein at least one of the inks is a Silver ink.

3. The sensor system of claim 1, wherein at least one of the inks is a carbon based resin screen printable ink.

4. The sensor system of claim 1, wherein at least one side of the fabric or substrate incorporates therein one or more of said inks in varying amounts to create a varying conductivity / resistivity in the Z axis of the fabric or substrate.

5. The sensor system of claim 1, wherein a multiplexing electronic circuit is used in association with the mat, which circuit is capable of addressing each of the intersections of the conductive or resistive ink of each of the layers through a multiplexer, so as to allow the measurement of the load at each created sensor intersection for pressure or shear.

6. The sensor system of claim 1, wherein multiple printed ink layers of different resistances are employed.

7. The sensor system of claim 1, wherein circuit connectors between the fabric or substrate and the electronics circuit are employed to greatly simplify, during manufacture of the system, the assembly thereof and improve the feel and performance of the map produced from use of the system, by eliminating wires.

8. The sensor system of claim 1, wherein said mat assembly can be placed between a person and a support surface, thereby to measure the forces applied to the body of the person by the surface that it is seated or lying thereupon.

9. The sensor system of claim 8, wherein the system further comprises an associated data processing system, having a computer software generated graphical display of the forces measured between the body and said support surface, showing location and magnitude of the forces.
INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 16/43369

A. CLASSIFICATION O F SUBJECT MATTER
IPC(8) - G01L 1/00 (2016.01)
CPC - Y10T29/42, G01L1/16, H01L41/1 136

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - G01L 1/00 (2016.01)
CPC - Y10T29/42, G01L1/16, H01L41/1 136

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
IPC(8) - G01L 1/00 (2016.01); CPC - Y10T29/42, G01L1/16, H01L41/1 T16, H01L41/317, G01L1/142, H01L41/1 132, H01L41/314, H01L41/081, G01L1/18, H01L41/094; USPC - 73/777

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Electronic Database Searched: PatBase; Google Patents/Scholar
Search Terms Used pressure, force, sensor, detector, conductive, resistive, silver, carbon, ink, layers, substrate, multiplexor, body, seat, sit, laying down

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
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<tbody>
<tr>
<td>X</td>
<td>US 2012/0055257 A1 (Shaw-Klein) 08 March 2012 (08.03.2012), entire document, especially para. [0023], [0029], [0032], [0050], [0052], [0066], [0076]</td>
<td>1-4, 6-7</td>
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<tr>
<td>Y</td>
<td>US 6,155,120 A (Taylor) 05 December 2000 (05.12.2000), col. 9, ln 1-22, col. 15, ln. 54-65</td>
<td>5, 8-9</td>
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<td>Y</td>
<td>US 2015/0015399 A1 (Gleckler et al.) 15 January 2015 (15.01.2015), para. [0032]-[0038], [0217], [0239]-[0245].</td>
<td>8, 9</td>
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<td>A</td>
<td>US 201 1/029038 A1 (Hoshino et al.) 01 December 201 1 (01.12.201 1), entire document</td>
<td>1-9</td>
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</table>

Further documents are listed in the continuation of Box C.

Date of the actual completion of the international search
02 December 2016

Date of mailing of the international search report
28 DEC 2016

Name and mailing address of the ISA/US
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Authorized officer:
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PCT Helpdesk: 571-272-4300
PCT OGP: 571-272-7774

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