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(56) Documents Cited
EP 0450129 A1 US 5510784 A US 4550384 A
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# (54) Data entry device

(57) A data entry device is provided having transducers responsive to the deformation of a surface in order to determine where a force is acting on that surface. In one embodiment which can serve as a keyboard, a digitising tablet or a pointing device, a planar resiliently deformable sheet 10 is supported at its periphery. Transducers 20,22,24,26 measure the local displacement or deformation of the surface and these measurements enable the position and, if desired, also the magnitude of the applied force to be calculated. Various types of transducer including optical, strain gauge and capacitive types are envisaged.

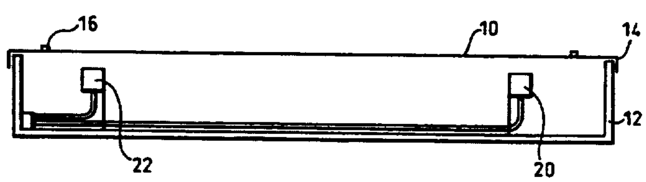


Fig.2.

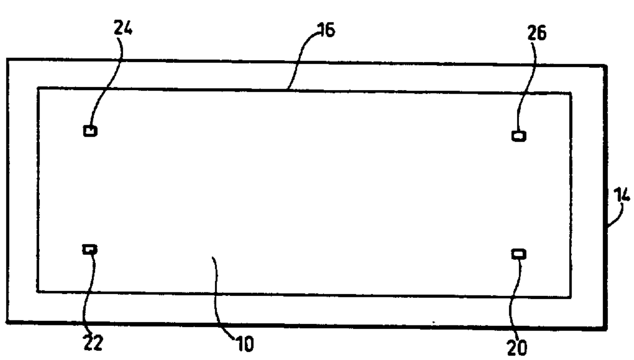


Fig.3.

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1995

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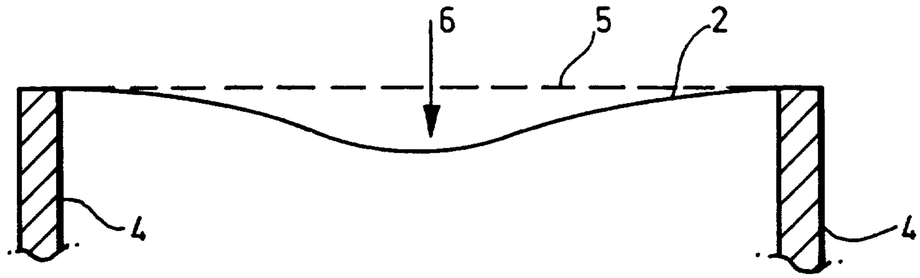



Fig.1.

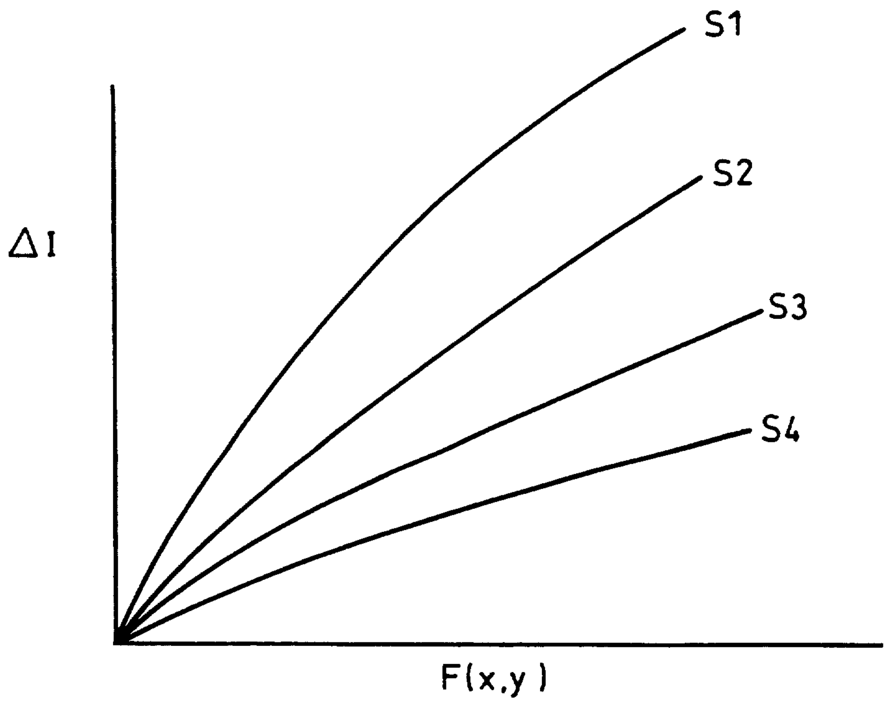



Fig.4.

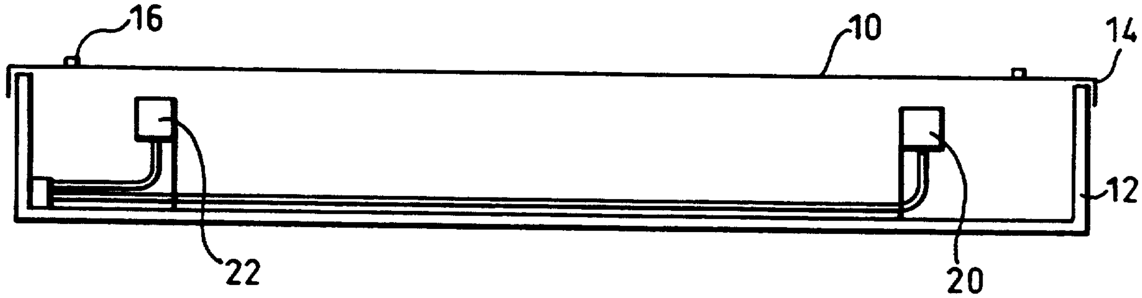



Fig.2.

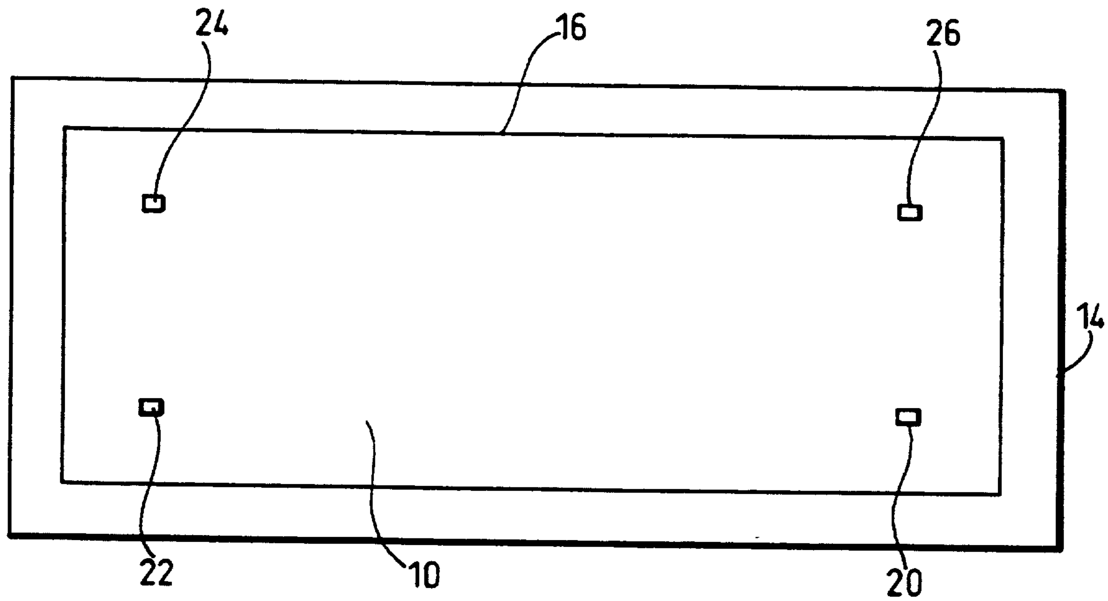
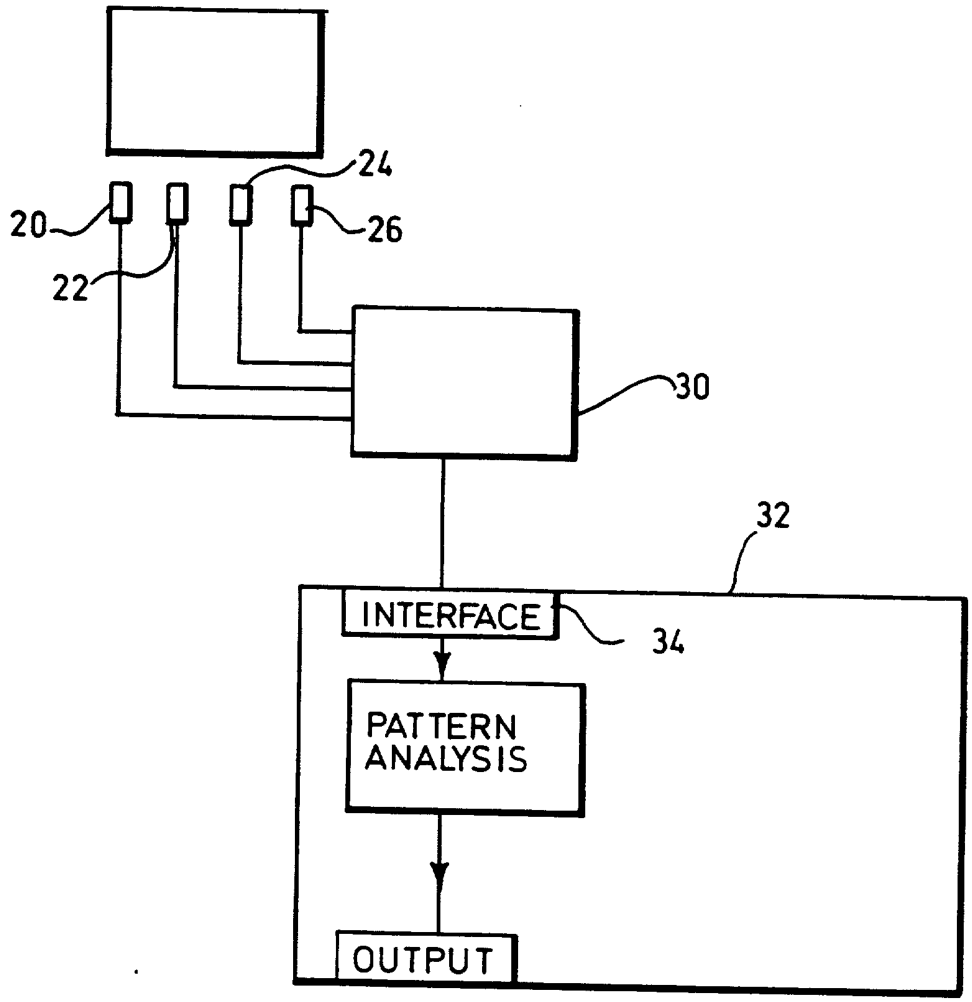



Fig.3.


20
22
24
26
30
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INTERFACE
34
PATTERN ANALYSIS
OUTPUT

Fig.5.

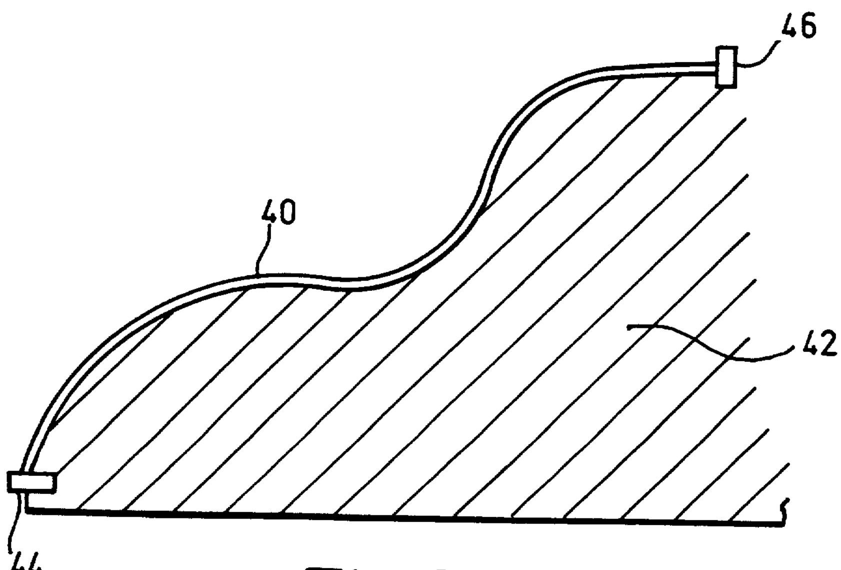
46
40
42
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Fig.6.

# DATA ENTRY DEVICE

The present invention relates to a data entry device. Such a device is suitable for use as a keyboard, a pointer, a digitising tablet, a weight sensor, a position sensor and a force sensor.

Data entry devices, such as keyboards, contain a plurality of sensing elements, for example, switches, which monitor respective areas of the data entry device. Similarly, devices such as scribble pads on portable computers again consist of a large number of sensors each responsive to force applied in an associated sector of the pad. The large number of sensors required makes the pad relatively expensive to manufacture, and relatively difficult to interconnect with other data processing equipment.

According to a first aspect of the present invention, there is provided a data entry device comprising a deformable surface and N transducers responsive to deformation of the deformable surface, where N is an integer greater than 1, the surface and transducers cooperating such that output signals from the transducers are indicative of a force being applied to the surface at a position distant from the transducers and enable the position to be determined.

It is thus possible to provide a data entry device that can identify the position of a region of contact with a sensing surface of the device. The sensing surface is not sub-divided into a plurality of sensing regions each having an associated transducer. However, the sensing device can be regarded as being, at least, capable of identifying a point of contact in M discrete areas of the device, where M is an integer greater than N.

Preferably, the deformable surface is a substantially resiliently deformable surface. Suitable examples of such a surface include: a rubber membrane which may, or may not, be pretensioned; plastic sheeting; plastics moulded to a predetermined shape; metal sheet; stiff board or plates; flexible sheets supported on resilient substrates, and so on. The above list is not intended to be exhaustive, and it will be appreciated from the description of the embodiments that a surprisingly large number of surfaces can function as the deformable surface.

Preferably, the deformable surface is supported at at least one portion thereof. Advantageously, the surface is supported at its periphery by a frame. The frame may be arranged to place the surface under tension or compression. The frame may form an integral part of the deformable surface.

Preferably, the transducers are arranged to measure the deflection of the surface. Any suitable transducer can be used. Thus, the transducers may require a mechanical connection or contact with the surface. Such transducers include resistive or variable reluctance types where an arm of the transducer is connected to, or biased into contact with, the deformable surface. Alternatively, non-contact transducers such as capacitive, pressure or optical transducers may be used. Optical transducers measuring deformation as a function of the light intensity reflected from associated portions of the deformable surface have been found, in testing, to be extremely reliable and have the advantage that the data entry device can then be made free of electrical devices. This enables a data entry pad to be formed for use in dangerous or difficult environments, i.e. explosive atmospheres or wet or submarine conditions, where electronics are unsuitable.

In an embodiment of the present invention, a rectangular sheet of plastics material (having properties similar to the plastics lid of a "TUPPAWARE" container) and having dimensions of approximately 45 cm x 30 cm is supported around its periphery on a box frame. Four optical sensors are located adjacent the corners of the deformable surface at approximately 7 cm from each edge of the respective corners. Such an arrangement has exhibited sufficient resolution to be usable as a fully functional keyboard for a computer (having 102 keys) and also to function as a pointing device (i.e. equivalent to a mouse or track ball) and also to function as a digitising tablet.

A larger version of the embodiment may be used in order to measure weight distribution. This may be of benefit as part of a medical diagnosis of orthopaedic or spinal problems. Furthermore, change of weight distribution as a function of time can also be measured and analyzed to monitor the performance of a system or a person's motion. Larger embodiments of the present invention using a deformable surface able to withstand great loads may, for example, be used as public weigh bridges in order to check the weight and weight distribution of vehicles. Analysis of weight and weight distribution can also be used to determine object shape and orientation and object identification.

Alternatively, at least one transducer can be arranged to measure tension within the deformable surface. In such an arrangement, the deformable surface may be supported at its periphery on a frame, or may be supported by a deformable substrate. The substrate may be profiled so as to be non-planar. The deformable surface may be attached to the substrate at a plurality of positions in order to conform accurately to the profile of the substrate. The substrate can take the shape of a functional article, such as a chair or bed, thereby enabling monitoring of a person's weight distribution and movement to be performed. Alternatively, substrate may take the form of a functional articles, such as part of a home appliance or, for example, an automobile dashboard. In such an arrangement various areas of the dashboard may be designated as switches and be touched in order to select and perform various functions within an automobile. Part of the dashboard may be designated as a light switch such that when that part of the dashboard is touched, the status of the lights is changed in accordance with a preprogrammed strategy. The local deformation of the dashboard caused by touching it causes stresses to be set up in the deformable surface which are transmitted across the surface to the transducers. The fact that such a data input device can be formed in virtually any shape desired enables the sensor to be used an input to a data processor for many different purposes. The sensor could, for example, be formed in the shape of a human organ to teach doctors to palpate correctly.

According to a second aspect of the present invention, there is provided a data acquisition system comprising a data entry device according to the first aspect of the present invention, and a data processor for processing the output of the transducers.

A number of techniques are suitable for processing the output of the transducers. This can be selected depending upon the task that the data entry device has to perform. In the case of a device comprising a planar deformable surface supported in a frame, the deformation of the surface under load is predictable from a analysis of the physical construction of the data entry device. Under such circumstance, the output of the sensors may be analyzed by a programable data processor executing a predetermined algorithm. Alternatively, the response of the data entry device can be determined by mapping the output of the sensors as a function of a varying load applied at varying positions. The map characteristics may be stored in a look-up table and interpolation of the stored values may be used to further enhance the resolution of the system. In a further arrangement, the data entry device may be connected to a neural network which is then trained to recognise the responses of the transducers to various input stimuli.

An advantage of the sensor, particularly when used in place of switches or data entry pads, is that additional transducers may be provided within the device to provide redundancy. Consequently, the occurrence of a force applied to the deformable surface is measured by a plurality of transducers and the failure of one or more of the transducers can be tolerated. This gives rise to a high integrity data entry device which may be used for controlling the operation of safety critical systems.

It is thus possible to provide a reliable data entry device which is inexpensive to construct, reliable, and robust.

The present invention will further be described, with reference to the accompanying drawings, in which:

Figure 1 is a schematic illustration of the deflection of a resilient surface in response to a load;

Figure 2 illustrates a data entry device constituting an embodiment of the present invention in cross-section;;

Figure 3 is a plan view of the data entry device shown in Figure 2;

Figure 4 schematically illustrates the deflection as measured by the first fourth sensors S1 to S4 of the embodiment shown in Figure 3 in response to a force applied at an arbitrary position;

Figure 5 schematically illustrates a data acquisition system incorporating a data entry device constituting an embodiment of the present invention; and

Figure 6 schematically illustrates a data entry device constituting a second embodiment of the present invention.

Figure 1 schematically illustrates a reliantly deformable surface 2 supported at its periphery by support elements 4. In an unloaded state, surface 2 is substantially planar as illustrated by the chain line 5. If a force is applied to the surface, as illustrated by arrow 6, the surface 2 deforms. The amount by which a portion of the surface becomes displaced from its rest position is a function of the force applied to the surface, the distance of that portion from the point of application of the force, the distance of that portion from the structure supporting the surface, and the physical properties of the surface itself. It is thus possible to deduce the position and magnitude of a force applied to the surface given sufficient measurements of deformation at various positions. Furthermore, if it is only desired to estimate the position of the force and not its magnitude, the problem becomes more tractable because the properties of the surface need not be so well known. In fact, the position of a force can be identified merely from the ratio of the changes of displacement as measured at a plurality of points over the surface.

Figure 2 schematically illustrates a cross-section of a data entry device constituting an embodiment of the present invention. The data entry device comprises a resiliently deformable surface 10 which engages around its periphery with a supporting frame 12. The surface 10 is formed with a peripheral depending lip 14 which abuts the sides of the supporting frame 12 in order to hold the surface 10 in contact with the frame 12. The surface 10 also has a rectangular lip 16 formed thereon. The lip 16 acts as a frame for holding templates in position on the data entry device. One template may be in the form of a standard computer keyboard, whereas other templates may have modified key arrangements for particular data entry applications. The lip 16 can be omitted and the surface 10 may be printed in order to have a particular data entry arrangement, such as a Qwerty keyboard, permanently shown thereon.

Four optical transducers 20,22,24 and 26 are located beneath the surface 10, as shown in Figure 3, and measure the deflection of the surface by measuring the displacement of those portions of the surface located immediately above the respective transducers. Each transducer comprises an optical source, such as a light emitting diode, and a photodetector. Light from the light emitting diode is reflected from the surface and received by the photodetector. The light diverges as it propagates away from the front light emitting diode, and consequently, the intensity of the light received at the photodetector is a function of the path length from the light emitting diode to the surface 10 and back to the photodetector. It should be noted that the light source and photodetector can be located remotely from the surface 10 and light can be directed to and received from the surface via optical waveguides, such as fibre optic cables.

Outputs S1,S2,S3 and S4 of the first to fourth transducers respectively, are schematically illustrated in Figure 4. Force is plotted along the ordinate and change in reflected intensity ΔI is plotted along the abscissa. If a force is applied at an arbitrary position $X_1$, $Y_1$, and the value of that force is increased from zero then a family of curves representing the outputs S1 to S4 of the sensors will be derived. An exemplary family of curves is shown in Figure 4. If the position to which the force is to be applied is moved to a new arbitrary position $X_2$, $Y_2$, and the magnitude of the force is increased from zero, then a different family of curves representing the sensors' outputs will be observed. It will be appreciated that, for a fixed value of force, the output of each sensor defines a respective surface as a function of the position at which the force is applied. In the above example, it is desired to determine only three properties of the force (X position, Y position, and magnitude). Thus, the use of four sensors to measure these three properties allows the solution to be overdetermined and reliable measurements to be made. It will be appreciated that the number of sensors can be increased to further increase the accuracy of the system.

In the case of a data entry device for use as a keyboard, or mouse, or digitising tablet, it is not necessary to measure the magnitude of the force. Thus, the problem is well determined when four sensors are used. Thus, the measurements of deflection are constantly scanned and compared with a model in order to determine the position at which the force acts. In the case of a simple arrangement such as a keyboard where the surface 10 has a regular shape it is relatively easy to determine the point at which the force acts by algebraic analysis implemented within a data processor. In the case of a keyboard, the central position of each key is known. The position at which the force was applied is estimated and checked against the key positions. If the force originates from an acceptable area associated with a key position, then it is assumed that the key has been struck. Adjacent keys may be separated by guard areas to reduce the risk of mis-keying.

It is sometimes required for two or more keys of a keyboard to be pressed simultaneously. It is possible to provide extra keys on the keyboard corresponding to selected ones of the multiple key strokes. However, it is also possible to determine the positions of two or more points of contact with the surface 10 since the deformation of the surface is a linear super-position of the individual responses. Thus, provided a sufficient number of sensors are provided, it is possible to identify the position of each of the points of contact. In order for the analytical approach to work well, it is preferably that each of the curves S1 to S4 as illustrated in Figure 4 are relatively linear. Thus, only four or five sensors are required in order to provide a fully functional keyboard having one hundred or more keys. The key positions may be ignored in order to provide the functionality of a pointing device such as a mouse. This pointing device can be used in an absolute mode (where a position of the pad always corresponds to a predetermined portion of the display) or a relative mode (where absolute position is not monitored by motion is detected and used to guide an icon on a graphical user interface).

In the case of systems having an irregularly shaped data entry pad, such as might be encountered when the data entry device forms an integral part of a car dashboard, it may be computationally easier to map the response of the data entry device in response to stimulation or to connect the data entry device as the input to a suitably trained neural network.

In the embodiment described with reference to Figure 1 to 4, the surface 10 is of a plastics material which undergoes relatively little stretching during the deformation. However, if the data entry device has a surface 10 made of a different material, such as a rubber or a fabric, then the preferred mode of sensing deformation may be by attaching strain gauges to the surface in order to measure stretching of the surface.

Figure 5 schematically illustrates a data processing system incorporating the data entry device as shown in Figures 1 to 4.

The outputs of the first to fourth transducers 20 to 26 are connected to respective input of a signal conditioning unit 30. The signal conditioning unit 30 may include amplifiers and filters and optionally analogue to digital converters and multiplexers, so as to condition the analogue input signals and present them in a form suitable for automatic interpretation by a data processor 32. The data processor 32 receives the measurements from the sensors via an interface 34 and then analyses the signals in order to determine the position, or positions, of the forces acting on the data entry device. Once the positions have been determined, these can be output from the data processor or subjected to further processing, in order to perform object identification or other desired tasks.

It should be appreciated that depending on the combination of sensor type and measurement surface, it is possible to measure shearing forces as well as forces acting normal to the surface.

The behaviour of the sensor can be adapted, for example, by introducing pressurised gas into the volume beneath the surface 10, in order to vary the load measuring capability of the device.

Figure 6 schematically illustrates a further embodiment of the present invention in which a sensing surface 40 is formed in intimate contact with a resiliently deformable substrate 42. Transducers 44 and 46 measure the tension of the surface 40 and its periphery. However, further tension measuring transducers can be provided at a position intermediate the periphery of the surface 40. Between four and six transducers are expected to be sufficient to provide coverage of a keyboard or instrument control panel. Such a sensor can be moulded into any arbitrary shape, for example, a mattress, a chair, a car dashboard, an artificial human organ, and so on, such that the distribution of forces acting on that item can be analyzed. Thus, the chair and mattress could be used to diagnose orthopaedic problems, the car dashboard can be used to replace discrete switches, and the artificial human organ can be used to train doctors in examination techniques.

In each embodiment, the surface should be elastic and exhibit deflection in bending or tension, or both, or some other repeatable deformation. Consistent behaviour is required. Visco-elastic behaviour of the surface is not, in general, considered to be a problem, but may affect the response under some circumstances. Rubber and some polymers have already been used successfully in experiments, but it will be appreciated that metals, textiles and some other composite mediums can also be used. The degree of flexibility of the surface that is required depends upon the application (i.e. the resolution, force and deflection to be sensed).

The provision of fixed boundary supports to ensure repeatable surface behaviour is an important consideration in the sensor design.

It is thus possible to provide a robust and inexpensive sensor device which can be used in a variety of applications.

**CLAIMS**

1. A measurement device comprising a deformable surface and N transducers responsive to the deformation of the deformable surface, where N is an integer greater than one, the surface and transducers cooperating such that output signals from the transducers are indicative of a force being applied to the surface at a position distant from the transducers and enables the position to be determined.

2. A measurement device as claimed in claim 1, in which the device can identify a point of contact on M discrete areas of the device, where M is an integer greater than N.

3. A measurement device as claimed in claim 1 or 2 in which the deformable surface is resiliently deformable.

4. A measurement device as claimed in any one of the preceding claims, in which the deformable surface comprises a rubber membrane, plastic sheeting, moulded plastic, metal sheet, stiff board or flexible sheets, on a resilient substrate.

5. A measurement device as claimed in any one of the preceding claims, in which the deformable surface is supported at at least one portion thereof.

6. A measurement device as claimed in claim 5, in which the deformable surface is supported at its periphery by a frame.

7. A measurement device as claimed in claim 6, in which the frame is an integral part of the deformable device.

8. A measurement device as claimed in any one of the preceding claims, in which the deformable surface is under tension or compression.

9. A measurement device as claimed in any one of the preceding claims, in which the transducers measure the deflection of the deformable surface.

10. A measurement device as claimed in any one of the preceding claims, in which the transducers contact the deformable surface.

11. A measurement device as claimed in any one of claims 1 to 9, in which non-contact transducers are used to measure deflection of the deformable surface.

12. A measurement device as claimed in claim 11, in which the transducers are capacitive, pressure or optical transducers.

13. A measurement device as claimed in claim 11, in which

the transducers are optical transducers which measure the deflection of the deformable surface as a function of light intensity reflected from the deformable surface.

14. A measurement device as claimed in any one of the preceding claims, in which at least one transducer is arranged to measure tension within the deformable surface.

15. A data entry device, comprising a measurement device as claimed in any one of the preceding claims.

16. A data entry device as claimed in claim 15, in which the data entry device is a keyboard.

17. A data entry device as claimed in claim 16, in which the keyboard is a computer keyboard.

18. A data entry device as claimed in claim 17, in which the keyboard is a QWERTY keyboard.

19. A data entry device as claimed in any one of claims 15 to 18, in which the data entry device is a pointing device.

20. A data entry device as claimed in any one of claims 15 to 19 in which the data entry device is a digitising tablet.

21. A measurement device as claimed in any one of claims 1 to 14 for measuring weight and load distribution.

22. An apparatus for use in medical investigation of orthopaedic or spinal problems, comprising a measurement device as claimed in claim 21.

23. A weighbridge for checking weight and/or load distribution of a vehicle, comprising a measurement device as claimed in claim 21.

24. A vehicle dashboard comprising a measurement device as claimed in any one of claims 1 to 19.

25. A measurement system, comprising a measurement device as claimed in any one of the preceding claims and a data processor responsive to the transducers for determining where a force is applied to the deformable surface.

26. A method of determining where a load has been applied to a deformable surface, comprising the steps of measuring deformation of the surface in response to the load at N positions, where N is an integer greater than one, and comparing the amounts of deformation in order to determine the position at which the load has been applied.

27. A measurement device substantially as hereinbefore described with reference to Figures 2 and 3 of the accompanying drawings.

28. A measurement device substantially as hereinbefore

described with reference to Figure 5 of the accompanying drawings.

29. A measurement device substantially as hereinbefore described with reference to Figure 6 of the accompanying drawings.

The Patent Office

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**Application No:** GB 9609167.3
**Claims searched:** 1-29

**Examiner:** M. G. Clarke
**Date of search:** 15 April 1997

# Patents Act 1977
# Search Report under Section 17

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): G1A AEEX, AENC, AENX, AEXP; G1N NAQB; G4H HKG, HKV

Int Cl (Ed.6): G06K 11/08, 11/16

Other: ----------------

**Documents considered to be relevant:**

| Category | Identity of document and relevant passage | | Relevant to claims |
|---|---|---|---|
| A | EP0450129A1 | MBB GmbH - whole document | 2,16,17 |
| X | US5510784 | assigned to US Philips Corpn - see especially Figs. 2-5 | 1-3, 5,14,26 at least |
| X | US4550384 | assigned to Alps Electric Co - whole document | 1,3,5,6,14 20,25,26 at least |
| X | US4542375 | assigned to AT&T Bell Labs - whole document | 1,12,15,20 and 26 at least |

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