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FINGERPRINT SENSOR.

This invention relates to a fingerprint recording apparatus and in particular to apparatus in which the representations of the human fingerprint are faithfully reproduced in the form of electrical or magnetic signals which are then recorded in relation to the positions from which they are generated.

According to the invention there is provided a fingerprint sensor comprising an array of individually actuable sensing cells, the cells each having discrete force sensitive switch means actuated by the presence or absence of contact of the respective cell by a fingerprint epidermal ridge to produce output signals representative of those sensing cells which have been actuated.

In the first application a thin plastic sheet, upon which platelets of metal have been deposited, is placed above a matrix construction of fine conductors.Current is applied to either the rows or columns of the matrix and connection between the rows and columns takes place when a platelet is caused to bridge the gap (see Fig 1) between the contact pads. This occurs on contact with a human finger when the plastic sheet is deformed by the ridges of skin forming the 'fingerprint' pattern.The resulting electrical signal is then latched into a shift register from where it may be stored or manipulated by a microprocesor.

In the second (preferred) application the platelets deposited upon the underside of the plastic sheet, comprise a resin containing ferrous oxide (or they may be made from permalloy or other easily magnetisable material).When the thin plastic sheet is placed on a flat surface (glass) and subjected to a uniform magnetic field, generated by an electromagnet held at a discrete distance from the surface of the platelets, whilst a fingertip is pressed upon it,(See FIG 3) the platelets become magnetised, only where the ridges of skin forming the 'fingerprint' pattern have made contact with the thin plastic sheet.This generates a pattern of magnetic poles within the platelets representative of the fingerprint, in which form it may be read by an electromagnetic recording head (see FIG 3) and subsequently manipulated by a microprocessor.
Alternatively, the magnetic 'image' may be transferred or induced into the upper layers of a magnetic 'bubble memory'using an induction coil (SEE FIG 4). Bubble memories are well understood and have been in production for many years

and the status of magnetic domains within the magnetic garnet is easy to determine using existing technology. The main direction of polarisation of the magnetic garnet is vertically downwards and the memory is non volatile. Thus the fingerprint input may be easily transferred, digitised automatically and stored in a form readily available for manipulation.

In an other configuration the patterned metal coating shown in FIG 1 may be replaced by polyvinylidene difluoride, which is a piezoelectric film. When used to bridge the gap between the contact pads as in FIG 1, an electrical signal is generated by the material as a result of the applied pressure of the finger upon the sensor. Distortion of the piezoelectric crystals within coating the may be caused by altering the topography of the sensor in order to optimise the output from the crystal, or alternatively, the platelet may be fixed to the contact pads in a prestressed form (see FIG 5).Its subsequent deflection under imposed load generating a signal. In all other respects the sensor construction remains substantially the same.

In yet another configuration the platelets may be coated with poly(sulphur nitride). Poly(silver nitride) is a pressure sensitive polymer which may be used to coat a semiconducting platelet. Under the combined action of applied pressure and distortion of the platelet as in FIG 5 above the poly(sulphur nitride coating may be used as a switch or barrier, allowing the flow of current to be controlled at the sensor contact pad.In order to optimise the order of signal generated the 'bridge' of plastic is designed to be at or close to its crippling load (see EULER's theory of struts) so that mechanical movement of the 'bridge' takes place on contact.This condition applies to both configurations where piezo-electrical and Poly(silver nitride are used.

Fingerprint records were first introduced in the United Kingdom in 1901. Using ink, an impression of the fingerprint ridge pattern was recorded on paper. Comparison of two fingerprint samples was then made visually . In 1978 Wegstein and Rafferty in a study for the FBI showed that rapid matching of fingerprint impressions could be carried out by locating the endings and bifurcations of the ridges which comprise the fingerprint pattern.The proceedure changed little until recently when a number of sources expressed an interest in Automatic Fingerprint Recognition systems.Most systems rely on optical methods, making use of an image presented on the face of transparent material which is subsequently scanned and then recorded.Most of the systems reduced to practice have been slow, cumbersome and expensive. Additionally, because of the nature of technologies used the recorded impressions lack quality of detail which complicates the process of positive identification .

Three dimensional studies of the fingerprint profile reveals that the amplitude or distance between the tip of a ridge and the bottom of a trough is typically about 12 microns and the pitch from ridge to ridge typically 400 microns. For this reason a sensor of the type described herein must have a cell resolution of 100 microns or greater and be capable of switching within a distance of 6 microns.

According to the present invention a means of recording fingerprint data is provided with the construction shown in FIG 1. A very thin sheet of polyethelene terphthate (FIG 1a) which has been coated with metal platelets is held separated from a rigid substrate (FIG 1b) which supports a series of fine conducting electrodes (FIG 1c).When a human finger is pressed onto the plastic sheet it deforms (see FIG 2) and the plastic sheet faithfully reproduces the physical form of an impinged fingerprint.(This phenomenon only occurs when the thickness of the sheet is less than 5 microns and the metal coating less than 1000 Angstrom Units.)

The distortion causes metallised platelets on the surface surface of the plastic sheet to be brought into contact with contact pads directly under the the ridges causing an electrical current to flow. The electrode is connected to the input port of a shift register (FIG 6f) causing its status to alter.The gate or latch of the shift register generates a 'high' (1) or a 'low' (0) depending upon whether contact has been made between the metallised film and the electrodes.This change in status is monitored by a microcontroller (Fig 6g) which is linked to a computer (not shown). In this manner, a detailed map of the fingerprint ridge pattern may be constructed using a '1' for ridge presence and a '0' for no contact.

A typical small sample array is shown in FIG 7 and if a matrix is constructed as in FIG 4, where the plastic film (FIG 7a) has a patterned metal coating and the substrate (FIG 7b) supports two metal layers of conductors (FIG 7c) comprising the matrix a highly detailed 'map' may be constructed of the fingerprint ridge pattern. In particular, the main features of a fingerprint, known as 'minutiae' can be located. These features comprise ridge endings (FIG 8) and ridge bifurcations (Fig 9) and may be located within the matrix by examination of the data stream obtained from the shift registers.

A diagrammatic representation of a fingerprint is shown in FIG 10 and the 'minutiae' encircled .These have been extracted and produced in their relative positions in FIG 11 to form a template or constellation. The fourteen unique bits of data may be stored on terms of their x-y co-ordinates or in terms of their distance from a datum, which is the centriod or epicentre of the constellation,thus considerably reducing the amount of data which needs to be stored and at the same time reducing the time required to make comparisons of fingerprints. Further,it also eliminates problems created by translational and rotational movements of the finger within the sampling matrix during data capture.

If both a positive and a negative of the fingerprint are produced and overlayed so that their contours coincide then the combined picture is 'blacked out'. If however one picture is shifted one ridge pitch with respect to the other and then added the combined picture reveals a missmatch where the 'minutae' occur. The records may be shifted one ridge pitch in the vertical (Y) and horizontal (X) directions and subtracted from each other to yield a 'constellation'. In digital terms this process is the same as the exclusive-or process in an exclusive-or gate where only the difference between two data streams is saved when they are added together.

The position of the 'minutae' may be automatically determined when the above apparatus is constructed as in FIG 12 . where the output from the latches is applied to two shift registers which effect discrete delays in the data streams. The shift register output is then EXCLUSIVE-OR ADDED in sequence to generate the configuration of minutae or 'constellation' depicted in FIG 11.Further data processing reduces this 'constellation' to the co-ordinates of each 'star' and its angular relationship to the epicentre of the 'constellation.As well as storing this information in the memory of a microprocessor the data can be translated into code and written onto the magnetic strip of a credit card. The design for handling the electronic signals generated by the sensor may be employed in all of the applications described above whence a compact device amy be constructed capable of interrogating its user on contact with the fingertip.

The sensor is compact and inexpensive. It can be constructed using thin film techniques on a flexible substrate and may be built into a credit card or act as a stand-alone device where it can be used as a means of access control.

CLAIMS

1. A fingerprint sensor comprising an array of individually actuable sensing cells, the cells each having discrete force sensitive switch means actuated by the presence or absence of contact of the respective cell by a fingerprint epidermal ridge to produce output signals representative of those sensing cells which have been actuated.

2. A fingerprint sensor according to claim 1 wherein the sensor comprises a plurality of first conductors, a plurality of second conductors overlying, separated from, and crossing the first conductors, switch means associated with each cross-over point, and a resiliently deformable film overlying the second conductors and having a plurality of discrete conductive elements on its lower surface to operate the switch means in response to applied pressure.

3. A fingerprint sensor according to claim 1 wherein the sensor comprises a plurality of first conductors, a plurality of second conductors overlying, separated from, and crossing the first conductors, and each sensing cell includes switch means responsive to applied pressure and associated with a cross-over point, the switch means being pre-stressed piezoelectric elements each having one end connected to a respective one of the first conductors and another end connected to a respective one of the second conductors.

4. A fingerprint sensor according to claim 2 or claim 3 wherein said first conductors are parallel to each other and said second conductors are parallel to each other.

5. A fingerprint sensor according to claim 1, wherein the sensor includes a resiliently deformable film above a surface and each sensing cell comprises a discrete magnetisable sensing element on the film's surface, the extent of magnetisation of each magnetisable sensing element being responsive to pressure applied thereto, and the sensor further comprising magnetising means for magnetising the magentisable sensing elements, detection means

responsive to the extent of magnetisation of each of the sensing elements to produce output signals distinguishing those elements contacted by an epidermal ridge from those not so contacted.

6. A fingerprint sensor according to claim 5 wherein the detection means includes an electromagnetic recording head.

7. A fingerprint sensor according to claim 5 wherein the detection means includes a magnetic bubble memory and an associated induction coil.

8. A fingerprint sensor according to any of the preceding claims wherein the array of sensing cells is on a plastics card.

9. A fingerprint sensor according to any of claims 1 to 8 further comprising first processing means for processing the output signals to produce a sensed pattern digital signal or image representative of a sensed fingerprint pattern, memory means for storing the sensed pattern signal or image, second processing means for producing an inverted signal or negative image of the sensed pattern signal or image, third processing means for shifting said inverted signal or negative image one ridge pitch with respect to the sensed pattern signal or image, and fourth processing means for adding the shifted inverted signal or negative image and the sensed pattern signal or image to produce a processed signal image indicative of the relative positions of fingerprint pattern ridge minutiae.

10. A method of sensing a fingerprint pattern comprising the steps of; actuating an array of discrete force sensitive switches by the presence or absence of contact of each switch by a fingerprint epidermal ridge to produce output signals representative of those switches which have been actuated, producing a sensed pattern digital signal or image of the sensed fingerprint pattern, storing said sensed pattern signal or image in a memory, producing an inverted signal or negative image of said sensed pattern signal or image, shifting said inverted signal or negative image one ridge pitch with respect to said sensed pattern signal or image, adding said shifted inverted signal or negative image to said stored sensed pattern signal or image to

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produce an output signal or image indicative of the relative positions of ridge minutiae of the fingerprint pattern.

11. A fingerprint sensor substantially as herein described and with reference to the accompanying figures.

12. A method of sensing a fingerprint pattern substantially as herein described and with reference to the accompanying figures.