United States Patent [19]

Hurst et al.

[11] **3,911,215**

[45] **Oct. 7, 1975**

[54] **DISCRIMINATING CONTACT SENSOR**

[75] Inventors: **George S. Hurst; William C. Colwell, Jr.**, both of Oak Ridge, Tenn.

[73] Assignee: **Elographics, Inc.**, Oak Ridge, Tenn.

[22] Filed: **Mar. 18, 1974**

[21] Appl. No.: **452,784**

[52] **U.S. Cl.** .... **178/18;** 200/86 R

[51] **Int. Cl.²** **H01H 43/08;** H04N 1/00

[58] **Field of Search** .... 200/86 R, 153 M, 46, 159; 178/18, 19, 20; 33/1 M; 340/272

[56] **References Cited**

UNITED STATES PATENTS

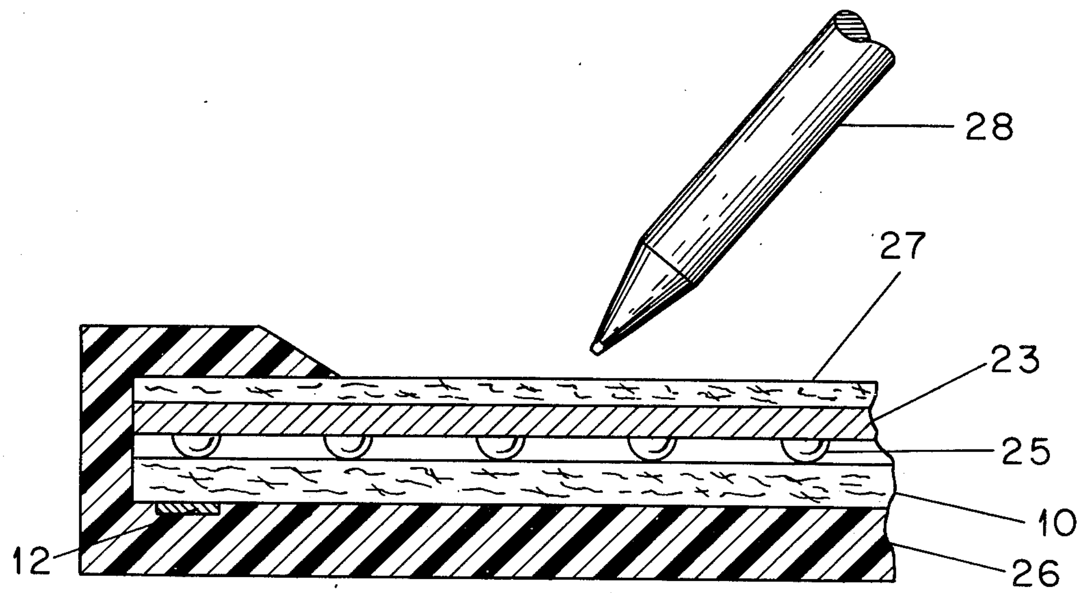
3,617,666	11/1971	Braue	200/86 R
3,632,874	1/1972	Malavard et al.	178/18
3,668,337	6/1972	Sinclair	200/86 R
3,722,086	3/1973	Wikkerink et al.	200/86 R

Primary Examiner—Thomas A. Robinson
Attorney, Agent, or Firm—Martin J. Skinner

[57] **ABSTRACT**

A sensor construction is described for normally maintaining two juxtaposed electrical potential carrying sheets, at least one being flexible, separated from each other but permitting contact therebetween when an object of specified radius of curvature is pressed against the flexible sheet. The separation of the sheets is accomplished by producing discrete small buttons of insulation, preferably on the flexible sheet, with the spacing and the height of the buttons determining the largest radius of curvature to which the sensor will respond. This construction is specifically applied to a telescriber sensor or the like whereby contact is made only by depression of the flexible sheet with a writing instrument and not by any portion of a writer's hand.

6 Claims, 5 Drawing Figures



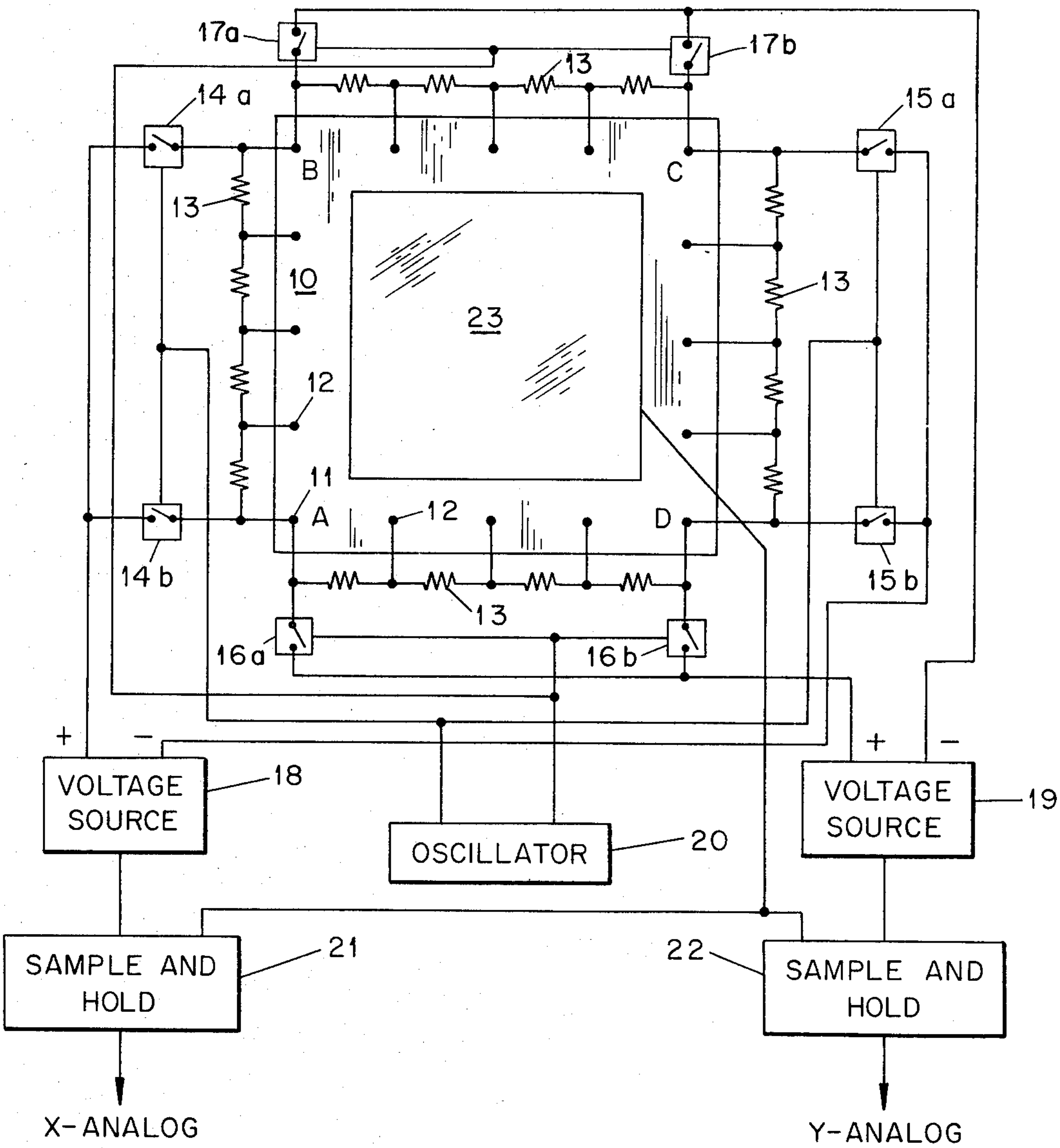


FIG. 1
(Prior Art)

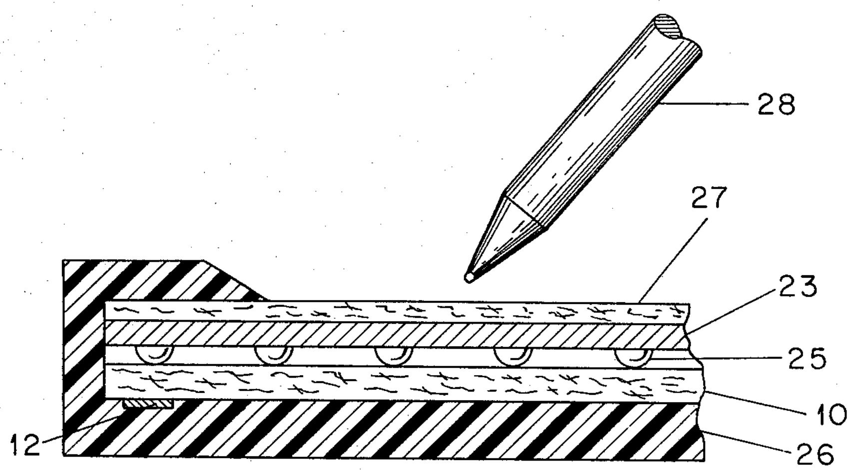


FIG. 5

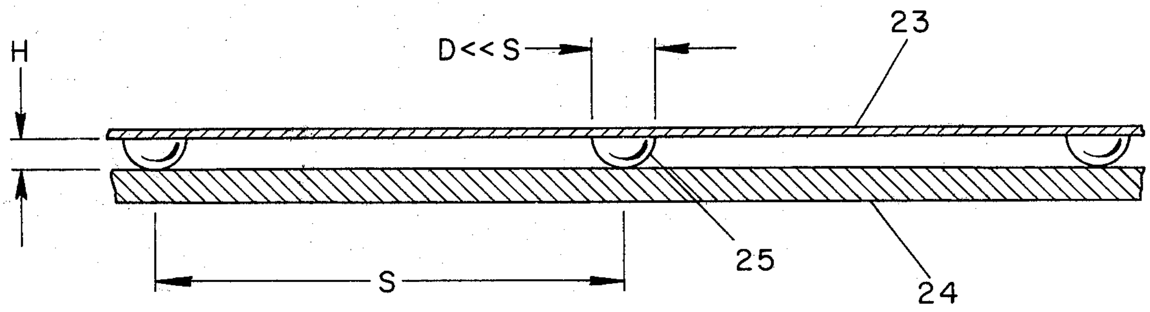


FIG. 2

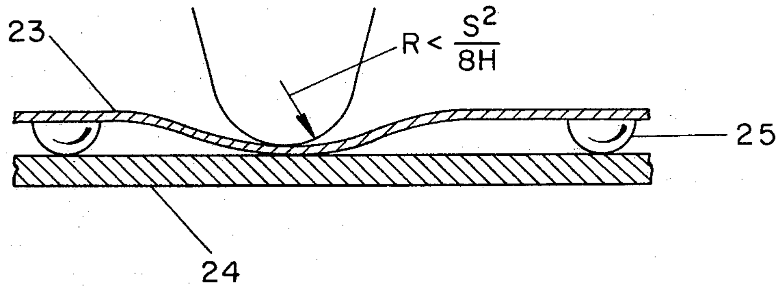


FIG. 3

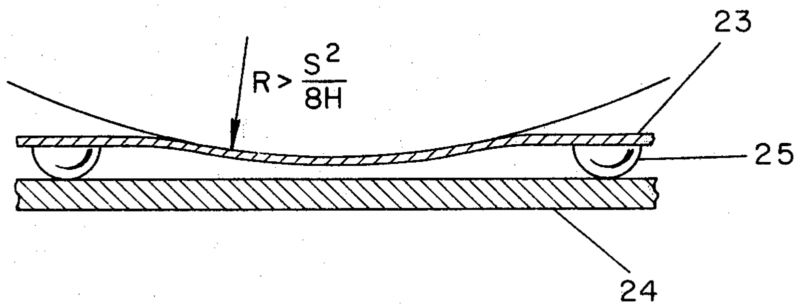


FIG. 4

DISCRIMINATING CONTACT SENSOR

BACKGROUND OF THE INVENTION

Our invention relates generally to the insulation of one electrical potential carrying sheet from a second such sheet except when contact therebetween is purposely desired, and more specifically to insulation means whereby the sheets are brought into contact only by an object having a radius of curvature less than a specific value, the value being established by the arrangement of the insulation. The invention is illustrated as applied to writing sensors useful for the electrographic determination of coordinates of a point or for the telemetry of drawings, signatures and the like.

Typical of the prior art in this field is found in U.S. Pat. No. 3,632,874 issued to L. C. Malavard et al. In that patent, and specifically FIG. **9**, a conductive sheet of flexible material is separated only by an air space from a second surface or sheet to which is applied orthogonal electrical fields. A writing instrument is used to bring the sheets together and thereby generate *x*- and *y*-related signals as the writing instrument is moved. However, it may be seen that finger tips, knuckles, the edge of the hand, or other objects could deform the flexible sheet and give rise to erroneous output signals.

In copending application Ser. No. 244,629, now U.S. Pat. No. 3,798,370, issued to G. S. Hurst on Mar. 19, **1974**, a sensor is described in which a "deformable" insulation is utilized between a flexible conductive grounding sheet and a resistive sheet having the orthogonal electric fields. In one embodiment a gel separates the layers. Although the gel provides the necessary insulation between the sheets, it is not a practical solution for production units because of the care required to produce a reproducible characteristic. A second embodiment, in the form of a nylon net or the like, is amenable to the production of sensors and is satisfactory for many applications of the sensor. However, when handwriting is performed on the sensors fabricated using the net, the nonuniform thickness (the threads versus the knots) of even the finest available net material may be felt during the writing. Also, movement of the net between the layers gives rise to gradual deterioration of the materials in contact therewith.

SUMMARY OF THE INVENTION

Our invention in its simplest form utilizes a distribution of small discrete insulating buttons of uniform height to normally separate two electrical potential carrying sheets where at least one of the sheets is flexible. The buttons may be either uniformly or randomly distributed and are preferably affixed to the flexible sheet. The spacing and height of the insulating buttons are chosen, assuming a fixed diameter, so as to prevent contact of the layers by an object having a radius of curvature greater than a selected value and thereby discriminate between objects of different radii of curvature. Specifically, the dimensions are chosen to permit contact between the layers upon deformation by a conventional writing instrument but prevent contact by any part of a hand holding the writing instrument. In this structure we eliminate any physical or psychological deterrents to normal handwriting.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram of a simplified circuit, substantially as found in above-referenced copending application (now U.S. Pat. No. 3,798,370), for the purpose of permitting a description herein of one application of our invention;

FIG. **2** is an enlarged cross sectional drawing illustrating the most general form of the subject matter of our invention;

FIG. **3** is an enlarged cross sectional view of our invention when contacted by an object of less than a specified radius of curvature for a given set of parameters for the insulation;

FIG. **4** is an enlarged cross sectional view of our invention when contacted by an object of greater than a specified radius of curvature; and

FIG. **5** is an enlarged cross section drawing of an electrographic sensor embodying our invention for point coordinate determination, written telemetry and the like.

DETAILED DESCRIPTION

The underlying principle of our invention may be explained through the use of FIG. **2** which shows the essential components of the sensor in an enlarged cross sectional view. Two substantially planar and parallel sheets **23, 24** are assumed to have an electrical potential applied thereto by any conventional means such as described hereinafter. Sheet **23** is flexible, so as to be deformable toward the second sheet **24** which may be rigid. Typical of the flexible material is "Velostat," a conductive plastic distributed by Customs Materials, Inc., of Chelmsford, Mass., or Mylar (E. I. DuPont) with an aluminized surface as manufactured by numerous companies. The second sheet may be a conductive metal plate or, alternatively, a resistive paper supported on an appropriate backing. If a resistive sheet is utilized, a typical material is resistance paper Type L, manufactured by Knowlton Bros., Watertown, N. Y., having a resistance of 1000 to 2000 ohms per square.

Separating the sheets **23** and **24** are a plurality of distributed insulation buttons **25** preferably attached, as shown, to the flexible sheet for most applications. These buttons are of substantially equal diameter, D, and height, H, and may be randomly or uniformly distributed with a spacing, S, being either an average spacing (if random) or the actual center-to-center spacing (if uniform). The diameter, D, is very much smaller than the spacing, S. In general, a small diameter is desirable, and the height and spacing are chosen for a particular application of the layered structure. The insulating buttons **25** may be applied to sheet **23** using one of several standard techniques again depending upon the dimensions. Typical application methods are air-jet spraying, electrostatic spraying, rollers and silk screen techniques. The material utilized to form the buttons may be, for example, insulating printer's ink, epoxy paint or varnish.

With the construction shown in FIG. **2,** we have determined that the height and spacing (with a small fixed diameter) will affect the manner of deforming sheet **23** so as to contact sheet **24.** We have developed a quantitative relationship for the condition that the two sheets can be brought into contact by pressing the flexible sheet with an object. This relationship can be expressed in terms of the radius of curvature, R, of the pressing object using the equation $R \approx S^2/8H$. An object having a radius of curvature smaller than the value of $S^2/8H$ will bring about contact of the layers, as shown in FIG. **3.** In contrast, an object of radius of curvature greater than $S^2/8H$ will not bring about contact, as illustrated in FIG. **4.**

This characteristic of discrimination by the structure as to the radius of curvature may be used, for example, to determine the number of particles of a given size range that impinge against the flexible layer **23.** Thus, the structure would be used as a switch in a conventional electrical counting system. The use of several sensors each having a discrimination corresponding to different values of R would provide an electrical counting system capable of counting the number of impinging particles having various radii of curvature.

Our invention, however, is of particular value in telemetry sensors and coordinate determining sensors. Typical of such sensors is that described in the aforementioned copending patent application of G. S. Hurst. This may be understood by referring to FIG. **1** which is a schematic circuit diagram of that patent application, and to FIG. **5** which is an enlarged cross section of a sensor embodying our present invention for use with the circuit of FIG. **1.** Referring first to FIG. **1,** a uniform highly resistive sheet **10** is suitably mounted by any conventional means to a support (not shown) so as to form a plane. In each corner of sheet **10** are spot electrodes **11** as at points A, B, C, and D. Spaced between the corner spot electrodes, in a row-like manner, are edge spot electrodes **12** along each edge of sheet **10.** Three edge electrodes are shown along each edge for illustration; an actual sensor may have more or less for a particular size and application.

Connected between adjacent spopt electrodes **11** and **12** are individual discrete high precision (e.g., 0.1 to 1.0%) resistors **13.** These resistors **13,** in series along each edge, form four resistor networks joined to electrodes **11** at points A, B, C and D. It will be recognized that this structure, using discrete resistors, permits the choice of preferred precision resistive elements to assist in the establishment of uniform electrical gradients in the resistive paper **10.**

The ends of each resistor network are connected, in an appropriate sequence, to a voltage source **18** or **19** by appropriate switches such as **14***a*, **14***b*, etc., in order to achieve orthogonal electric fields. Although a single switch across each network would function in the same manner, solid state switches required for rapid operation (e.g., 10^4–10^5 Hz) often exhibit ohmic resistance in the closed position. However, the resistance of each of the contacts of a chip of four switches is substantially equal and thus the circuit as shown overcomes the effect of differing internal resistance. Operation of the switches **14–17** is governed by the output signals of oscillator **20.**

Further details of the electrical circuit may be found in the cited copending application (now U.S. Pat. No. 3,798,370). The operation of the circuit results in uniform orthogonal electric fields being generated in resistive sheet **10** during mutually exclusive time periods. Accordingly, when any specific electrical potential (such as an electrical ground) is applied at a point on the resistive sheet, as by bringing sheet **23** into contact with sheet **10,** output signals are produced that are related to the x- and y-coordinates of the point. The coordinates are sampled at the rate of the oscillator; thus, the coordinates of a "moving point" may be followed from the signals generated at the output of conventional sample-and-hold circuits **21, 22.** These sample-and-hold circuits maintain the signal due to one coordinate while the other coordinate signal is being measured and then update the signal with new values.

In practice, the resistive sheet **10** is made a portion of a sensor unit such as illustrated in FIG. **5.** This shows the sheet **10** and an electrode **12** mounted within a case **26.** Spaced above resistive sheet **10,** and parallel thereto, is the flexible conductive sheet **23** such as formed from aluminzed Mylar or the like. The flexible layer **23** is normally separated by the insulator buttons **25** from the resistive sheet **10** as described hereinabove. Placed upon the flexible sheet **23** is a protective cover sheet **27.** Any conventional writing instrument **28,** such as a ball-point pen or pencil, may be moved over the surface of the cover sheet **27,** or another sheet (not shown) laid thereon, so as to depress the flexible sheet **23** to bring about contact with the resistive sheet **10** thus initiating electrical signals corresponding to the coordinates of the contact point.

In order that the writing instrument **28,** if moved continuously on the sheet **27,** will not be above an insulating button **25** more than about 1% of the time, a maximum button size (diameter) of less than 0.005 in. (0.125 mm) is preferred. With this condition, the time of interruption of electrical contact between sheets **10** and **23** during continuous writing will be much less than 1%. The spacing between buttons **25** should be much greater than the diameter of the buttons and for this application may be in a range of about 0.025 to 0.075 in. (0.635 – 1.9 mm). The height of the buttons, if less than about 0.005 in. (0.125 mm) cannot be felt as writing occurs. In order to provide reasonable discrimination between pressure of a writing instrument and portions of a writer's hand, the above-cited equation, $R \approx S^2/8H$, may be used to determine the value of R for various values of separation, S, and height, H. For example, if $S = 0.030$ in. (0.66 mm) and $H = 0.001$ in. (0.025 mm) then R equals about 0.1 in. (2.54 mm). With $S = 0.050$ and $H = 0.002$ in. (1.27 and 0.05 mm, respectively), R becomes 0.15 in. (3.8 mm). Either of these values are sufficiently small such that the portions of a writer's hand will not cause contact between the flexible sheet **23** and the resistive sheet **10.** However, an instrument like a ball-point pen with a radius of curvature of about 0.025 in. (0.635 mm) will readily cause contact as it moves across the surface except when over a button (1% or less of the surface). Accordingly, continuous writing may be performed with output signals being derived continuously that are proportional to the writing instrument position.

The output signals of the circuit may be utilized in many ways. For example, if the sensor is utilized for signature verification, the signals may be transmitted to a remote station where a duplicate of the signature may be produced using conventional equipment (e.g., an oscilloscope). Alternatively, the signals may be compared with signals held in storage in a computer for verification of the identity.

In another utilization, data points on graphs and the like may be digitized, displayed, reproduced and/or stored. This would apply also to storage of information related to sketches of proposed design of an apparatus part, etc., until a final design is completed. Furthermore, output signals derived from data may be processed by a programmed calculator to compute desired information.

Having described several applications for our invention, it will become apparent to those versed in the art that the basic sensor has many applications. We mean, by the term basic sensor, a composite of a pair of sheets, each being capable of carrying an electrical potential and at least one being flexible, separated by small discrete buttons of insulating medium. The preferred dimensions of the insulating buttons will vary according to the utilization of our discriminating sensor. For most applications, one of the layers will be a resistive sheet in which may be established orthogonal electric fields. Although we prefer applying the present invention to the sensor of the cited copending application (now U.S. Pat. No. 3,798,370), it may be applied to sensors such as those described in U.S. Pat. Nos. 3,632,874, 3,449,516, 3,670,103, etc.

I claim:

1. A discriminating contact sensor which will respond only to a contacting object having a radius of curvature less than a specific value, which comprises: a first sheet of a flexible material capable of being energized to establish an electrical potential thereon, a second sheet capable of being energized to establish an electrical potential thereon in juxtaposition with the first sheet, and a plurality of substantially uniform discrete insulating buttons electrically separating the first and second sheets throughout the sensor, the buttons having a height and an average spacing whereby the maximum radius of curvature of the object to which the sensor will respond is approximately equal to the square of the average spacing between the buttons divided by eight times the height of the buttons.

2. The sensor of claim **1** wherein the insulating buttons are substantially circular in a section parallel to the first and second sheets and have a diameter from about 0.001 to about 0.015 in., an average spacing between adjacent buttons of from about 0.025 to about 0.075 in. and a height in a direction perpendicular to the first and second sheets of from about 0.0005 to about 0.015 in.

3. An improved electrographic sensor for writing thereon of the type wherein a uniform resistive sheet having electrodes attached thereto for the application of orthogonal electrical potentials is overlaid with a flexible conductive sheet and spaced therefrom so as to normally prevent contact therebetween but permit contact when the flexible sheet is deformed by an object having a radius of curvature less than a specific value, wherein the improvement comprises: discrete insulator buttons of substantially uniform size electrically separating the sheets throughout the sensor, the buttons having a height and an average spacing whereby the maximum radius of curvature of the object to which the sensor will respond is approximately equal to the square of the average spacing between the buttons divided by eight times the height of the buttons.

4. The sensor of claim **3** wherein the insulating buttons are attached to the surface of the conductive sheet.

5. The sensor of claim **3** wherein the buttons have a diameter from about 0.001 to about 0.015 in., the height thereof is from about 0.0005 to about 0.015 in., and the average spacing between the buttons is from about 0.025 to about 0.075 in.

6. The sensor of claim **3** wherein the electrodes attached to the resistive sheet are a plurality of spot electrodes equally spaced along each edge of the resistive sheet; and further comprising a plurality of discrete resistors each of which are connected between adjacent of the spot electrodes whereby a series resistor network is formed along each edge of the resistive sheet.

* * * * *