United States Patent

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[72] Inventor Biagio F. Ambrosio
Woodland Hills, Calif.
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[73] Assignee Telautograph Corporation
Los Angeles, Calif.

[54] **PRESSURE-SENSING TABLET**
12 Claims, 8 Drawing Figs.

[52] **U.S. Cl.** .... **340/173 R,** 200/46, 178/18, 340/347 P
[51] **Int. Cl.** **G11c 5/02,** G11c 7/00, G11c 17/00
[50] **Field of Search** .... 340/173, 347 P; 178/18–20; 200/46

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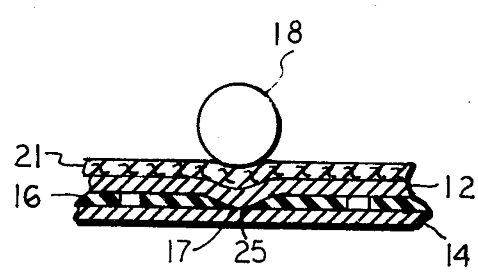
Primary Examiner—Stanley M. Urynowicz, Jr.
Attorneys—Samuel Lindenberg and Arthur Freilich

ABSTRACT: A pressure-sensing encoder tablet which detects the movement of a pointed writing instrument is disclosed. The tablet includes a resilient, perforated insulating elastoner sheet disposed between the conductive surfaces of first and second incoder sheets. The perforations are spaced in a uniform pattern and are of a diameter sufficient to permit the writing point under normal writing pressure to deform said first sheet into contact with said second sheet. The perforations are formed by disposing the elastoner sheet in front of a laser and pulsing the laser to form a repeating line pattern of uniformly spaced and sized perforations.



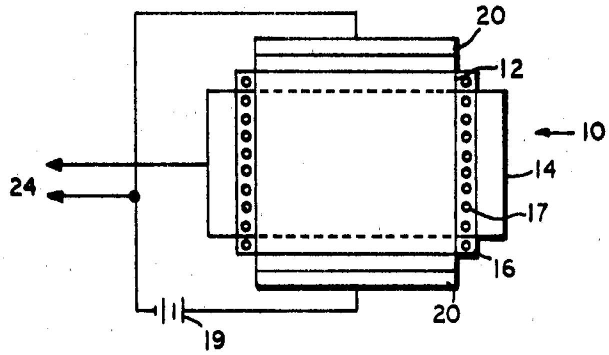


FIG. 1

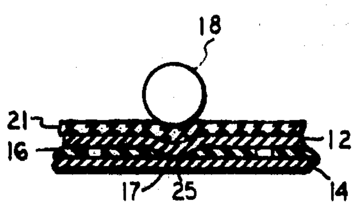


FIG. 2

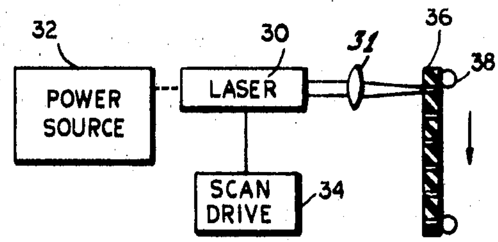


FIG. 3

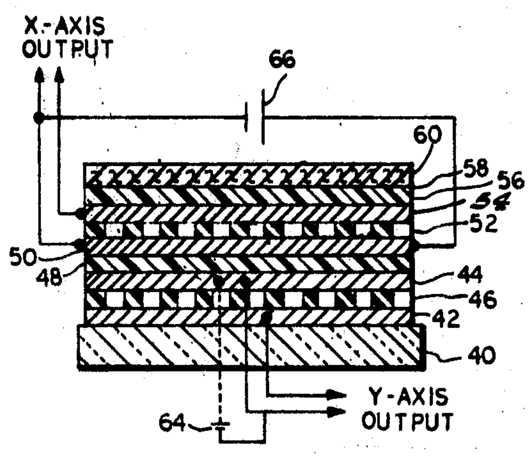


FIG. 4

INVENTOR.
BIAGIO F. AMBROSIO

BY Lindenberg & Freilich
ATTORNEYS.

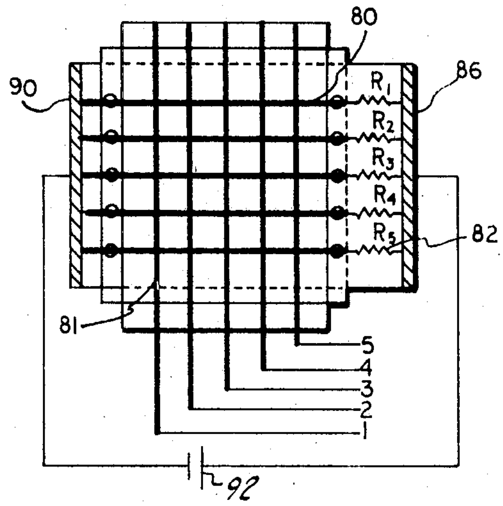


FIG. 5

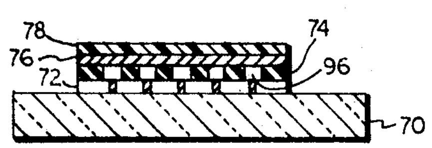


FIG. 6

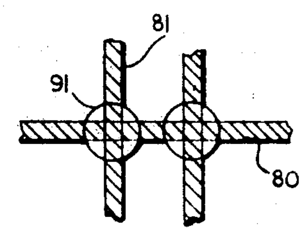


FIG. 7

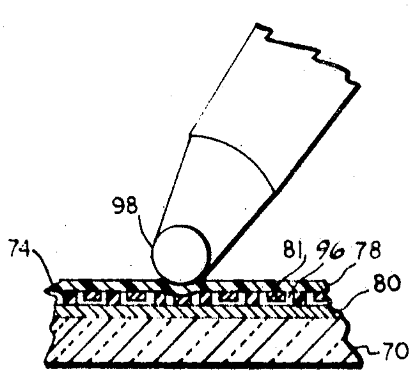


FIG. 8

INVENTOR.
BIAGIO F. AMBROSIO
BY [signature]
ATTORNEYS.

PRESSURE-SENSING TABLET

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a graphic input device and, more particularly to a free-pen pressure-sensing tablet.

2. Description of the Prior Art

The available man-machine graphical communication devices provide far from optimum communication, considerably reducing the capabilities of either the machine or the user. To be fully effective, the devices must be natural and simple to operate, and be readily related to more conventional design tools, such as pencil or pen and paper.

The most familiar device for on1line graphic input is the light pen which consists of on-line photosensor which produces an electric output when it senses a spot displayed on a computer-controlled cathode-ray tube. However, material cannot be traced from hard copy and there is not hard copy input. A number of relatively simple devices employ a mechanical linkage between a stylus and an analog or digital encoding transducer or potentiometer. The disadvantages of the coupled devices are the restrictions of the mechanical linkage, its basic analog nature and the unnaturalness of the use of a linked pen.

The Rand tablet closer matches man's existing dexterity with a penlike instrument on a horizontal surface and does not require hand-directed creation of information on a surface coincidental with a display device, such as in the light pen. However, the Rand tablet requires capacitive coupling through the stylus, and the tablets are very expensive, even in small sizes, due to the intricate complexity of the stylus following electronics.

Pressure-Sensing analog and digital sheet encoder tablets have been suggested but have not been adopted since the accuracy and resolution have been low, and the mechanical properties poor and failure and cost of the tablets have been potentially high.

OBJECTS AND SUMMARY OF THE INVENTION

It is therefore an object of the invention to provide a pressure-sensing encoder tablet that is reliable, of relatively low cost and provides output signals indicative of the location of a free-pen, stylus or pencil.

A further object of the invention is the provision of a pressure-sensing encoder that is not sensitive to forces applied to the face of the tablet encoder from large objects but is sensitive to the forces applied to the tablet from the writing point of a pen, pencil or stylus.

Another object of the invention is the provision of a free-pen writing tablet that directly converts movement of a pen, pencil or stylus over a platen or paper into electrical signals, the magnitude of which is proportional to the position of the writing instrument on the platen or paper.

These and other objects and many attendant advantages of the invention will become apparent as the description proceeds.

The pressure-sensing encoder tablet in accordance with the invention detects the movement of an electrically and mechanically uncoupled pointed writing instrument over the surface thereof. The tablet comprises a first deformable sheet having an electrically conductive surface, a second sheet having an electrically conductive surface and a resilient insulator sheet disposed between the conductive surfaces of said first and second sheets. The resilient sheet contains a uniform pattern of writing instrument point receiving perforations. The first and second sheets preferably comprise a thin sheet of deformable organic synthetic resin, such as Mylar (a polyester), having coated thereon a thin layer of metal, such as copper, silver, gold or aluminum, which may be in the form of a continuous film or in a grid of thin spaced parallel conductive lines. The assembly of deformable sheets is preferably supported on a rigid platen, such as a sheet of glass.

The resilient insulator sheet serves to electrically insulate the first and second conductive sheets during normal unstressed conditions. On the application of writing pressure, the perforations, which are from about 2 to 8 mils in diameter and are separated by about 1 to 3 mils, permit the point of the writing instrument to deform the top sheet into said perforation to a sufficient depth to make contact between the conductive surfaces of said first and second sheets.

The resilient insulator sheet has sufficient compressibility to avoid contact between the sheets when the hand of the writer presses on the surface of the top sheet or when the pen or other light implement is laid on the surface of the tablet. The resilient insulator sheet is preferably a diene elastomer, such as natural rubber, or a synthetic butadiene copolymer, such as SBR having a thickness of 1 to 3 mils and a compressive strength about 5 pounds per square inch, preferably about 20 pounds per square inch, and a Shore Hardness of from 30 to 40 percent.

The tablet can further include means for impressing an electrical signal on said first sheet and means connected to said first and second sheets for detecting the value of said signal to provide a signal indicative of the location of the writing instrument point wherever it makes contact between said sheets.

The invention will now become better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic illustration of a single-coordinate, free-pen, encoding tablet;

FIG. 2 is a cross-sectional view of the tablet of FIG. 1 shown with a ball-pen point applied to a sheet of paper;

FIG. 3 is a block and schematic diagram of a system for forming a resilient, perforated insulator sheet according to the invention;

FIG. 4 is a cross-sectional view of one form of tablet designed to detect by pressure the X and Y coordinates of the writing point;

FIG. 5 is a schematic view of a digital tablet;

FIG. 6 is a cross-sectional view of the tablet of FIG. 5:

FIG. 7 is an enlarged view of an intersection of the grid lines of the tablet of FIG. 5; and

FIG. 8 is a further view of the tablet of FIG. 5 showing a point contact of the grid lines induced by pressure of a ball-pen point.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIGS. 1 and 2, a single-coordinate encoding tablet **10** is illustrated. The tablet **10** includes a thin resistive top sheet **12** and a conductive bottom sheet **14** separated by a resiliently deformable perforated elastomer sheet **16**. The perforations **17** are arranged in a repeating line pattern and are of a diameter sufficient to accept the deformation produced in the top sheet **12** by means of a writing instrument point **18** to a sufficient depth to make contact during deformation between the top and bottom sheets **12** and **14**.

The top sheet **12** is formed of a thin conductive film, such as copper, and electrode busses **20** of a highly conductive metal, such as silver or gold, are provided along each edge of the sheet. A source of potential **19** is connected to the busses **20** and applied across the top sheet **12**. Pressure from the writing point **18** of the writing instrument onto a sheet of paper **21**, forces the paper sheet, and top sheet **12** into the perforation **17** and makes contact between sheets **12** and **14** at a given point **25** inducing an analog voltage signal detected at the edge **24** of sheet **14**, the signal value being proportional to the X-coordinate of the point contact location.

The thin metallic films are preferably supported on thin deformable insulative organic resin plastic substrates such as polyethylene or a polyester, for example, Mylar. The substrate and films are of minimum thickness compatible with the desired mechanical properties of the final tablet, and suitably, the substrate and metal film are each from below 1 to 3 mils in thickness. The top sheet may contain a continuous metallic film or may contain a series of parallel separated lines forming a grid. The spacing of the lines is selected to provide coordinate detection signals compatible with acceptable line resolution for the desired application and is usually from 30 lines per inch to 200 lines per inch.

The size of the tablet is determined by the application. It can be typical letter size of 8½ inches by 11 inches or can be of smaller dimensions to accommodate business forms as in conventional telewriter instruments or of larger size for use in on-line date processing as a graphic input to a man-computer interface system.

The tablet of the invention is intended to permit completely natural manipulation of the penlike writing instrument. In the natural writing position, the edge of the palm rests on the tablet surface and distributes the weight of the arm to the surface. The fingers and wrist then apply sufficient pressure to the pen point to mark a sheet of paper and to simultaneously bring the conductive surfaces together at the contact point to develop a marking signal.

The resilient perforated elastomer sheet has a compressive strength sufficient to resist the pressure applied by the weight of the hand, suitably above 5 p.s.i and preferably about 20 p.s.i., but deforms to permit contact of the conductive sheets through the perforations when a pen point is applied. A ball pen point is typically about 30 to 40 mils in diameter. Writing force sufficient to provide a permanent copy of paper and to deform the underlying tablet of about 0.5 to 3 pounds will distribute about at least 10^4 p.s.i. to the tablet through the point.

The thickness of the resilient sheet is maintained as low as possible consistent with maintaining separation of the sheets under normal hand pressure and is preferably from 1 to 3 mils in thickness. An elastomer such as SBR rubber having a Shore Hardness of 30–40 will provide sufficient compressive resistance to normal hand forces and will deform under the force of a writing point.

The perforations are of a diameter to accept under writing point pressure the deformed top conductive film and, its backing and paper, if present, to a sufficient depth to provide contact with the sheets. For a 27 mil writing point, the perforations are suitably about 4 to 6 mils and for a 40 mil point about 6 to 8 mils. The perforations are spaced to provide a resolution of 30 to 200 lines per inch.

When the conductive or resistive sheet is provided in the form of a grid, the perforations are spaced over the grid lines and the grid line thickness is selected to provide a wide base for contact with the second conductive sheet. For example, if 100-lpi resolution is desired, the grid lines can be 2 mils wide with an 8 mil separation. The perforations can then be 8 mils in diameter with 10 mil separation between centers which leaves 2 mils of elastomer between the edges of the perforations.

It has been found very difficult to drill holes in a thin elastomer sheet by conventional means. In attempts to perforate the thin rubber sheet by puncturing or drilling, the resilient sheet would deform or tear and evenly spaced and sized perforations could not be provided. However, in accordance with this invention, a rubber is conveniently and accurately perforated by applying a laser beam collimated to the desired diameter to the sheet and scanning the sheet with the laser and pulsing the laser at the center of each perforation location.

Referring now to FIG. 3, a laser **30** pulsed by power source **32** to form a beam collimated by lens **31** onto a sheet **36**. The laser **30** is incrementally driven by scan drive **34** across a sheet **36** of elastomer. The power source **32** pulses the laser **30** at each perforation location corresponding to an increment of the scan drive movement. At the end of each line of movement, the scan drive returns to the opposite edge of the sheet and the drive rolls **38** advance the sheet one increment to the succeeding line.

The Y-coordinate of the writing point can be detected by providing a second assembly of resistive and conductive sheets in registration with those of FIG. **1**. Referring now to FIG. **4**, one form of an analog tablet encoder includes a rigid glass platen **40** having a thin conductive film **42** applied to the surface thereof. The film **42** is separated from a thin resistive film **44** by a perforated, insulator elastomer sheet **46**. The resistive film **44** is applied to a deformable Mylar sheet **48** which carries a second resistive film **50** on the top surface thereof. The second film **50** is covered with a second perforated elastomer sheet **52** which is turn is covered with a conductive film **54** supported on a Mylar sheet **56**, the top surface **58** of which receives a writing point directly or indirectly through a sheet of paper **60** placed on the top surface thereof.

An X-axis voltage source **66** is applied to the top and bottom of second resistive film **50** and X-axis analog voltage is detected from the edge of conductive film **54**. A second Y-axis voltage source **64** is applied across resistive film **44**, and an X-axis analog voltage output is derived from the edge of conductive film **42**.

Variations of the analog sheet encoder can readily be provided to follow the movement of the writing instrument. Phase detection or frequency difference techniques can be utilized to produce X and Y signals indicative of the location of the contact point. However, the analog systems have an inherently low accuracy due to electrical or mechanical interference and analog drift.

Referring now to FIGS. **5** and **6**, a simplified digital system is illustrated comprising a rigid glass platen **70** on which is printed an X-line grid **72**. For purposes of simplification, only 5 lines of the grid are illustrated. A perforated resilient elastomer sheet **74** is interposed between the grid **72** and an X-grid **76** supported on a top Mylar sheet **78** which forms the surface of the tablet.

Each one **80** of the X-grid **76** is connected to resistors **82** R_1—R_5 which are of different incremental values such as 1, 2, 4, 8 and 16 ohms. The resistors R_1—R_5 are imprinted onto the bottom surface of the Mylar sheet **78** and are connected to a thin film forming a bus **86** along one edge of the sheet. The X-grid lines **80** are connected to a second bus **90** along the second edge of the sheet. A voltage source **92** is connected to busses **86** and **90**. Contact at any intersection **91** of the X- and Y-lines **80** and **81** will develop an output voltage in the Y-lines which is indicative both of the X- and y-locations by the fact that the selected Y-line is energized and by the fact that the X-voltage signal will be a digital value related to the resistor connected to that X-line. The combined X-Y signal is then sent to a decoding section for further processing and utilization.

Referring now to FIG. **7**, an enlarged section of a 100-lpi tablet is disclosed. The X- and Y-lines **80** and **81** are each 2 mils in width and are separated by 8 mils. The perforation **96** through each sheet is 8 mils in diameter and the perforations disposed on 10 mil centers and, therefore, a 2 mil section of rubber remains between each perforation. A 40 mil pen point **98** when applied to the top surface of Mylar sheet **78** will make point contact between X and Y-lines **80** and **81** at the intersection **91** thereof.

The pressure-sensing encoder tablet of this invention can be utilized to sketch, edit, compose or trace straight or curvilinear data. It can be utilized in telewriter transmitters or as a graphic input to a computer controlled cathode-ray tube display. The display control can multiplex the pen position information with computer-generated information so the the CRT displays a composite of the pen position and the computer. The horizontal surface and use of pen or pencil offers complete naturalness to the user.

I claim:

1. A pressure-sensing encoder tablet for detecting the movement of a pointed writing instrument over the surface thereof comprising in combination:

a first sheet comprising a deformable of synthetic organic resin having a thin electrically conductive layer of metal coated on one surface thereof;

a second sheet having an electrically conductive surface facing the electrically conductive layer of the first sheet;

a resilient, deformable insulating sheet consisting essentially of a diene elastomer having a thickness of from 1 to 3 mils and a compression strength sufficient to withstand at least 20 p.s.i. without permitting contact of the conductive surfaces of said first and second sheets disposed between the conductive surfaces of said first and second sheets; said insulating sheet containing a uniform pattern of writing point receiving perforations having substantially the same diameter of between 2 to 8 mils and substantially the same separation between perforations of from 1 to 3 mils; and

a rigid platen for supporting said sheets.

2. A tablet according to claim 1 further including means for impressing an electrical signal on said first sheet and means connected to said first and second sheet for detecting the value of said signal.

3. A tablet according to claim 1 in which said second sheet comprises a sheet of conductive metal.

4. A tablet according to claim 1 in which said first and second sheets comprise a film of conductive metal adherent to a sheet of deformable synthetic organic plastic.

5. A tablet according to claim 1 in which said platen is formed of glass.

6. A tablet according to claim 1 in which said tablet further includes a third conductive sheet and a second perforated resilient insulator sheet; said tablet being assembled with said third conductive sheet disposed between said insulator sheets with the outer surface of said insulator sheets in contact with the conductive surfaces of said first and second sheets.

7. A tablet according to claim 1 in which said writing point has a diameter from about 30 to 40 mils.

8. A tablet according to claim 1 in which said conductive layer is in the form of a grid comprising a series of spaced, parallel conductive lines of metal.

9. A tablet according to claim 8 further including a differently valued resistor connected to each of said lines.

10. A tablet according to claim 9 further including means for impressing a voltage on said lines and means connected to said first and second sheets for detecting the voltage drop through each of said lines.

11. A tablet according to claim 1 in which the Shore hardness of said elastomer is about 30 to 40.

12. A tablet according to claim 11 in which said sheet is perforated by vaporization of sheet material by a laser beam collimated to the diameter of the perforation.

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