UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
MARSHALL DIVISION

POWER2B, INC., *Plaintiff*, v. SAMSUNG ELECTRONICS CO., LTD. and SAMSUNG ELECTRONICS AMERICA, INC., *Defendants*.	Case No. _____

COMPLAINT FOR PATENT INFRINGEMENT

Plaintiff Power2B, Inc. (Power2B) files this complaint for patent infringement against Defendants Samsung Electronics Co., Ltd. (SEC) and Samsung Electronics America, Inc. (SEA) (collectively, Samsung) and states as follows:

I. NATURE OF THE ACTION

1. This is an original complaint for patent infringement pursuant to 35 U.S.C. §§ 100 *et seq*. As further stated herein, Power2B alleges that Samsung infringes one or more claims of patents owned by Power2B.

II. THE PARTIES

2. Power2B is a Delaware corporation having an address of 1302 Ozone Ave., Santa Monica, CA 90405.

3. Upon information and belief, SEC is a corporation organized under the laws of the Republic of Korea, having a place of business at 129, Samsung-Ro, Yeongtong-Gu, Gyeonggi, 16677, Republic of Korea. SEC may be served with process pursuant to Federal Rule of Civil Procedure 4(f)(1).

4. Upon information and belief, SEA is a corporation organized under the laws of New York, having a principal place of business at 85 Challenger Rd., Ridgefield Park, NJ 97660. SEA maintains a regular and established place of business with offices and/or other facilities in this District including at 6625 Excellence Way, Plano, TX 75023 and 1301 E. Lookout Dr., Richardson, TX 75082. SEA may be served with process through its registered agent, CT Corporation System, 1999 Bryan St., Ste. 900, Dallas, TX 75201.

5. SEC designs, manufactures, and provides to the United States, this District and other markets a wide variety of products and services, including consumer electronics, mobile phones, handheld devices, tablets, laptops and other personal computers, storage devices, televisions, and electronic devices.

6. Upon information and belief, SEA is a wholly-owned subsidiary of SEC and is responsible for domestic distribution of Samsung's consumer electronics products, including the products accused of infringement herein.

III. JURISDICTION AND VENUE

7. This Court has subject matter jurisdiction pursuant to 28 U.S.C. §§ 1331 and 1338(a).

8. This Court has personal jurisdiction over Samsung because it has conducted and continues to regularly conduct business within the State of Texas and this District. Samsung has purposefully and voluntarily availed itself of the privileges of conducting business in the United States, the State of Texas, and this District by continuously and systematically placing goods into the stream of commerce through an established distribution channel with the expectation that they will be purchased by consumers in this District. Samsung directly and/or through intermediaries (including distributors, sales agents, and others), ships, distributes, sells, offers to

sell, imports, advertises, makes, and/or uses its products (including but not limited to the products accused of infringement herein) in the United States, the State of Texas, and this District.

9. SEA is registered to do business in Texas and maintains an agent for service of process in Texas. SEA maintains places of business within the Eastern District of Texas, including at 6625 Excellence Way, Plano, TX 75023 and 1301 E. Lookout Dr., Richardson, TX 75082.

10. Upon information and belief, Samsung has authorized retailers that offer and sell products on its behalf in this District, including products accused of infringement herein. Samsung has committed infringing acts in this District by, *inter alia*, directly and/or indirectly making, using, selling, offering to sell or importing products that infringe one or more claims of Power2B's patents, namely U.S. Patent Nos. 7,952,570; 8,547,364; 8,816,994; 9,946,369; and 10,664,070. Samsung's infringing acts within this District have established minimum contacts with the State of Texas and this District.

11. Power2B's causes of action arise directly from Samsung's business contacts and other activities in the State of Texas and this District.

12. Samsung has derived substantial revenues from its infringing acts within the State of Texas and this District.

13. Venue is proper in this District as to SEC pursuant to 28 U.S.C. § 1391(c)(3) because it is not a resident of the United States and may therefore be sued in any judicial district.

14. Venue is proper in this District as to SEA pursuant to 28 U.S.C. §§ 1391(b) and 1400(b) because SEA has committed acts of infringement in this District and has regular and established places of business in this District.

15. Joinder of SEC and SEA is proper because they are related entities that are either jointly and severally liable for infringement, or that make, use, sell, offer to sell, and/or import the same or similar products accused of infringement herein. Further, upon information and belief, SEC and SEA use the same underlying hardware and/or software in their infringing products and therefore the factual question of infringement will substantially overlap between SEC and SEA. Power2B anticipates there will be substantial overlap between SEC and SEA with respect to discovery.

16. Samsung has committed acts of infringement in this District and does business in this District, including making sales and/or providing service and support for customers and/or end-users in this District. Samsung purposefully and voluntarily sold one or more infringing products with the expectation they would be purchased in this District. These infringing products have been and continue to be purchased in this District. Thus, Samsung has committed acts of infringement within the United States, the State of Texas, and this District.

17. Samsung has established minimum contacts with this District such that the exercise of jurisdiction over Samsung would not offend traditional notions of fair play and substantial justice.

IV. THE ASSERTED PATENTS

18. On May 31, 2011, the United States Patent and Trademark Office (USPTO) duly and legally issued United States Patent No. 7,952,570 ('570 patent) entitled "Computer Navigation" and naming Robert Lipman and Sarah Lipman as inventors. A copy of the '570 patent is submitted herewith as Exhibit A.

19. On October 1, 2013, the USPTO duly and legally issued United States Patent No. 8,547,364 ('364 patent) entitled "Input System for Controlling Electronic Device" and naming

Robert Lipman and Sarah Lipman as inventors. A copy of the '364 patent is submitted herewith as Exhibit B.

20. On August 26, 2014, the USPTO duly and legally issued United States Patent No. 8,816,994 ('994 patent) entitled "Input System for Controlling Electronic Device" and naming Robert Lipman and Sarah Lipman as inventors. A copy of the '994 patent is submitted herewith as Exhibit C.

21. On April 17, 2018, the USPTO duly and legally issued United States Patent No. 9,946,369 ('369 patent) entitled "Input System for Controlling Electronic Device" and naming Robert Lipman and Sarah Lipman as inventors. A copy of the '369 patent is submitted herewith as Exhibit D.

22. On May 26, 2020, the USPTO duly and legally issued United States Patent No. 10,664,070 ('070 patent) entitled "Input System for Controlling Electronic Device" and naming Robert Lipman and Sarah Lipman as inventors. A copy of the '070 patent is submitted herewith as Exhibit E.

23. Power2B asserts and alleges that Samsung has infringed and continues to infringe at least one claim of each of the '570 patent, '364 patent, '994 patent, '369 patent, and '070 patents (collectively, the Asserted Patents).

V. FACTUAL ALLEGATIONS

Overview of the Patented Technology

24. Sarah and Robert Lipman founded Power2B in 2004. At the time, electronic devices presented unique design challenges relating to size constraints, power consumption, and processing limitations. These design challenges persist and are relevant to the design of electronic devices to this day.

25. Ms. Lipman recognized that then-existing electronic devices such as personal digital assistants (PDAs), mobile devices, tablets, televisions, and the like lacked intuitive navigation interfaces and tools for controlling device operations. Accordingly, Power2B was formed to develop new interactive systems and technologies that accounted for and addressed the various design challenges of then-existing electronic devices.

26. Power2B invented and implemented new stylus-based interfaces having power-efficient, cost-effective, and small form-factor sensors and processing circuitry. For example, Power2B's inventive technology incorporates hardware sensors that are arranged and positioned relative to input areas (e.g. display screens) corresponding to a given electronic device. In operation, Power2B's hardware sensors and corresponding circuitry are configured to detect light or electromagnetic radiation emitted by an input object such as a stylus, determine relative positions and/or orientations of the stylus based on detected electromagnetic radiation, and translate such positions and/or orientations into meaningful and intuitive inputs to control device operations.

27. All applicable rights have been assigned to Power2B, and Power2B is the owner of the Asserted Patents and the patented inventions relating to its stylus-based interactive systems and technologies.

Power2B's Interactions with Samsung

28. Between 2006 and 2010, Power2B had multiple meetings with Samsung executives, during which Power2B provided live demonstrations and disclosed prototypes of its stylus-based interactive systems and technologies. Power2B provided proprietary and confidential technical information related to its interactive systems and technologies to Samsung. Power2B also provided prototypes to Samsung for internal technical evaluation.

29. Samsung expressed interest in licensing or otherwise obtaining the right to use Power2B's patented technology.

30. Through these dealings, Samsung gained actual knowledge and notice of Power2B's patents, including patents comprising the Asserted Patents, and patent applications from which patents comprising the Asserted Patents issued.

31. Samsung broke off communications with Power2B after receiving detailed technical information about Power2B's technologies.

32. In 2011, around a year after Power2B's initial negotiations with Samsung, Samsung released its first Galaxy Note mobile device. Samsung's Galaxy Note devices have stylus-based interfaces, which include Samsung's "S-pen" stylus and a digitizer.[1]

33. In 2012, around two years after Power2B's initial negotiations with Samsung ended, Samsung reengaged Power2B and requested additional specific and detailed technical information about Power2B's interactive systems and technologies, including information related to coordinate position extraction, distance detection, chipsets, supporting circuitry, power consumption, screen thickness, capacitive screen capabilities, and sensor quantities and arrangements. Upon information and belief, Samsung requested information to continue development of the Accused Products, and Samsung intended to and did use such information in the production of the Accused Products.

34. Based on Samsung's representations and the parties' previous interactions, Power2B believed that Samsung had a genuine interest in licensing or otherwise acquiring the right to use Power2B's patented technology, and thus provided additional information to

[1] *See, e.g.*, https://news.samsung.com/global/10-for-10-highlights-from-a-decade-of-galaxy-innovation.

Samsung. But shortly after Power2B provided the additional information, Samsung again ceased discussions.

35. Despite Samsung's representations that it wished to license or otherwise acquire the right to use Power2B's patented technology, Samsung utilized information acquired from Power2B to develop the Accused Products.

36. At all times, Power2B believed that Samsung was acting in good faith and that Samsung was seriously and genuinely interested licensing or otherwise acquiring the right to use Power2B's patented technology.

The Accused Products

37. Samsung has sold and continues to sell devices incorporating Power2B's patented stylus-based interfaces, including Samsung's Note, Note 2-10, and Note 20 devices and associated product lines; Samsung's Galaxy Tab, Tab A, Tab 2, Tab S3-S7, Tab Active, Tab Active 2-3, and ATIV Tab devices and associated product lines; Galaxy Z Fold 3, Galaxy S21, Galaxy Book, Galaxy Book 2, Galaxy Book Flex, Galaxy Book Pro, Galaxy Book Pro 360 and associated product lines; Chromebook and associated product lines; Notebook 7 Spin, Notebook S51, Notebook 9, and associated product lines ("Accused Products"). [2]

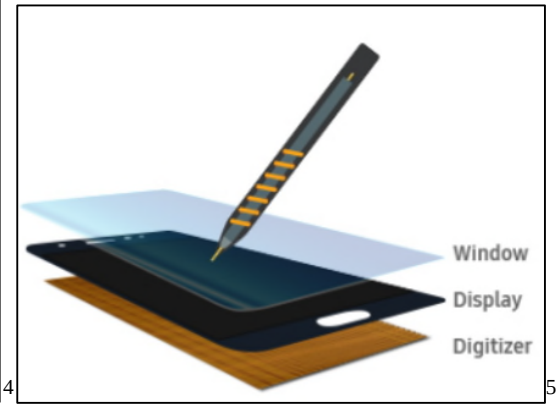
38. For example, the Accused Products have infringing stylus-based interfaces that include an input stylus and electromagnetic detection sensors—namely, Samsung's S-pen stylus

[2]Each device and associated product line includes all corresponding devices designated under the same "Note," "Tab," and "Book" names, including, for example, devices designated as "mini," "plus," "sport," "edge," "ultra," "pro," and the like.

and a digitizer. Upon information and belief, all of Samsung's S-pen compatible devices include a digitizer.[3]

39. Below are images depicting a number of hardware components common to all Accused Products, which include at least (1) Samsung's S-pen, (2) a display, and (3) a digitizer.

4



5

40. The displays for the Accused Products include touch-sensitive Light Emitting Diode (LED) displays, Liquid Crystal Displays (LCDs), Organic Light Emitting Diode (OLED) displays, and Active Matrix Organic Light Emitting Diode (AMOLED) displays.[6]

41. The displays for the Accused Products provide input areas and display content, such as selectable options or icons. Below are exemplary images showing a Samsung Galaxy Note device, which includes Samsung's S-pen, a touch-sensitive display, and a digitizer. As

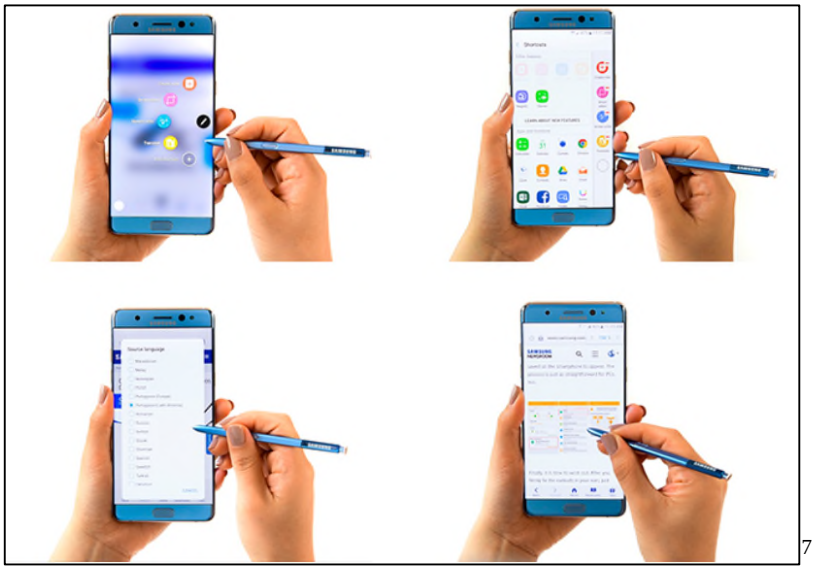
[3] *See, e.g.*, https://news.samsung.com/global/galaxy-book-pro-360s-s-pen-draws-inspiration-from-a-decade-of-collaboration-with-wacom; https://www.wacom.com/en-us/about-wacom/news-and-events/2021/1449; https://www.wacom.com/en-us/overlays/products/wacom-one-list-of-android-devices.

[4] https://news.samsung.com/global/dissecting-the-galaxy-note-take-a-look-inside.

[5] https://news.samsung.com/global/in-depth-look-more-than-just-a-writing-tool-the-s-pen-of-the-galaxy-note7.

[6] *See, e.g.*, https://news.samsung.com/global/galaxy-note-series-at-a-glance.

shown, the touch-sensitive display provides an input area and displays selectable icons or options.

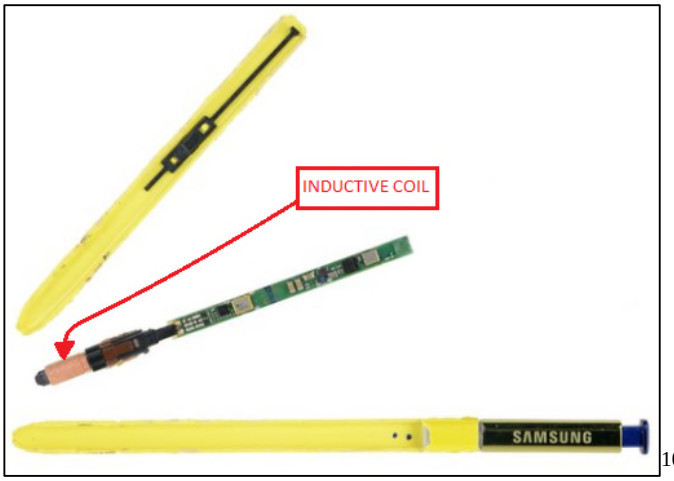
 [7]

42. Samsung's S-pen is an input object that performs functions similar to a digital pen and/or a conventional computer mouse.[8] Samsung's S-pen is configured to provide inputs to and control operations for corresponding Accused Products. Samsung's S-pen includes internal circuitry that uses electromagnetic resonance (EMR) technology.[9] For example, the S-pen's internal circuitry includes inductor-capacitor (LC) hardware configured to emit light or electromagnetic radiation. Below is an image of Samsung's S-pen hardware, showing an inductive coil positioned near one end of the S-pen.

[7] https://news.samsung.com/global/hands-on-the-galaxy-note7.

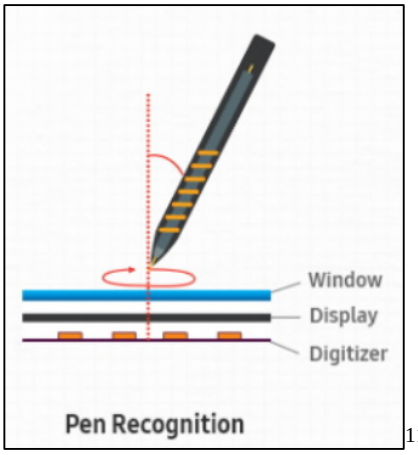
[8] https://news.samsung.com/global/galaxy-note-4-explained-s-pen.

[9] https://news.samsung.com/global/in-depth-look-1-a-new-way-to-communicate-the-s-pen-of-the-galaxy-note8.



[10]

43. Below is another image illustrating basic operations of Samsung's EMR technology as employed by Samsung's S-pen and digitizer.



[11]

44. As shown, Samsung's digitizer includes stylus-detection sensors, which form a sensing layer under the touch-sensitive display area. In particular, the digitizer includes a plurality of light sensors or coils arranged in a sensor array.[12]

[10] https://www.ifixit.com/Teardown/Samsung+Galaxy+Note9+Teardown/112412.

[11] https://news.samsung.com/global/in-depth-look-more-than-just-a-writing-tool-the-s-pen-of-the-galaxy-note7.

[12] http://www.wacom.jp/jp/customercare/download/catalogue/pdf/0507_EMR_Pen_Technology_E.pdf.

45. In general operation for the Accused Products, Samsung's digitizer generates a magnetic field around at least the display area. Internal circuitry of Samsung's S-pen interacts with and receives electrical charge from the magnetic field generated by the digitizer. In response, Samsung's S-pen emits and directs a beam of electromagnetic radiation. Samsung's S-pen emits a conical beam of non-collimated light, which intersects with and forms a pattern of electromagnetic radiation on the display of a corresponding device. The digitizer is positioned proximate to the display or input area, and it is configured to detect the S-pen's location[13] and "tilt" or orientation based on detected electromagnetic radiation.[14] Upon information and belief, the digitizer detects the location and/or orientation of the S-pen based, in part, on a pattern of electromagnetic radiation, which may correspond to locations of respective digitizer sensors.[15]

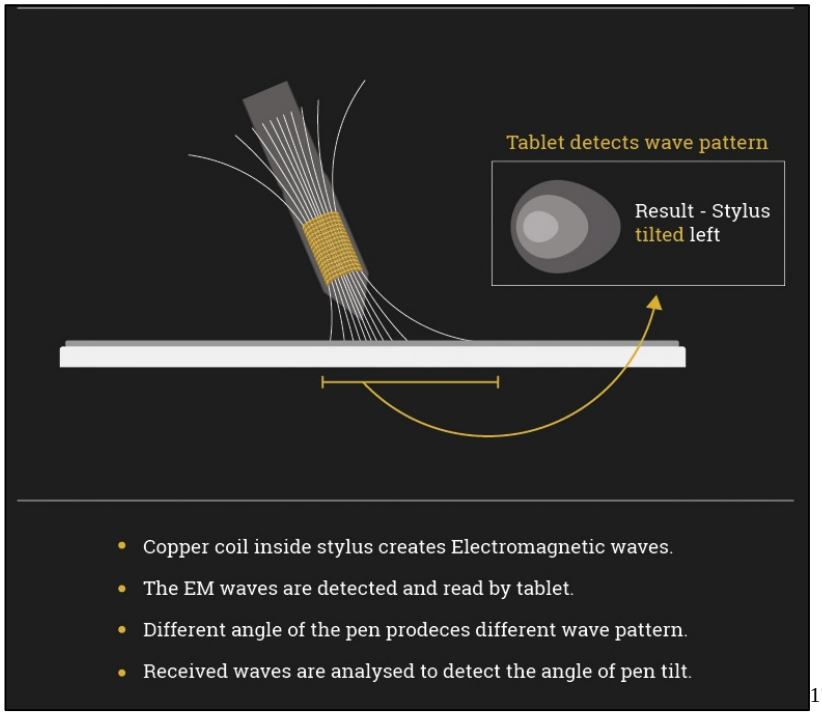
46. For example, the images below illustrate features of EMR technology used by the Accused Products.[16] In particular, the images illustrate a pattern of electromagnetic radiation generated by the same or similar circuitry as Samsung's S-pen. Here, the stylus emits a conical beam of light that forms a radiation pattern on an input area. Due to the circular windings of the inductor coil (e.g. copper coil), the radiation pattern formed on the input area has an elliptical shape with an eccentricity that depends on the tilt or orientation of the stylus.

[13] https://news.samsung.com/global/dissecting-the-galaxy-note-take-a-look-inside.

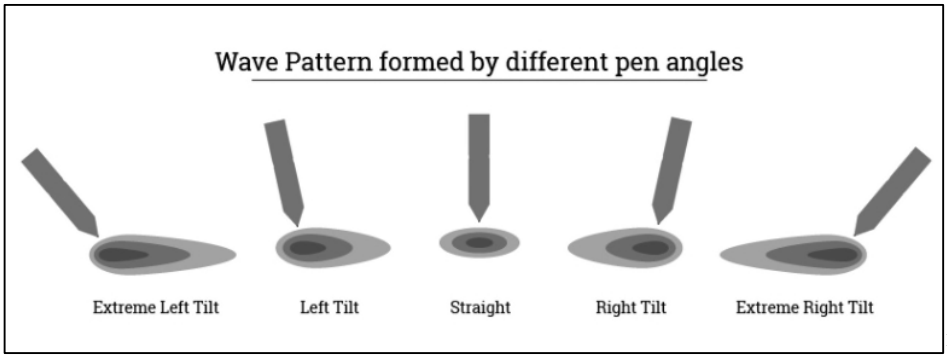
[14] https://news.samsung.com/global/hands-on-the-galaxy-book-a-powerful-portable-pc-experience.

[15] *See e.g.*, https://essentialpicks.com/tilt-sensitivity-and-rotation-in-stylus/.

[16] https://essentialpicks.com/tilt-sensitivity-and-rotation-in-stylus/.



[17]



[18]

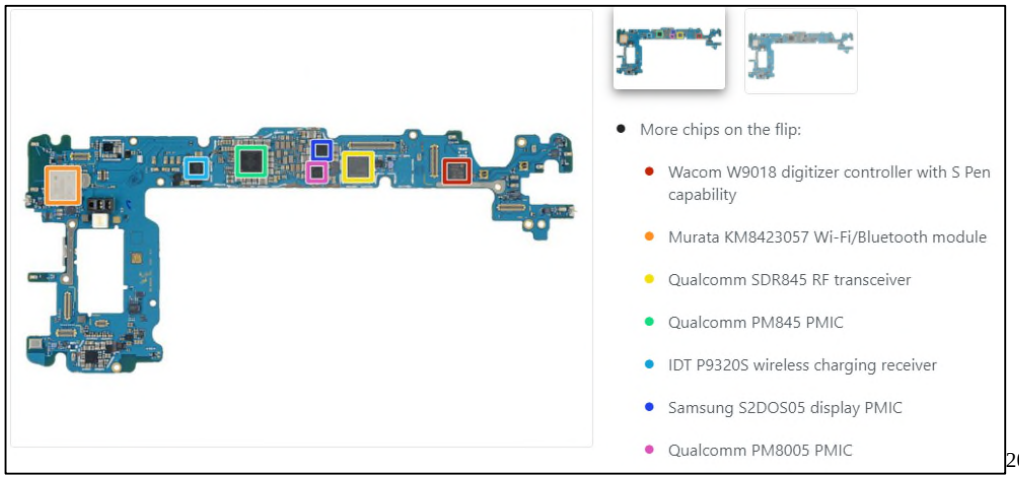
47. The Accused Products also employ input circuitry coupled to digitizer sensors to support S-pen functions. For example, the input circuitry can include analog-to-digital circuitry, controllers, processing circuitry, and/or processing units configured to receive and translate detection signals from digitizer sensors into functional input signals for controlling the Accused Products. Collectively, the S-pen, digitizer, and corresponding circuitry "allow users to execute

[17] *Id.*

[18] *Id.*

commands much faster and easier. Therefore, Samsung evolved the role of the S Pen by giving users not only the ability to use it like a pen, but also a mouse."[19]

48. Below is an image of internal hardware for an exemplary Samsung Galaxy Note 9 device, which includes input circuitry such as a digitizer controller and circuitry that couples the controller to digitizer sensors. Upon information and belief, all of the Accused Products include the digitizer controller and circuitry.



[20]

49. The infringing stylus-based interfaces employed by the Accused Products are also configured to determine two-dimensional positions of the S-pen, three-dimensional positions of the S-pen, and orientations of the S-pen. For example, the Accused Products display a cursor on a display screen that corresponds to a two-dimensional position, direction, and/or orientation of the S-pen. The Accused Products further update and move the cursor on the display screen based on movements of the S-pen, similar to a conventional computer mouse and cursor. The Accused Products also determine a distance in a third dimension of the S-pen relative to the

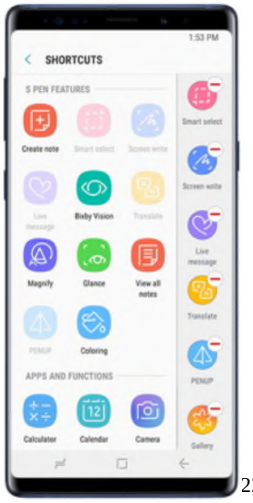
[19] https://news.samsung.com/global/galaxy-note-4-explained-s-pen.

[20] https://www.ifixit.com/Teardown/Samsung+Galaxy+Note9+Teardown/112412.

device. For example, a digitizer recognizes the S-pen's magnetic field and detects the S-pen when it hovers (without contact) within a specific distance from the device.[21]

50. The Accused Products also execute various stylus-based or S-pen functions relating to an emitted beam of electromagnetic radiation. Example stylus-based functions include selection, preview (e.g. "Air View"), magnification, and a suite of "Air Commands."

51. Upon information and belief, all of the Accused Products support at least "Air Commands." Below are images of an exemplary Samsung Galaxy Note 9 device showing a menu of Air Commands and S-pen functions.



[22]

52. Samsung specifically marketed and continues to market the infringing stylus-based interfaces and S-pen functions in Accused Products.

[21] https://news.samsung.com/global/in-depth-look-more-than-just-a-writing-tool-the-s-pen-of-the-galaxy-note7; https://news.samsung.com/global/in-depth-look-1-a-new-way-to-communicate-the-s-pen-of-the-galaxy-note8.

[22] https://news.samsung.com/global/4-tips-to-get-the-most-out-of-the-galaxy-note9s-powerful-s-pen.

Samsung's Acts of Infringement

53. Samsung has made, used, sold, offered to sell and/or imported infringing products, and continues to do so, including the Accused Products.

54. By doing so, Samsung has directly infringed the Asserted Patents.

55. Samsung has engaged and continues to engage in a pattern of conduct intended to induce and/or contribute to the infringement of others, such as its customers and end-users. These actions have included and include making, selling, offering to sell, and/or importing products that infringe the Asserted Patents.

56. Through its actions, Samsung induces and/or contributes to the infringement of the Asserted Patents, and thus indirectly infringes the Asserted Patents.

57. There is an actual, substantial, and continuing justiciable controversy between Power2B and Samsung regarding Samsung's infringement of the Asserted Patents. Absent a judgment and injunction from this Court, Samsung will continue to infringe the Asserted Patents and cause damage and irreparable harm to Power2B.

58. Despite being aware and having knowledge of Power2B's patents, and recognizing the value and benefits of Power2B's patented technology, Samsung has elected to infringe the Asserted Patents, including by incorporating Power2B's technology into at least the Accused Products.

59. Samsung's infringement is willful. Samsung continues to commit acts of infringement despite a high likelihood that its actions constitute infringement, and Samsung knew or should have known that its actions constituted an unjustifiably high risk of infringement.

60. Samsung's acts of infringement have been willful as of the date it became aware of the patented technology/invention(s) and/or the Asserted Patents, and no later than the filing

of this complaint for patent infringement and/or the date this complaint for patent infringement was served on Samsung.

61. In accordance with 35 U.S.C. § 287, Samsung has had actual notice and knowledge of each of the Asserted Patents since at least as early as their respective priority dates, and otherwise had such actual notice and knowledge at all relevant times, and no later than the filing of this complaint for patent infringement and/or the date this complaint for patent infringement was served on Samsung.

62. Samsung cannot avail itself of any defense pursuant to 35 U.S.C. § 287 as Power2B is under no obligation to mark a patented product or the performance of a patented method, and at no time was Power2B or any predecessor-in-interest to Power2B subject to an obligation to mark a patented product or the performance of a patented method.

VI. COUNT ONE
(Infringement of U.S. Patent No. 7,952,570)

63. Power2B incorporates the preceding paragraphs by reference as if fully set forth.

64. Power2B owns all right, title and interest in and to the ’570 patent, and holds all substantial rights pertinent thereto, including the right to sue and recover for all past, current, and future damages for Samsung’s infringement.

65. The ’570 patent is valid and enforceable and directed to patentable subject matter.

66. Through at least the Accused Products, Samsung infringes at least claim 1 of the ’570 patent.

67. Claim 1 of the ’570 patent recites: an electronic input device.

68. The Accused Products are electronic input devices because they are configured to receive inputs via at least input-sensitive display screens and/or digitizers.

69. Claim 1 of the ’570 patent recites: an input object wherein said input object includes a source of said electromagnetic radiation.

70. The Accused Products include an input object wherein said input object includes a source of said electromagnetic radiation. For example, the Accused Products include Samsung’s “S-pen” stylus, which is an input object that is a source of electromagnetic radiation.

71. Claim 1 of the ’570 patent recites: an input area.

72. The Accused Products include an input area. For example, the Accused Products have LED, LCD, OLED, or AMOLED displays that provide an input area.

73. Claim 1 of the ’570 patent recites: a sensor array positioned outside said input area operative to sense and provide an output indication of position and at least two of orientation, shape and size of an electromagnetic radiation pattern on said input area produced by said input object.

74. The Accused Products have a sensor array positioned outside said input area operative to sense and provide an output indication of position and at least two of orientation, shape, and size of an electromagnetic radiation pattern on said input area produced by said input object. For example, the Accused Products include a digitizer or sensor array positioned outside the display or input area. The digitizer further senses the position and orientation of Samsung’s S-pen relative to the input area. Upon information and belief, the digitizer senses the orientation of Samsung’s S-pen based on characteristics relating to the shape and size of an electromagnetic radiation pattern formed by the beam of light emitted from the S-pen that intersects with the display or input area. In particular, upon information and belief, these characteristics include an elliptical eccentricity.

75. In addition, upon information and belief, the digitizer provides an output indication of the position and at least two of orientation, shape and size of an electromagnetic radiation pattern in order to determine one or more of the S-pen's two-dimensional position, three-dimensional position, and/or orientation, and to support other S-pen functions relating to the cursor, selection, preview, magnification, Air Commands, and the like.

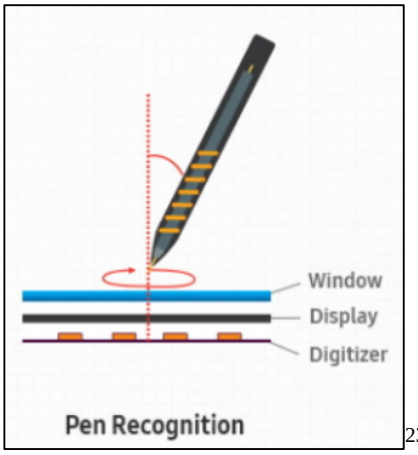
76. Claim 1 of the '570 patent recites: input circuitry receiving said output indication and providing an electronic input representing at least one of two-dimensional position, three-dimensional position and orientation of said input object.

77. The Accused Products have input circuitry receiving an output indication and providing an electronic input representing at least one of two-dimensional position, three-dimensional position and orientation of an input object. For example, the Accused Products employ input circuitry coupled to digitizer sensors to support S-pen functions. The input circuitry is configured to receive output indications or signals from the digitizer sensors and provide corresponding electronic input signals representing one or more of the S-pen's two-dimensional position, three-dimensional position, and/or orientation. For example, input circuitry is configured to provide electronic input signals representing the S-pen's two dimensional position, as evidenced by the display of a cursor that corresponds with the two-dimensional position of the S-pen. In addition, the input circuitry is configured to provide electronic input signals representing a distance or a third dimension of the S-pen relative to the device. Finally, the input circuitry is configured to provide an electronic input representing the tilt or orientation of the S-pen relative to the device.

78. Claim 1 of the '570 patent recites: wherein said source of said electromagnetic radiation produces a conical beam which intersects said input area in an elliptical pattern having

elliptical eccentricity which is a function of the orientation of said input object in a plane perpendicular to said input area.

79. The Accused Products include Samsung's S-pen, which is a source of electromagnetic radiation. Samsung's S-pen produces a conical beam that intersects the display or input area in an elliptical pattern with an elliptical eccentricity. The elliptical pattern has elliptical eccentricity that is a function of the S-pen's orientation in a plane perpendicular to the display. For example, Samsung's S-pen includes circuitry such as a copper coil having coil windings positioned near one end (e.g. a tip). The coil produces a conical beam of light that intersects the display and forms an elliptical pattern having an elliptical eccentricity. The Accused Products also detect the S-pen's tilt, which is a function of its orientation in a plane perpendicular to the input area. For example, the images below illustrate basic operations of Samsung's electromagnetic resonance (EMR) technology. As shown, the conical beam of light emitted by Samsung's S-pen intersects an input area in an elliptical pattern having elliptical eccentricity which is a function of the orientation of the S-pen in a plane perpendicular to the input area.



[23]

[23] https://news.samsung.com/global/in-depth-look-more-than-just-a-writing-tool-the-s-pen-of-the-galaxy-note7.

80. Samsung has infringed and continues to infringe the ’570 patent under 35 U.S.C. § 271(a), directly, literally and/or under the doctrine of equivalents, by making, using, selling, and/or offering to sell in the United States and/or importing into the United States, the Accused Products, during the term of the ’570 patent.

81. Samsung has actual knowledge of the ’570 patent, and has had knowledge of the ’570 patent at all relevant times, and knows the above-described actions, if taken, would constitute infringement of the ’570 patent.

82. Alternatively, Samsung believes there is a high probability that others will infringe the ’570 patent as a result of its actions but has remained willfully blind to the infringing nature of those actions.

83. Samsung took the above-described actions with the intent to cause acts of infringement of the ’570 patent by others, such as its customers and end-users.

84. Samsung has actively induced infringement and continues to actively induce infringement of the ’570 patent under 35 U.S.C. § 271(b) by making, selling, offering to sell and/or importing the Accused Products, and through activities relating to selling, marketing, advertising, promotion, support, and/or distribution of the Accused Products.

85. Samsung infringes the ’570 patent by contributing to the infringement of others, such as its customers and end-users, by making, selling, offering to sell, and/or importing or exporting one or more components of the Accused Products used to practice one or more claims of the ’570 patent, that constitute a material part of the invention(s) claimed in the ’570 patent, and that have no substantial non-infringing use, with knowledge that such components are especially made or adapted for use in infringing the ’570 patent.

86. Through its actions Samsung infringes the ’570 patent under 35 U.S.C. § 271(c).

87. Samsung's actions and infringement of the '570 patent are without license or authorization from Power2B.

88. Samsung's acts of infringement have caused Power2B to suffer damages. Power2B is entitled to and seeks to recover from Samsung pursuant to 35 U.S.C. § 284 the damages it has sustained as a result of Samsung's wrongful actions in an amount subject to proof at trial, and in no event less than a reasonable royalty, together with interest and costs.

89. Additionally, Samsung's acts of infringement have caused and continue to cause immediate and irreparable harm to Power2B. Unless such acts of infringement are permanently enjoined by the Court, Samsung will continue to cause immediate and irreparable harm to Power2B for which there is no adequate remedy at law. Power2B is entitled to and seeks injunctive relief pursuant to 35 U.S.C. § 283.

90. Samsung's acts of infringement have at all relevant times been willful and/or Samsung has acted with bad faith.

91. Power2B is entitled to and seeks to recover from Samsung pursuant to 35 U.S.C. § 284 the damages it has sustained as a result of Samsung's willful/bad faith infringement in an amount up to three times the amount of damages found or assessed.

VII. COUNT TWO
(Infringement of U.S. Patent No. 8,547,364)

92. Power2B incorporates the preceding paragraphs by reference as if fully set forth.

93. Power2B owns all right, title and interest in and to the '364 patent, and holds all substantial rights pertinent thereto, including the right to sue and recover for all past, current, and future damages for Samsung's infringement.

94. The '364 patent is valid and enforceable and directed to patentable subject matter.

95. Through at least the Accused Products, Samsung infringes at least claim 10 of the ’364 patent.

96. Claim 10 of the ’364 patent recites: an electronic input device.

97. The Accused Products are electronic input devices because they are configured to receive inputs via at least input-sensitive display screens and/or digitizers.

98. Claim 10 of the ’364 patent recites: a physical input area.

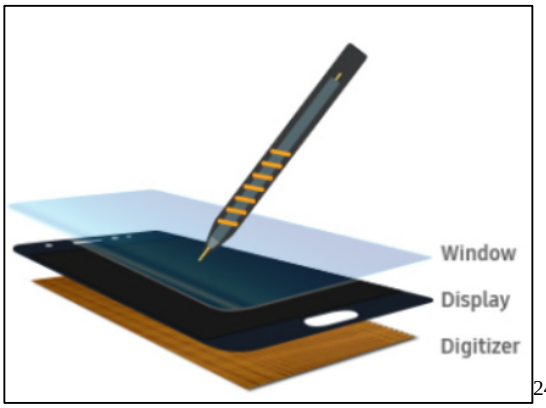
99. The Accused Products have physical input areas. For example, the Accused Products have LED, LCD, OLED, or AMOLED displays that provide a physical (e.g. touch-sensitive) input area. In addition, the Accused Products also include a digitizer, which provides a physical input area coincident and/or proximate to the display. For example, a physical touch between the S-pen and the display changes the frequency of the S-pen’s emitted electromagnetic radiation, which changes the light received by the digitizer sensors.

100. Claim 10 of the ’364 patent recites: an input object projecting an electromagnetic radiation pattern on the input area.

101. The Accused Products include an input object projecting an electromagnetic radiation pattern on an input area. For example, the Accused Products include Samsung’s S-pen, which is a stylus that projects a beam of electromagnetic radiation that forms an electromagnetic pattern on an input area.

102. Claim 10 of the ’364 patent recites: a sensor array at least partially circumscribing and immediately proximate the input area, wherein the sensor array senses the electromagnetic radiation pattern thereon and provides an output indication of position, and at least two of orientation, shape and size of the electromagnetic radiation pattern on the input area.

103. The Accused Products include a sensor array at least partially circumscribing and immediately proximate an input area, wherein the sensor array senses an electromagnetic radiation pattern thereon and provides an output indication of position, and at least two of orientation, shape and size of the electromagnetic radiation pattern on the input area. For example, below is a representative image of the Accused Products showing the position and placement of a digitizer or sensor array relative to a touch-sensitive display or input area.



[24]

104. As shown, a digitizer at least partially circumscribes and is positioned immediately proximate a display or input area. In addition, the digitizer senses the electromagnetic radiation pattern thereon. As discussed, the digitizer detects at least the position and tilt or orientation of the S-pen. In particular, upon information and belief, the EMR technology used by the S-pen and digitizer detects the tilt or orientation based on geometric characteristics of the electromagnetic radiation incident on the input area, which characteristics include a shape or size of the radiation pattern. Further, in order to support various S-pen features such as a cursor display and tilt detection, the digitizer outputs a signal or output indication of the position, orientation, shape, and/or size of the radiation pattern.

[24] https://news.samsung.com/global/in-depth-look-more-than-just-a-writing-tool-the-s-pen-of-the-galaxy-note7.

105. Claim 10 of the ’364 patent recites: wherein the electromagnetic radiation pattern includes an elliptical shape having an eccentricity that is a function of the orientation of the input object relative to the input area.

106. The Accused Products provide an input object that projects an electromagnetic radiation pattern, where the pattern includes an elliptical shape having an eccentricity that is a function of the orientation of the input object relative to the input area. For example, Samsung’s S-pen produces/projects a beam of light that intersects the input area or display screen in an elliptical shape having an elliptical eccentricity, and the elliptical eccentricity is a function of the orientation of an input object in a plane perpendicular to an input area. Samsung’s S-pen uses EMR technology and includes circuitry such as a copper coil. The coil emits or projects a conical beam of light that intersects with and forms a radiation pattern on the input area. The radiation pattern includes geometric characteristics such as an elliptical shape having an elliptical eccentricity. The Accused Products detect the S-pen’s tilt or orientation based on the radiation pattern and more specifically, based on the elliptical shape and its elliptical eccentricity.

107. Claim 10 of the ’364 patent recites: input circuitry receiving the output indication and providing an electronic input representing at least one of two-dimensional position, three-dimensional position, and orientation of the input object.

108. The Accused Products include input circuitry receiving the output indication and providing an electronic input representing at least one of two-dimensional position, three-dimensional position, and orientation of the input object. For example, the Accused Products employ input circuitry coupled to a digitizer to support S-pen functions, and the input circuitry receives an output indication from the digitizer. The input circuitry can include, for example, a digitizer controller. Upon information and belief, the digitizer controller receives output signals

or the output indication from digitizer sensors and provides an electronic input representing one or more of two-dimensional position, three-dimensional position, and/or orientation of the S-pen. The Accused Products use an output indication to support S-pen features, such as displaying a cursor on a display screen that corresponds to the position or tilt of the S-pen.

109. Samsung has infringed and continues to infringe the ’364 patent under 35 U.S.C. § 271(a), directly, literally and/or under the doctrine of equivalents, by making, using, selling, and/or offering to sell in the United States and/or importing into the United States, the Accused Products, during the term of the ’364 patent.

110. Samsung has actual knowledge of the ’364 patent, and has had knowledge of the ’364 patent at all relevant times, and knows the above-described actions, if taken, would constitute infringement of the ’364 patent.

111. Alternatively, Samsung believes there is a high probability that others will infringe the ’364 patent as a result of its actions but has remained willfully blind to the infringing nature of those actions.

112. Samsung took the above-described actions with the intent to cause acts of infringement of the ’364 patent by others, such as its customers and end-users.

113. Samsung has actively induced infringement and continues to actively induce infringement of the ’364 patent under 35 U.S.C. § 271(b) by making, selling, offering to sell and/or importing the Accused Products, and through activities relating to selling, marketing, advertising, promotion, support, and/or distribution of the Accused Products.

114. Samsung infringes the ’364 patent by contributing to the infringement of others, such as its customers and end-users, by making, selling, offering to sell, and/or importing or exporting one or more components of the Accused Products used to practice one or more claims

of the ’364 patent, that constitute a material part of the invention(s) claimed in the ’364 patent, and that have no substantial non-infringing use, with knowledge that such components are especially made or adapted for use in infringing the ’364 patent.

115. Through its actions Samsung infringes the ’364 patent under 35 U.S.C. § 271(c).

116. Samsung’s actions and infringement of the ’364 patent are without license or authorization from Power2B.

117. Samsung’s acts of infringement have caused Power2B to suffer damages. Power2B is entitled to and seeks to recover from Samsung pursuant to 35 U.S.C. § 284 the damages it has sustained as a result of Samsung’s wrongful actions in an amount subject to proof at trial, and in no event less than a reasonable royalty, together with interest and costs.

118. Additionally, Samsung’s acts of infringement have caused and continue to cause immediate and irreparable harm to Power2B. Unless such acts of infringement are permanently enjoined by the Court, Samsung will continue to cause immediate and irreparable harm to Power2B for which there is no adequate remedy at law. Power2B is entitled to and seeks injunctive relief pursuant to 35 U.S.C. § 283.

119. Samsung’s acts of infringement have at all relevant times been willful and/or Samsung has acted with bad faith.

120. Power2B is entitled to and seeks to recover from Samsung pursuant to 35 U.S.C. § 284 the damages it has sustained as a result of Samsung’s willful/bad faith infringement in an amount up to three times the amount of damages found or assessed.

VIII. COUNT THREE
(Infringement of U.S. Patent No. 8,816,994)

121. Power2B incorporates the preceding paragraphs by reference as if fully set forth.

122. Power2B owns all right, title and interest in and to the ’994 patent, and holds all substantial rights pertinent thereto, including the right to sue and recover for all past, current, and future damages for Samsung’s infringement.

123. The ’994 patent is valid and enforceable and directed to patentable subject matter.

124. Through at least the Accused Products, Samsung infringes at least claim 1 of the ’994 patent.

125. Claim 1 of the ’994 patent recites: an electronic input device.

126. The Accused Products are electronic input devices because they are configured to receive inputs via at least touch-sensitive display screens and/or digitizers.

127. Claim 1 of the ’994 patent recites: an input object.

128. The Accused Products include an input object. For example, the Accused Products include Samsung’s S-pen, which is an input object.

129. Claim 1 of the ’994 patent recites: an input area.

130. The Accused Products have an input area. For example, the Accused Products have display screens or input areas.

131. Claim 1 of the ’994 patent recites: wherein the input object is operative to direct a geometric beam of electromagnetic radiation.

132. The Accused Products include an input object that is operative to direct a geometric beam of electromagnetic radiation. For example, the Accused Products include Samsung’s S-pen, which has internal circuitry for emitting electromagnetic radiation. In particular, the S-pen’s internal circuitry includes at least a coil that directs a conical beam of electromagnetic radiation from the S-pen.

133. Claim 1 of the ’994 patent recites: an electromagnetic radiation pattern produced on the input area by the beam directed from the input object, wherein geometrical characteristics of the pattern are a function of the spatial relationship of the input object relative to the input area.

134. The Accused Products, and more particularly the S-pen, directs a conical beam of electromagnetic radiation on an input area, where the electromagnetic radiation pattern includes geometrical characteristics that are a function of a spatial relationship of the input object relative to the input area. For example, the Accused Products detect when the S-pen hovers (without contact) within a specified distance. A greater distance between the S-pen and the input area provides more space for the S-pen’s conical beam of radiation to spread and results in a wider area for the electromagnetic radiation pattern (e.g. a larger circle/ellipse pattern). Conversely, a smaller distance between the S-pen and the input area provides less space for the S-pen’s conical beam of radiation to spread and results in a smaller area for the electromagnetic radiation pattern (e.g. a smaller circle/ellipse pattern). In this fashion, the electromagnetic radiation pattern includes geometric characteristics that are a function of the spatial relationship between the S-pen relative to the input area.

135. Claim 1 of the ’994 patent recites: sensing means positioned at least partially at a periphery of the input area, operative to sense and provide an output indication of at least two of position, orientation, shape, and size of the electromagnetic radiation pattern.

136. The Accused Products include sensing means positioned at least partially at a periphery of the input area, operative to sense and provide an output indication of at least two of position, orientation, shape, and size of the electromagnetic radiation pattern. For example, the Accused Products include a digitizer or sensing means that is positioned at least partially at a

periphery of the input area. The digitizer in the Accused Products includes sensing coils that form a sensing plane that overlaps with a periphery of the input area. In addition, the digitizer in the Accused Products is operative to sense and provide an output indication of two or more of the position, orientation, shape, and/or size of an electromagnetic radiation pattern. For example, the digitizer supports various S-pen features such as displaying a cursor and detecting the tilt, which depends on two or more output indications.

137. Claim 1 of the ’994 patent recites: processing circuitry operative to receive the output indication and provide an electronic input representing at least one of two-dimensional position, three-dimensional position, and orientation of the input object relative to the input area.

138. The Accused Products have processing circuitry operative to receive an output indication and provide an electronic input representing at least one of two-dimensional position, three-dimensional position, and orientation of an input object relative to an input area. For example, the processing circuitry in the Accused Products include digitizer controllers and Central Processing Units (CPUs) such as ARM Cortex, Exynos, Mongoose, and Snapdragon processors. In addition, the processing circuitry in the Accused Products receives an output indication from a digitizer and provides electronic inputs that support various S-pen features. These features include displaying cursors corresponding to one or more of the S-pen’s two-dimensional position, three-dimensional position, and/or orientation (e.g. tilt) relative to an input area.

139. Samsung has infringed and continues to infringe the ’994 patent under 35 U.S.C. § 271(a), directly, literally and/or under the doctrine of equivalents, by making, using, selling, and/or offering to sell in the United States and/or importing into the United States, the Accused Products, during the term of the ’994 patent.

140. Samsung has actual knowledge of the ’994 patent, and has had knowledge of the ’994 patent at all relevant times, and knows the above-described actions, if taken, would constitute infringement of the ’994 patent.

141. Alternatively, Samsung believes there is a high probability that others will infringe the ’994 patent as a result of its actions but has remained willfully blind to the infringing nature of those actions.

142. Samsung took the above-described actions with the intent to cause acts of infringement of the ’994 patent by others, such as its customers and end-users.

143. Samsung has actively induced infringement and continues to actively induce infringement of the ’994 patent under 35 U.S.C. § 271(b) by making, selling, offering to sell and/or importing the Accused Products, and through activities relating to selling, marketing, advertising, promotion, support, and/or distribution of the Accused Products.

144. Samsung infringes the ’994 patent by contributing to the infringement of others, such as its customers and end-users, by making, selling, offering to sell, and/or importing or exporting one or more components of the Accused Products used to practice one or more claims of the ’994 patent, that constitute a material part of the invention(s) claimed in the ’994 patent, and that have no substantial non-infringing use, with knowledge that such components are especially made or adapted for use in infringing the ’994 patent.

145. Through its actions Samsung infringes the ’994 patent under 35 U.S.C. § 271(c).

146. Samsung’s actions and infringement of the ’994 patent are without license or authorization from Power2B.

147. Samsung’s acts of infringement have caused Power2B to suffer damages. Power2B is entitled to and seeks to recover from Samsung pursuant to 35 U.S.C. § 284 the

damages it has sustained as a result of Samsung's wrongful actions in an amount subject to proof at trial, and in no event less than a reasonable royalty, together with interest and costs.

148. Additionally, Samsung's acts of infringement have caused and continue to cause immediate and irreparable harm to Power2B. Unless such acts of infringement are permanently enjoined by the Court, Samsung will continue to cause immediate and irreparable harm to Power2B for which there is no adequate remedy at law. Power2B is entitled to and seeks injunctive relief pursuant to 35 U.S.C. § 283.

149. Samsung's acts of infringement have at all relevant times been willful and/or Samsung has acted with bad faith.

150. Power2B is entitled to and seeks to recover from Samsung pursuant to 35 U.S.C. § 284 the damages it has sustained as a result of Samsung's willful/bad faith infringement in an amount up to three times the amount of damages found or assessed.

IX. COUNT FOUR
(Infringement of U.S. Patent No. 9,946,369)

151. Power2B incorporates the preceding paragraphs by reference as if fully set forth.

152. Power2B owns all right, title and interest in and to the '369 patent, and holds all substantial rights pertinent thereto, including the right to sue and recover for all past, current, and future damages for Samsung's infringement.

153. The '369 patent is valid and enforceable and directed to patentable subject matter.

154. Through at least the Accused Products, Samsung infringes at least claim 1 of the '369 patent.

155. Claim 1 of the '369 patent recites: an interactive device.

156. The Accused Products are interactive devices because they are configured to display visual content and execute functions in response to interactive inputs. In addition, the Accused products include interactive input-sensitive displays and/or digitizers.

157. Claim 1 of the ’369 patent recites: a housing having a screen to display one or more selectable options to a user.

158. The Accused Products include a housing having a screen to display one or more selectable options to a user. For example, the Accused Products include a housing for a display such as LED displays, LCDs, OLED displays, and/or AMOLED displays. In addition, the display for each Accused Product displays content, including graphical icons or selectable options to a user.

159. Claim 1 of the ’369 patent recites: a plurality of light sensors disposed in the housing, each sensor configured to detect a portion of light incident on the device and provide an output signal based on the portion of light detected.

160. The Accused Products include a plurality of light sensors disposed in a housing, each sensor configured to detect a portion of light incident on the device and provide an output signal based on the portion of light detected. For example, the Accused Products include a digitizer disposed in a housing. The digitizer includes a plurality of light sensors or coils, where each sensor is configured to detect light incident on the device and provide an output signal based on the portion of the light detected.

161. Claim 1 of the ’369 patent recites: a processing unit.

162. The Accused Products include a processing unit configured to perform various operations. For example, the Accused Products have one or more digitizer controllers and CPUs such as ARM Cortex, Exynos, Mongoose, and Snapdragon processors.

163. Claim 1 of the ’369 patent recites: receive the output signal from one or more light sensors; determine, based on the output signal, a position of an object in a three-dimensional (3D) space relative to the interactive device; and determine the position of the object corresponds to one of the selectable options based on a first dimension and a second dimension of the 3D space.

164. The Accused Products include a processing unit configured to receive an output signal from one or more light sensors; determine, based on an output signal, a position of an object in a three-dimensional (3D) space relative to the interactive device; and determine the position of the object corresponds to one of the selectable options based on a first dimension and a second dimension of a 3D space. For example, the Accused Products, and more specifically the processing unit, are configured to support various S-pen features such as displaying a cursor, moving the cursor over selectable options or graphical icons, and executing functions in applications corresponding to the graphical icons. Upon information and belief, the processing unit in the Accused Products receives output signals from digitizer sensors and determines the position of the S-pen in 3D space relative to the device. In particular, the processing unit determines a 2D coordinate position of the S-pen corresponding to the 2D cursor display position (e.g. X and Y dimensions). In addition, the processing unit detects when the S-pen hovers (without contact) within a specified distance or a third dimension (e.g. a Z dimension). The processing unit also moves a cursor over displayed graphical icons based on the 2D cursor display position. The processing unit determines a position of the S-pen in a 3D space relative to the device and determines the position of the object corresponds to one of the selectable options based on a first dimension and a second dimension of the 3D space.

165. Claim 1 of the ’369 patent recites: determine, based on a change in the output signal, movement of the object relative to the interactive device in a third dimension of the 3D space; and execute, based on the movement of the object, a function related to at least one of the one or more selectable options.

166. The processing unit for the Accused Products is configured to determine, based on a change in the output signal, movement of an object relative to the interactive device in a third dimension of the 3D space; and execute, based on the movement of the object, a function related to at least one of one or more selectable options. For example, the processing unit for the Accused Products detects when the S-pen hovers (without contact) within a specified distance or the third dimension (e.g. a Z dimension). In particular, the processing unit determines movement of the S-pen in the third dimension based on changes in light detected by digitizer sensors. The processing unit further executes a function related to a graphical icon based on movement of the S-pen.

167. Samsung has infringed and continues to infringe the ’369 patent under 35 U.S.C. § 271(a), directly, literally and/or under the doctrine of equivalents, by making, using, selling, and/or offering to sell in the United States and/or importing into the United States, the Accused Products, during the term of the ’369 patent.

168. Samsung has actual knowledge of the ’369 patent, and has had knowledge of the ’369 patent at all relevant times, and knows the above-described actions, if taken, would constitute infringement of the ’369 patent.

169. Alternatively, Samsung believes there is a high probability that others will infringe the ’369 patent as a result of its actions but has remained willfully blind to the infringing nature of those actions.

170. Samsung took the above-described actions with the intent to cause acts of infringement of the ’369 patent by others, such as its customers and end-users.

171. Samsung has actively induced infringement and continues to actively induce infringement of the ’369 patent under 35 U.S.C. § 271(b) by making, selling, offering to sell and/or importing the Accused Products, and through activities relating to selling, marketing, advertising, promotion, support, and/or distribution of the Accused Products.

172. Samsung infringes the ’369 patent by contributing to the infringement of others, such as its customers and end-users, by making, selling, offering to sell, and/or importing or exporting one or more components of the Accused Products used to practice one or more claims of the ’369 patent, that constitute a material part of the invention(s) claimed in the ’369 patent, and that have no substantial non-infringing use, with knowledge that such components are especially made or adapted for use in infringing the ’369 patent.

173. Through its actions Samsung infringes the ’369 patent under 35 U.S.C. § 271(c).

174. Samsung’s actions and infringement of the ’369 patent are without license or authorization from Power2B.

175. Samsung’s acts of infringement have caused Power2B to suffer damages. Power2B is entitled to and seeks to recover from Samsung pursuant to 35 U.S.C. § 284 the damages it has sustained as a result of Samsung’s wrongful actions in an amount subject to proof at trial, and in no event less than a reasonable royalty, together with interest and costs.

176. Additionally, Samsung’s acts of infringement have caused and continue to cause immediate and irreparable harm to Power2B. Unless such acts of infringement are permanently enjoined by the Court, Samsung will continue to cause immediate and irreparable harm to

Power2B for which there is no adequate remedy at law. Power2B is entitled to and seeks injunctive relief pursuant to 35 U.S.C. § 283.

177. Samsung's acts of infringement have at all relevant times been willful and/or Samsung has acted with bad faith.

178. Power2B is entitled to and seeks to recover from Samsung pursuant to 35 U.S.C. § 284 the damages it has sustained as a result of Samsung's willful/bad faith infringement in an amount up to three times the amount of damages found or assessed.

X. COUNT FIVE
(Infringement of U.S. Patent No. 10,664,070)

179. Power2B incorporates the preceding paragraphs by reference as if fully set forth.

180. Power2B owns all right, title and interest in and to the '070 patent, and holds all substantial rights pertinent thereto, including the right to sue and recover for all past, current, and future damages for Samsung's infringement.

181. The '070 patent is valid and enforceable and directed to patentable subject matter.

182. Through at least the Accused Products, Samsung infringes at least claim 1 of the '070 patent.

183. Claim 1 of the '070 patent recites: an interactive device.

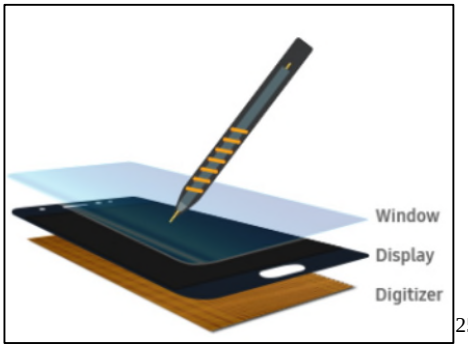
184. The Accused Products are interactive devices because they are configured to display visual content and execute functions in response to interactive inputs. In addition, the Accused products include interactive input-sensitive display screens and/or digitizers.

185. Claim 1 of the '070 patent recites: a stylus for emitting a beam of electromagnetic radiation.

186. The Accused Products include a stylus for emitting a beam of electromagnetic radiation. For example, the Accused Products include Samsung's S-pen, which is a stylus that emits a beam of electromagnetic radiation.

187. Claim 1 of the '070 patent recites: a display screen disposed in a housing, the display screen displaying one or more selectable icons, the display screen forming a touch-sensitive display plane.

188. The Accused Products include a display screen disposed in a housing, the display screen displaying one or more selectable icons, the display screen forming a touch-sensitive display plane. For example, the Accused Products include touch-sensitive displays such as LED, LCD, OLED, or AMOLED display screens. In addition, the displays display visual content such as graphical or selectable icons. The displays further form a touch-sensitive display plane. The image below shows a touch-sensitive display plane as employed by the Accused Products.



[25]

189. Claim 1 of the '070 patent recites: a sensor array disposed in the housing and forming a sensitive layer in a sensor plane proximate to the display screen, the sensor array is configured to detect at least a portion of the beam of electromagnetic radiation incident on the display screen.

[25] https://news.samsung.com/global/in-depth-look-more-than-just-a-writing-tool-the-s-pen-of-the-galaxy-note7.

190. The Accused Products have a sensor array disposed in a housing and forming a sensitive layer in a sensor plane proximate to a display screen, the sensor array is configured to detect at least a portion of a beam of electromagnetic radiation incident on the display screen. For example, the Accused Products include a digitizer or sensor array disposed in a housing. As shown in the image above, the digitizer in each Accused Product forms a sensitive layer in a sensor plane proximate to the display screen. In addition, a digitizer is configured to detect at least a portion of a beam of light emitted by the S-pen incident on the display screen.

191. Claim 1 of the ’070 patent recites: a processing unit.

192. The Accused Products include a processing unit configured to perform various operations. For example, the Accused Products have one or more digitizer controllers and CPUs such as ARM Cortex, Exynos, Mongoose, and Snapdragon processors.

193. Claim 1 of the ’070 patent recites: receive an output signal from the sensor array; determine the output signal from the sensor array corresponds to a distribution pattern of electromagnetic radiation; and determine a three-dimensional position of the stylus relative to the interactive device based on the distribution pattern.

194. The Accused Products include a processing unit configured to receive an output signal from a sensor array; determine the output signal from the sensor array corresponds to a distribution pattern of electromagnetic radiation; and determine a three-dimensional position of a stylus relative to the interactive device based on a distribution pattern. For example, the processing unit in the Accused Products is coupled to a digitizer and is configured to receive an output from the digitizer. In addition, the Accused Products use EMR technology, and upon information and belief, an output from the digitizer corresponds to a distribution pattern of electromagnetic radiation—namely, a radiation pattern corresponding to the S-pen’s emitted

beam of light. The processing unit is further configured to determine the tilt or orientation of the S-pen, which also corresponds to a distribution pattern of electromagnetic radiation. With respect to 3D position, upon information and belief, the processing unit detects when the S-pen is positioned within a specified distance based on a distribution pattern. For example, the distribution pattern changes depending on the distance and angular orientation between the S-pen and an input area. The processing unit further determines the 3D position of the S-pen based on a distribution pattern to support various S-pen features such as displaying a cursor, moving a cursor over selectable options or graphical icons, and executing functions in applications corresponding to the graphical icons.

195. Claim 1 of the ’070 patent recites: determine the three-dimensional position of the stylus corresponds to a first selectable icon of the one or more selectable icons based on the output signal; determine at least a portion of the output signal corresponds to a selection function associated with the first selectable icon; and execute, based on the selection function, a function related to the first selectable icon.

196. The Accused Products include a processing unit configured to determine a three-dimensional position of a stylus corresponds to a first selectable icon of one or more selectable icons based on an output signal; determine at least a portion of the output signal corresponds to a selection function associated with a first selectable icon; and execute, based on the selection function, a function related to the first selectable icon. For example, the Accused Products. and more specifically the processing unit, are configured to support various S-pen features such as displaying a cursor, moving a cursor over selectable options or graphical icons, and executing functions in applications corresponding to the graphical icons. In particular, the processing unit receives an output signal from a digitizer and based on the output signal, the processing unit

determines a 2D coordinate position of the S-pen corresponding to the 2D cursor display position (e.g. X and Y dimensions). In addition, the processing unit detects when the S-pen hovers (without contact) within a specified distance of a third dimension (e.g. a Z dimension) based on an output signal. The processing unit is also configured to move the cursor over a displayed graphical icon based on the 3D position of the S-pen. When positioned over a displayed graphical icon, the processor can select the icon and execute a function such as highlighting the icon, previewing content relating to the icon (or a selected image), displaying a menu corresponding to the icon, and so on.[26]

197. Samsung has infringed and continues to infringe the ’070 patent under 35 U.S.C. § 271(a), directly, literally and/or under the doctrine of equivalents, by making, using, selling, and/or offering to sell in the United States and/or importing into the United States, the Accused Products, during the term of the ’070 patent.

198. Samsung has actual knowledge of the ’070 patent, and has had knowledge of the ’070 patent at all relevant times, and knows the above-described actions, if taken, would constitute infringement of the ’070 patent.

199. Alternatively, Samsung believes there is a high probability that others will infringe the ’070 patent as a result of its actions but has remained willfully blind to the infringing nature of those actions.

200. Samsung took the above-described actions with the intent to cause acts of infringement of the ’070 patent by others, such as its customers and end-users.

[26] *See, e.g.*, https://www.samsung.com/global/galaxy/what-is/air-view/; https://news.samsung.com/global/4-tips-to-get-the-most-out-of-the-galaxy-note9s-powerful-s-pen.

201. Samsung has actively induced infringement and continues to actively induce infringement of the ’070 patent under 35 U.S.C. § 271(b) by making, selling, offering to sell and/or importing the Accused Products, and through activities relating to selling, marketing, advertising, promotion, support, and/or distribution of the Accused Products.

202. Samsung infringes the ’070 patent by contributing to the infringement of others, such as its customers and end-users, by making, selling, offering to sell, and/or importing or exporting one or more components of the Accused Products used to practice one or more claims of the ’070 patent, that constitute a material part of the invention(s) claimed in the ’070 patent, and that have no substantial non-infringing use, with knowledge that such components are especially made or adapted for use in infringing the ’070 patent.

203. Through its actions Samsung infringes the ’070 patent under 35 U.S.C. § 271(c).

204. Samsung’s actions and infringement of the ’070 patent are without license or authorization from Power2B.

205. Samsung’s acts of infringement have caused Power2B to suffer damages. Power2B is entitled to and seeks to recover from Samsung pursuant to 35 U.S.C. § 284 the damages it has sustained as a result of Samsung’s wrongful actions in an amount subject to proof at trial, and in no event less than a reasonable royalty, together with interest and costs.

206. Additionally, Samsung’s acts of infringement have caused and continue to cause immediate and irreparable harm to Power2B. Unless such acts of infringement are permanently enjoined by the Court, Samsung will continue to cause immediate and irreparable harm to Power2B for which there is no adequate remedy at law. Power2B is entitled to and seeks injunctive relief pursuant to 35 U.S.C. § 283.

207. Samsung's acts of infringement have at all relevant times been willful and/or Samsung has acted with bad faith.

208. Power2B is entitled to and seeks to recover from Samsung pursuant to 35 U.S.C. § 284 the damages it has sustained as a result of Samsung's willful/bad faith infringement in an amount up to three times the amount of damages found or assessed.

XI. EXCEPTIONAL CASE

209. This is an exceptional case and Power2B is entitled to and seeks a determination and ruling from the Court that this case is exceptional and awarding its reasonable and necessary attorneys' fees pursuant to 35 U.S.C. § 285.

XII. JURY DEMAND

Pursuant to Federal Rule of Civil Procedure 38(b), Power2B demands a trial by jury on all issues so triable.

XIII. PRAYER FOR RELIEF

Power2B prays that the Court enter judgment in its favor and against Samsung as follows:

a) a judgment and award that Samsung has infringed, either literally and/or under the doctrine of equivalents, each of the Asserted Patents;

b) a judgment and order finding that Samsung's infringement has been willful;

c) a permanent injunction prohibiting Samsung from further acts of infringement;

d) a judgment and order requiring Samsung to pay Power2B its damages, costs, expenses, and enhanced damages to which Power2B is entitled due to Samsung's infringement and willfulness;

e) a judgment and order requiring Samsung to provide an accounting and to pay Power2B supplemental damages, including without limitation, pre-judgment and post-judgment interest;

f) a judgment and order finding that this is an exceptional case within the meaning of 35 U.S.C. § 285 and awarding Power2B its reasonable and necessary attorneys' fees; and

g) such other and further relief to which it may be entitled.

Dated: September 3, 2021.

Respectfully submitted,

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EXHIBIT A

US007952570B2

(12) United States Patent
Lipman et al.

(10) Patent No.: US 7,952,570 B2
(45) Date of Patent: May 31, 2011

(54) **COMPUTER NAVIGATION**

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(73) Assignee: **Power2B, Inc.**, Santa Monica, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 953 days.

(21) Appl. No.: **11/006,486**

(22) Filed: **Dec. 6, 2004**

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Related U.S. Application Data

(63) Continuation of application No. PCT/GB03/02533, filed on Jun. 9, 2003.

(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
G09G 3/28 (2006.01)
G06F 3/033 (2006.01)

(52) **U.S. Cl.** **345/182**; 178/19.05

(58) **Field of Classification Search** 345/156–184
See application file for complete search history.

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(57) **ABSTRACT**

An electronic device comprises a display for displaying data stored on said electronic device; input means; sensing means for sensing the three-dimensional position of the input means relative to said device; and control means for controlling the data displayed on said display in dependence on the three-dimensional position of the input means relative to said device. The input means includes a source of electromagnetic radiation for directing an infrared conical beam onto the display. The sensing means can sense the elliptical eccentricity of the electromagnetic radiation incident on the display to determine the angle at which it strikes the display, and can sense the area of the electromagnetic radiation incident on the display to determine the distance of the input means from the display.

22 Claims, 2 Drawing Sheets

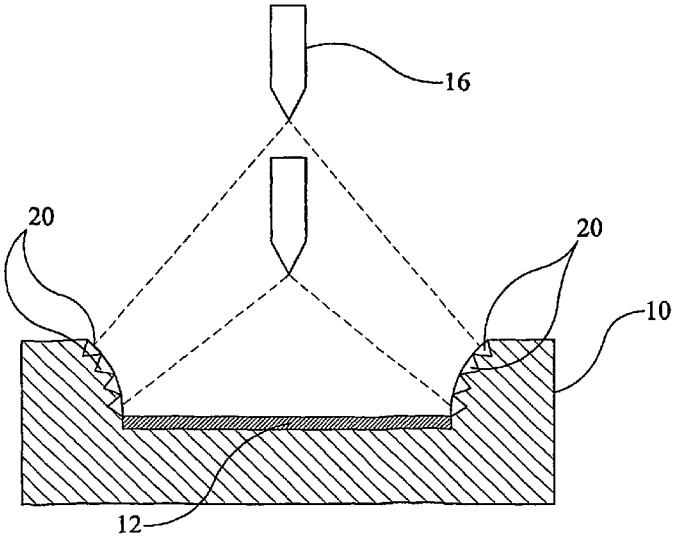

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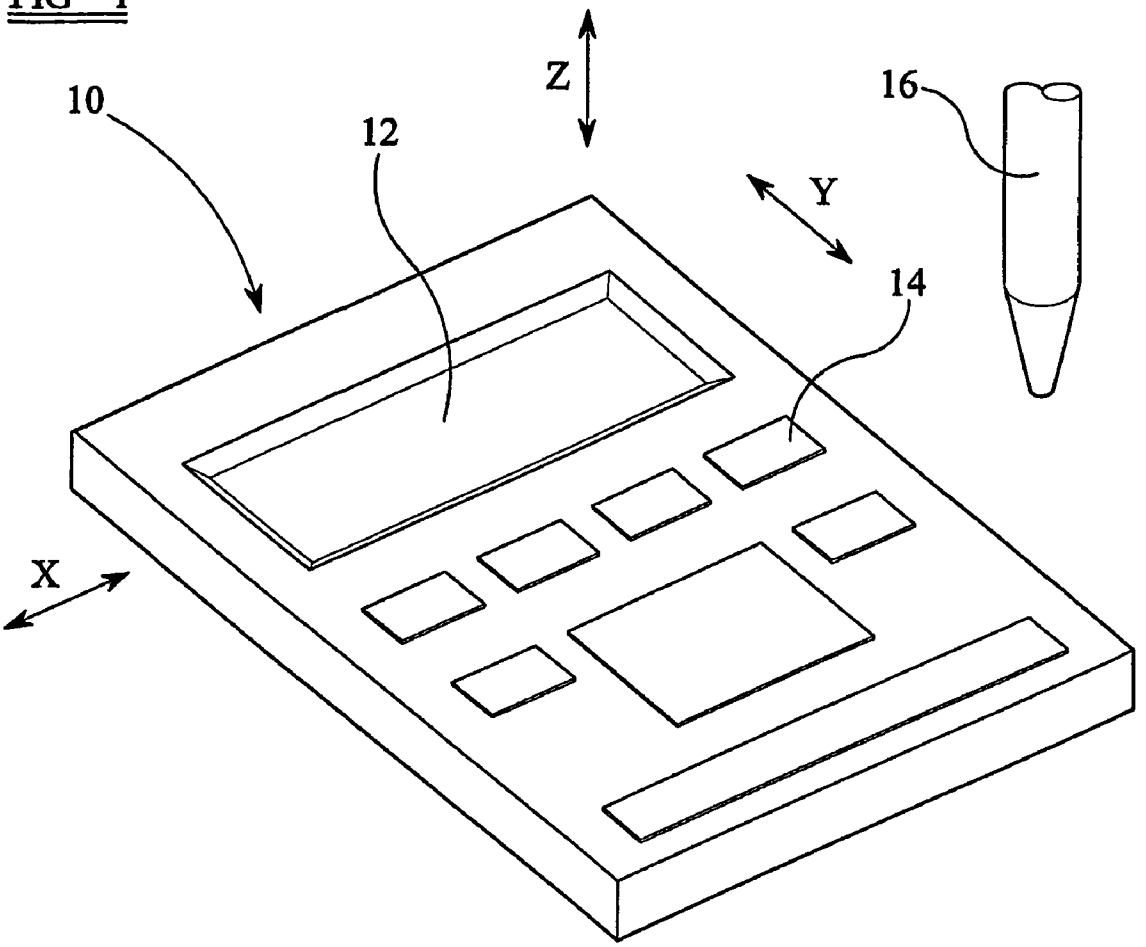
FIG 1



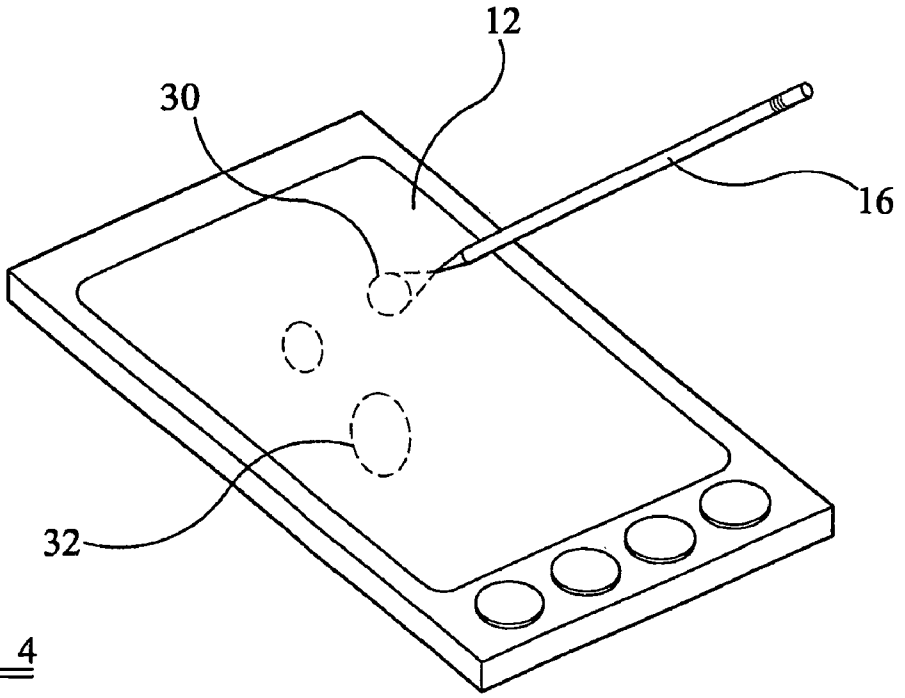


FIG 4

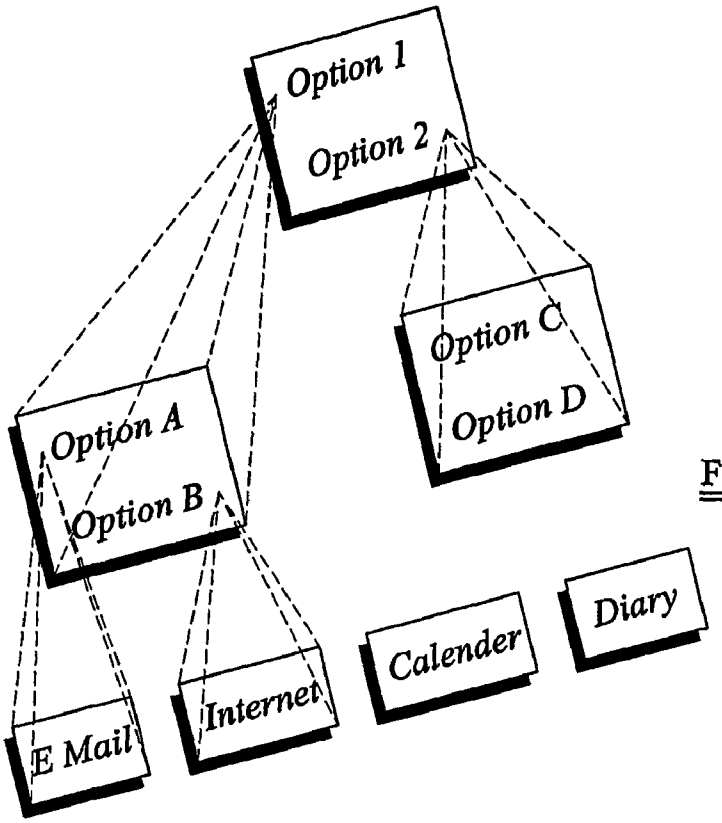

Option 1
Option 2
Option C
Option D
Option A
Option B
E Mail
Internet
Calender
Diary

FIG 2

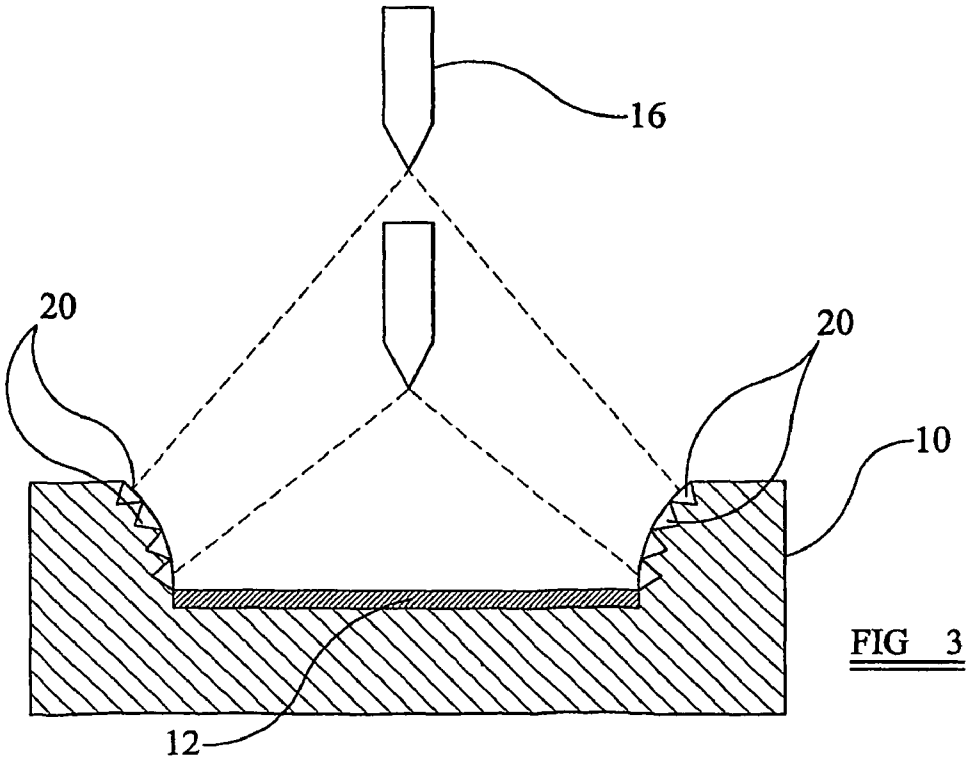

16
20
20
10
12

FIG 3

COMPUTER NAVIGATION

The present invention relates to computer navigation and particularly, but not exclusively, to an apparatus which facilitates navigation of software stored on the apparatus even where the display for the apparatus is small.

It is known to provide small, hand-held computer devices such as pocket organisers, Personal Digital Assistants (PDA's), cellular phones or the like. The current trend is to manufacture such devices to be as small in size as possible. Smaller devices are more easily carried and generally require a reduced power supply.

However, a significant disadvantage of such devices is that the reduced size forces a reduction in the size of the user interface, and particularly in the size of the screen or display used to display information or data stored on or processed by the device.

Many such devices have the processing power of conventional desktop or laptop computers or of similar devices many times their size and a number of products, such as the WACOM® and SONY® VAIO® pocket computers, are fully operable portable computers which use operating systems such as MICROSOFT® WINDOWS® or the like.

Those familiar with such pocket devices will appreciate the problem of displaying all of the necessary information on a relatively small display, particularly where the user is able to select specific functions from a large number of options. Conventionally, the selection of one option, for example, results in a new "window" opening which displays further options and sub options. Whilst devices having large displays are able to organise the data so that it is displayed in a more easily understood manner, devices having smaller screens tend to use data "layers" or "levels" whereby the selection of one option having a number of sub options causes the full screen to display the sub options fully eclipsing the original menu. The accidental selection of the wrong option requires a number of steps to return the display to the original list of options.

It would be advantageous to provide a pocket computer or hand held device which incorporates means for enabling easier access to data on the device and improves the user interface of the device.

According to one aspect of the present invention, therefore, there is provided an electronic device having a display for displaying data stored thereon, input means and control means for controlling the data displayed on said display in dependence on the three-dimensional position of the input means with respect to said device.

Preferably, the device includes means for sensing or monitoring the position of the input means relative to the device.

In one embodiment, the input means includes a transmitter for transmitting a signal and the display includes sensing means for sensing the position at which the signal strikes the display. The signal may be in the form of a conical or circular infrared beam and the sensing means may be operable to sense the area and/or the intensity of the beam as it strikes the display thereby to determine the three dimensional position of the input device relative to the display.

According to another aspect of the invention there is provided an input device for a computer or the like having a display for displaying data stored thereon, the input device comprising input means, and sensing means for sensing the three dimensional position of the input means relative thereto and applying a position signal to said computer or the like in dependence on said three dimensional position thereby to control the data displayed on said display.

The present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

FIG. **1** shows illustratively a device according to the invention;

FIG. **2** shows illustratively the concept of data "levels";

FIG. **3** shows illustratively a cross-section through a device according to one embodiment of the invention; and

FIG. **4** shows illustratively one embodiment in which the stylus when moved closer to the display produces a circle or ellipse of smaller dimensions than the circle or ellipse formed when the stylus is moved away.

Referring to FIG. **1**, an electronic device according to the invention is shown generally at **10**. The device **10** may be, for example, a hand-held or "palm-top" computer, a personal digital assistant (PDA) or a mobile communication device such as a mobile telephone. The device **10** is capable of storing and displaying data from a display or screen **12** which may be a liquid crystal display, a dot matrix display or a TFT (thin film transistor) display.

Conventionally, the user of the device **10** controls the data displayed on the display **12** by means of a number of buttons **14** located on the device or by an input device such as a scratch pad or tracker ball. Alternatively, many such devices incorporate touch-sensitive displays which permit the user to select options or to change the data on the display **12** by means of a pencil-shaped pointing device which is physically pressed against the display at the required position thereby to select the required option. Such touch sensitive displays are able only to determine the two-dimensional, X-Y position of the pointing device relative to the display **12** when the pointing device is pressed against the surface of the display.

A disadvantage of such devices is that in order to achieve the required reduction in size to enable the device to be used as a hand-held device or pocket computer, the display **12** is made correspondingly smaller in size. However, depending on the application for which the device is intended, the display **12** may be required to display similar amounts of data to that of a conventional desktop or lap-top computer having a display which may be an order of magnitude larger in size. The small size of the display **12** reduces the amount of data which can be displayed at any given time.

To minimise the effects of this, the device is programmed to display data in a number of "levels" whereby the display **12** initially displays, for example, four options which are selectable by the user. Selecting one of these options, by means of the pointing device for example, may cause the display **12** to display a second "level" of options, for example in the form of a drop down list or menu commonly used in conventional computers. Each option displayed in the list may produce a further drop down list.

It will be appreciated that the number of levels used by the device is generally proportional to the number of options available to the user and inversely proportional to the size of the display. It is therefore quite common to find that a user may be required to select several options in order to activate a particular function of the device. This is time consuming and can be irritating to the user. Moreover, the generating of a drop down list or the like may obscure completely the original list so that an erroneous selection may require the user to manually exit from the current list in order to return to the original set of options. This may significantly increase the number of operations required to be made by the user.

According to the preferred form of the invention, the device **10** has a display **12** for displaying data stored on the device **10** which can be controlled by input means in the form of an input device **16**. In the preferred embodiment, the input

device **16** takes the form of a pen-shaped instrument, hereafter termed a "stylus" which allows the user to select various options displayed on the display **12**. The concept of the invention is that the electronic device **10** is able to detect or monitor the three dimensional position of the stylus **16** relative to the device **10**, and in particular relative to the display. This permits, effectively "three-dimensional control" of the display **12** which can be used, for example, to achieve the following control functions.

Movement of the stylus **16** in the X or Y directions relative to the display **12** causes the cursor on the display **12** (for example the mouse pointer or equivalent) to move accordingly, in the manner of a conventional mouse. Importantly, however, movement of the stylus **16** in the Z direction, i.e. in a direction generally perpendicular to the display **12**, performs a "zoom" function which, depending on the direction of movement of the stylus **16**, either towards or away from the display, causes the display **12** either to zoom in or to zoom out.

In one embodiment, for example, movement of the stylus **16** in a direction towards the display **12** causes the data in the region of the display **12** corresponding to the X-Y position of the stylus **16** to be magnified in a manner similar to that achieved by the "zoom in" function of conventional computers and computer programs. Thus, the data in the region of the display **12** corresponding to the X-Y position of the stylus **16** is enlarged as the stylus **16** is moved closer to the display **12**. This zooming in of the display **12** permits data relating to sub options to be displayed in place of the original option. However, whereas conventional software offers an "incremental zoom" with each discrete selection, the device described with reference to the drawings provides continuous zoom through constantly refreshed information based on the computed trajectory of the stylus. Continuous zoom makes possible an intuitive and responsive user interface.

When "zoom in" or "zoom out" reaches a pre-determined threshold, data relating to sub-options is displayed in addition to, or in place of (or first one then the other), the original option.

FIG. **2** illustrates the concept of "levels" of information to be displayed by the display **12**. Initially, the displays "level **1**" data which, as illustrated in FIG. **3**, may give the user two choices, OPTION **1** and OPTION **2**, which are selectable by the user. OPTION **1** represents specific "level **2**" data which may, for example, include a further two choices, OPTION A and OPTION B. OPTIONs A and B represent respective "level **3**" data which may, for example, represent different functions which the device **10** can perform, for example to send an e-mail or to access the internet.

Similarly, OPTION **2** in the level **1** data may correspond to OPTIONS C and D in the second level data, each of which represents different functions which may be performed by the device **10**, for example opening a calendar or opening a diary.

In conventional devices, to select the internet function from the above example, the user would be required to press the stylus **16** onto the screen at OPTION **1** and then again at OPTION B and finally on the internet option. Thus, three separate operations are required. An incorrect selection, for example selection of OPTION A instead of OPTION B requires the user to select an "exit" option (not shown) in order to return to the level **1** data.

The present invention, on the other hand, permits the user to select, for example, the internet, with a minimum of individual operations. For example, in one embodiment, the user moves the stylus **16** over the part of the display **12** containing OPTION **1** and then moves the stylus **16** towards the display. The device **10** interprets the movement of the stylus **16** towards the screen as a "zoom in" operation which zooms the display **12** through the level **1** data towards the level **2** data until OPTION A and OPTION B are displayed on the screen. The user then alters the position of the stylus **16** in the X-Y plane until the stylus **16** is positioned over the OPTION B icon and again moves the stylus **16** towards the display. This movement "zooms in" through the level **2** data towards the level **3** data until the internet icon appears on the screen. This can then be selected by the user in the conventional manner, for example, by pressing the stylus **16** onto the screen at the required location.

It will be understood that the present invention relies on the ability of the device **10** to monitor, track or otherwise detect the X-Y-Z, three-dimensional position of the stylus **16** relative to the display **12** whilst the stylus **16** is not in contact with the display **12** itself, unlike conventional touch-sensitive displays. This may be achieved in a number of ways.

In one embodiment, the stylus **16** is a so-called "smart stylus" which contains a source of electromagnetic radiation, for example an infrared emitter, an LED or other such light emitting device (not shown). The stylus **16** emits a beam of light, for example infrared or other spectrum light, from a circular, spherical, or other shaped tip. The light is sensed by a sensitive layer (not shown) positioned over, or incorporate in, the display **12**. The light sensitive layer may, for example, be in the form of a CCD or CMOS infrared sensitive array or the like. As the stylus **16** is moved across the display **12**, only certain parts of the sensitive layer will be illuminated by the beam of light emitted by the stylus **16** and this will be detected by the sensitive layer. The sensitive layer determines the appropriate X-Y coordinates of the stylus **16** and sends a corresponding position signal to the central processing unit or similar of the device **10** which adjusts the display **12** accordingly. FIG. **4** is an example of this embodiment. The stylus **16** when moved closer to the display produces a circle or ellipse **30** of smaller dimensions than the circle or ellipse **32** formed when the stylus is moved away. The same eccentricity of the ellipse means that the input stylus is at the same angle to the display and the size of the area indicates the distance of the stylus from the display.

In an alternative embodiment, the stylus **16** operates in the manner of a conventional light pen and contains a light sensor or photodiode therein which senses the light given off by the display. The display **12** is scanned as in a conventional television screen so that the image is continually refreshed across and down the display **12** in a so-called raster scan. This continual refreshing causes the pixels in the display **12** to alternatively brighten and then dim at a very high frequency such that the effect is invisible to the naked eye.

However, the photodiode is able to detect this bright/dim effect and when the light received by the photodiode steps from dim to light, the stylus **16** sends a signal to the display controller in the device **10**. Since the display controller creates the display signal, it knows the position of the current raster line and so it can determine which pixel on the display **12** is being refreshed when the stylus **16** sends the signal to the controller. The display controller then sets a latch which feeds two numbers, representative of the X and Y coordinates of the pixel, to the central processing unit or similar of the device **10** which is therefore able to determine where on the screen the stylus **16** is pointed.

The above examples describe only how the device **10** determines the X-Y coordinates of the stylus **16** relative to the display **12**. It will be understood that the device **10** must also determine the Z-coordinate, i.e. the distance of the stylus **16** from the display. Again this can be achieved in a number of ways.

In one embodiment, the stylus **16** emits a beam of electromagnetic radiation, for example infrared or other spectrum light which is transmitted in a conical beam which widens in diameter with distance from the tip of the stylus **16**.

The light incident on the display **12** and hence the sensitive layer is in the form of an ellipse, the eccentricity of which depends on the angle at which the light strikes the display **12** and hence the stylus **16** is being held. An eccentricity of 1, for example, is indicative of a circle of incident light and a vertically held stylus **16**.

The distribution of the light incident on the sensitive layer will vary with distance from the light source in the stylus **16**. When the stylus **16** is positioned at a distance from the sensitive layer of the display, the total area of the sensitive layer illuminated will be relatively large but the intensity of the incident light will be low. As the stylus **16** is moved closer to the display, the area the light incident upon the sensitive layer will decrease but the intensity will increase. At very short distances from the display, the area of the display **12** illuminated by the light from the stylus **16** will be small but the intensity will be high.

In order to measure the intensity of the incident light the continuous range of possible intensities may be divided into a number of thresholds of stimulation. Hence, the intensity of the light may be calculated according to which thresholds it falls between.

In operation, the sensitive layer detects the light incident on the display **12** and sends appropriate signals to the processing unit of the device **10**. The elliptical eccentricity of the light incident on the display **12** is then calculated and from this the angle at which the stylus **16** is determined. The total area of light incident on the display **12** may also be calculated and from this the distance of the stylus **16** from the display **12** may be determined. Alternatively or additionally, the intensity of the incident light may be measured and used either to independently determine the distance of the stylus **16** from the display **12** or to refine the result of the calculation based on the measured area.

The angle of the stylus **16**, in conjunction with the distance of the stylus **16** from the display **12** are then used to determine the vertical height of the stylus **16** above the display **12**. Hence the position of the stylus **16**, in the Z-dimension, is determined by the device **10**.

Repetitive calculation of the stylus position, several times a second, as the stylus **16** is moved allows a stylus trajectory to be recorded. The stylus trajectory may then be used to assist in anticipating the intentions of the user.

The location and angle of the stylus **16** may also be used to determine when the user makes a selection without physical contact between the stylus **16** and the display. A simple dipping motion, for example, could be used to represent the selection. Alternatively or additionally the area and/or intensity of the light may also be used to represent a contactless selection. Such a selection may be indicated, for example, by the area of incident light falling below a certain minimum threshold and/or the intensity rising above a certain maximum threshold.

In a different embodiment, illustrated in FIG. **3**, the device **10** is provided with a plurality of light sensors **20** positioned around the perimeter of the display **12**. The light sensors are segmented or layered in the Z-direction such that as the stylus **16** moves towards or away from the display **12**, different or segments or layers of the light sensors will be illuminated by the conical beam emitted by the stylus **16**. In particular, as the stylus **16** moves closer to the screen, fewer of the light sensors around the display **12** will be illuminated, as illustrated in FIG. **3**. The signals from the sensors are interpreted by the processing unit of the device **10**, which thus calculates the distance of the stylus **16** from the display **12**.

In yet a further embodiment, not shown, the display **12** is inset or sunk into the body of the device **10** to provide a surrounding wall. The wall is provided on two faces with a plurality of light emitting devices and on the other two faces by a corresponding number of light sensing devices. The light emitted by the light emitters are sensed by the opposing light sensors such that if the stylus **16** is moved towards the display **12**, it will interrupt the light transmitted between some of the light emitters and the corresponding light sensors which will indicate to the device **10** that the stylus **16** has moved closer to the display. If the light emitters and sensors are layered in the Z-direction, this can provide an indication of the distance of the stylus **16** from the display.

It will be clear to those skilled in the art that there are a number of possible ways of sensing the X-Y-Z, three-dimensional position of the stylus **16** relative to the display, the above examples representing particularly simple and advantageous techniques. The important feature of the invention is that the user is able to alter the data displayed by the device **10** by moving the stylus **16** or other input device in three dimensions relative to the device **10** or the display **12** of the device **10**.

It will be further understood that there are a number of modifications or improvements or variations on the above described invention which may provide particular advantages. Where the stylus **16** incorporates a light emitting device to produce a conical beam, the power of the device may be selected to produce a beam which is of a predetermined length and conical angle to restrict the amount of movement in the Z-direction required by the user to perform the zoom in or zoom out functions. The type of light emitter can be selected as desired to provide infrared or visible light or other forms of electromagnetic radiation may be used. The stylus **16** may alternatively include both a photodiode, to enable its use similar to a light pen, and a light emitter for establishing the Z-coordinate information. The stylus **16** may be connected to the device **10** by means of a cable for transmitting or receiving signals to and from the electronic device **10**. Alternatively, the stylus **16** may be remotely linked to the device **10** or no data link may be provided at all. The latter situation is possible where a light emitting device is employed in the stylus **16**.

The stylus could optionally be attached to the device with a simple tether (spiral plastic cord, etc.) simply to prevent its loss from a place where many people might use it often, such as a refrigerator, computer or a commercial site.

The device **10** may incorporate a touch-sensitive screen or a conventional screen by which a selection is achieved by means of a button or the like located on the stylus **16** which causes a signal to be sent to the electronic device **10**, similar to conventional light guns or the like. Where a sensitive layer is used, this may be formed of any suitable material, which may additionally or alternatively be heat-sensitive. The sensitive layer may be layered above or below the screen of the display **12** or integrated therewith. The sensitivity and qualities of the material chosen can be selected as desired.

While the above described embodiments talk of sensing the position of the stylus **16** relative to the display **12** of the device **10**, it will be appreciated that the three dimensional position of the stylus **16** relative to any other part of the device **10** or relative to any fixed location could be used for the same purpose. In this regard, the invention may provide only a stylus **16** and a sensing "pad" or the like which is able to determine the three dimensional position of the stylus **16** relative thereto. The pad could be connected for communication with the electronic device **10** by any suitable means

which will be well understood. Such an embodiment may enable the stylus **16** and "pad" to be used with conventional desk top or laptop computers in place of the more conventional mouse, scratch pad or tracker ball.

It will be appreciated that the device **10** of the invention provides a number of advantages over existing systems. In particular, depth/height coordinates of the stylus **16** can be calculated from the device **10** and enable software on the device **10** to adapt the contents of the display **12** as the distance from the display **12** or device **10** changes. When the stylus **16** is brought closer to the display, the device **10** interprets this movement as an intention to select a coordinate within a specific range and zoom all of the information displayed within that coordinate to fill a larger part of the display. This enables the information display to intuitively come "closer" to meet the intention of the user. In addition, more space becomes available on the display **12** because fewer of the level **1** choices are shown and additional layers of choices, such as contextual menus, could be selectively added permitting more selections to be made with fewer "clicks" or selections of the stylus **16**. Where two or more levels of selection are required, movement of the stylus **16** may permit the device **10** to anticipate the selection required by the user to allow the selection to be made with only a single operation of the stylus **16**.

The invention claimed is:

1. An electronic input device comprising:

an input object wherein said input object includes a source of said electromagnetic radiation;

an input area;

a sensor array positioned outside said input area operative to sense and provide an output indication of position and at least two of orientation, shape and size of an electromagnetic radiation pattern on said input area produced by said input object; and

input circuitry receiving said output indication and providing an electronic input representing at least one of two-dimensional position, three-dimensional position and orientation of said input object; and

wherein said source of said electromagnetic radiation produces a conical beam which intersects said input area in an elliptical pattern having elliptical eccentricity which is a function of the orientation of said input object in a plane perpendicular to said input area.

2. An electronic input device according to claim **1** and also comprising a display providing a visually sensible output which is responsive to said electronic input.

3. An electronic input device according to claim **1** and wherein said sensor array is also operative to sense and provide at least one output indication of intensity of electromagnetic radiation in said electromagnetic radiation pattern.

4. An electronic input device according to claim **3** and wherein said input circuitry is operative to provide an electronic input which is at least partially based on the sensed intensity of electromagnetic radiation in said electromagnetic radiation pattern.

5. An electronic input device according to claim **3** and wherein said sensor array is operative to provide said output indication of intensity of electromagnetic radiation relative to a plurality of intensity thresholds.

6. An electronic input device according to claim **3** and wherein said sensor array is also operative to provide an output indication of the area of the sensor array illuminated by said electromagnetic radiation pattern.

7. An electronic input device according to claim **6** and wherein:

said area of the sensor array illuminated has a direct variable relationship with the distance from said input object to said input area; and

said intensity of electromagnetic radiation has an inverse variable relationship with the distance from said input object to said input area.

8. An electronic input device according to claim **7** and wherein the symmetry of at least one of said area of the sensor array illuminated and said intensity of electromagnetic radiation correlates with the orientation of said input object in at least one plane relative to said input area.

9. An electronic input device according to claim **1** and also comprising interface circuitry operative in response to said output indication for providing continuously variable user inputs based on at least one of said two-dimensional position, said three dimensional position; and said orientation of said input object.

10. An electronic input device according to claim **1** and wherein said sensor array is operative to provide an output indication of each of position, orientation, shape and size of an electromagnetic radiation pattern on said input area produced by said input object.

11. An electronic input device according to claim **10** and wherein said sensor array is also operative to sense and provide an output indication of intensity of electromagnetic radiation in said electromagnetic radiation pattern.

12. An electronic input device according to claim **10** and wherein said input object comprises a source of said electromagnetic radiation.

13. An electronic input device according to claim **12** and wherein said source of said electromagnetic radiation produces a conical beam which impinges on said input area, producing said electromagnetic radiation pattern on said input area in the form of an ellipse having elliptical eccentricity which is a function of orientation of said input object in a plane other than a plane parallel to said input area.

14. An electronic device according to claim **13** and wherein said input circuitry is operative to calculate said orientation of said input object from said elliptical eccentricity, based on said output indication from said sensor array.

15. An electronic device according to claim **10** and wherein said sensor array is also operative to sense and provide an output indication of intensity of electromagnetic radiation in said electromagnetic radiation pattern and wherein said input circuitry is operative to provide an electronic input which is at least partially based on the sensed intensity of electromagnetic radiation in said electromagnetic radiation pattern.

16. An electronic input device according to claim **10** and also comprising a display providing a visually sensible output which is responsive to said electronic input.

17. An electronic input device according to claim **1** and wherein said input circuitry is operative to calculate said orientation of said input object from said elliptical eccentricity, based on said output indication from said sensor array.

18. An electronic input device according to claim **1** and wherein said conical beam widens in diameter as the distance from said input object to said input area increases.

19. An electronic input device according to claim **1** and wherein said sensor array is positioned adjacent the perimeter of said input area.

20. An electronic input device comprising:

an input object;

an input area;

a sensor array positioned outside said input area operative to sense and provide an output indication of position and

at least two of orientation, shape and size of an electromagnetic radiation pattern on said input area produced by said input object;

input circuitry receiving said output indication and providing an electronic input representing at least one of two-dimensional position, three-dimensional position and orientation of said input object, said electronic input representing orientation includes an electronic input representing angular orientation of said input object relative to said input area; and

said input object includes a source of said electromagnetic radiation, and wherein said sensing array senses an electromagnetic radiation pattern which correlates with but is not itself representational of an elliptical pattern produced by a conical beam which intersects said input area in a pattern forming an ellipse having properties which are a function of at least one of position, distance and orientation of said input.

21. An electronic input device comprising:

a physical input area;

an input stylus projecting an electromagnetic radiation pattern on said input area;

a sensor array at least partially circumscribing and immediately proximate said input area, said sensor array operative to sense said electromagnetic radiation pattern on said input area and to provide an output indication of position and at least two of orientation, shape and size of said electromagnetic radiation pattern on said input area;

wherein said electromagnetic radiation pattern includes an elliptical pattern having elliptical eccentricity that is a function of the orientation of said input stylus relative to said input area; and

input circuitry receiving said output indication and providing an electronic input representing at least one of two-dimensional position, three-dimensional position and orientation of said input stylus.

22. An electronic input device comprising:

an input object;

an input area;

a sensor array positioned outside said input area operative to sense and provide an output indication of position and at least two of orientation, shape and size of an electromagnetic radiation pattern on said input area produced by said input object;

wherein said input object produces a beam of electromagnetic radiation that intersects said input area in an elliptical pattern having elliptical eccentricity which is a function of the orientation of said input object in a plane perpendicular to said input area; and

input circuitry receiving said output indication and providing an electronic input representing at least one of two-dimensional position, three-dimensional position and orientation of said input object.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,952,570 B2
APPLICATION NO. : 11/006486
DATED : May 31, 2011
INVENTOR(S) : Lipman et al.

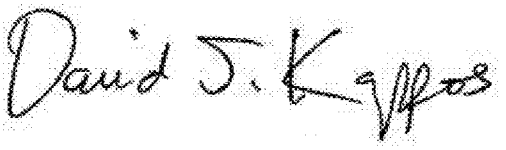
It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Claims:

Column 8, line 39 (Claim 14, line 1) please insert the word --input-- after "electronic."

Column 8, line 43 (Claim 15, line 1) please insert the word --input-- after "electronic."

Signed and Sealed this
Sixteenth Day of August, 2011



David J. Kappos
Director of the United States Patent and Trademark Office

EXHIBIT B

US008547364B2

(12) **United States Patent**
Lipman et al.

(10) **Patent No.: US 8,547,364 B2**
(45) **Date of Patent: *Oct. 1, 2013**

(54) **INPUT SYSTEM FOR CONTROLLING ELECTRONIC DEVICE**

(75) Inventors: **Robert Michael Lipman**, Jerusalem (IL); **Sarah Michelle Lipman**, Jerusalem (IL)

(73) Assignee: **Power2B, Inc.**, Santa Monica, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/114,580**

(22) Filed: **May 24, 2011**

(65) **Prior Publication Data**

US 2011/0241832 A1 Oct. 6, 2011

Related U.S. Application Data

(63) Continuation of application No. 11/006,486, filed on Dec. 6, 2004, now Pat. No. 7,952,570, which is a continuation of application No. PCT/GB03/02533, filed on Jun. 9, 2003.

(30) **Foreign Application Priority Data**

Jun. 8, 2002 (GB) 0213215.7

(51) **Int. Cl.**
G09G 3/28 (2013.01)
G06F 3/033 (2013.01)

(52) **U.S. Cl.**
USPC **345/182**; 178/19.05

(58) **Field of Classification Search**
USPC 345/183, 182; 178/19.05
See application file for complete search history.

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Primary Examiner — Adam J Snyder
(74) *Attorney, Agent, or Firm* — Paul Y. Feng; The Eclipse Group LLP

(57) **ABSTRACT**

An electronic device comprises a display for displaying data stored on said electronic device; input means; sensing means for sensing the three-dimensional position of the input means relative to said device; and control means for controlling the data displayed on said display in dependence on the three-dimensional position of the input means relative to said device. The input means includes a source of electromagnetic radiation for directing an infrared conical beam onto the display. The sensing means can sense the elliptical eccentricity of the electromagnetic radiation incident on the display to determine the angle at which it strikes the display, and can sense the area of the electromagnetic radiation incident on the display to determine the distance of the input means from the display.

21 Claims, 2 Drawing Sheets

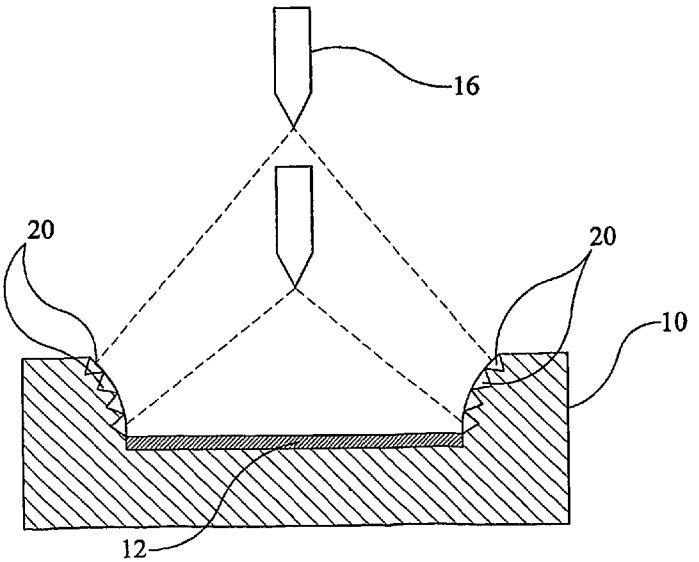

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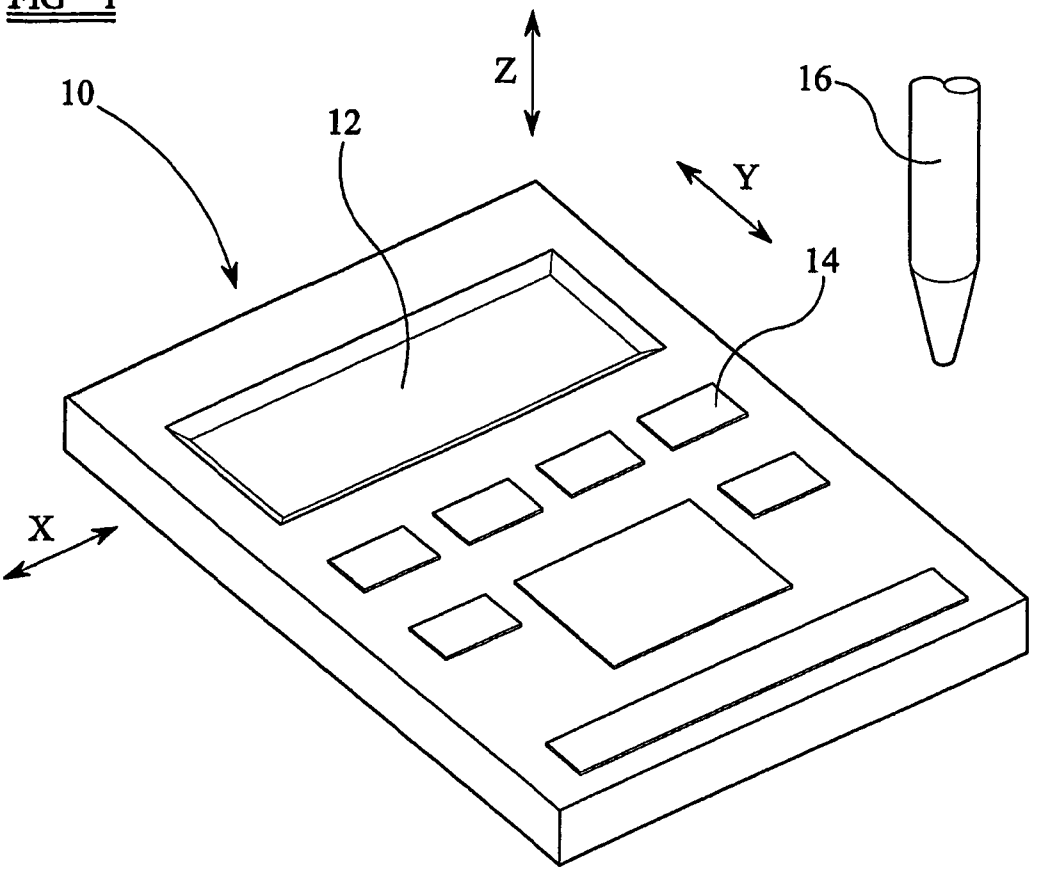
FIG 1



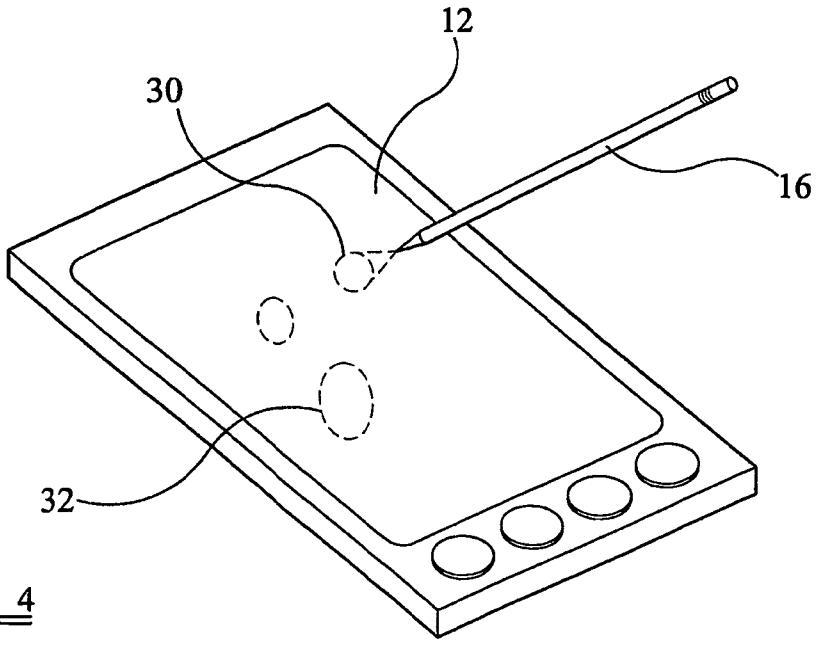


FIG 4

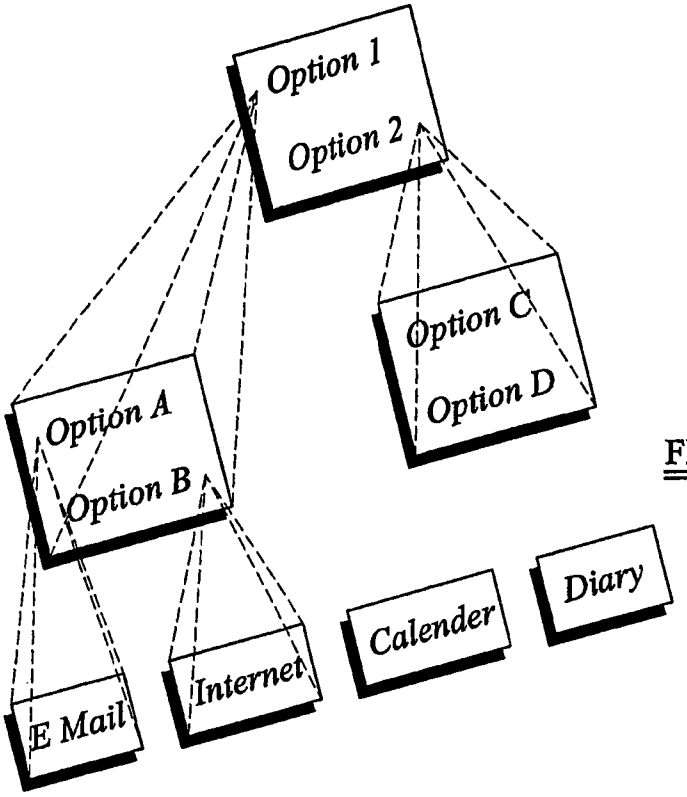

Option 1
Option 2
Option C
Option D
Option A
Option B
E Mail
Internet
Calender
Diary

FIG 2

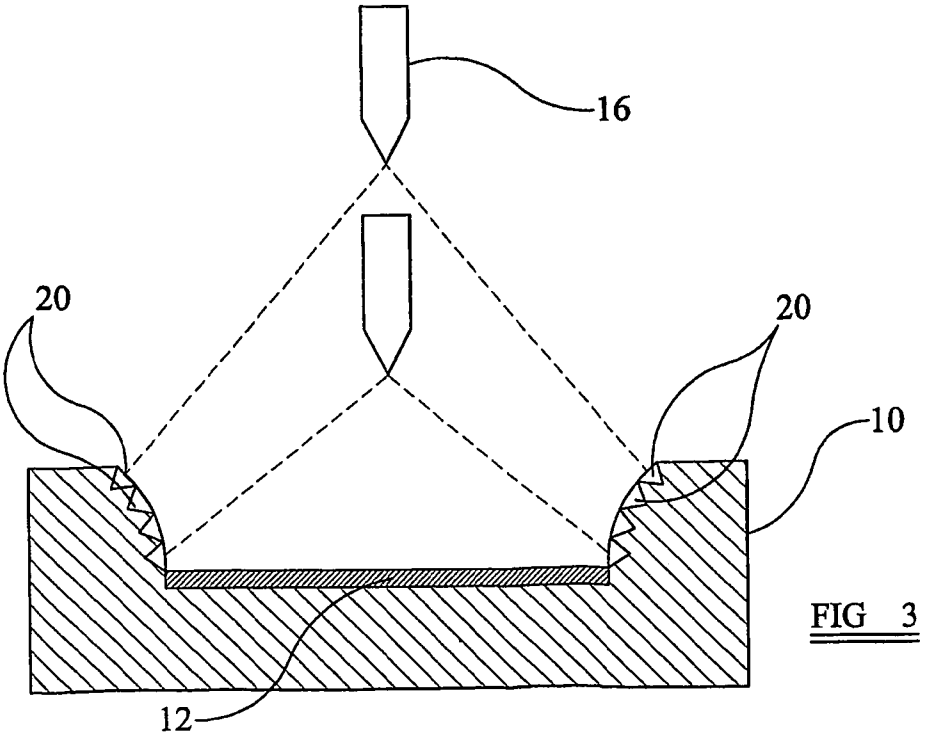

16
20
20
10
12

FIG 3

INPUT SYSTEM FOR CONTROLLING ELECTRONIC DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of parent application having application Ser. No. 11/006,486, filed Dec. 6, 2004, now U.S. Pat. No. 7,952,570, which is a continuation of International Application No. PCT/GB03/02533, filed Jun. 9, 2003, which claims priority to United Kingdom Application No. 0213215.7, filed Jun. 8, 2002, all of which are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

The present invention relates to computer navigation and particularly, but not exclusively, to an apparatus which facilitates navigation of software stored on the apparatus even where the display for the apparatus is small.

It is known to provide small, hand-held computer devices such as pocket organisers, Personal Digital Assistants (PDA's), cellular phones or the like. The current trend is to manufacture such devices to be as small in size as possible. Smaller devices are more easily carried and generally require a reduced power supply.

However, a significant disadvantage of such devices is that the reduced size forces a reduction in the size of the user interface, and particularly in the size of the screen or display used to display information or data stored on or processed by the device.

Many such devices have the processing power of conventional desktop or laptop computers or of similar devices many times their size and a number of products, such as the WACOM® and SONY® VAIO® pocket computers, are fully operable portable computers which use operating systems such as MICROSOFT® WINDOWS® or the like.

Those familiar with such pocket devices will appreciate the problem of displaying all of the necessary information on a relatively small display, particularly where the user is able to select specific functions from a large number of options. Conventionally, the selection of one option, for example, results in a new "window" opening which displays further options and sub options. Whilst devices having large displays are able to organise the data so that it is displayed in a more easily understood manner, devices having smaller screens tend to use data "layers" or "levels" whereby the selection of one option having a number of sub options causes the full screen to display the sub options fully eclipsing the original menu. The accidental selection of the wrong option requires a number of steps to return the display to the original list of options.

It would be advantageous to provide a pocket computer or hand held device which incorporates means for enabling easier access to data on the device and improves the user interface of the device.

BRIEF SUMMARY OF THE INVENTION

According to one aspect of the present invention, therefore, there is provided an electronic device having a display for displaying data stored thereon, input means and control means for controlling the data displayed on said display in dependence on the three-dimensional position of the input means with respect to said device.

Preferably, the device includes means for sensing or monitoring the position of the input means relative to the device.

In one embodiment, the input means includes a transmitter for transmitting a signal and the display includes sensing means for sensing the position at which the signal strikes the display. The signal may be in the form of a conical or circular infrared beam and the sensing means may be operable to sense the area and/or the intensity of the beam as it strikes the display thereby to determine the three-dimensional position of the input device relative to the display.

According to another aspect of the invention there is provided an input device for a computer or the like having a display for displaying data stored thereon, the input device comprising input means, and sensing means for sensing the three-dimensional position of the input means relative thereto and applying a position signal to said computer or the like in dependence on said three-dimensional position thereby to control the data displayed on said display.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

FIG. **1** shows illustratively a device according to the invention;

FIG. **2** shows illustratively the concept of data "levels";

FIG. **3** shows illustratively a cross-section through a device according to one embodiment of the invention; and

FIG. **4** shows illustratively one embodiment in which the stylus when moved closer to the display produces a circle or ellipse of smaller dimensions than the circle or ellipse formed when the stylus is moved away.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. **1**, an electronic device according to the invention is shown generally at **10**. The device **10** may be, for example, a hand-held or "palm-top" computer, a personal digital assistant (PDA) or a mobile communication device such as a mobile telephone. The device **10** is capable of storing and displaying data from a display or screen **12** which may be a liquid crystal display, a dot matrix display or a TFT (thin film transistor) display.

Conventionally, the user of the device **10** controls the data displayed on the display **12** by means of a number of buttons **14** located on the device or by an input device such as a scratch pad or tracker ball. Alternatively, many such devices incorporate touch-sensitive displays which permit the user to select options or to change the data on the display **12** by means of a pencil-shaped pointing device which is physically pressed against the display at the required position thereby to select the required option. Such touch sensitive displays are able only to determine the two-dimensional, X-Y position of the pointing device relative to the display **12** when the pointing device is pressed against the surface of the display.

A disadvantage of such devices is that in order to achieve the required reduction in size to enable the device to be used as a hand-held device or pocket computer, the display **12** is made correspondingly smaller in size. However, depending on the application for which the device is intended, the display **12** may be required to display similar amounts of data to that of a conventional desktop or lap-top computer having a display which may be an order of magnitude larger in size. The small size of the display **12** reduces the amount of data which can be displayed at any given time.

To minimise the effects of this, the device is programmed to display data in a number of "levels" whereby the display **12**

initially displays, for example, four options which are selectable by the user. Selecting one of these options, by means of the pointing device for example, may cause the display **12** to display a second "level" of options, for example in the form of a drop down list or menu commonly used in conventional computers. Each option displayed in the list may produce a further drop down list.

It will be appreciated that the number of levels used by the device is generally proportional to the number of options available to the user and inversely proportional to the size of the display. It is therefore quite common to find that a user may be required to select several options in order to activate a particular function of the device. This is time consuming and can be irritating to the user. Moreover, the generating of a drop down list or the like may obscure completely the original list so that an erroneous selection may require the user to manually exit from the current list in order to return to the original set of options. This may significantly increase the number of operations required to be made by the user.

According to the preferred form of the invention, the device **10** has a display **12** for displaying data stored on the device **10** which can be controlled by input means in the form of an input device **16**. In the preferred embodiment, the input device **16** takes the form of a pen-shaped instrument, hereafter termed a "stylus" which allows the user to select various options displayed on the display **12**. The concept of the invention is that the electronic device **10** is able to detect or monitor the three-dimensional position of the stylus **16** relative to the device **10**, and in particular relative to the display. This permits, effectively "three-dimensional control" of the display **12** which can be used, for example, to achieve the following control functions.

Movement of the stylus **16** in the X or Y directions relative to the display **12** causes the cursor on the display **12** (for example the mouse pointer or equivalent) to move accordingly, in the manner of a conventional mouse. Importantly, however, movement of the stylus **16** in the Z direction, i.e. in a direction generally perpendicular to the display **12**, performs a "zoom" function which, depending on the direction of movement of the stylus **16**, either towards or away from the display, causes the display **12** either to zoom in or to zoom out.

In one embodiment, for example, movement of the stylus **16** in a direction towards the display **12** causes the data in the region of the display **12** corresponding to the X-Y position of the stylus **16** to be magnified in a manner similar to that achieved by the "zoom in" function of conventional computers and computer programs. Thus, the data in the region of the display **12** corresponding to the X-Y position of the stylus **16** is enlarged as the stylus **16** is moved closer to the display **12**. This zooming in of the display **12** permits data relating to sub options to be displayed in place of the original option. However, whereas conventional software offers an "incremental zoom" with each discrete selection, the device described with reference to the drawings provides continuous zoom through constantly refreshed information based on the computed trajectory of the stylus. Continuous zoom makes possible an intuitive and responsive user interface.

When "zoom in" or "zoom out" reaches a pre-determined threshold, data relating to sub-options is displayed in addition to, or in place of (or first one then the other), the original option.

FIG. **2** illustrates the concept of "levels" of information to be displayed by the display **12**. Initially, the displays "level **1**" data which, as illustrated in FIG. **3**, may give the user two choices, OPTION **1** and OPTION **2**, which are selectable by the user. OPTION **1** represents specific "level **2**" data which may, for example, include a further two choices, OPTION A and OPTION B. OPTIONs A and B represent respective "level **3**" data which may, for example, represent different functions which the device **10** can perform, for example to send an e-mail or to access the internet.

Similarly, OPTION **2** in the level **1** data may correspond to OPTIONS C and D in the second level data, each of which represents different functions which may be performed by the device **10**, for example opening a calendar or opening a diary.

In conventional devices, to select the internet function from the above example, the user would be required to press the stylus **16** onto the screen at OPTION **1** and then again at OPTION B and finally on the internet option. Thus, three separate operations are required. An incorrect selection, for example selection of OPTION A instead of OPTION B requires the user to select an "exit" option (not shown) in order to return to the level **1** data.

The present invention, on the other hand, permits the user to select, for example, the internet, with a minimum of individual operations. For example, in one embodiment, the user moves the stylus **16** over the part of the display **12** containing OPTION **1** and then moves the stylus **16** towards the display. The device **10** interprets the movement of the stylus **16** towards the screen as a "zoom in" operation which zooms the display **12** through the level **1** data towards the level **2** data until OPTION A and OPTION B are displayed on the screen. The user then alters the position of the stylus **16** in the X-Y plane until the stylus **16** is positioned over the OPTION B icon and again moves the stylus **16** towards the display. This movement "zooms in" through the level **2** data towards the level **3** data until the internet icon appears on the screen. This can then be selected by the user in the conventional manner, for example, by pressing the stylus **16** onto the screen at the required location.

It will be understood that the present invention relies on the ability of the device **10** to monitor, track or otherwise detect the X-Y-Z, three-dimensional position of the stylus **16** relative to the display **12** whilst the stylus **16** is not in contact with the display **12** itself, unlike conventional touch-sensitive displays. This may be achieved in a number of ways.

In one embodiment, the stylus **16** is a so-called "smart stylus" which contains a source of electromagnetic radiation, for example an infrared emitter, an LED or other such light emitting device (not shown). The stylus **16** emits a beam of light, for example infrared or other spectrum light, from a circular, spherical, or other shaped tip. The light is sensed by a sensitive layer (not shown) positioned over, or incorporate in, the display **12**. The light sensitive layer may, for example, be in the form of a CCD or CMOS infrared sensitive array or the like. As the stylus **16** is moved across the display **12**, only certain parts of the sensitive layer will be illuminated by the beam of light emitted by the stylus **16** and this will be detected by the sensitive layer. The sensitive layer determines the appropriate X-Y coordinates of the stylus **16** and sends a corresponding position signal to the central processing unit or similar of the device **10** which adjusts the display **12** accordingly. FIG. **4** is an example of this embodiment. The stylus **16** when moved closer to the display produces a circle or ellipse **30** of smaller dimensions than the circle or ellipse **32** formed when the stylus is moved away. The same eccentricity of the ellipse means that the input stylus is at the same angle to the display and the size of the area indicates the distance of the stylus from the display.

In an alternative embodiment, the stylus **16** operates in the manner of a conventional light pen and contains a light sensor or photodiode therein which senses the light given off by the display. The display **12** is scanned as in a conventional tele-

vision screen so that the image is continually refreshed across and down the display **12** in a so-called raster scan. This continual refreshing causes the pixels in the display **12** to alternatively brighten and then dim at a very high frequency such that the effect is invisible to the naked eye.

However, the photodiode is able to detect this bright/dim effect and when the light received by the photodiode steps from dim to light, the stylus **16** sends a signal to the display controller in the device **10**. Since the display controller creates the display signal, it knows the position of the current raster line and so it can determine which pixel on the display **12** is being refreshed when the stylus **16** sends the signal to the controller. The display controller then sets a latch which feeds two numbers, representative of the X and Y coordinates of the pixel, to the central processing unit or similar of the device **10** which is therefore able to determine where on the screen the stylus **16** is pointed.

The above examples describe only how the device **10** determines the X-Y coordinates of the stylus **16** relative to the display **12**. It will be understood that the device **10** must also determine the Z-coordinate, i.e. the distance of the stylus **16** from the display. Again this can be achieved in a number of ways.

In one embodiment, the stylus **16** emits a beam of electromagnetic radiation, for example infrared or other spectrum light which is transmitted in a conical beam which widens in diameter with distance from the tip of the stylus **16**.

The light incident on the display **12** and hence the sensitive layer is in the form of an ellipse, the eccentricity of which depends on the angle at which the light strikes the display **12** and hence the stylus **16** is being held. An eccentricity of 1, for example, is indicative of a circle of incident light and a vertically held stylus **16**.

The distribution of the light incident on the sensitive layer will vary with distance from the light source in the stylus **16**. When the stylus **16** is positioned at a distance from the sensitive layer of the display, the total area of the sensitive layer illuminated will be relatively large but the intensity of the incident light will be low. As the stylus **16** is moved closer to the display, the area the light incident upon the sensitive layer will decrease but the intensity will increase. At very short distances from the display, the area of the display **12** illuminated by the light from the stylus **16** will be small but the intensity will be high.

In order to measure the intensity of the incident light the continuous range of possible intensities may be divided into a number of thresholds of stimulation. Hence, the intensity of the light may be calculated according to which thresholds it falls between.

In operation, the sensitive layer detects the light incident on the display **12** and sends appropriate signals to the processing unit of the device **10**. The elliptical eccentricity of the light incident on the display **12** is then calculated and from this the angle at which the stylus **16** is determined. The total area of light incident on the display **12** may also be calculated and from this the distance of the stylus **16** from the display **12** may be determined. Alternatively or additionally, the intensity of the incident light may be measured and used either to independently determine the distance of the stylus **16** from the display **12** or to refine the result of the calculation based on the measured area.

The angle of the stylus **16**, in conjunction with the distance of the stylus **16** from the display **12** are then used to determine the vertical height of the stylus **16** above the display **12**. Hence the position of the stylus **16**, in the Z-dimension, is determined by the device **10**.

Repetitive calculation of the stylus position, several times a second, as the stylus **16** is moved allows a stylus trajectory to be recorded. The stylus trajectory may then be used to assist in anticipating the intentions of the user.

The location and angle of the stylus **16** may also be used to determine when the user makes a selection without physical contact between the stylus **16** and the display. A simple dipping motion, for example, could be used to represent the selection. Alternatively or additionally the area and/or intensity of the light may also be used to represent a contactless selection. Such a selection may be indicated, for example, by the area of incident light falling below a certain minimum threshold and/or the intensity rising above a certain maximum threshold.

In a different embodiment, illustrated in FIG. **3**, the device **10** is provided with a plurality of light sensors **20** positioned around the perimeter of the display **12**. The light sensors are segmented or layered in the Z-direction such that as the stylus **16** moves towards or away from the display **12**, different or segments or layers of the light sensors will be illuminated by the conical beam emitted by the stylus **16**. In particular, as the stylus **16** moves closer to the screen, fewer of the light sensors around the display **12** will be illuminated, as illustrated in FIG. **3**. The signals from the sensors are interpreted by the processing unit of the device **10**, which thus calculates the distance of the stylus **16** from the display **12**.

In yet a further embodiment, not shown, the display **12** is inset or sunk into the body of the device **10** to provide a surrounding wall. The wall is provided on two faces with a plurality of light emitting devices and on the other two faces by a corresponding number of light sensing devices. The light emitted by the light emitters are sensed by the opposing light sensors such that if the stylus **16** is moved towards the display **12**, it will interrupt the light transmitted between some of the light emitters and the corresponding light sensors which will indicate to the device **10** that the stylus **16** has moved closer to the display. If the light emitters and sensors are layered in the Z-direction, this can provide an indication of the distance of the stylus **16** from the display.

It will be clear to those skilled in the art that there are a number of possible ways of sensing the X-Y-Z, three-dimensional position of the stylus **16** relative to the display, the above examples representing particularly simple and advantageous techniques. The important feature of the invention is that the user is able to alter the data displayed by the device **10** by moving the stylus **16** or other input device in three dimensions relative to the device **10** or the display **12** of the device **10**.

It will be further understood that there are a number of modifications or improvements or variations on the above described invention which may provide particular advantages. Where the stylus **16** incorporates a light emitting device to produce a conical beam, the power of the device may be selected to produce a beam which is of a predetermined length and conical angle to restrict the amount of movement in the Z-direction required by the user to perform the zoom in or zoom out functions. The type of light emitter can be selected as desired to provide infrared or visible light or other forms of electromagnetic radiation may be used. The stylus **16** may alternatively include both a photodiode, to enable its use similar to a light pen, and a light emitter for establishing the Z-coordinate information. The stylus **16** may be connected to the device **10** by means of a cable for transmitting or receiving signals to and from the electronic device **10**. Alternatively, the stylus **16** may be remotely linked to the device **10** or no data link may be provided at all. The latter situation is possible where a light emitting device is employed in the stylus **16**.

The stylus could optionally be attached to the device with a simple tether (spiral plastic cord, etc.) simply to prevent its loss from a place where many people might use it often, such as a refrigerator, computer or a commercial site.

The device **10** may incorporate a touch-sensitive screen or a conventional screen by which a selection is achieved by means of a button or the like located on the stylus **16** which causes a signal to be sent to the electronic device **10**, similar to conventional light guns or the like. Where a sensitive layer is used, this may be formed of any suitable material, which may additionally or alternatively be heat-sensitive. The sensitive layer may be layered above or below the screen of the display **12** or integrated therewith. The sensitivity and qualities of the material chosen can be selected as desired.

While the above described embodiments talk of sensing the position of the stylus **16** relative to the display **12** of the device **10**, it will be appreciated that the three-dimensional position of the stylus **16** relative to any other part of the device **10** or relative to any fixed location could be used for the same purpose. In this regard, the invention may provide only a stylus **16** and a sensing "pad" or the like which is able to determine the three-dimensional position of the stylus **16** relative thereto. The pad could be connected for communication with the electronic device **10** by any suitable means which will be well understood. Such an embodiment may enable the stylus **16** and "pad" to be used with conventional desk top or laptop computers in place of the more conventional mouse, scratch pad or tracker ball.

It will be appreciated that the device **10** of the invention provides a number of advantages over existing systems. In particular, depth/height coordinates of the stylus **16** can be calculated from the device **10** and enable software on the device **10** to adapt the contents of the display **12** as the distance from the display **12** or device **10** changes. When the stylus **16** is brought closer to the display, the device **10** interprets this movement as an intention to select a coordinate within a specific range and zoom all of the information displayed within that coordinate to fill a larger part of the display. This enables the information display to intuitively come "closer" to meet the intention of the user. In addition, more space becomes available on the display **12** because fewer of the level **1** choices are shown and additional layers of choices, such as contextual menus, could be selectively added permitting more selections to be made with fewer "clicks" or selections of the stylus **16**. Where two or more levels of selection are required, movement of the stylus **16** may permit the device **10** to anticipate the selection required by the user to allow the selection to be made with only a single operation of the stylus **16**.

The invention claimed is:

1. An electronic input device, comprising:
- an input object projecting a conical beam of electromagnetic radiation;
- an input area having a periphery receiving the conical beam of electromagnetic radiation thereon;
- wherein the input object is spaced apart from and not in contact with the input area;
- a pattern produced on the input area by the input object;
- a sensor array positioned at the periphery of the input area operative to sense and provide an output indication of position and at least two of orientation, shape and size of the electromagnetic radiation pattern;
- wherein the electromagnetic radiation pattern includes an elliptical shape having an eccentricity that is a function of the orientation of the input object relative to the input area; and
- input circuitry receiving the output indication and providing an electronic input representing at least one of two-dimensional position, three-dimensional position, and orientation of the input object.

2. An electronic input device according to claim **1**, wherein the orientation of the input object represents an angular orientation of the input object relative to the input area.

3. An electronic input device according to claim **1**, wherein the device further comprises a display providing a visually sensible output which is responsive to the electronic input.

4. An electronic input device according to claim **1**, wherein the input object includes a stylus having a cylindrical shape with an end that emits the electromagnetic radiation.

5. An electronic input device according to claim **1**, wherein the electromagnetic radiation includes radiation selected from the group consisting of infra red light, ultraviolet light, visible light, and collimated light.

6. An electronic input device according to claim **1**, wherein the sensor array senses and provides at least one output indication of intensity of the electromagnetic radiation in the electromagnetic radiation pattern.

7. An electronic input device according to claim **6**, wherein the input circuitry provides an electronic input that is at least partially based on the sensed intensity of the electromagnetic radiation in the electromagnetic radiation pattern.

8. An electronic input device according to claim **1**, wherein the device further comprises interface circuitry operative in response to the output indication for providing continuously variable user inputs based on at least one of the two-dimensional position, three-dimensional position, and the orientation of the input object.

9. An electronic input device according to claim **1**, wherein the sensor array is operative to provide an output indication of each of position, orientation, shape and size of the electromagnetic radiation pattern on the input area produced by the input object.

10. An electronic input device, comprising:
- a physical input area;
- an input object projecting an electromagnetic radiation pattern on the input area;
- a sensor array at least partially circumscribing and immediately proximate the input area, wherein the sensor array senses the electromagnetic radiation pattern thereon and provides an output indication of position, and at least two of orientation, shape and size of the electromagnetic radiation pattern on the input area;
- wherein the electromagnetic radiation pattern includes an elliptical shape having an eccentricity that is a function of the orientation of the input object relative to the input area; and
- input circuitry receiving the output indication and providing an electronic input representing at least one of two-dimensional position, three-dimensional position, and orientation of the input object.

11. An electronic input device according to claim **10**, wherein the projected electromagnetic radiation produces a conical beam that intersects the input area in an elliptical pattern having an elliptical eccentricity which is a function of the orientation of the input object in a plane perpendicular to the input area.

12. An electronic input device according to claim **10**, wherein the input circuitry is operative to calculate the orientation of the input object from the elliptical eccentricity based on the output indication from the sensor array.

13. An electronic input device according to claim **10**, wherein the sensor array is also operative to sense and provide

an output indication of intensity of the electromagnetic radiation in the electromagnetic radiation pattern.

14. An electronic input device according to claim **10**, wherein the electromagnetic radiation produces a conical beam that impinges on the input area, producing the electromagnetic radiation pattern on the input area in the form of an ellipse having an eccentricity which is a function of the orientation of the input object in a plane other than a plane parallel to the input area.

15. An electronic input device according to claim **14**, wherein the conical beam widens in diameter as the distance from the input object to the input area increases.

16. An electronic input device according to claim **10**, wherein the electromagnetic radiation pattern includes an asymmetrical shape.

17. A method for making an electronic input device, comprising:

providing an input object and a physical input area;

providing a sensor array positioned partially circumscribing and immediately proximate the input area;

projecting an electromagnetic radiation pattern from the input object on to the input area;

sensing a portion of the electromagnetic radiation pattern by the sensor array;

providing an output indication of position, and at least two of orientation, shape and size of the electromagnetic radiation pattern on the input area, based on the electromagnetic radiation pattern, which pattern includes an elliptical shape having an eccentricity that is a function of the orientation of the input object relative to the input area; and

providing input circuitry that receives the output indication, which input circuitry provides an electronic input representing at least one of two-dimensional position, three-dimensional position, and orientation of the input object.

18. A method for making an electronic input device according to claim **17**, the method further comprising moving the input object closer to and farther away from the input area, detecting the changes in three-dimensional positions of the input object relative to the input area, and generating zoom in and zoom out operations.

19. A method for making an electronic input device according to claim **17**, the method further comprising moving the input object closer to and farther away from the input area, detecting the changes in intensity of the electromagnetic pattern on the input area, and generating zoom in and zoom out operations.

20. A method for making an electronic input device according to claim **17**, the method further comprising detecting thresholds of intensity of the electromagnetic radiation pattern on the input area, and generating control signals by the input circuitry.

21. A method for making an electronic input device according to claim **17**, wherein the sensor array is positioned at least partially circumscribing the input area and at least partially coextensive with the input area.

* * * * *

EXHIBIT C

US008816994B2

(12) **United States Patent**
Lipman et al.

(10) **Patent No.: US 8,816,994 B2**
(45) **Date of Patent: *Aug. 26, 2014**

(54) **INPUT SYSTEM FOR CONTROLLING ELECTRONIC DEVICE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **14/042,409**

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Related U.S. Application Data

(63) Continuation of application No. 13/114,580, filed on May 24, 2011, now Pat. No. 8,547,364, which is a continuation of application No. 11/006,486, filed on Dec. 6, 2004, now Pat. No. 7,952,570, which is a continuation of application No. PCT/GB03/02533, filed on Jun. 9, 2003.

(30) **Foreign Application Priority Data**

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G06F 3/03	(2006.01)
G06F 3/0482	(2013.01)
G06F 3/0354	(2013.01)
G06F 3/038	(2013.01)
G06F 1/16	(2006.01)
G06F 3/033	(2013.01)

(52) **U.S. Cl.**

CPC ***G06F 3/0317*** (2013.01); ***G06F 3/0304*** (2013.01); ***G06F 3/0482*** (2013.01); ***G06F 3/03545*** (2013.01); ***G06F 3/0386*** (2013.01); ***G06F 1/1626*** (2013.01); *G06F 2203/04806* (2013.01)

USPC **345/183**; 178/19.05

(58) **Field of Classification Search**

USPC 345/183; 178/19.05

See application file for complete search history.

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(57) **ABSTRACT**

An electronic device includes a display for displaying data stored on said electronic device; input means; sensing means for sensing the three-dimensional position of the input means relative to said device; and control means for controlling the data displayed on said display in dependence on the three-dimensional position of the input means relative to said device. The input means includes a source of electromagnetic radiation for directing an infrared conical beam onto the display. The sensing means can sense the elliptical eccentricity of the electromagnetic radiation incident on the display to determine the angle at which it strikes the display, and can sense the area of the electromagnetic radiation incident on the display to determine the distance of the input means from the display.

10 Claims, 2 Drawing Sheets

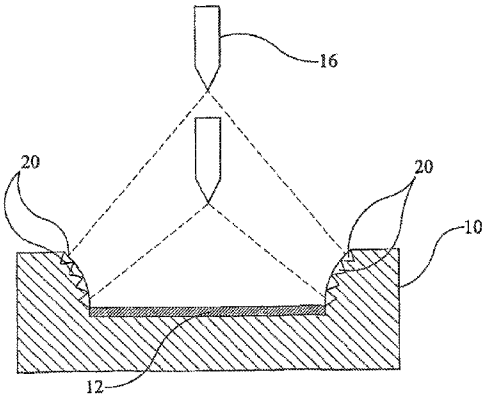

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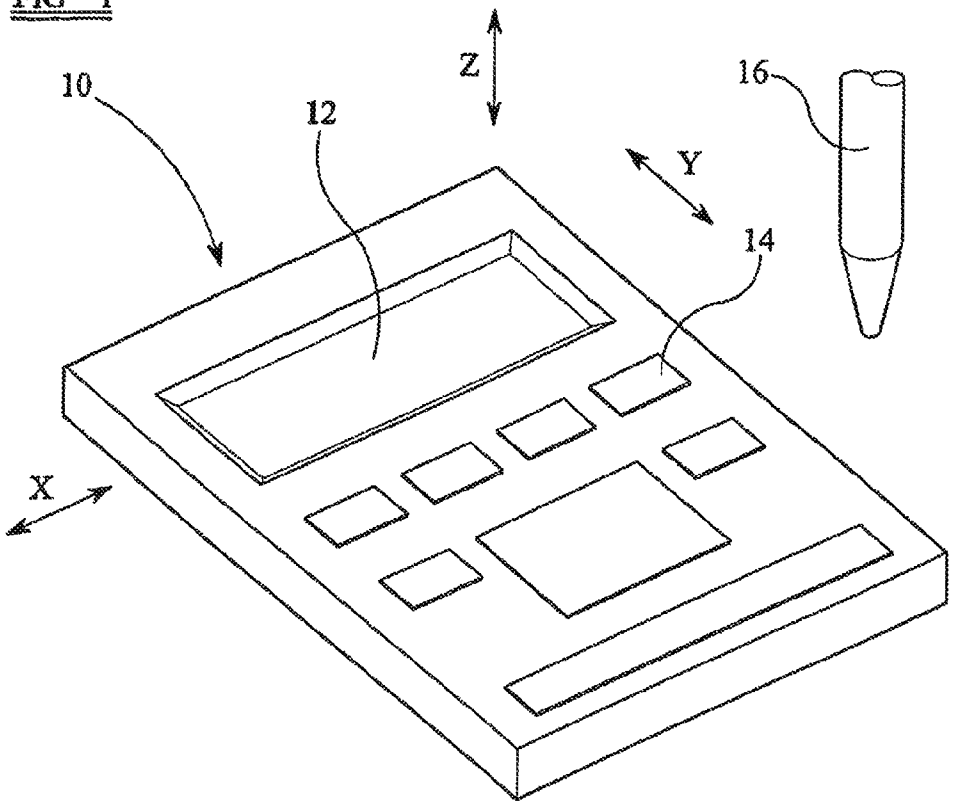
FIG 1



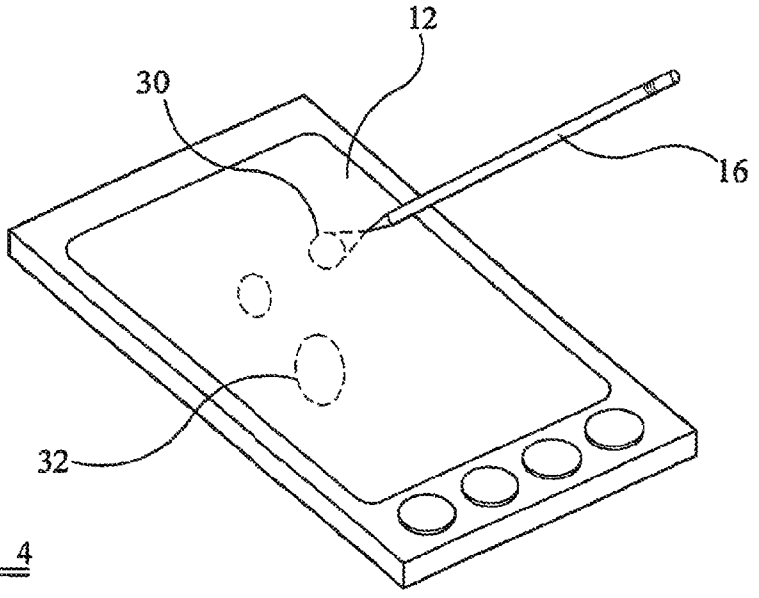


FIG 4

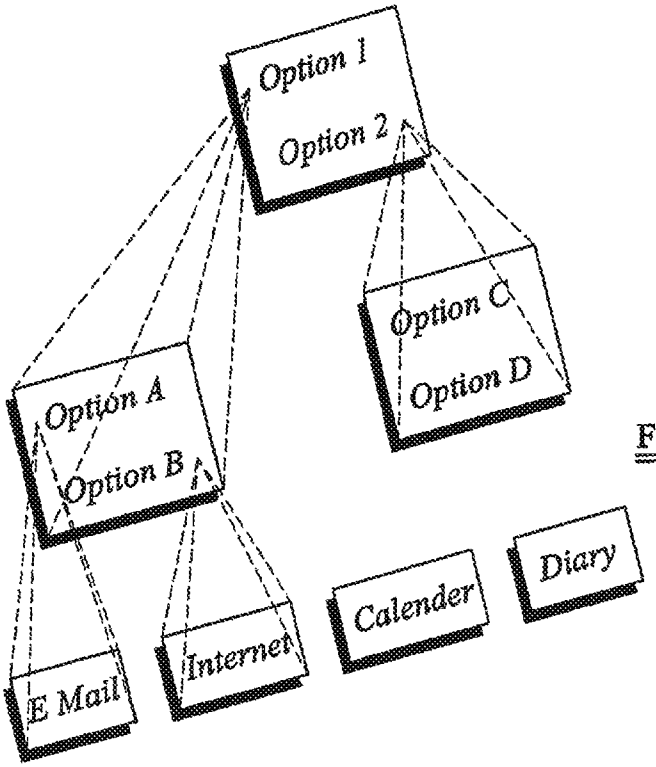

Option 1
Option 2
Option C
Option D
Option A
Option B
E Mail
Internet
Calender
Diary

FIG 2

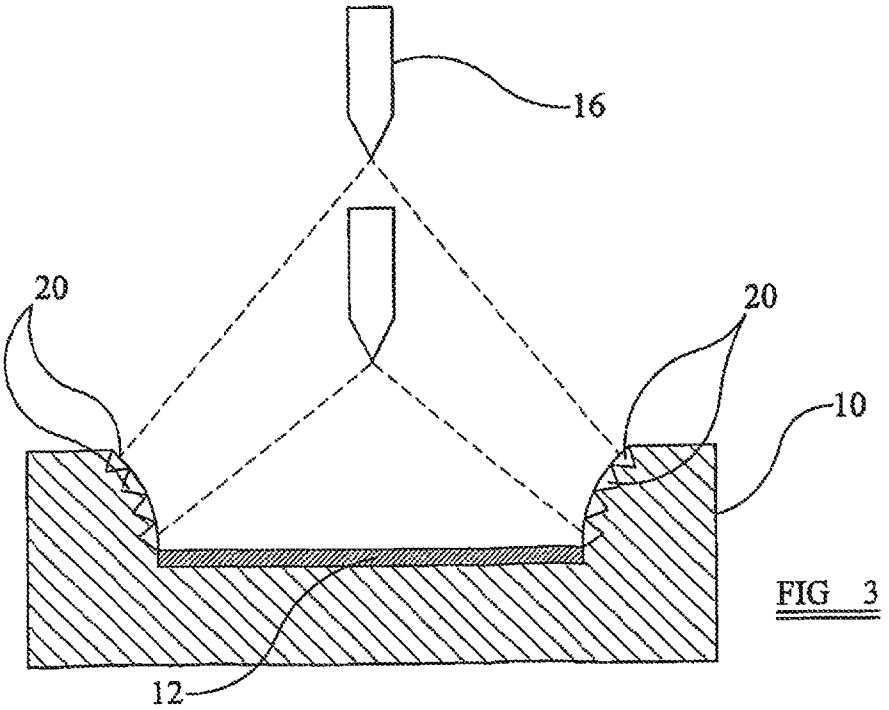

16
20
20
10
12

FIG 3

INPUT SYSTEM FOR CONTROLLING ELECTRONIC DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of application Ser. No. 13/114,580, filed May 24, 2011, now U.S. Pat. No. 8,547,364, which is a continuation of application Ser. No. 11/006,486, filed Dec. 6, 2004, now U.S. Pat. No. 7,952,570, which is a continuation of International Application No. PCT/GB03/02533, filed Jun. 9, 2003, which claims priority to United Kingdom Application No. 0213215.7, filed Jun. 8, 2002, all of which are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

The present invention relates to computer navigation and particularly, but not exclusively, to an apparatus which facilitates navigation of software stored on the apparatus even where the display for the apparatus is small.

It is known to provide small, hand-held computer devices such as pocket organizers, Personal Digital Assistants (PDA's), cellular phones or the like. The current trend is to manufacture such devices to be as small in size as possible. Smaller devices are more easily carried and generally require a reduced power supply.

However, a significant disadvantage of such devices is that the reduced size forces a reduction in the size of the user interface, and particularly in the size of the screen or display used to display information or data stored on or processed by the device.

Many such devices have the processing power of conventional desktop or laptop computers or of similar devices many times their size and a number of products, such as the WACOM® and SONY® VAIO® pocket computers, are fully operable portable computers which use operating systems such as MICROSOFT® WINDOWS® or the like.

Those familiar with such pocket devices will appreciate the problem of displaying all of the necessary information on a relatively small display, particularly where the user is able to select specific functions from a large number of options. Conventionally, the selection of one option, for example, results in a new "window" opening which displays further options and sub options. Whilst devices having large displays are able to organize the data so that it is displayed in a more easily understood manner, devices having smaller screens tend to use data "layers" or "levels" whereby the selection of one option having a number of sub options causes the full screen to display the sub options fully eclipsing the original menu. The accidental selection of the wrong option requires a number of steps to return the display to the original list of options.

It would be advantageous to provide a pocket computer or hand held device which incorporates means for enabling easier access to data on the device and improves the user interface of the device.

BRIEF SUMMARY OF THE INVENTION

According to one aspect of the present invention, therefore, there is provided an electronic device having a display for displaying data stored thereon, input means and control means for controlling the data displayed on said display in dependence on the three-dimensional position of the input means with respect to said device.

Preferably, the device includes means for sensing or monitoring the position of the input means relative to the device.

In one embodiment, the input means includes a transmitter for transmitting a signal and the display includes sensing means for sensing the position at which the signal strikes the display. The signal may be in the form of a conical or circular infrared beam and the sensing means may be operable to sense the area and/or the intensity of the beam as it strikes the display thereby to determine the three-dimensional position of the input device relative to the display.

According to another aspect of the invention there is provided an input device for a computer or the like having a display for displaying data stored thereon, the input device comprising input means, and sensing means for sensing the three-dimensional position of the input means relative thereto and applying a position signal to said computer or the like in dependence on said three-dimensional position thereby to control the data displayed on said display.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

FIG. **1** shows illustratively a device according to the invention;

FIG. **2** shows illustratively the concept of data "levels";

FIG. **3** shows illustratively a cross-section through a device according to one embodiment of the invention; and

FIG. **4** shows illustratively one embodiment in which the stylus when moved closer to the display produces a circle or ellipse of smaller dimensions than the circle or ellipse formed when the stylus is moved away.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. **1**, an electronic device according to the invention is shown generally at **10**. The device **10** may be, for example, a hand-held or "palm-top" computer, a personal digital assistant (PDA) or a mobile communication device such as a mobile telephone. The device **10** is capable of storing and displaying data from a display or screen **12** which may be a liquid crystal display, a dot matrix display or a TFT (thin film transistor) display.

Conventionally, the user of the device **10** controls the data displayed on the display **12** by means of a number of buttons **14** located on the device or by an input device such as a scratch pad or tracker ball. Alternatively, many such devices incorporate touch-sensitive displays which permit the user to select options or to change the data on the display **12** by means of a pencil-shaped pointing device which is physically pressed against the display at the required position thereby to select the required option. Such touch sensitive displays are able only to determine the two-dimensional, X-Y position of the pointing device relative to the display **12** when the pointing device is pressed against the surface of the display.

A disadvantage of such devices is that in order to achieve the required reduction in size to enable the device to be used as a hand-held device or pocket computer, the display **12** is made correspondingly smaller in size. However, depending on the application for which the device is intended, the display **12** may be required to display similar amounts of data to that of a conventional desktop or lap-top computer having a display which may be an order of magnitude larger in size. The small size of the display **12** reduces the amount of data which can be displayed at any given time.

To minimize the effects of this, the device is programmed to display data in a number of "levels" whereby the display **12** initially displays, for example, four options which are selectable by the user. Selecting one of these options, by means of the pointing device for example, may cause the display **12** to display a second "level" of options, for example in the form of a drop down list or menu commonly used in conventional computers. Each option displayed in the list may produce a further drop down list.

It will be appreciated that the number of levels used by the device is generally proportional to the number of options available to the user and inversely proportional to the size of the display. It is therefore quite common to find that a user may be required to select several options in order to activate a particular function of the device. This is time consuming and can be irritating to the user. Moreover, the generating of a drop down list or the like may obscure completely the original list so that an erroneous selection may require the user to manually exit from the current list in order to return to the original set of options. This may significantly increase the number of operations required to be made by the user.

According to the preferred form of the invention, the device **10** has a display **12** for displaying data stored on the device **10** which can be controlled by input means in the form of an input device **16**. In the preferred embodiment, the input device **16** takes the form of a pen-shaped instrument, hereafter termed a "stylus" which allows the user to select various options displayed on the display **12**. The concept of the invention is that the electronic device **10** is able to detect or monitor the three-dimensional position of the stylus **16** relative to the device **10**, and in particular relative to the display. This permits, effectively "three-dimensional control" of the display **12** which can be used, for example, to achieve the following control functions.

Movement of the stylus **16** in the X or Y directions relative to the display **12** causes the cursor on the display **12** (for example the mouse pointer or equivalent) to move accordingly, in the manner of a conventional mouse. Importantly, however, movement of the stylus **16** in the Z direction, i.e. in a direction generally perpendicular to the display **12**, performs a "zoom" function which, depending on the direction of movement of the stylus **16**, either towards or away from the display, causes the display **12** either to zoom in or to zoom out.

In one embodiment, for example, movement of the stylus **16** in a direction towards the display **12** causes the data in the region of the display **12** corresponding to the X-Y position of the stylus **16** to be magnified in a manner similar to that achieved by the "zoom in" function of conventional computers and computer programs. Thus, the data in the region of the display **12** corresponding to the X-Y position of the stylus **16** is enlarged as the stylus **16** is moved closer to the display **12**. This zooming in of the display **12** permits data relating to sub options to be displayed in place of the original option. However, whereas conventional software offers an "incremental zoom" with each discrete selection, the device described with reference to the drawings provides continuous zoom through constantly refreshed information based on the computed trajectory of the stylus. Continuous zoom makes possible an intuitive and responsive user interface.

When "zoom in" or "zoom out" reaches a pre-determined threshold, data relating to sub-options is displayed in addition to, or in place of (or first one then the other), the original option.

FIG. **2** illustrates the concept of "levels" of information to be displayed by the display **12**. Initially, the displays "level **1**" data which, as illustrated in FIG. **3**, may give the user two

choices, OPTION **1** and OPTION **2**, which are selectable by the user. OPTION **1** represents specific "level **2**" data which may, for example, include a further two choices, OPTION A and OPTION B. OPTIONs A and B represent respective "level 3" data which may, for example, represent different functions which the device **10** can perform, for example to send an e-mail or to access the internet.

Similarly, OPTION **2** in the level **1** data may correspond to OPTIONS C and D in the second level data, each of which represents different functions which may be performed by the device **10**, for example opening a calendar or opening a diary.

In conventional devices, to select the internet function from the above example, the user would be required to press the stylus **16** onto the screen at OPTION **1** and then again at OPTION B and finally on the internet option. Thus, three separate operations are required. An incorrect selection, for example selection of OPTION A instead of OPTION B requires the user to select an "exit" option (not shown) in order to return to the level **1** data.

The present invention, on the other hand, permits the user to select, for example, the internet, with a minimum of individual operations. For example, in one embodiment, the user moves the stylus **16** over the part of the display **12** containing OPTION **1** and then moves the stylus **16** towards the display. The device **10** interprets the movement of the stylus **16** towards the screen as a "zoom in" operation which zooms the display **12** through the level **1** data towards the level **2** data until OPTION A and OPTION B are displayed on the screen. The user then alters the position of the stylus **16** in the X-Y plane until the stylus **16** is positioned over the OPTION B icon and again moves the stylus **16** towards the display. This movement "zooms in" through the level **2** data towards the level **3** data until the internet icon appears on the screen. This can then be selected by the user in the conventional manner, for example, by pressing the stylus **16** onto the screen at the required location.

It will be understood that the present invention relies on the ability of the device **10** to monitor, track or otherwise detect the X-Y-Z, three-dimensional position of the stylus **16** relative to the display **12** whilst the stylus **16** is not in contact with the display **12** itself, unlike conventional touch-sensitive displays. This may be achieved in a number of ways.

In one embodiment, the stylus **16** is a so-called "smart stylus" which contains a source of electromagnetic radiation, for example an infrared emitter, an LED or other such light emitting device (not shown). The stylus **16** emits a beam of light, for example infrared or other spectrum light, from a circular, spherical, or other shaped tip. The light is sensed by a sensitive layer (not shown) positioned over, or incorporate in, the display **12**. The light sensitive layer may, for example, be in the form of a CCD or CMOS infrared sensitive array or the like. As the stylus **16** is moved across the display **12**, only certain parts of the sensitive layer will be illuminated by the beam of light emitted by the stylus **16** and this will be detected by the sensitive layer. The sensitive layer determines the appropriate X-Y coordinates of the stylus **16** and sends a corresponding position signal to the central processing unit or similar of the device **10** which adjusts the display **12** accordingly. FIG. **4** is an example of this embodiment. The stylus **16** when moved closer to the display produces a circle or ellipse **30** of smaller dimensions than the circle or ellipse **32** formed when the stylus is moved away. The same eccentricity of the ellipse means that the input stylus is at the same angle to the display and the size of the area indicates the distance of the stylus from the display.

In an alternative embodiment, the stylus **16** operates in the manner of a conventional light pen and contains a light sensor

or photodiode therein which senses the light given off by the display. The display **12** is scanned as in a conventional television screen so that the image is continually refreshed across and down the display **12** in a so-called raster scan. This continual refreshing causes the pixels in the display **12** to alternatively brighten and then dim at a very high frequency such that the effect is invisible to the naked eye.

However, the photodiode is able to detect this bright/dim effect and when the light received by the photodiode steps from dim to light, the stylus **16** sends a signal to the display controller in the device **10**. Since the display controller creates the display signal, it knows the position of the current raster line and so it can determine which pixel on the display **12** is being refreshed when the stylus **16** sends the signal to the controller. The display controller then sets a latch which feeds two numbers, representative of the X and Y coordinates of the pixel, to the central processing unit or similar of the device **10** which is therefore able to determine where on the screen the stylus **16** is pointed.

The above examples describe only how the device **10** determines the X-Y coordinates of the stylus **16** relative to the display **12**. It will be understood that the device **10** must also determine the Z-coordinate, i.e. the distance of the stylus **16** from the display. Again this can be achieved in a number of ways.

In one embodiment, the stylus **16** emits a beam of electromagnetic radiation, for example infrared or other spectrum light which is transmitted in a conical beam which widens in diameter with distance from the tip of the stylus **16**.

The light incident on the display **12** and hence the sensitive layer is in the form of an ellipse, the eccentricity of which depends on the angle at which the light strikes the display **12** and hence the stylus **16** is being held. An eccentricity of 1, for example, is indicative of a circle of incident light and a vertically held stylus **16**.

The distribution of the light incident on the sensitive layer will vary with distance from the light source in the stylus **16**. When the stylus **16** is positioned at a distance from the sensitive layer of the display, the total area of the sensitive layer illuminated will be relatively large but the intensity of the incident light will be low. As the stylus **16** is moved closer to the display, the area the light incident upon the sensitive layer will decrease but the intensity will increase. At very short distances from the display, the area of the display **12** illuminated by the light from the stylus **16** will be small but the intensity will be high.

In order to measure the intensity of the incident light the continuous range of possible intensities may be divided into a number of thresholds of stimulation. Hence, the intensity of the light may be calculated according to which thresholds it falls between.

In operation, the sensitive layer detects the light incident on the display **12** and sends appropriate signals to the processing unit of the device **10**. The elliptical eccentricity of the light incident on the display **12** is then calculated and from this the angle at which the stylus **16** is determined. The total area of light incident on the display **12** may also be calculated and from this the distance of the stylus **16** from the display **12** may be determined. Alternatively or additionally, the intensity of the incident light may be measured and used either to independently determine the distance of the stylus **16** from the display **12** or to refine the result of the calculation based on the measured area.

The angle of the stylus **16**, in conjunction with the distance of the stylus **16** from the display **12** are then used to determine the vertical height of the stylus **16** above the display **12**. Hence the position of the stylus **16**, in the Z-dimension, is determined by the device **10**.

Repetitive calculation of the stylus position, several times a second, as the stylus **16** is moved allows a stylus trajectory to be recorded. The stylus trajectory may then be used to assist in anticipating the intentions of the user.

The location and angle of the stylus **16** may also be used to determine when the user makes a selection without physical contact between the stylus **16** and the display. A simple dipping motion, for example, could be used to represent the selection. Alternatively or additionally the area and/or intensity of the light may also be used to represent a contactless selection. Such a selection may be indicated, for example, by the area of incident light falling below a certain minimum threshold and/or the intensity rising above a certain maximum threshold.

In a different embodiment, illustrated in FIG. **3**, the device **10** is provided with a plurality of light sensors **20** positioned around the perimeter of the display **12**. The light sensors are segmented or layered in the Z-direction such that as the stylus **16** moves towards or away from the display **12**, different or segments or layers of the light sensors will be illuminated by the conical beam emitted by the stylus **16**. In particular, as the stylus **16** moves closer to the screen, fewer of the light sensors around the display **12** will be illuminated, as illustrated in FIG. **3**. The signals from the sensors are interpreted by the processing unit of the device **10**, which thus calculates the distance of the stylus **16** from the display **12**.

In yet a further embodiment, not shown, the display **12** is inset or sunk into the body of the device **10** to provide a surrounding wall. The wall is provided on two faces with a plurality of light emitting devices and on the other two faces by a corresponding number of light sensing devices. The light emitted by the light emitters are sensed by the opposing light sensors such that if the stylus **16** is moved towards the display **12**, it will interrupt the light transmitted between some of the light emitters and the corresponding light sensors which will indicate to the device **10** that the stylus **16** has moved closer to the display. If the light emitters and sensors are layered in the Z-direction, this can provide an indication of the distance of the stylus **16** from the display.

It will be clear to those skilled in the art that there are a number of possible ways of sensing the X-Y-Z, three-dimensional position of the stylus **16** relative to the display, the above examples representing particularly simple and advantageous techniques. The important feature of the invention is that the user is able to alter the data displayed by the device **10** by moving the stylus **16** or other input device in three dimensions relative to the device **10** or the display **12** of the device **10**.

It will be further understood that there are a number of modifications or improvements or variations on the above described invention which may provide particular advantages. Where the stylus **16** incorporates a light emitting device to produce a conical beam, the power of the device may be selected to produce a beam which is of a predetermined length and conical angle to restrict the amount of movement in the Z-direction required by the user to perform the zoom in or zoom out functions. The type of light emitter can be selected as desired to provide infrared or visible light or other forms of electromagnetic radiation may be used. The stylus **16** may alternatively include both a photodiode, to enable its use similar to a light pen, and a light emitter for establishing the Z-coordinate information. The stylus **16** may be connected to the device **10** by means of a cable for transmitting or receiving signals to and from the electronic device **10**. Alternatively, the

stylus **16** may be remotely linked to the device **10** or no data link may be provided at all. The latter situation is possible where a light emitting device is employed in the stylus **16**.

The stylus could optionally be attached to the device with a simple tether (spiral plastic cord, etc.) simply to prevent its loss from a place where many people might use it often, such as a refrigerator, computer or a commercial site.

The device **10** may incorporate a touch-sensitive screen or a conventional screen by which a selection is achieved by means of a button or the like located on the stylus **16** which causes a signal to be sent to the electronic device **10**, similar to conventional light guns or the like. Where a sensitive layer is used, this may be formed of any suitable material, which may additionally or alternatively be heat-sensitive. The sensitive layer may be layered above or below the screen of the display **12** or integrated therewith. The sensitivity and qualities of the material chosen can be selected as desired.

While the above described embodiments talk of sensing the position of the stylus **16** relative to the display **12** of the device **10**, it will be appreciated that the three-dimensional position of the stylus **16** relative to any other part of the device **10** or relative to any fixed location could be used for the same purpose. In this regard, the invention may provide only a stylus **16** and a sensing "pad" or the like which is able to determine the three-dimensional position of the stylus **16** relative thereto. The pad could be connected for communication with the electronic device **10** by any suitable means which will be well understood. Such an embodiment may enable the stylus **16** and "pad" to be used with conventional desk top or laptop computers in place of the more conventional mouse, scratch pad or tracker ball.

It will be appreciated that the device **10** of the invention provides a number of advantages over existing systems. In particular, depth/height coordinates of the stylus **16** can be calculated from the device **10** and enable software on the device **10** to adapt the contents of the display **12** as the distance from the display **12** or device **10** changes. When the stylus **16** is brought closer to the display, the device **10** interprets this movement as an intention to select a coordinate within a specific range and zoom all of the information displayed within that coordinate to fill a larger part of the display. This enables the information display to intuitively come "closer" to meet the intention of the user. In addition, more space becomes available on the display **12** because fewer of the level **1** choices are shown and additional layers of choices, such as contextual menus, could be selectively added permitting more selections to be made with fewer "clicks" or selections of the stylus **16**. Where two or more levels of selection are required, movement of the stylus **16** may permit the device **10** to anticipate the selection required by the user to allow the selection to be made with only a single operation of the stylus **16**.

The invention claimed is:

1. An electronic input device, comprising:
- an input object;
- an input area;
- wherein the input object is operative to direct a geometric beam of electromagnetic radiation;
- an electromagnetic radiation pattern produced on the input area by the beam directed from the input object, wherein geometrical characteristics of the pattern are a function of the spatial relationship of the input object relative to the input area;
- sensing means positioned at least partially at a periphery of the input area, operative to sense and provide an output indication of at least two of position, orientation, shape, and size of the electromagnetic radiation pattern; and
- processing circuitry operative to receive the output indication and provide an electronic input representing at least one of two-dimensional position, three-dimensional position, and orientation of the input object relative to the input area.

2. An electronic input device according to claim **1**, wherein the device further comprises a display providing a visually sensible output which is responsive to the input object.

3. An electronic input device according to claim **1**, wherein the input object includes a stylus having a cylindrical shape with an end that emits the electromagnetic radiation.

4. An electronic input device according to claim **1**, wherein the electromagnetic radiation includes radiation selected from the group consisting of infra red light, ultraviolet light, visible light, and collimated light.

5. An electronic input device, comprising:
- an input object;
- an input area;
- wherein the input object is operative to direct a shaped geometric beam of electromagnetic radiation;
- an electromagnetic radiation pattern produced on the input area by the beam directed from the input object;
- sensing means positioned at a periphery of the input area operative to sense and provide an output indication of at least two of position, orientation, shape, and size of the electromagnetic radiation pattern; and
- processing circuitry operative to receive the output indication and provide an electronic input representing at least one of two-dimensional position, three-dimensional position, and orientation of the input object relative to the input area.

6. A method for making an electronic input device, comprising:
- providing an input object;
- providing a physical input area;
- providing a sensor array positioned at least partially circumscribing and immediately proximate the input area;
- projecting electromagnetic radiation from the input object on to the input area to create an electromagnetic radiation pattern on the input area;
- sensing a portion of the electromagnetic radiation by the sensor array;
- providing an output indication of position and at least two of orientation, shape, and size of the sensed portion of the electromagnetic radiation; and
- providing input circuitry that receives the output indication and provides an electronic input representing at least one of two-dimensional position, three-dimensional position, and orientation of the input object.

7. The method of claim **6**, wherein the electromagnetic radiation pattern is created on the input area and includes an elliptical shape having a geometry which is a function of the location of the input object relative to the input area.

8. An electronic input device, comprising:
- an input area;
- an input object projecting a beam of electromagnetic radiation on the input area;
- a sensor array positioned outside the input area operative to sense and provide an output indication of position and at least two of orientation, shape and size of said electromagnetic radiation on the input area produced by the input object;
- wherein the electromagnetic radiation pattern includes an elliptical shape having a size that is a function of the distance of the input object relative to the input area; and
- input circuitry receiving the output indication and providing an electronic input representing at least one of two-

dimensional position, three-dimensional position, and orientation of the input object.

9. An electronic input device, comprising:

an input object emitting electromagnetic radiation;

an input area;

a sensor array positioned outside the input area operative to sense and provide an output indication of position and at least two of orientation, shape, and size of an electromagnetic radiation pattern on the input area produced by the input object;

input circuitry receiving the output indication and providing an electronic input representing at least one of two-dimensional position, three-dimensional position and orientation of the input object;

wherein the electronic input representing orientation includes an electronic input representing angular orientation of the input object relative to the input area; and

the input object includes a source of the electromagnetic radiation, and wherein the sensing array senses the electromagnetic radiation pattern correlating to an elliptical pattern produced by a conical beam that intersects the input area in a pattern forming the ellipse having properties that are a function of at least one of position, distance and orientation of the input object.

10. An electronic input device, comprising:

an input object directing an electromagnetic beam;

an input area;

an electromagnetic radiation pattern produced on the input area by the beam directed from the input object;

sensing means positioned at least partially at a periphery of the input area, operative to sense and provide an output indication of the area and intensity of the beam as the beam strikes the input area, thereby to determine the three-dimensional position of the input object relative to the input area; and

processing circuitry operative to receive the output indication and provide an electronic input representing the three-dimensional position of the input object relative to the input area.

* * * * *

EXHIBIT D

US009946369B2

(12) **United States Patent**
Lipman et al.

(10) **Patent No.: US 9,946,369 B2**
(45) **Date of Patent: Apr. 17, 2018**

(54) **INPUT SYSTEM FOR CONTROLLING ELECTRONIC DEVICE**

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(73) Assignee: **POWER2B, Inc.**, Santa Monica, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 51 days.

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(30) **Foreign Application Priority Data**

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G06F 3/0354 (2013.01)
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(52) **U.S. Cl.**
CPC ***G06F 3/03545*** (2013.01); ***G06F 1/1626*** (2013.01); ***G06F 3/0304*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC G06F 3/03542; G06F 3/03545; G06F 1/1626; G06F 3/0304; G06F 3/0386; G06F 3/0482; G06F 3/0317; G06F 3/0383
(Continued)

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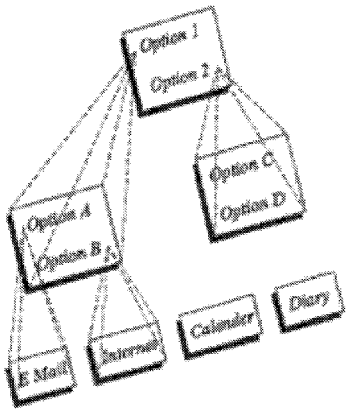
Primary Examiner — Adam J Snyder
(74) *Attorney, Agent, or Firm* — Adam P. Daniels, Esq.; Polsinelli LLP

(57) **ABSTRACT**

An electronic device includes a display for displaying data stored on the electronic device; input means; sensing means for sensing the three-dimensional position of the input means relative to the device; and control means for controlling the data displayed on the display in dependence on the three-dimensional position of the input means relative to the device. The input means includes a source of electromagnetic radiation for directing an infrared conical beam onto the display. The sensing means can sense the elliptical eccentricity of the electromagnetic radiation incident on the display to determine the angle at which it strikes the display, and can sense the area of the electromagnetic radiation
(Continued)



incident on the display to determine the distance of the input means from the display.

17 Claims, 3 Drawing Sheets

Related U.S. Application Data

continuation of application No. 14/042,409, filed on Sep. 30, 2013, now Pat. No. 8,816,994, which is a continuation of application No. 13/114,580, filed on May 24, 2011, now Pat. No. 8,547,364, which is a continuation of application No. 11/006,486, filed on Dec. 6, 2004, now Pat. No. 7,952,570, which is a continuation of application No. PCT/GB03/02533, filed on Jun. 9, 2003.

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G06F 3/03	(2006.01)
G06F 3/038	(2013.01)
G06F 3/0482	(2013.01)
G06F 3/033	(2013.01)

(52) **U.S. Cl.**

CPC ***G06F 3/0317*** (2013.01); ***G06F 3/0383*** (2013.01); ***G06F 3/0386*** (2013.01); ***G06F 3/0482*** (2013.01); *G06F 2203/04806* (2013.01)

(58) **Field of Classification Search**

USPC 345/182; 178/19.05

See application file for complete search history.

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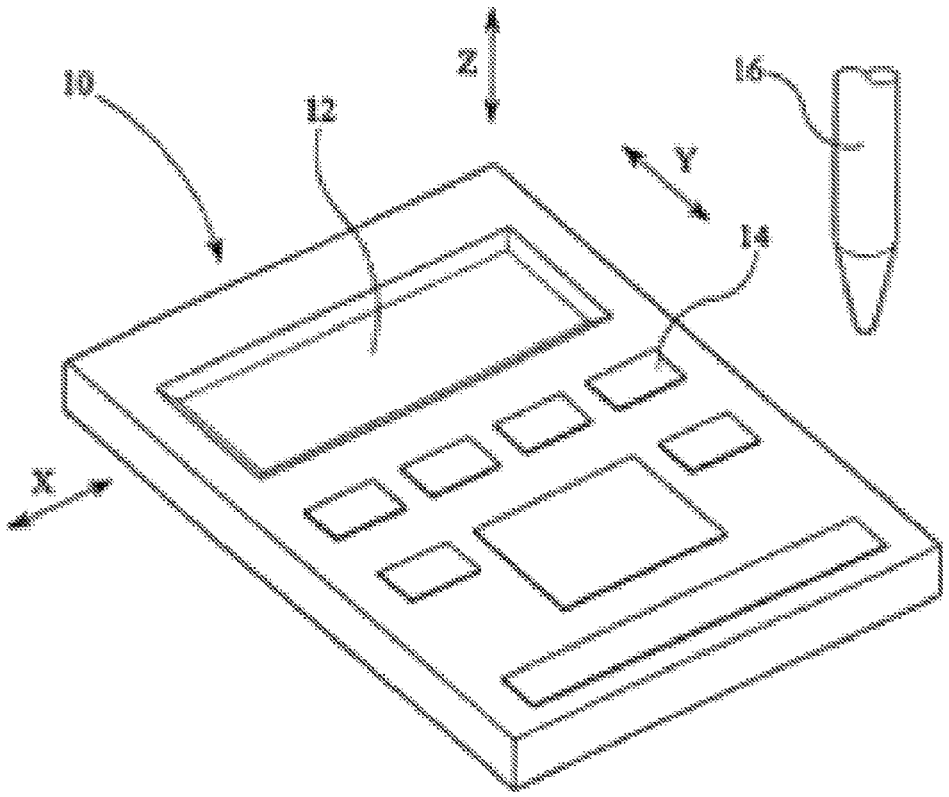

FIG. 1

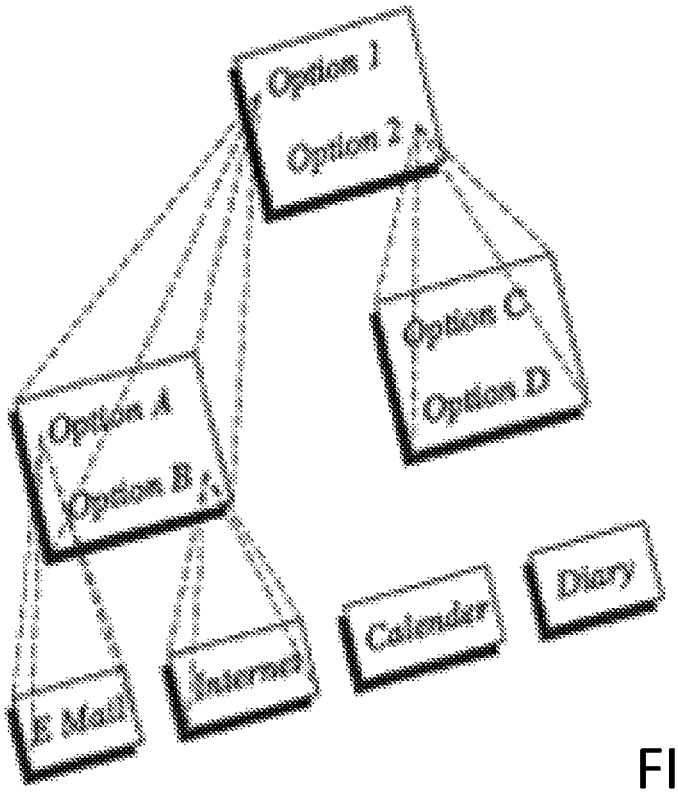
Option 1
Option 2
Option C
Option D
Option A
Option B
Calendar
Diary

FIG. 2

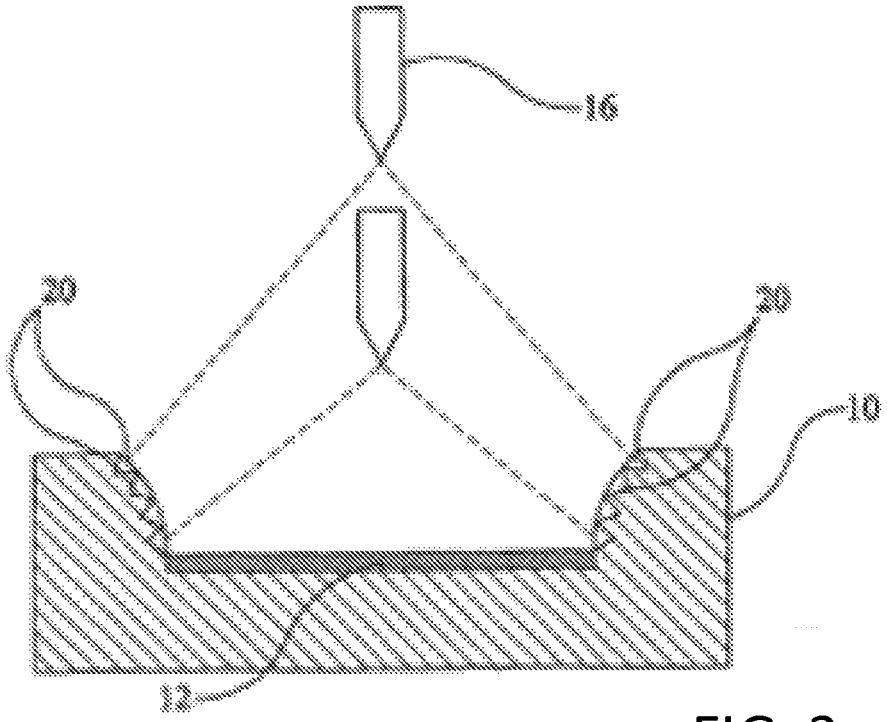
16
20
20
10
12

FIG. 3

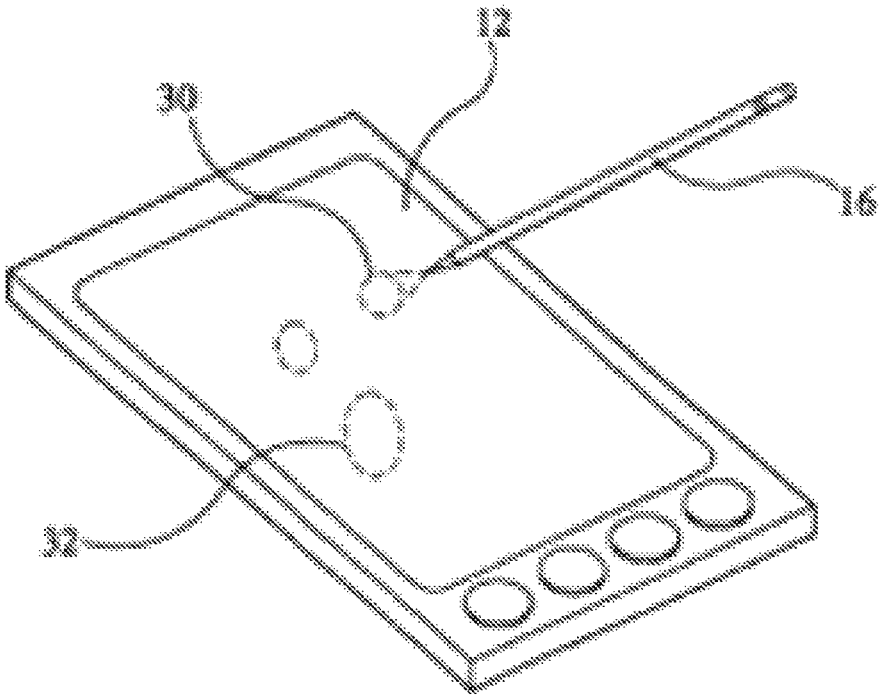

FIG. 4

INPUT SYSTEM FOR CONTROLLING ELECTRONIC DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 14/468,014, filed Aug. 25, 2014, now U.S. Pat. No. 9,454,178, which is a continuation of U.S. patent application Ser. No. 14/042,409, filed Sep. 30, 2013, now U.S. Pat. No. 8,816,994, which is a continuation of U.S. patent application Ser. No. 13/114,580, filed May 24, 2011, now U.S. Pat. No. 8,547,364, which is a continuation of U.S. patent application Ser. No. 11/006,486, filed Dec. 6, 2004, now U.S. Pat. No. 7,952,570, which is a continuation of International Application No. PCT/GB03/02533, filed Jun. 9, 2003, which claims priority to United Kingdom Patent Application No. 0213215.7, filed Jun. 8, 2002, the entirety of each is hereby incorporated by reference.

TECHNICAL FIELD

The present invention relates to computer navigation and particularly, but not exclusively, to an apparatus which facilitates navigation of software stored on the apparatus even where the display for the apparatus is small.

BACKGROUND

It is known to provide small, hand-held computer devices such as pocket organizers, Personal Digital Assistants (PDA's), cellular phones or the like. The current trend is to manufacture such devices to be as small in size as possible. Smaller devices are more easily carried and generally require a reduced power supply.

However, a significant disadvantage of such devices is that the reduced size forces a reduction in the size of the user interface, and particularly in the size of the screen or display used to display information or data stored on or processed by the device.

Many such devices have the processing power of conventional desktop or laptop computers or of similar devices many times their size and a number of products, such as the WACOM® and SONY® VAIO® pocket computers, are fully operable portable computers which use operating systems such as MICROSOFT® WINDOWS® or the like.

Those familiar with such pocket devices will appreciate the problem of displaying all of the necessary information on a relatively small display, particularly where the user is able to select specific functions from a large number of options. Conventionally, the selection of one option, for example, results in a new "window" opening which displays further options and sub options. Whilst devices having large displays are able to organize the data so that it is displayed in a more easily understood manner, devices having smaller screens tend to use data "layers" or "levels" whereby the selection of one option having a number of sub options causes the full screen to display the sub options fully eclipsing the original menu. The accidental selection of the wrong option requires a number of steps to return the display to the original list of options.

It would be advantageous to provide a pocket computer or hand held device which incorporates means for enabling easier access to data on the device and improves the user interface of the device.

SUMMARY

According to one aspect of the present invention, therefore, there is provided an electronic device having a display for displaying data stored thereon, input means and control means for controlling the data displayed on the display in dependence on the three-dimensional position of the input means with respect to the device.

Preferably, the device includes means for sensing or monitoring the position of the input means relative to the device.

In one embodiment, the input means includes a transmitter for transmitting a signal and the display includes sensing means for sensing the position at which the signal strikes the display. The signal may be in the form of a conical or circular infrared beam and the sensing means may be operable to sense the area and/or the intensity of the beam as it strikes the display thereby to determine the three-dimensional position of the input device relative to the display.

According to another aspect of the invention there is provided an input device for a computer or the like having a display for displaying data stored thereon, the input device comprising input means, and sensing means for sensing the three-dimensional position of the input means relative thereto and applying a position signal to the computer or the like in dependence on the three-dimensional position thereby to control the data displayed on the display.

BRIEF DESCRIPTION OF THE DRAWINGS

The embodiments herein may be better understood by referring to the following description in conjunction with the accompanying drawings. Understanding that these drawings depict only exemplary embodiments of the disclosure and are not therefore to be considered to be limiting of its scope, the principles herein are described and explained with additional specificity and detail through the use of the accompanying drawings in which:

FIG. **1** shows illustratively a device according to the invention;

FIG. **2** shows illustratively the concept of data "levels";

FIG. **3** shows illustratively a cross-section through a device according to one embodiment of the invention; and

FIG. **4** shows illustratively one embodiment in which the stylus when moved closer to the display produces a circle or ellipse of smaller dimensions than the circle or ellipse formed when the stylus is moved away.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

Referring to FIG. **1**, an electronic device according to the invention is shown generally at **10**. The device **10** may be, for example, a hand-held or "palm-top" computer, a personal digital assistant (PDA) or a mobile communication device such as a mobile telephone. The device **10** is capable of storing and displaying data from a display or screen **12** which may be a liquid crystal display, a dot matrix display or a TFT (thin film transistor) display.

Conventionally, the user of the device **10** controls the data displayed on the display **12** by means of a number of buttons **14** located on the device or by an input device such as a scratch pad or tracker ball. Alternatively, many such devices incorporate touch-sensitive displays which permit the user to select options or to change the data on the display **12** by means of a pencil-shaped pointing device which is physically pressed against the display at the required position thereby to select the required option. Such touch sensitive displays are able only to determine the two-dimensional,

X-Y position of the pointing device relative to the display **12** when the pointing device is pressed against the surface of the display.

A disadvantage of such devices is that in order to achieve the required reduction in size to enable the device to be used as a hand-held device or pocket computer, the display **12** is made correspondingly smaller in size. However, depending on the application for which the device is intended, the display **12** may be required to display similar amounts of data to that of a conventional desktop or lap-top computer having a display which may be an order of magnitude larger in size. The small size of the display **12** reduces the amount of data which can be displayed at any given time.

To minimize the effects of this, the device is programmed to display data in a number of "levels" whereby the display **12** initially displays, for example, four options which are selectable by the user. Selecting one of these options, by means of the pointing device for example, may cause the display **12** to display a second "level" of options, for example in the form of a drop down list or menu commonly used in conventional computers. Each option displayed in the list may produce a further drop down list.

It will be appreciated that the number of levels used by the device is generally proportional to the number of options available to the user and inversely proportional to the size of the display. It is therefore quite common to find that a user may be required to select several options in order to activate a particular function of the device. This is time consuming and can be irritating to the user. Moreover, the generating of a drop down list or the like may obscure completely the original list so that an erroneous selection may require the user to manually exit from the current list in order to return to the original set of options. This may significantly increase the number of operations required to be made by the user.

According to the preferred form of the invention, the device **10** has a display **12** for displaying data stored on the device **10** which can be controlled by input means in the form of an input device **16**. In the preferred embodiment, the input device **16** takes the form of a pen-shaped instrument, hereafter termed a "stylus" which allows the user to select various options displayed on the display **12**. The concept of the invention is that the electronic device **10** is able to detect or monitor the three-dimensional position of the stylus **16** relative to the device **10**, and in particular relative to the display. This permits, effectively "three-dimensional control" of the display **12** which can be used, for example, to achieve the following control functions.

Movement of the stylus **16** in the X or Y directions relative to the display **12** causes the cursor on the display **12** (for example the mouse pointer or equivalent) to move accordingly, in the manner of a conventional mouse. Importantly, however, movement of the stylus **16** in the Z direction, i.e. in a direction generally perpendicular to the display **12**, performs a "zoom" function which, depending on the direction of movement of the stylus **16**, either towards or away from the display, causes the display **12** either to zoom in or to zoom out.

In one embodiment, for example, movement of the stylus **16** in a direction towards the display **12** causes the data in the region of the display **12** corresponding to the X-Y position of the stylus **16** to be magnified in a manner similar to that achieved by the "zoom in" function of conventional computers and computer programs. Thus, the data in the region of the display **12** corresponding to the X-Y position of the stylus **16** is enlarged as the stylus **16** is moved closer to the display **12**. This zooming in of the display **12** permits data relating to sub options to be displayed in place of the original option. However, whereas conventional software offers an "incremental zoom" with each discrete selection, the device described with reference to the drawings provides continuous zoom through constantly refreshed information based on the computed trajectory of the stylus. Continuous zoom makes possible an intuitive and responsive user interface.

When "zoom in" or "zoom out" reaches a pre-determined threshold, data relating to sub-options is displayed in addition to, or in place of (or first one then the other), the original option.

FIG. **2** illustrates the concept of "levels" of information to be displayed by the display **12**. Initially, the displays "level 1" data which, as illustrated in FIG. **2**, may give the user two choices, OPTION 1 and OPTION 2, which are selectable by the user. OPTION 1 represents specific "level 2" data which may, for example, include a further two choices, OPTION A and OPTION B. OPTIONs A and B represent respective "level 3" data which may, for example, represent different functions which the device **10** can perform, for example to send an e-mail or to access the internet.

Similarly, OPTION 2 in the level 1 data may correspond to OPTIONS C and D in the second level data, each of which represents different functions which may be performed by the device **10**, for example opening a calendar or opening a diary.

In conventional devices, to select the internet function from the above example, the user would be required to press the stylus **16** onto the screen at OPTION 1 and then again at OPTION B and finally on the internet option. Thus, three separate operations are required. An incorrect selection, for example selection of OPTION A instead of OPTION B requires the user to select an "exit" option (not shown) in order to return to the level 1 data.

The present invention, on the other hand, permits the user to select, for example, the internet, with a minimum of individual operations. For example, in one embodiment, the user moves the stylus **16** over the part of the display **12** containing OPTION 1 and then moves the stylus **16** towards the display. The device **10** interprets the movement of the stylus **16** towards the screen as a "zoom in" operation which zooms the display **12** through the level 1 data towards the level 2 data until OPTION A and OPTION B are displayed on the screen. The user then alters the position of the stylus **16** in the X-Y plane until the stylus **16** is positioned over the OPTION B icon and again moves the stylus **16** towards the display. This movement "zooms in" through the level 2 data towards the level 3 data until the internet icon appears on the screen. This can then be selected by the user in the conventional manner, for example, by pressing the stylus **16** onto the screen at the required location.

It will be understood that the present invention relies on the ability of the device **10** to monitor, track or otherwise detect the X-Y-Z, three-dimensional position of the stylus **16** relative to the display **12** whilst the stylus **16** is not in contact with the display **12** itself, unlike conventional touch-sensitive displays. This may be achieved in a number of ways.

In one embodiment, the stylus **16** is a so-called "smart stylus" which contains a source of electromagnetic radiation, for example an infrared emitter, an LED or other such light emitting device (not shown). The stylus **16** emits a beam of light, for example infrared or other spectrum light, from a circular, spherical, or other shaped tip. The light is sensed by a sensitive layer (not shown) positioned over, or incorporate in, the display **12**. The light sensitive layer may, for example, be in the form of a CCD or CMOS infrared sensitive array or the like. As the stylus **16** is moved across the display **12**, only certain parts of the sensitive layer will

be illuminated by the beam of light emitted by the stylus **16** and this will be detected by the sensitive layer. The sensitive layer determines the appropriate X-Y coordinates of the stylus **16** and sends a corresponding position signal to the central processing unit or similar of the device **10** which adjusts the display **12** accordingly. FIG. **4** is an example of this embodiment. The stylus **16** when moved closer to the display produces a circle or ellipse **30** of smaller dimensions than the circle or ellipse **32** formed when the stylus is moved away. The same eccentricity of the ellipse means that the input stylus is at the same angle to the display and the size of the area indicates the distance of the stylus from the display.

In an alternative embodiment, the stylus **16** operates in the manner of a conventional light pen and contains a light sensor or photodiode therein which senses the light given off by the display. The display **12** is scanned as in a conventional television screen so that the image is continually refreshed across and down the display **12** in a so-called raster scan. This continual refreshing causes the pixels in the display **12** to alternatively brighten and then dim at a very high frequency such that the effect is invisible to the naked eye.

However, the photodiode is able to detect this bright/dim effect and when the light received by the photodiode steps from dim to light, the stylus **16** sends a signal to the display controller in the device **10**. Since the display controller creates the display signal, it knows the position of the current raster line and so it can determine which pixel on the display **12** is being refreshed when the stylus **16** sends the signal to the controller. The display controller then sets a latch which feeds two numbers, representative of the X and Y coordinates of the pixel, to the central processing unit or similar of the device **10** which is therefore able to determine where on the screen the stylus **16** is pointed.

The above examples describe only how the device **10** determines the X-Y coordinates of the stylus **16** relative to the display **12**. It will be understood that the device **10** must also determine the Z-coordinate, i.e. the distance of the stylus **16** from the display. Again this can be achieved in a number of ways.

In one embodiment, the stylus **16** emits a beam of electromagnetic radiation, for example infrared or other spectrum light which is transmitted in a conical beam which widens in diameter with distance from the tip of the stylus **16**.

The light incident on the display **12** and hence the sensitive layer is in the form of an ellipse, the eccentricity of which depends on the angle at which the light strikes the display **12** and hence the stylus **16** is being held. An eccentricity of 1, for example, is indicative of a circle of incident light and a vertically held stylus **16**.

The distribution of the light incident on the sensitive layer will vary with distance from the light source in the stylus **16**. When the stylus **16** is positioned at a distance from the sensitive layer of the display, the total area of the sensitive layer illuminated will be relatively large but the intensity of the incident light will be low. As the stylus **16** is moved closer to the display, the area the light incident upon the sensitive layer will decrease but the intensity will increase. At very short distances from the display, the area of the display **12** illuminated by the light from the stylus **16** will be small but the intensity will be high.

In order to measure the intensity of the incident light the continuous range of possible intensities may be divided into a number of thresholds of stimulation. Hence, the intensity of the light may be calculated according to which thresholds it falls between.

In operation, the sensitive layer detects the light incident on the display **12** and sends appropriate signals to the processing unit of the device **10**. The elliptical eccentricity of the light incident on the display **12** is then calculated and from this the angle at which the stylus **16** is determined. The total area of light incident on the display **12** may also be calculated and from this the distance of the stylus **16** from the display **12** may be determined. Alternatively or additionally, the intensity of the incident light may be measured and used either to independently determine the distance of the stylus **16** from the display **12** or to refine the result of the calculation based on the measured area.

The angle of the stylus **16**, in conjunction with the distance of the stylus **16** from the display **12** are then used to determine the vertical height of the stylus **16** above the display **12**. Hence the position of the stylus **16**, in the Z-dimension, is determined by the device **10**.

Repetitive calculation of the stylus position, several times a second, as the stylus **16** is moved allows a stylus trajectory to be recorded. The stylus trajectory may then be used to assist in anticipating the intentions of the user.

The location and angle of the stylus **16** may also be used to determine when the user makes a selection without physical contact between the stylus **16** and the display. A simple dipping motion, for example, could be used to represent the selection. Alternatively or additionally the area and/or intensity of the light may also be used to represent a contactless selection. Such a selection may be indicated, for example, by the area of incident light falling below a certain minimum threshold and/or the intensity rising above a certain maximum threshold.

In a different embodiment, illustrated in FIG. **3**, the device **10** is provided with a plurality of light sensors **20** positioned around the perimeter of the display **12**. The light sensors are segmented or layered in the Z-direction such that as the stylus **16** moves towards or away from the display **12**, different or segments or layers of the light sensors will be illuminated by the conical beam emitted by the stylus **16**. In particular, as the stylus **16** moves closer to the screen, fewer of the light sensors around the display **12** will be illuminated, as illustrated in FIG. **3**. The signals from the sensors are interpreted by the processing unit of the device **10**, which thus calculates the distance of the stylus **16** from the display **12**.

In yet a further embodiment, not shown, the display **12** is inset or sunk into the body of the device **10** to provide a surrounding wall. The wall is provided on two faces with a plurality of light emitting devices and on the other two faces by a corresponding number of light sensing devices. The light emitted by the light emitters are sensed by the opposing light sensors such that if the stylus **16** is moved towards the display **12**, it will interrupt the light transmitted between some of the light emitters and the corresponding light sensors which will indicate to the device **10** that the stylus **16** has moved closer to the display. If the light emitters and sensors are layered in the Z-direction, this can provide an indication of the distance of the stylus **16** from the display.

It will be clear to those skilled in the art that there are a number of possible ways of sensing the X-Y-Z, three-dimensional position of the stylus **16** relative to the display, the above examples representing particularly simple and advantageous techniques. The important feature of the invention is that the user is able to alter the data displayed

by the device **10** by moving the stylus **16** or other input device in three dimensions relative to the device **10** or the display **12** of the device **10**.

It will be further understood that there are a number of modifications or improvements or variations on the above described invention which may provide particular advantages. Where the stylus **16** incorporates a light emitting device to produce a conical beam, the power of the device may be selected to produce a beam which is of a predetermined length and conical angle to restrict the amount of movement in the Z-direction required by the user to perform the zoom in or zoom out functions. The type of light emitter can be selected as desired to provide infrared or visible light or other forms of electromagnetic radiation may be used. The stylus **16** may alternatively include both a photodiode, to enable its use similar to a light pen, and a light emitter for establishing the Z-coordinate information. The stylus **16** may be connected to the device **10** by means of a cable for transmitting or receiving signals to and from the electronic device **10**. Alternatively, the stylus **16** may be remotely linked to the device **10** or no data link may be provided at all. The latter situation is possible where a light emitting device is employed in the stylus **16**.

The stylus could optionally be attached to the device with a simple tether (spiral plastic cord, etc.) simply to prevent its loss from a place where many people might use it often, such as a refrigerator, computer or a commercial site.

The device **10** may incorporate a touch-sensitive screen or a conventional screen by which a selection is achieved by means of a button or the like located on the stylus **16** which causes a signal to be sent to the electronic device **10**, similar to conventional light guns or the like. Where a sensitive layer is used, this may be formed of any suitable material, which may additionally or alternatively be heat-sensitive. The sensitive layer may be layered above or below the screen of the display **12** or integrated therewith. The sensitivity and qualities of the material chosen can be selected as desired.

While the above described embodiments talk of sensing the position of the stylus **16** relative to the display **12** of the device **10**, it will be appreciated that the three-dimensional position of the stylus **16** relative to any other part of the device **10** or relative to any fixed location could be used for the same purpose. In this regard, the invention may provide only a stylus **16** and a sensing "pad" or the like which is able to determine the three-dimensional position of the stylus **16** relative thereto. The pad could be connected for communication with the electronic device **10** by any suitable means which will be well understood. Such an embodiment may enable the stylus **16** and "pad" to be used with conventional desk top or laptop computers in place of the more conventional mouse, scratch pad or tracker ball.

It will be appreciated that the device **10** of the invention provides a number of advantages over existing systems. In particular, depth/height coordinates of the stylus **16** can be calculated from the device **10** and enable software on the device **10** to adapt the contents of the display **12** as the distance from the display **12** or device **10** changes. When the stylus **16** is brought closer to the display, the device **10** interprets this movement as an intention to select a coordinate within a specific range and zoom all of the information displayed within that coordinate to fill a larger part of the display. This enables the information display to intuitively come "closer" to meet the intention of the user. In addition, more space becomes available on the display **12** because fewer of the level 1 choices are shown and additional layers of choices, such as contextual menus, could be selectively added permitting more selections to be made with fewer "clicks" or selections of the stylus **16**. Where two or more levels of selection are required, movement of the stylus **16** may permit the device **10** to anticipate the selection required by the user to allow the selection to be made with only a single operation of the stylus **16**.

The invention claimed is:

1. An interactive device comprising:
- a housing having a screen to display one or more selectable options to a user;
- a plurality of light sensors disposed in the housing, each sensor configured to detect a portion of light incident on the device and provide an output signal based on the portion of light detected; and
- a processing unit configured to:
  - receive the output signal from one or more light sensors;
  - determine, based on the output signal, a position of an object in a three-dimensional (3D) space relative to the interactive device;
  - determine the position of the object corresponds to one of the selectable options based on a first dimension and a second dimension of the 3D space;
  - determine, based on a change in the output signal, movement of the object relative to the interactive device in a third dimension of the 3D space; and
  - execute, based on the movement of the object, a function related to at least one of the one or more selectable options.

2. The interactive device of claim **1**, wherein the screen defines a plane formed in the first dimension and the second dimension, wherein a distance between the object and the device defines the third dimension wherein the processing unit is further configured to:
- detect a pre-defined movement of the object in the third dimension; and
- select one option of the selectable options based on the pre-defined movement.

3. The interactive device of claim **1**, further comprising at least one light emitting device disposed on the housing.

4. The interactive device of claim **1**, wherein the object comprises one of a stylus or finger.

5. The interactive device of claim **1**, wherein the function comprises at least one of a zoom operation or a selection operation.

6. The interactive device of claim **5**, wherein the processing unit is further configured to execute the function when the output signal exceeds a pre-determined threshold.

7. The interactive device of claim **1**, wherein the function comprises a display operation to display a sub-menu for one option of the selectable options.

8. The interactive device of claim **1**, wherein the function comprises a selection operation to select one option of the selectable options.

9. The interactive device of claim **1**, wherein the output signal comprises data representing an intensity level of light incident on the device.

10. The interactive device of claim **1**, wherein the processing unit is further configured to calculate an angle of the object with respect to the screen based on the output signal.

11. A method comprising:
- detecting, by one or more sensors of an interactive device, light associated with an object in proximity to the interactive device;
- determining, by a processor of the interactive device, a position of the object in a three-dimensional (3D) space

relative to the interactive device based on the light detected by the one or more sensors;

determining, by the processor, the position of the object in a first dimension and a second dimension of the 3D space corresponds to at least one selectable element displayed on a display screen of the interactive device;

determining, by the processor, the position of the object in a third dimension of the 3D space corresponds to a distance between the interactive device and the object;

calculating, by the processor, a change in the distance based on the light detected by the one or more sensors; and

executing, by the processor, a function related to the at least one selectable element based on the change in the distance.

12. The method of claim **11**, wherein executing the function comprises performing at least one of a zoom operation or a selection operation.

13. The method of claim **11**, wherein executing the function comprises displaying a sub-menu of options related to the selectable element.

14. The method of claim **11**, wherein executing the function comprises selecting an option related to the selectable element.

15. The method of claim **11**, further comprising:

determining, by the processor, the change in the distance corresponds to a pre-defined motion; and

selecting, by the processor, an option related to the selectable element based on the pre-defined motion.

16. The method of claim **11**, wherein detecting the light associated with the object further comprises detecting an intensity level of light associated with the object.

17. The method of claim **11**, further comprising:

calculating, by the processor, an angle of the object with respect to the interactive device based on the light detected by the one or more sensors.

* * * * *

EXHIBIT E

US010664070B2

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Lipman et al.

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(45) **Date of Patent: *May 26, 2020**

(54) **INPUT SYSTEM FOR CONTROLLING ELECTRONIC DEVICE**

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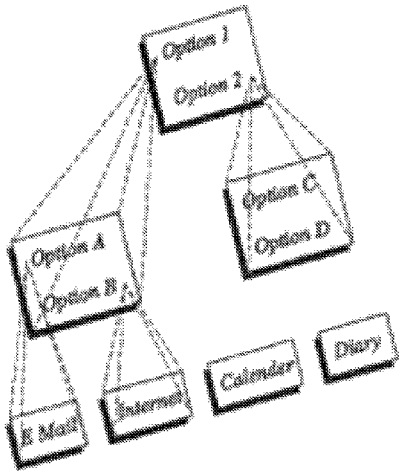
(57) **ABSTRACT**

An electronic device includes a display for displaying data stored on the electronic device; input means; sensing means for sensing the three-dimensional position of the input means relative to the device; and control means for controlling the data displayed on the display in dependence on the three-dimensional position of the input means relative to the device. The input means includes a source of electromagnetic radiation for directing an infrared conical beam onto the display. The sensing means can sense the elliptical eccentricity of the electromagnetic radiation incident on the display to determine the angle at which it strikes the display,
(Continued)



and can sense the area of the electromagnetic radiation incident on the display to determine the distance of the input means from the display.

18 Claims, 3 Drawing Sheets

Related U.S. Application Data

continuation of application No. 14/468,014, filed on Aug. 25, 2014, now Pat. No. 9,454,178, which is a continuation of application No. 14/042,409, filed on Sep. 30, 2013, now Pat. No. 8,816,994, which is a continuation of application No. 13/114,580, filed on May 24, 2011, now Pat. No. 8,547,364, which is a continuation of application No. 11/006,486, filed on Dec. 6, 2004, now Pat. No. 7,952,570, which is a continuation of application No. PCT/GB03/02533, filed on Jun. 9, 2003.

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See application file for complete search history.

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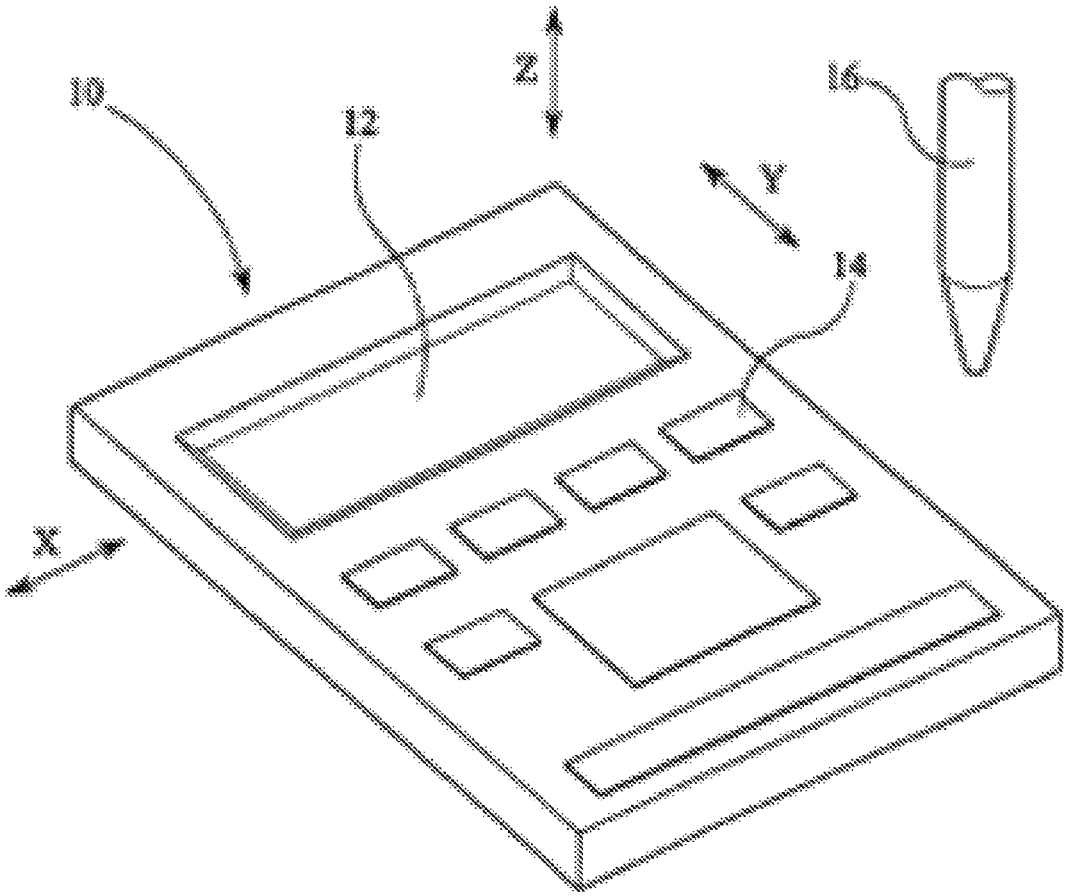

FIG. 1

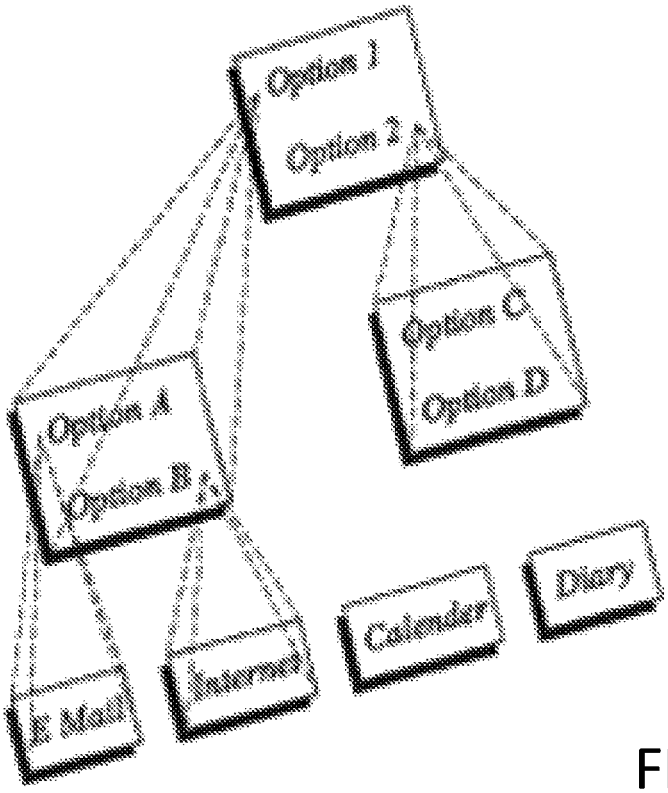
Option 1
Option 2
Option C
Option D
Option A
Option B
Diary
Calendar
E Mail

FIG. 2

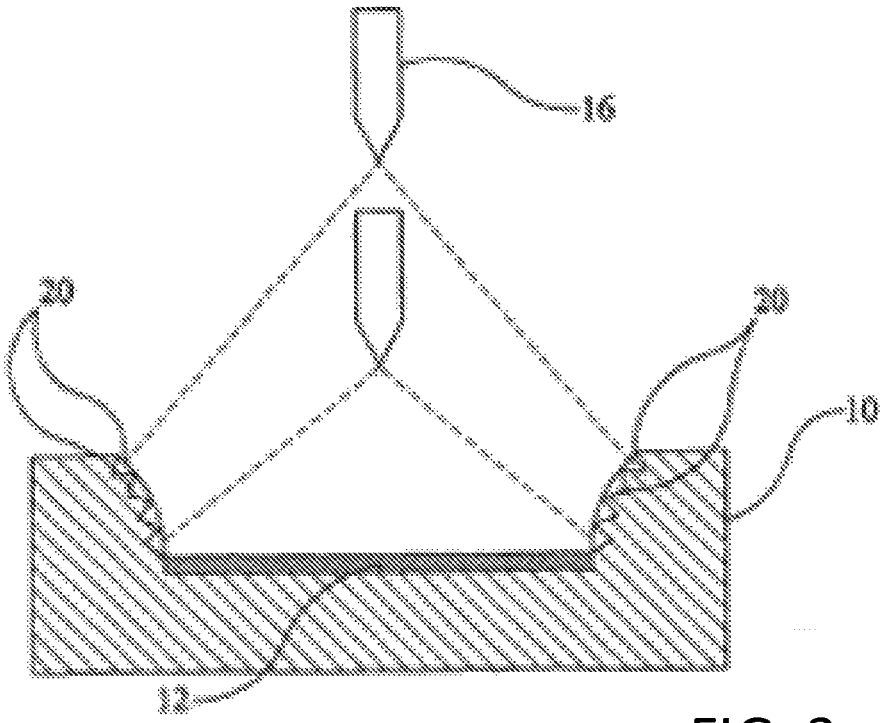
16
20
20
10
12

FIG. 3

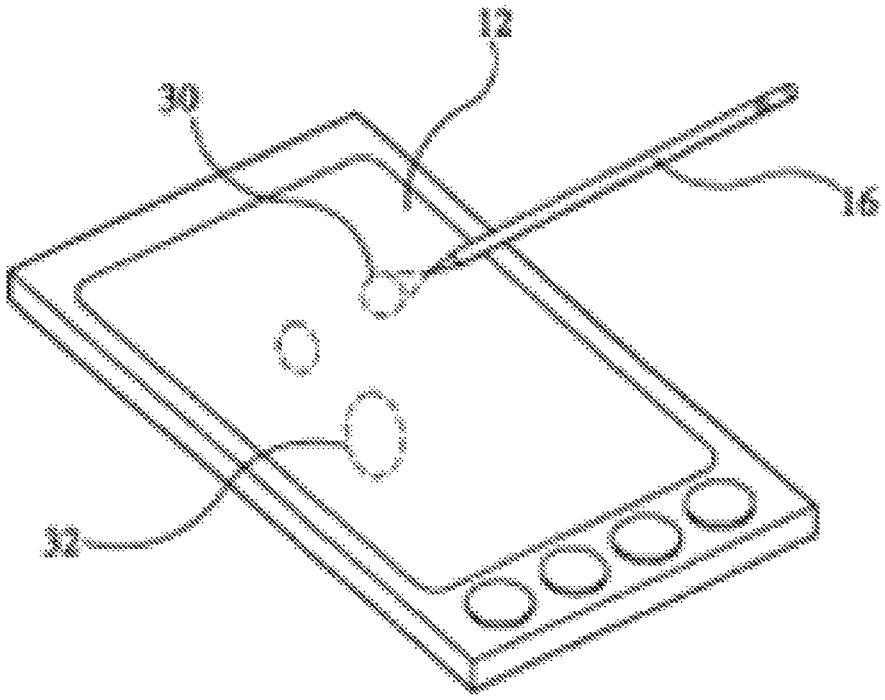

FIG. 4

INPUT SYSTEM FOR CONTROLLING ELECTRONIC DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 15/272,314, filed Sep. 21, 2016, which is a continuation of U.S. patent application Ser. No. 14/468,014, filed Aug. 25, 2014, now U.S. Pat. No. 9,454,178, which is a continuation of U.S. patent application Ser. No. 14/042,409, filed Sep. 30, 2013, now U.S. Pat. No. 8,816,994, which is a continuation of U.S. patent application Ser. No. 13/114,580, filed May 24, 2011, now U.S. Pat. No. 8,547,364, which is a continuation of U.S. patent application Ser. No. 11/006,486, filed Dec. 6, 2004, now U.S. Pat. No. 7,952,570, which is a continuation of International Application No. PCT/GB03/02533, filed Jun. 9, 2003, which claims priority to United Kingdom Patent Application No. 0213215.7, filed Jun. 8, 2002, the entirety of each is hereby incorporated by reference.

TECHNICAL FIELD

The present invention relates to computer navigation and particularly, but not exclusively, to an apparatus which facilitates navigation of software stored on the apparatus even where the display for the apparatus is small.

BACKGROUND

It is known to provide small, hand-held computer devices such as pocket organizers, Personal Digital Assistants (PDA's), cellular phones or the like. The current trend is to manufacture such devices to be as small in size as possible. Smaller devices are more easily carried and generally require a reduced power supply.

However, a significant disadvantage of such devices is that the reduced size forces a reduction in the size of the user interface, and particularly in the size of the screen or display used to display information or data stored on or processed by the device.

Many such devices have the processing power of conventional desktop or laptop computers or of similar devices many times their size and a number of products, such as the WACOM® and SONY® VAIO® pocket computers, are fully operable portable computers which use operating systems such as MICROSOFT® WINDOWS® or the like.

Those familiar with such pocket devices will appreciate the problem of displaying all of the necessary information on a relatively small display, particularly where the user is able to select specific functions from a large number of options. Conventionally, the selection of one option, for example, results in a new "window" opening which displays further options and sub options. Whilst devices having large displays are able to organize the data so that it is displayed in a more easily understood manner, devices having smaller screens tend to use data "layers" or "levels" whereby the selection of one option having a number of sub options causes the full screen to display the sub options fully eclipsing the original menu. The accidental selection of the wrong option requires a number of steps to return the display to the original list of options.

It would be advantageous to provide a pocket computer or hand held device which incorporates means for enabling easier access to data on the device and improves the user interface of the device.

SUMMARY

According to one aspect of the present invention, therefore, there is provided an electronic device having a display for displaying data stored thereon, input means and control means for controlling the data displayed on the display in dependence on the three-dimensional position of the input means with respect to the device.

Preferably, the device includes means for sensing or monitoring the position of the input means relative to the device.

In one embodiment, the input means includes a transmitter for transmitting a signal and the display includes sensing means for sensing the position at which the signal strikes the display. The signal may be in the form of a conical or circular infrared beam and the sensing means may be operable to sense the area and/or the intensity of the beam as it strikes the display thereby to determine the three-dimensional position of the input device relative to the display.

According to another aspect of the invention there is provided an input device for a computer or the like having a display for displaying data stored thereon, the input device comprising input means, and sensing means for sensing the three-dimensional position of the input means relative thereto and applying a position signal to the computer or the like in dependence on the three-dimensional position thereby to control the data displayed on the display.

BRIEF DESCRIPTION OF THE DRAWINGS

The embodiments herein may be better understood by referring to the following description in conjunction with the accompanying drawings. Understanding that these drawings depict only exemplary embodiments of the disclosure and are not therefore to be considered to be limiting of its scope, the principles herein are described and explained with additional specificity and detail through the use of the accompanying drawings in which:

FIG. **1** shows illustratively a device according to the invention;

FIG. **2** shows illustratively the concept of data "levels";

FIG. **3** shows illustratively a cross-section through a device according to one embodiment of the invention; and

FIG. **4** shows illustratively one embodiment in which the stylus when moved closer to the display produces a circle or ellipse of smaller dimensions than the circle or ellipse formed when the stylus is moved away.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

Referring to FIG. **1**, an electronic device according to the invention is shown generally at **10**. The device **10** may be, for example, a hand-held or "palm-top" computer, a personal digital assistant (PDA) or a mobile communication device such as a mobile telephone. The device **10** is capable of storing and displaying data from a display or screen **12** which may be a liquid crystal display, a dot matrix display or a TFT (thin film transistor) display.

Conventionally, the user of the device **10** controls the data displayed on the display **12** by means of a number of buttons **14** located on the device or by an input device such as a scratch pad or tracker ball. Alternatively, many such devices incorporate touch-sensitive displays which permit the user to select options or to change the data on the display **12** by means of a pencil-shaped pointing device which is physi-

cally pressed against the display at the required position thereby to select the required option. Such touch sensitive displays are able only to determine the two-dimensional, X-Y position of the pointing device relative to the display **12** when the pointing device is pressed against the surface of the display.

A disadvantage of such devices is that in order to achieve the required reduction in size to enable the device to be used as a hand-held device or pocket computer, the display **12** is made correspondingly smaller in size. However, depending on the application for which the device is intended, the display **12** may be required to display similar amounts of data to that of a conventional desktop or lap-top computer having a display which may be an order of magnitude larger in size. The small size of the display **12** reduces the amount of data which can be displayed at any given time.

To minimize the effects of this, the device is programmed to display data in a number of "levels" whereby the display **12** initially displays, for example, four options which are selectable by the user. Selecting one of these options, by means of the pointing device for example, may cause the display **12** to display a second "level" of options, for example in the form of a drop down list or menu commonly used in conventional computers. Each option displayed in the list may produce a further drop down list.

It will be appreciated that the number of levels used by the device is generally proportional to the number of options available to the user and inversely proportional to the size of the display. It is therefore quite common to find that a user may be required to select several options in order to activate a particular function of the device. This is time consuming and can be irritating to the user. Moreover, the generating of a drop down list or the like may obscure completely the original list so that an erroneous selection may require the user to manually exit from the current list in order to return to the original set of options. This may significantly increase the number of operations required to be made by the user.

According to the preferred form of the invention, the device **10** has a display **12** for displaying data stored on the device **10** which can be controlled by input means in the form of an input device **16**. In the preferred embodiment, the input device **16** takes the form of a pen-shaped instrument, hereafter termed a "stylus" which allows the user to select various options displayed on the display **12**. The concept of the invention is that the electronic device **10** is able to detect or monitor the three-dimensional position of the stylus **16** relative to the device **10**, and in particular relative to the display. This permits, effectively "three-dimensional control" of the display **12** which can be used, for example, to achieve the following control functions.

Movement of the stylus **16** in the X or Y directions relative to the display **12** causes the cursor on the display **12** (for example the mouse pointer or equivalent) to move accordingly, in the manner of a conventional mouse. Importantly, however, movement of the stylus **16** in the Z direction, i.e. in a direction generally perpendicular to the display **12**, performs a "zoom" function which, depending on the direction of movement of the stylus **16**, either towards or away from the display, causes the display **12** either to zoom in or to zoom out.

In one embodiment, for example, movement of the stylus **16** in a direction towards the display **12** causes the data in the region of the display **12** corresponding to the X-Y position of the stylus **16** to be magnified in a manner similar to that achieved by the "zoom in" function of conventional computers and computer programs. Thus, the data in the region of the display **12** corresponding to the X-Y position of the stylus **16** is enlarged as the stylus **16** is moved closer to the display **12**. This zooming in of the display **12** permits data relating to sub options to be displayed in place of the original option. However, whereas conventional software offers an "incremental zoom" with each discrete selection, the device described with reference to the drawings provides continuous zoom through constantly refreshed information based on the computed trajectory of the stylus. Continuous zoom makes possible an intuitive and responsive user interface.

When "zoom in" or "zoom out" reaches a pre-determined threshold, data relating to sub-options is displayed in addition to, or in place of (or first one then the other), the original option.

FIG. **2** illustrates the concept of "levels" of information to be displayed by the display **12**. Initially, the displays "level **1**" data which, as illustrated in FIG. **2**, may give the user two choices, OPTION **1** and OPTION **2**, which are selectable by the user. OPTION **1** represents specific "level **2**" data which may, for example, include a further two choices, OPTION A and OPTION B. OPTIONs A and B represent respective "level **3**" data which may, for example, represent different functions which the device **10** can perform, for example to send an e-mail or to access the internet.

Similarly, OPTION **2** in the level **1** data may correspond to OPTIONS C and D in the second level data, each of which represents different functions which may be performed by the device **10**, for example opening a calendar or opening a diary.

In conventional devices, to select the internet function from the above example, the user would be required to press the stylus **16** onto the screen at OPTION **1** and then again at OPTION B and finally on the internet option. Thus, three separate operations are required. An incorrect selection, for example selection of OPTION A instead of OPTION B requires the user to select an "exit" option (not shown) in order to return to the level **1** data.

The present invention, on the other hand, permits the user to select, for example, the internet, with a minimum of individual operations. For example, in one embodiment, the user moves the stylus **16** over the part of the display **12** containing OPTION **1** and then moves the stylus **16** towards the display. The device **10** interprets the movement of the stylus **16** towards the screen as a "zoom in" operation which zooms the display **12** through the level **1** data towards the level **2** data until OPTION A and OPTION B are displayed on the screen. The user then alters the position of the stylus **16** in the X-Y plane until the stylus **16** is positioned over the OPTION B icon and again moves the stylus **16** towards the display. This movement "zooms in" through the level **2** data towards the level **3** data until the internet icon appears on the screen. This can then be selected by the user in the conventional manner, for example, by pressing the stylus **16** onto the screen at the required location.

It will be understood that the present invention relies on the ability of the device **10** to monitor, track or otherwise detect the X-Y-Z, three-dimensional position of the stylus **16** relative to the display **12** whilst the stylus **16** is not in contact with the display **12** itself, unlike conventional touch-sensitive displays. This may be achieved in a number of ways.

In one embodiment, the stylus **16** is a so-called "smart stylus" which contains a source of electromagnetic radiation, for example an infrared emitter, an LED or other such light emitting device (not shown). The stylus **16** emits a beam of light, for example infrared or other spectrum light, from a circular, spherical, or other shaped tip. The light is sensed by a sensitive layer (not shown) positioned over, or incorporate in, the display **12**. The light sensitive layer may,

for example, be in the form of a CCD or CMOS infrared sensitive array or the like. As the stylus **16** is moved across the display **12**, only certain parts of the sensitive layer will be illuminated by the beam of light emitted by the stylus **16** and this will be detected by the sensitive layer. The sensitive layer determines the appropriate X-Y coordinates of the stylus **16** and sends a corresponding position signal to the central processing unit or similar of the device **10** which adjusts the display **12** accordingly. FIG. **4** is an example of this embodiment. The stylus **16** when moved closer to the display produces a circle or ellipse **30** of smaller dimensions than the circle or ellipse **32** formed when the stylus is moved away. The same eccentricity of the ellipse means that the input stylus is at the same angle to the display and the size of the area indicates the distance of the stylus from the display.

In an alternative embodiment, the stylus **16** operates in the manner of a conventional light pen and contains a light sensor or photodiode therein which senses the light given off by the display. The display **12** is scanned as in a conventional television screen so that the image is continually refreshed across and down the display **12** in a so-called raster scan. This continual refreshing causes the pixels in the display **12** to alternatively brighten and then dim at a very high frequency such that the effect is invisible to the naked eye.

However, the photodiode is able to detect this bright/dim effect and when the light received by the photodiode steps from dim to light, the stylus **16** sends a signal to the display controller in the device **10**. Since the display controller creates the display signal, it knows the position of the current raster line and so it can determine which pixel on the display **12** is being refreshed when the stylus **16** sends the signal to the controller. The display controller then sets a latch which feeds two numbers, representative of the X and Y coordinates of the pixel, to the central processing unit or similar of the device **10** which is therefore able to determine where on the screen the stylus **16** is pointed.

The above examples describe only how the device **10** determines the X-Y coordinates of the stylus **16** relative to the display **12**. It will be understood that the device **10** must also determine the Z-coordinate, i.e. the distance of the stylus **16** from the display. Again this can be achieved in a number of ways.

In one embodiment, the stylus **16** emits a beam of electromagnetic radiation, for example infrared or other spectrum light which is transmitted in a conical beam which widens in diameter with distance from the tip of the stylus **16**.

The light incident on the display **12** and hence the sensitive layer is in the form of an ellipse, the eccentricity of which depends on the angle at which the light strikes the display **12** and hence the stylus **16** is being held. An eccentricity of 1, for example, is indicative of a circle of incident light and a vertically held stylus **16**.

The distribution of the light incident on the sensitive layer will vary with distance from the light source in the stylus **16**. When the stylus **16** is positioned at a distance from the sensitive layer of the display, the total area of the sensitive layer illuminated will be relatively large but the intensity of the incident light will be low. As the stylus **16** is moved closer to the display, the area the light incident upon the sensitive layer will decrease but the intensity will increase. At very short distances from the display, the area of the display **12** illuminated by the light from the stylus **16** will be small but the intensity will be high.

In order to measure the intensity of the incident light the continuous range of possible intensities may be divided into a number of thresholds of stimulation. Hence, the intensity of the light may be calculated according to which thresholds it falls between.

In operation, the sensitive layer detects the light incident on the display **12** and sends appropriate signals to the processing unit of the device **10**. The elliptical eccentricity of the light incident on the display **12** is then calculated and from this the angle at which the stylus **16** is determined. The total area of light incident on the display **12** may also be calculated and from this the distance of the stylus **16** from the display **12** may be determined. Alternatively or additionally, the intensity of the incident light may be measured and used either to independently determine the distance of the stylus **16** from the display **12** or to refine the result of the calculation based on the measured area.

The angle of the stylus **16**, in conjunction with the distance of the stylus **16** from the display **12** are then used to determine the vertical height of the stylus **16** above the display **12**. Hence the position of the stylus **16**, in the Z-dimension, is determined by the device **10**.

Repetitive calculation of the stylus position, several times a second, as the stylus **16** is moved allows a stylus trajectory to be recorded. The stylus trajectory may then be used to assist in anticipating the intentions of the user.

The location and angle of the stylus **16** may also be used to determine when the user makes a selection without physical contact between the stylus **16** and the display. A simple dipping motion, for example, could be used to represent the selection. Alternatively or additionally the area and/or intensity of the light may also be used to represent a contactless selection. Such a selection may be indicated, for example, by the area of incident light falling below a certain minimum threshold and/or the intensity rising above a certain maximum threshold.

In a different embodiment, illustrated in FIG. **3**, the device **10** is provided with a plurality of light sensors **20** positioned around the perimeter of the display **12**. The light sensors are segmented or layered in the Z-direction such that as the stylus **16** moves towards or away from the display **12**, different or segments or layers of the light sensors will be illuminated by the conical beam emitted by the stylus **16**. In particular, as the stylus **16** moves closer to the screen, fewer of the light sensors around the display **12** will be illuminated, as illustrated in FIG. **3**. The signals from the sensors are interpreted by the processing unit of the device **10**, which thus calculates the distance of the stylus **16** from the display **12**.

In yet a further embodiment, not shown, the display **12** is inset or sunk into the body of the device **10** to provide a surrounding wall. The wall is provided on two faces with a plurality of light emitting devices and on the other two faces by a corresponding number of light sensing devices. The light emitted by the light emitters are sensed by the opposing light sensors such that if the stylus **16** is moved towards the display **12**, it will interrupt the light transmitted between some of the light emitters and the corresponding light sensors which will indicate to the device **10** that the stylus **16** has moved closer to the display. If the light emitters and sensors are layered in the Z-direction, this can provide an indication of the distance of the stylus **16** from the display.

It will be clear to those skilled in the art that there are a number of possible ways of sensing the X-Y-Z, three-dimensional position of the stylus **16** relative to the display, the above examples representing particularly simple and advantageous techniques. The important feature of the

invention is that the user is able to alter the data displayed by the device **10** by moving the stylus **16** or other input device in three dimensions relative to the device **10** or the display **12** of the device **10**.

It will be further understood that there are a number of modifications or improvements or variations on the above described invention which may provide particular advantages. Where the stylus **16** incorporates a light emitting device to produce a conical beam, the power of the device may be selected to produce a beam which is of a predetermined length and conical angle to restrict the amount of movement in the Z-direction required by the user to perform the zoom in or zoom out functions. The type of light emitter can be selected as desired to provide infrared or visible light or other forms of electromagnetic radiation may be used. The stylus **16** may alternatively include both a photodiode, to enable its use similar to a light pen, and a light emitter for establishing the Z-coordinate information. The stylus **16** may be connected to the device **10** by means of a cable for transmitting or receiving signals to and from the electronic device **10**. Alternatively, the stylus **16** may be remotely linked to the device **10** or no data link may be provided at all. The latter situation is possible where a light emitting device is employed in the stylus **16**.

The stylus could optionally be attached to the device with a simple tether (spiral plastic cord, etc.) simply to prevent its loss from a place where many people might use it often, such as a refrigerator, computer or a commercial site.

The device **10** may incorporate a touch-sensitive screen or a conventional screen by which a selection is achieved by means of a button or the like located on the stylus **16** which causes a signal to be sent to the electronic device **10**, similar to conventional light guns or the like. Where a sensitive layer is used, this may be formed of any suitable material, which may additionally or alternatively be heat-sensitive. The sensitive layer may be layered above or below the screen of the display **12** or integrated therewith. The sensitivity and qualities of the material chosen can be selected as desired.

While the above described embodiments talk of sensing the position of the stylus **16** relative to the display **12** of the device **10**, it will be appreciated that the three-dimensional position of the stylus **16** relative to any other part of the device **10** or relative to any fixed location could be used for the same purpose. In this regard, the invention may provide only a stylus **16** and a sensing "pad" or the like which is able to determine the three-dimensional position of the stylus **16** relative thereto. The pad could be connected for communication with the electronic device **10** by any suitable means which will be well understood. Such an embodiment may enable the stylus **16** and "pad" to be used with conventional desk top or laptop computers in place of the more conventional mouse, scratch pad or tracker ball.

It will be appreciated that the device **10** of the invention provides a number of advantages over existing systems. In particular, depth/height coordinates of the stylus **16** can be calculated from the device **10** and enable software on the device **10** to adapt the contents of the display **12** as the distance from the display **12** or device **10** changes. When the stylus **16** is brought closer to the display, the device **10** interprets this movement as an intention to select a coordinate within a specific range and zoom all of the information displayed within that coordinate to fill a larger part of the display. This enables the information display to intuitively come "closer" to meet the intention of the user. In addition, more space becomes available on the display **12** because fewer of the level **1** choices are shown and additional layers of choices, such as contextual menus, could be selectively added permitting more selections to be made with fewer "clicks" or selections of the stylus **16**. Where two or more levels of selection are required, movement of the stylus **16** may permit the device **10** to anticipate the selection required by the user to allow the selection to be made with only a single operation of the stylus **16**.

The invention claimed is:

1. An interactive device comprising:
- a stylus for emitting a beam of electromagnetic radiation;
- a display screen disposed in a housing, the display screen displaying one or more selectable icons, the display screen forming a touch-sensitive display plane;
- a sensor array disposed in the housing and forming a sensitive layer in a sensor plane proximate to the display screen, the sensor array is configured to detect at least a portion of the beam of electromagnetic radiation incident on the display screen; and
- a processing unit configured to:
  - receive an output signal from the sensor array;
  - determine the output signal from the sensor array corresponds to a distribution pattern of electromagnetic radiation;
  - determine a three-dimensional position of the stylus relative to the interactive device based on the distribution pattern;
  - determine the three-dimensional position of the stylus corresponds to a first selectable icon of the one or more selectable icons based on the output signal;
  - determine at least a portion of the output signal corresponds to a selection function associated with the first selectable icon; and
  - execute, based on the selection function, a function related to the first selectable icon.

2. The interactive device of claim **1**, wherein the processing unit is further configured to:
- determine the stylus is in proximity to the interactive device when the distribution pattern exceeds a threshold.

3. The interactive device of claim **1**
- wherein the display screen is configured to display a cursor corresponding to the three-dimensional position of the stylus.

4. The interactive device of claim **3**, wherein the display screen is further configured to move the position of the cursor based on movement of the stylus.

5. The interactive device of claim **3**, wherein the display screen is further configured to display a menu of additional selectable icons proximate to the cursor.

6. The interactive device of claim **1**, wherein at least one dimension of the three-dimensional position corresponds to a distance between the stylus and the interactive device.

7. The interactive device of claim **1**, wherein the processing unit is further configured to:
- determine the distribution pattern indicates an elliptical eccentricity; and
- determine an angle of the stylus relative to the display screen based on the elliptical eccentricity.

8. The interactive device of claim **1**, wherein the display screen is configured to display a cursor corresponding to a trajectory of the stylus.

9. The interactive device of claim **1**, wherein the sensor plane is substantially parallel to the touch-sensitive display plane.

10. An interactive system comprising:
- a stylus for emitting a beam of electromagnetic radiation;

a display screen disposed in a device, the display screen displaying one or more selectable icons, the display screen forming a touch-sensitive display plane;

a sensor array disposed in the device and forming a sensitive layer in a sensor plane proximate to the display screen, the sensor array is configured to detect at least a portion of the beam of electromagnetic radiation incident on the display screen; and

a processing unit in communication with the sensor array, the processing unit is configured to:

determine a distribution pattern of electromagnetic radiation based on the portion of the beam of electromagnetic radiation detected by the sensor array;

determine a three-dimensional position of the stylus relative to the interactive device based on the distribution pattern;

determine the three-dimensional position corresponds to a first selectable icon of the one or more selectable icons based on the output signal;

determine at least a portion of distribution pattern corresponds to a selection function associated with the first selectable icon; and

execute, based on the selection function, a function related to the first selectable icon.

11. The interactive device of claim **1**, wherein the processing unit is further configured to:

determine at least one of an area of the distribution pattern or an intensity of the portion of the beam of electromagnetic radiation incident on the display screen; and

wherein, when the processor determines the three-dimensional position of the stylus, the processor further determines the three-dimensional position of the stylus relative to the interactive device based on at least one of the area of the distribution pattern or the intensity of the beam of electromagnetic radiation.

12. The interactive system of claim **10**, wherein the sensor array plane is substantially parallel to the display screen.

13. The interactive system of claim **10**, wherein the processing unit is further configured to:

determine the stylus is in proximity to the interactive device when the portion of the beam of radiation exceeds a threshold.

14. The interactive system of claim **10**,

wherein the display screen is configured to display a cursor corresponding to the three-dimensional position of the stylus.

15. The interactive system of claim **14**, wherein the display screen is further configured to display a menu of additional selectable icons proximate to the stylus.

16. A method for interacting with a mobile device, the method comprising:

emitting a beam of electromagnetic radiation by a stylus;

displaying, by a display screen of the mobile device, one or more selectable icons, wherein the display screen forms a touch-sensitive display plane;

detecting, by a sensor array of the mobile device, at least a portion of the beam of electromagnetic radiation incident on the display screen, wherein the sensor array forms a sensitive layer in a sensor plane proximate to the display screen;

determining, by a processor of the mobile device, the portion of the beam of electromagnetic radiation detected by the sensor array corresponds to a distribution pattern of electromagnetic radiation;

determining, by the processor, a three-dimensional position of the stylus relative to the mobile device based on the distribution pattern;

determining, by a processor of the mobile device, the three-dimensional position of the stylus corresponds to a first selectable icon of the one or more selectable icons;

determining, by the processor, at least a portion of the beam of electromagnetic radiation corresponds to a selection function associated with the first selectable icon; and

executing, by the processor, a function related to the first selectable icon based on the selection function.

17. The method of claim **16**, further comprising:

displaying, by the display screen, a cursor proximate to the three-dimensional position of the stylus.

18. The method of claim **16**, further comprising:

determining, by the processor, the distribution pattern indicates an elliptical eccentricity; and

determining, by the processor, an angle of the stylus relative to the display screen based on the elliptical eccentricity, and

displaying a cursor on the display screen based on the angle of the stylus.

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