IN THE UNITED STATES DISTRICT COURT

FOR THE DISTRICT OF COLUMBIA

EPOS TECHNOLOGIES LTD.,
4 Haharash St., Hod Hasharon 45240, Israel,

Plaintiff,

v.

PEGASUS TECHNOLOGIES LTD.,

Defendant.

Case No. _____

COMPLAINT FOR DECLARATORY JUDGMENT OF NONINFRINGEMENT AND INVALIDITY OF U.S. PATENT NOS. 6,392,330; 6,624,371; 6,841,742; 6,326,565

Plaintiff EPOS TECHNOLOGIES LTD. ("EPOS"), by and through its attorneys, hereby alleges, upon personal knowledge with respect to itself and its own acts, and on information and belief with respect to itself and its own acts, and on information and belief with respect to all other matters, the following claims for declaratory relief against Defendant PEGASUS TECHNOLOGIES LTD. ("PEGASUS"):

1. This is an action for a declaratory judgment of patent noninfringement and invalidity for the purpose of resolving a question of actual controversy between the parties, as alleged herein.

JURISDICTION

2. This Court has jurisdiction over these claims for declaratory relief arising under the patent laws of the United States, 35 U.S.C. §§ 1 et seq., pursuant to 28 U.S.C. § 1338(a) and the Federal Declaratory Judgment Act, 28 U.S.C. §§ 2201 and 2202. On information and belief,

Defendant is subject to the personal jurisdiction of this Court pursuant to 35 U.S.C. § 293 and is amenable to service of process pursuant to 35 U.S.C. § 293 and Fed. R. Civ. P. 4(f).

3. Venue is proper pursuant to 28 U.S.C. § 1391. Plaintiff intends to sell products, which defendant asserts infringe the patents-in-suit, to customers located in this judicial district.

4. There is an actual controversy between the parties with regard to the non-infringement of United States Patent Nos. 6,392,330 (the "'330 patent"); 6,724,371 (the "'371 patent"); 6,841,742 (the "'742 patent"); and 6,326,565 (the "'565 patent"). A reasonable apprehension of a suit for infringement of the '330, '371, '742, and '565 patents has been created by the Defendant or those acting by or for the Defendant with respect to the ability of Plaintiff to make, use, sell, and/or offer to sell at least some of its products.

PARTIES

5. Plaintiff EPOS TECHNOLOGIES LTD. is a company organized and existing under the laws of British Virgin Islands, and whose business address is 4 Haharash St., Hod Hasharon 45240, Israel.

6. On information and belief, PEGASUS TECHNOLOGIES LTD. is a corporation organized and existing under the laws of Israel, and whose business address is 27 Hametzuda St., Azur 58001, Israel.

7. On information and belief, PEGASUS is a provider of electronic pen products that capture natural handwriting onto computing devices in real time. PEGASUS' product line includes handwriting capture devices for PCs, PDAs and cellular phones.

PATENTS IN SUIT

8. On information and belief, Defendant PEGASUS is the assignee of the '330 patent, entitled "Cylindrical Ultrasound Receivers and Transceivers Formed From Piezoelectric Film," issued May 21, 2002. The '330 patent on its face indicates it was assigned to Pegasus Technologies Ltd. On information and belief, based on the letter attached as Exhibit E, Defendant PEGASUS is the current assignee of the '330 patent. A true and correct copy of the '330 patent is attached as Exhibit A.

9. On information and belief, Defendant PEGASUS is the assignee of the '371 patent, entitled "Presentation Board Digitizers," issued April 20, 2004. The '371 patent on its face indicates it was assigned to Pegasus Technologies Ltd. On information and belief, based on the letter attached as Exhibit E, Defendant PEGASUS is the current assignee of the '371 patent. A true and correct copy of the '371 patent is attached as Exhibit B.

10. On information and belief, Defendant PEGASUS is the assignee of the '742 patent, entitled "Presentation Board Digitizer Systems," issued January 11, 2005. The '742 patent on its face indicates it was initially assigned to Luidia Inc. On information and belief, based on the letter attached as Exhibit E, Defendant PEGASUS is the current assignee of the '742 patent. A true and correct copy of the '742 patent is attached as Exhibit C.

11. On information and belief, Defendant PEGASUS was assigned the '565 patent, entitled "Marking Device For Electronic Presentation Board," issued December 4, 2001, by an assignment from Isaac Zloter to Defendant PEGASUS dated November 23, 1998. On information and belief, based on the letter attached as Exhibit E, Defendant PEGASUS is the current assignee of the '565 patent. A true and correct copy of the '565 patent is attached as Exhibit D.

EVENTS GIVING RISE TO THIS SUIT

12. EPOS' investors include Intel Capital, Walden Israel, Jerusalem Ventures Partners, and Dane-Elec.

13. On information and belief, Cedar Fund is a venture capital firm investing in high technology companies that has invested in PEGASUS.

14. On information and belief, Roni Hefetz, a general partner of Walden Israel, had a meeting with Gal Israely, a co-founder of Cedar Fund, on or around August 28, 2006, and during that meeting, Roni Hefetz informed Gal Israely that Walden Israel had invested in EPOS; Gal Israely responded by questioning why Walden Israel had invested in EPOS, and stated that PEGASUS would sue EPOS for patent infringement.

15. On information and belief, Steve Gray, Senior Investment Manager at Intel Capital, had a telephone call with Nimrod Schwartz, a board member at PEGASUS representing Cedar Fund, on or around November 13, 2006; during that telephone call, Nimrod Schwartz informed Steve Gray that PEGASUS believed EPOS was infringing PEGASUS' intellectual property and that PEGASUS threatened to seek an injunction as soon as EPOS had a product in the market.

16. On information and belief, Dane-Elec is a company in the business of marketing, *inter alia*, flash memory products. Since around November 16, 2006, EPOS has been in a business relationship with Dane-Elec to provide EPOS' products to Dane-Elec.

17. On information and belief, a representative of Dane-Elec named Jonathan Weizman met with a PEGASUS representative in late 2006; the PEGASUS representative stated to Jonathan Weizman that EPOS' products infringe PEGASUS' patents and that EPOS lacked sufficient manufacturing capabilities to fulfill any contractual obligations to provide products to Dane-Elec.

18. On December 31, 2006, PEGASUS, through its counsel, sent a letter to EPOS Development Ltd. (a wholly-owned subsidiary of EPOS Technologies Ltd.), stating that it was PEGASUS' belief that EPOS Technologies Ltd.'s "ultrasonic digital pen product … infringes one or more claims of at least the following issued U.S. Patents: U.S. 6,392,330[;] U.S. 6,724,371[;] U.S. 6,841,742[;] U.S. 6,326,565." A true and correct copy of the December 31, 2006 letter is attached as Exhibit E.

19. PEGASUS' December 31, 2006 letter requested that EPOS "forbear from making, using and/or selling the infringing product" and stated that "Pegasus is determined to vigorously enforce its intellectual property and will weigh all its legal options."

20. On information and belief, PEGASUS' December 31, 2006 letter was also sent to EPOS' investors, including Intel Capital, Walden Israel, and Jerusalem Ventures Partners, with the apparent intention of interfering with EPOS' relationship with those investors.

21. On information and belief, Steve Gray, Senior Investment Manager at Intel Capital, had a telephone call with Nimrod Schwartz, a board member at PEGASUS representing Cedar Fund, on or around January 28, 2007, and during that telephone call, Nimrod Schwartz asked Steve Gray whether he had received a copy of PEGASUS' December 31, 2006 letter; Steve Gray responded that EPOS was taking the matter seriously and that a formal response was being prepared.

22. Plaintiff EPOS TECHNOLOGIES LTD. therefore seeks a judicial determination and a declaration of the respective rights and duties of Plaintiff and Defendant with regard to the '330, '371, '742, and '565 patents and Plaintiff's products. Such a determination and declaration is necessary and appropriate at this time so that the parties may ascertain their respective rights and duties.

COUNT I

Declaratory Judgment of Non-Infringement of U.S. Patent No. 6,392,330

23. Plaintiff incorporates by reference, as though fully set forth, the allegations contained in paragraphs 1 through 22 of this Complaint.

24. Plaintiff has not directly infringed, contributed to the infringement of, or induced others to infringe, any claim of the '330 patent either literally or under the doctrine of equivalents.

25. On information and belief, Defendant is estopped from asserting a scope for the claims of the '330 patent sufficient to cover Plaintiff's products because of statements made on behalf of the applicant during the prosecution of the '330 patent before the United States Patent and Trademark Office.

26. Plaintiff has not willfully infringed any claim of the '330 patent.

COUNT II

Declaratory Judgment of Non-Infringement of U.S. Patent No. 6,624,371

27. Plaintiff incorporates by reference, as though fully set forth, the allegations contained in paragraphs 1 through 26 of this Complaint.

28. Plaintiff has not directly infringed, contributed to the infringement of, or induced others to infringe, any claim of the '371 patent either literally or under the doctrine of equivalents.

29. On information and belief, Defendant is estopped from asserting a scope for the claims of the '371 patent sufficient to cover Plaintiff's products because of statements made on behalf of the applicant during the prosecution of the '371 patent before the United States Patent and Trademark Office.

30. Plaintiff has not willfully infringed any claim of the '371 patent.

COUNT III

Declaratory Judgment of Non-Infringement of U.S. Patent No. 6,841,742

31. Plaintiff incorporates by reference, as though fully set forth, the allegations contained in paragraphs 1 through 30 of this Complaint.

32. Plaintiff has not directly infringed, contributed to the infringement of, or induced others to infringe, any claim of the '742 patent either literally or under the doctrine of equivalents.

33. On information and belief, Defendant is estopped from asserting a scope for the claims of the '742 patent sufficient to cover Plaintiff's products because of statements made on behalf of the applicant during the prosecution of the '742 patent before the United States Patent and Trademark Office.

34. Plaintiff has not willfully infringed any claim of the '742 patent.

COUNT IV

Declaratory Judgment of Non-Infringement of U.S. Patent No. 6,326,565

35. Plaintiff incorporates by reference, as though fully set forth, the allegations contained in paragraphs 1 through 34 of this Complaint.

36. Plaintiff has not directly infringed, contributed to the infringement of, or induced others to infringe, any claim of the '565 patent either literally or under the doctrine of equivalents.

37. On information and belief, Defendant is estopped from asserting a scope for the claims of the '565 patent sufficient to cover Plaintiff's products because of statements made on behalf of the applicant during the prosecution of the '565 patent before the United States Patent and Trademark Office.

38. Plaintiff has not willfully infringed any claim of the '565 patent.

COUNT V

Declaratory Judgment of Invalidity of U.S. Patent No. 6,392,330

39. Plaintiff incorporates by reference, as though fully set forth, the allegations contained in paragraphs 1 through 38 of this Complaint.

40. The '330 patent is invalid and unenforceable because, *inter alia*, the '330 patent was not obtained in a manner consistent with and required by the provisions of Title 35 of the United States Code, and in particular because it fails to comply with at least the required conditions for patentability under 35 U.S.C. §§ 102, 103 or 112.

COUNT VI

Declaratory Judgment of Invalidity of U.S. Patent No. 6,624,371

41. Plaintiff incorporates by reference, as though fully set forth, the allegations contained in paragraphs 1 through 40 of this Complaint.

42. The '371 patent is invalid and unenforceable because, *inter alia*, the '371 patent was not obtained in a manner consistent with and required by the provisions of Title 35 of the United States Code, and in particular because it fails to comply with at least the required conditions for patentability under 35 U.S.C. §§ 102, 103 or 112.

COUNT VII

Declaratory Judgment of Invalidity of U.S. Patent No. 6,841,742

43. Plaintiff incorporates by reference, as though fully set forth, the allegations contained in paragraphs 1 through 42 of this Complaint.

44. The '742 patent is invalid and unenforceable because, *inter alia*, the '742 patent was not obtained in a manner consistent with and required by the provisions of Title 35 of the

United States Code, and in particular because it fails to comply with at least the required conditions for patentability under 35 U.S.C. §§ 102, 103 or 112.

COUNT VIII

Declaratory Judgment of Invalidity of U.S. Patent No. 6,326,565

45. Plaintiff incorporates by reference, as though fully set forth, the allegations contained in paragraphs 1 through 44 of this Complaint.

46. The '565 patent is invalid and unenforceable because, *inter alia*, the '565 patent was not obtained in a manner consistent with and required by the provisions of Title 35 of the United States Code, and in particular because it fails to comply with at least the required conditions for patentability under 35 U.S.C. §§ 102, 103 or 112.

DEMAND FOR JURY TRIAL

47. Pursuant to Fed. R. Civ. P. 38, Plaintiff EPOS TECHNOLOGIES LTD. hereby demands a trial by jury of all issues so triable.

PRAYER FOR RELIEF

WHEREFORE, EPOS TECHNOLOGIES LTD. prays for judgment against Defendant as follows:

A. A declaratory judgment that Plaintiff does not infringe, contribute to the infringement of, or induce the infringement of, or willfully infringe, any claim of United States Patent Nos. 6,392,330; 6,724,371; 6,841,742; and 6,326,565;

B. A declaratory judgment that each of the claims of the United States Patent Nos. 6,392,330; 6,724,371; 6,841,742; and 6,326,565 are invalid and unenforceable;

C. That Defendant, its subsidiaries, affiliates, parent, successors, assigns, officers, agents, servants, employees, attorneys, and all persons acting in concert or in participation with them, or any of them, be enjoined from asserting any claim of United States Patent Nos. 6,392,330; 6,724,371; 6,841,742; and 6,326,565 against Plaintiff;

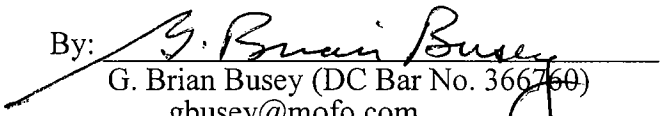
D. That this case be deemed exceptional and that Plaintiff be awarded its reasonable attorneys' fees pursuant to 35 U.S.C. § 285;

E. That Plaintiff be awarded its costs of suit; and

F. That Plaintiff be awarded such other and further relief as the Court deems just and proper.

Dated: March 1, 2007

Respectfully submitted,

By: 

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[1] Motions for pro hac vice admission to the Court's Bar will be forthcoming from Attorneys Press, Gallegos and Scheetz.

US006392330B1

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

(10) **Patent No.: US 6,392,330 B1**
(45) **Date of Patent: May 21, 2002**

(54) **CYLINDRICAL ULTRASOUND RECEIVERS AND TRANSCEIVERS FORMED FROM PIEZOELECTRIC FILM**

(75) Inventors: **Yitzhak Zloter**, Holon; **Gideon Shenholz**, Tel Aviv, both of (IL)

(73) Assignee: **Pegasus Technologies Ltd.**, Azoor (IL)

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

(21) Appl. No.: **09/586,889**

(22) Filed: **Jun. 5, 2000**

(51) **Int. Cl.**[7] **H01L 41/08**
(52) **U.S. Cl.** **310/334**; 310/366; 310/800
(58) **Field of Search** 310/334–337, 310/800, 346, 366, 369

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,816,774	A	*	6/1974	Ohnuki et al.	310/800 X
3,978,353	A	*	8/1976	Kinoshita	310/366
4,170,742	A	*	10/1979	Itagaki et al.	310/800 X
4,706,681	A		11/1987	Breyer et al.	
4,757,821	A		7/1988	Snyder	
4,758,691	A		7/1988	De Bruyne	
4,825,116	A	*	4/1989	Itoh et al.	310/335
4,906,886	A		3/1990	Breimesser et al.	
5,323,082	A	*	6/1994	Wright	310/328
5,339,290	A		8/1994	Greenstein	
5,384,029	A		1/1995	Campbell	
6,239,535	B1	*	5/2001	Toda et al.	310/334

* cited by examiner

Primary Examiner—Mark O. Budd
(74) *Attorney, Agent, or Firm*—Mark M. Friedman

(57) **ABSTRACT**

An ultrasound receiver includes a hollow cylinder formed primarily from flexible piezoeelectric film, the hollow cylinder having an outer surface, an inner surface, a central axis and a height measured parallel to the central axis. A sensing electrode is formed from conductive material applied to the inner surface, while a grounded electrode is formed from conductive material applied to the outer surface. The hollow cylinder is supported by a support structure configured to allow progagation of vibration waves circumferentially around a major part of the hollow cylinder. The sensing electrode is formed as a strip extending in an extensional direction substantially parallel to the central axis along a major part of the height, the strip subtending at the central axis an angle of not more than 90°.

18 Claims, 11 Drawing Sheets

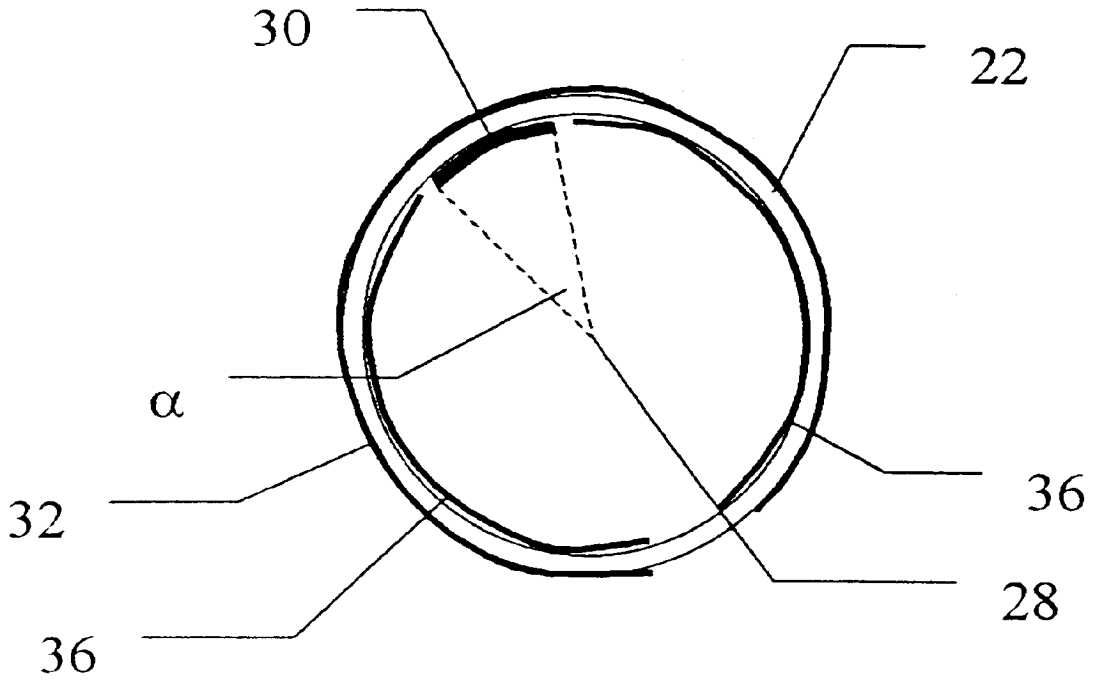


FIG. 1

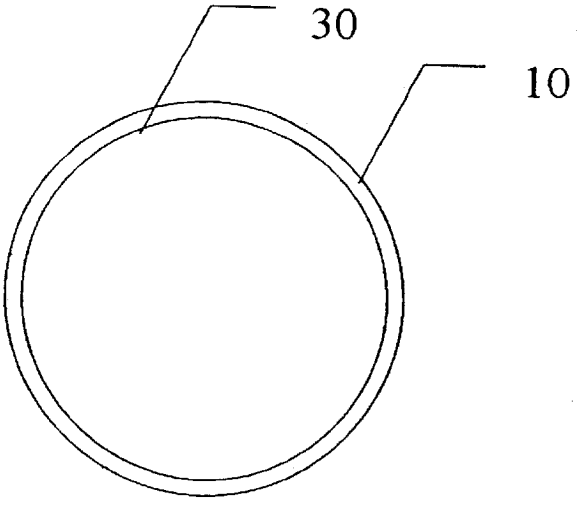


FIG. 2

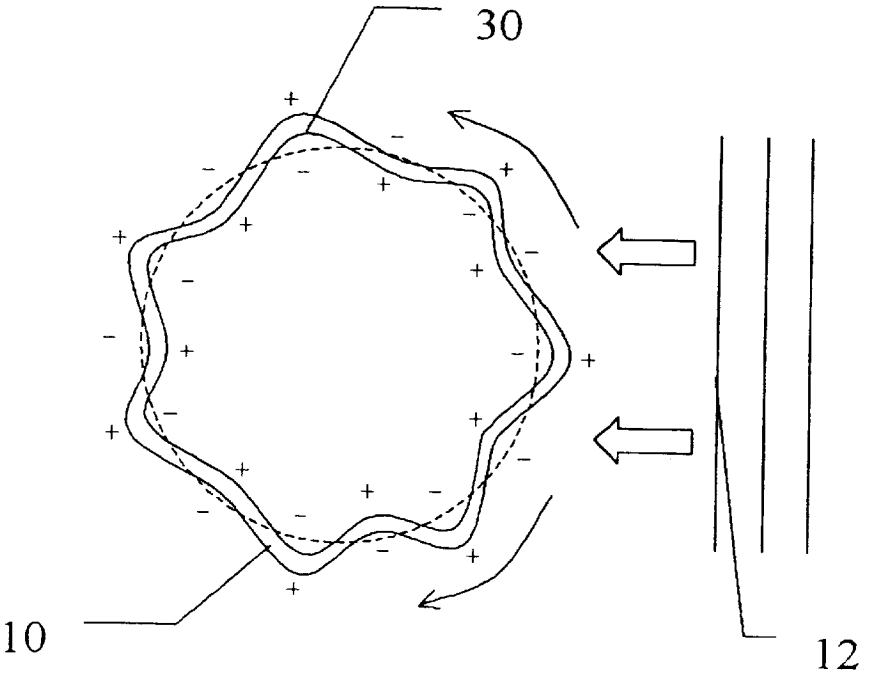


FIG. 3

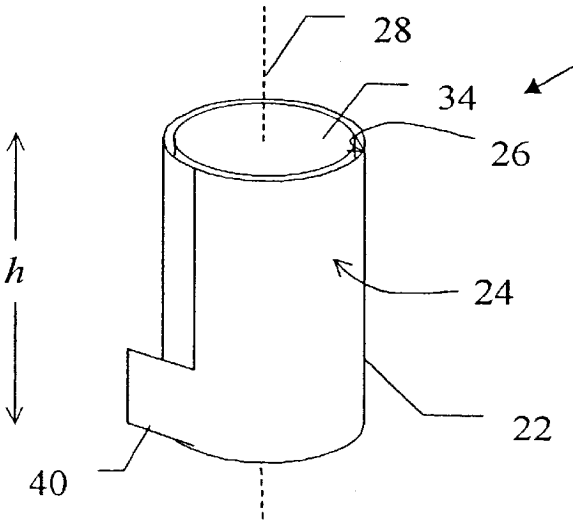


FIG. 4A

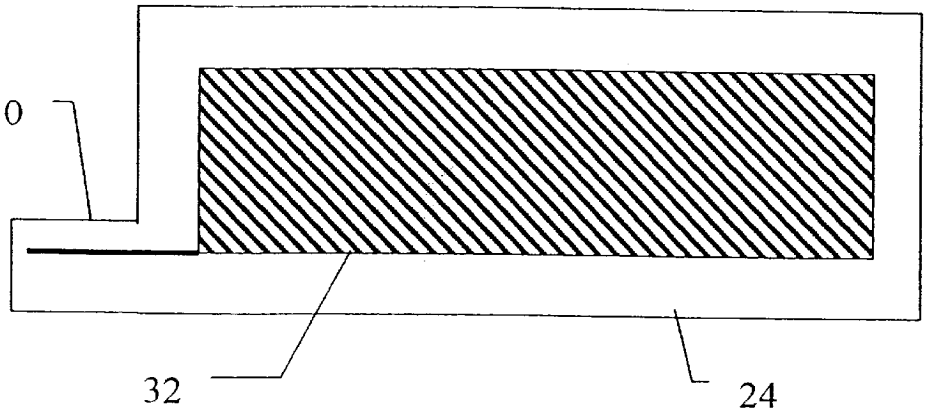


FIG. 4B

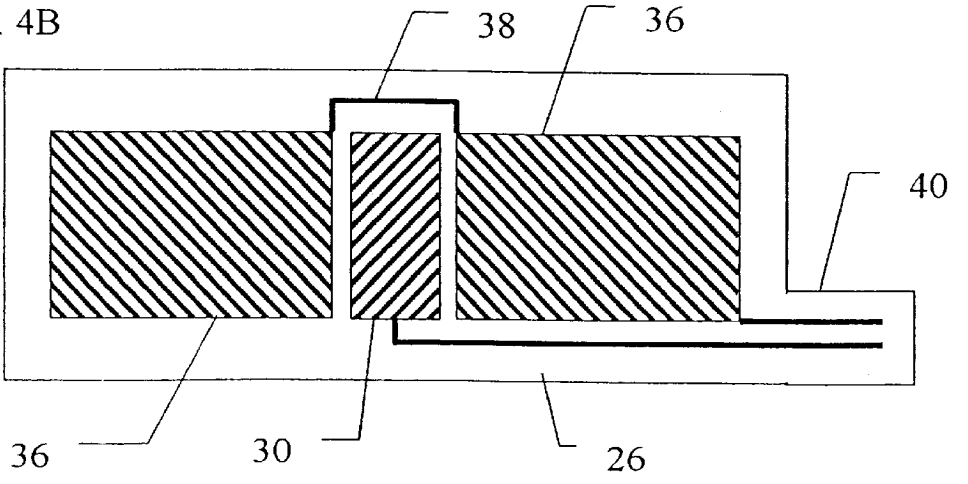


FIG. 4C

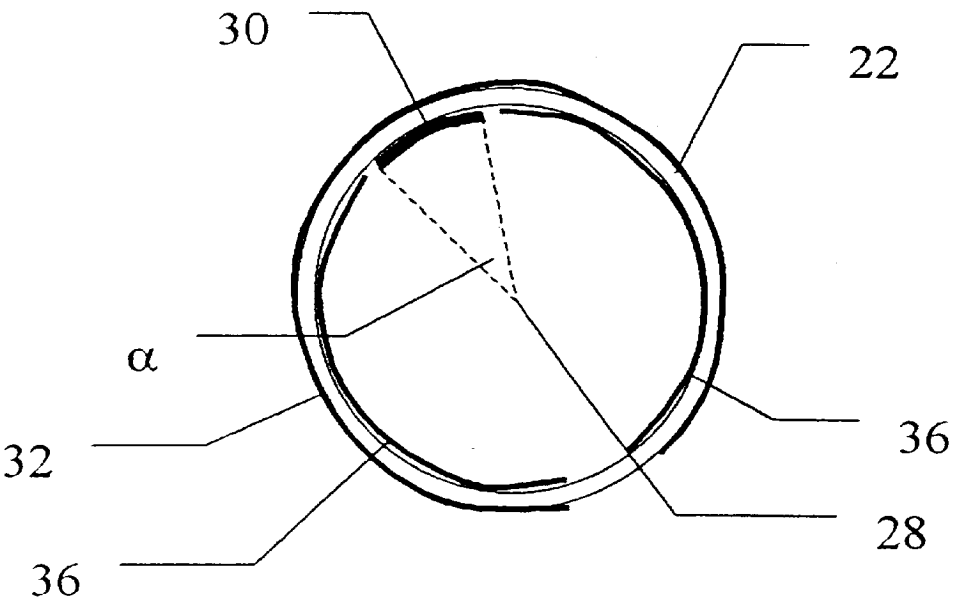


FIG. 5

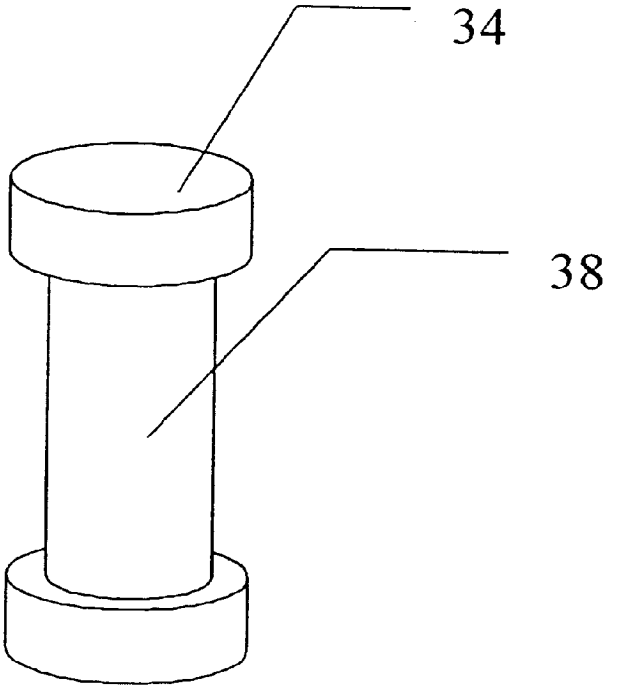
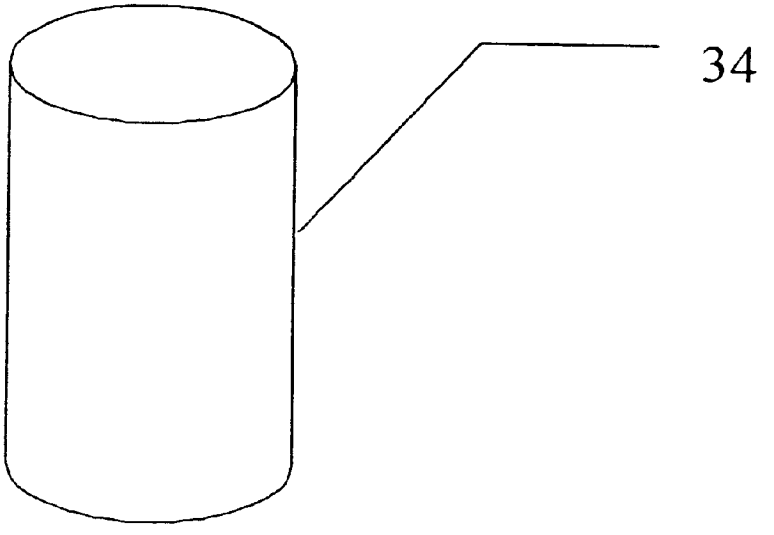


FIG. 6



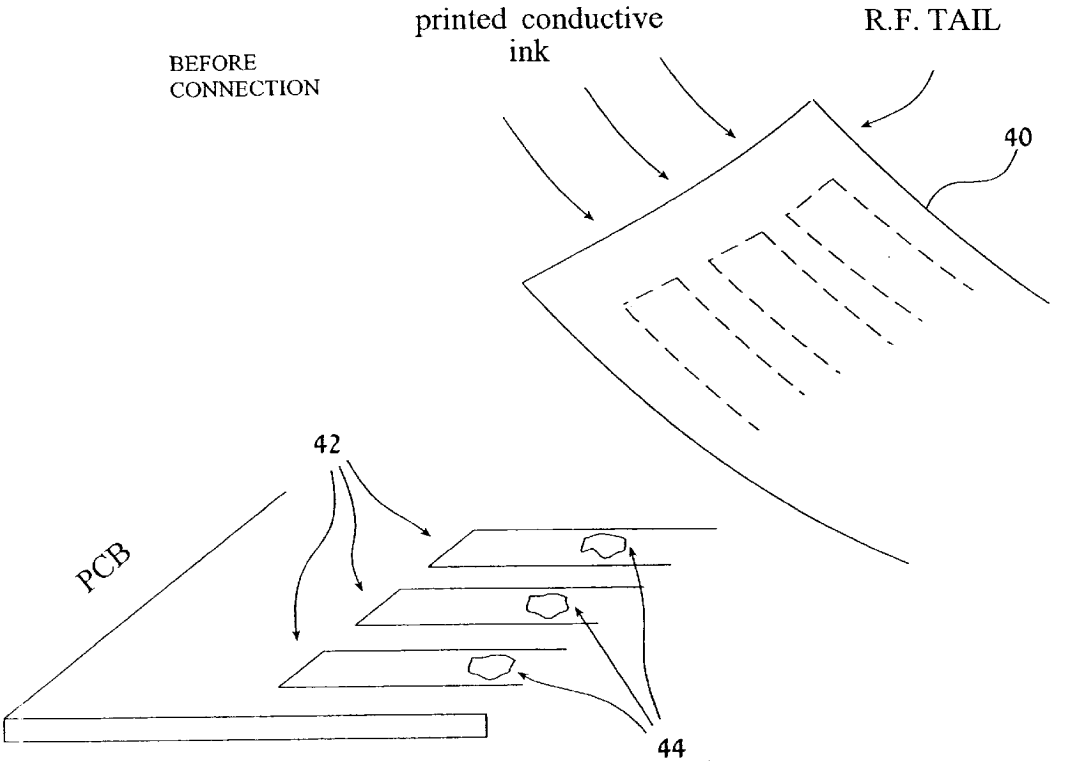

printed conductive ink
R.F. TAIL
BEFORE CONNECTION
40
42
PCB
44

FIG.7A

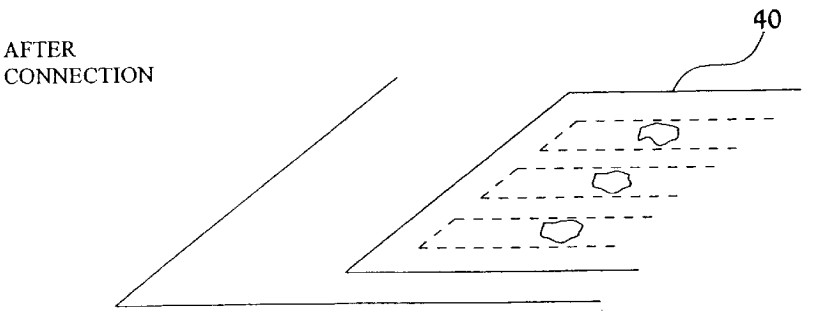

AFTER CONNECTION
40

FIG.7B

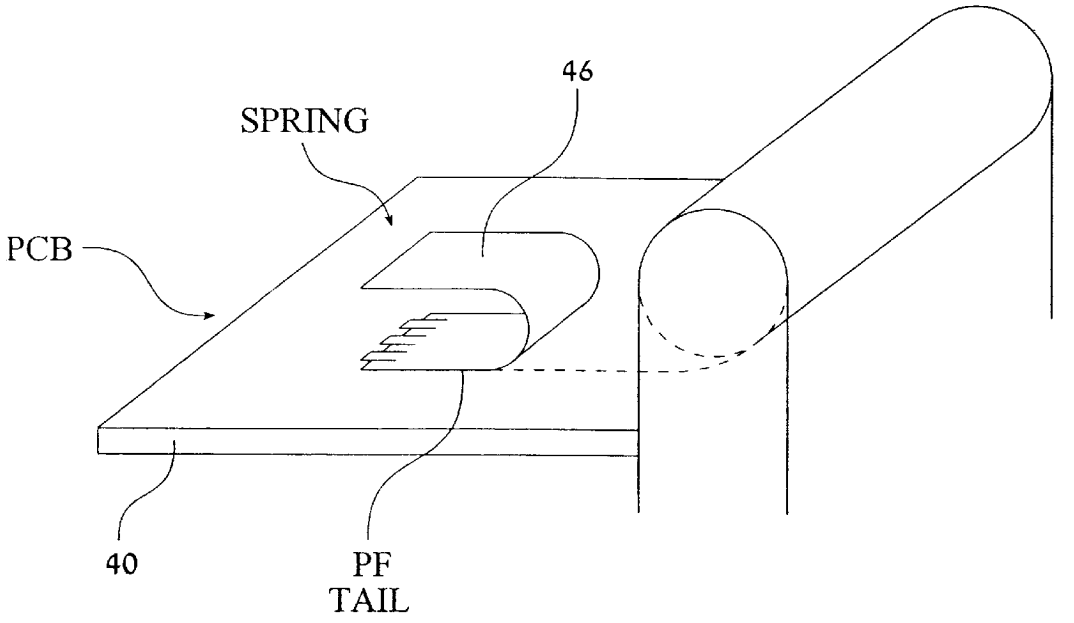


FIG.8

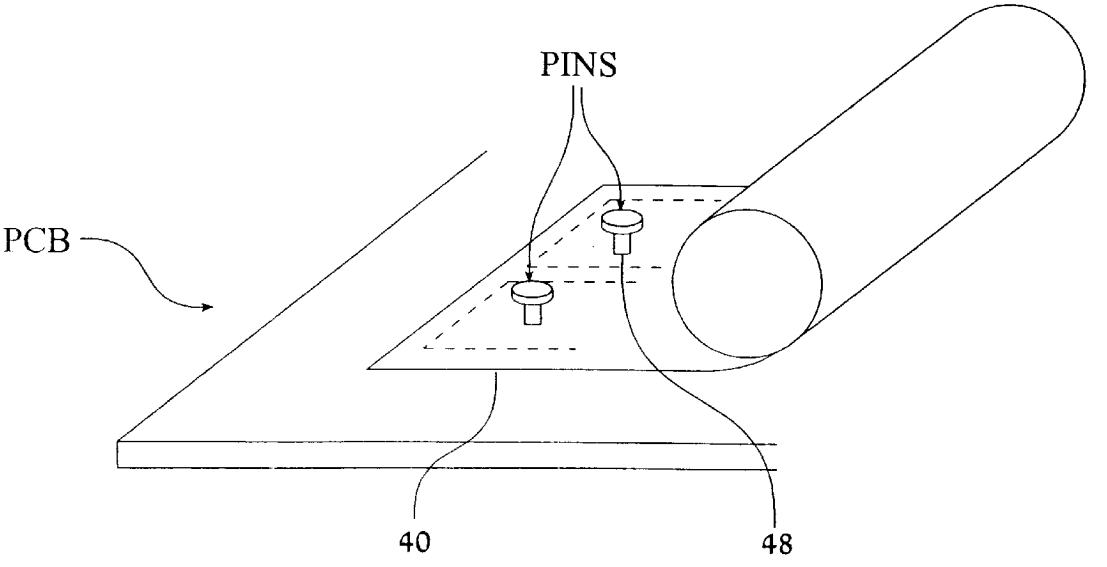


FIG.9

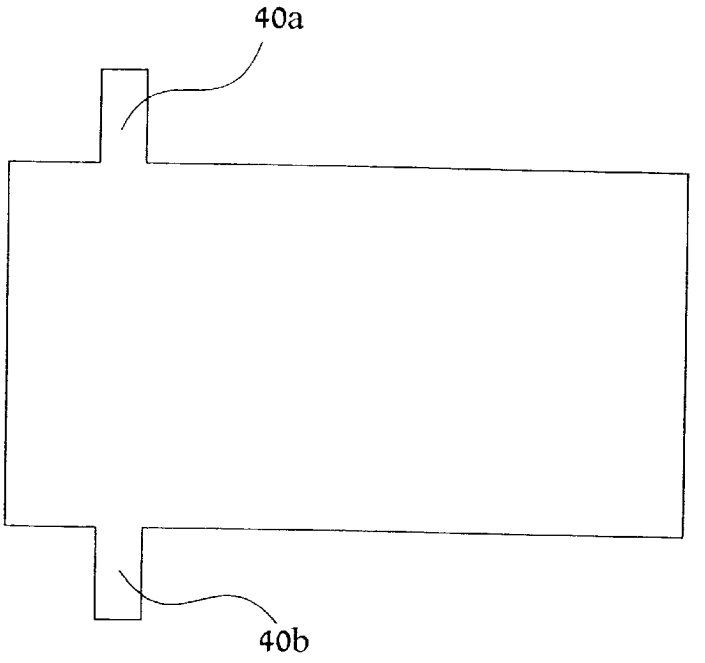


FIG.10A

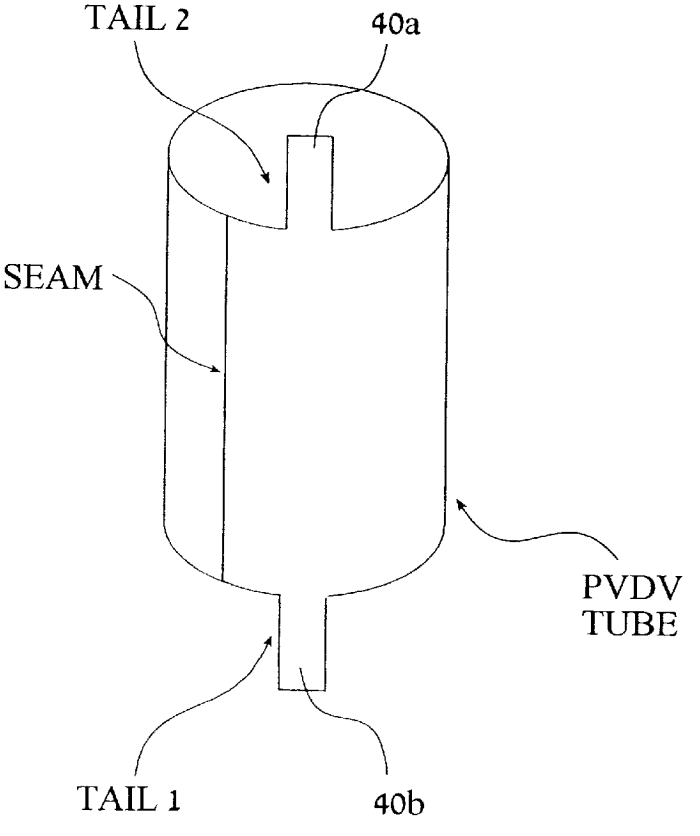


FIG.10B

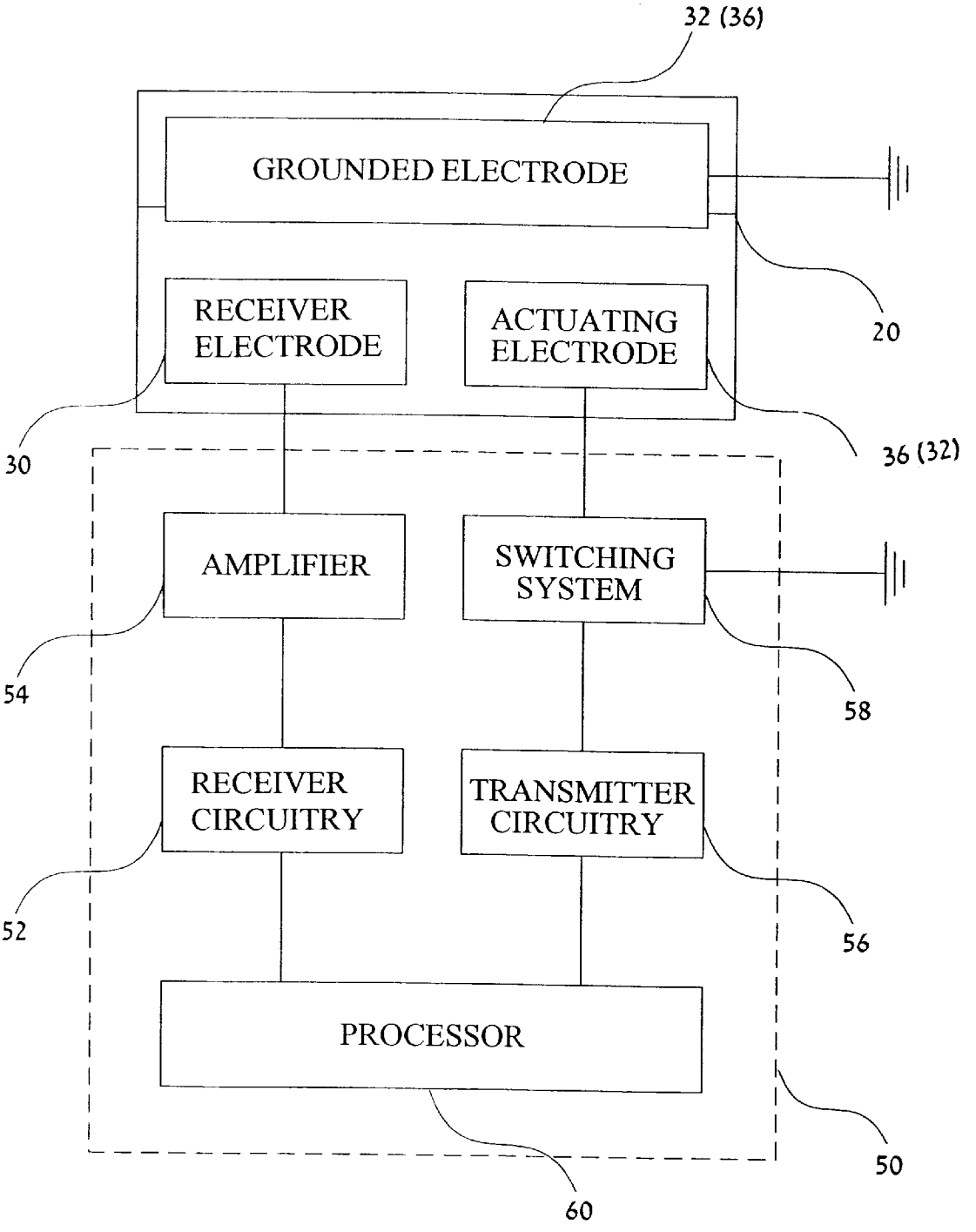

32 (36)
GROUNDED ELECTRODE
20
RECEIVER ELECTRODE
ACTUATING ELECTRODE
30
36 (32)
AMPLIFIER
SWITCHING SYSTEM
54
58
RECEIVER CIRCUITRY
TRANSMITTER CIRCUITRY
52
56
PROCESSOR
50
60

FIG.11

FIG. 12A

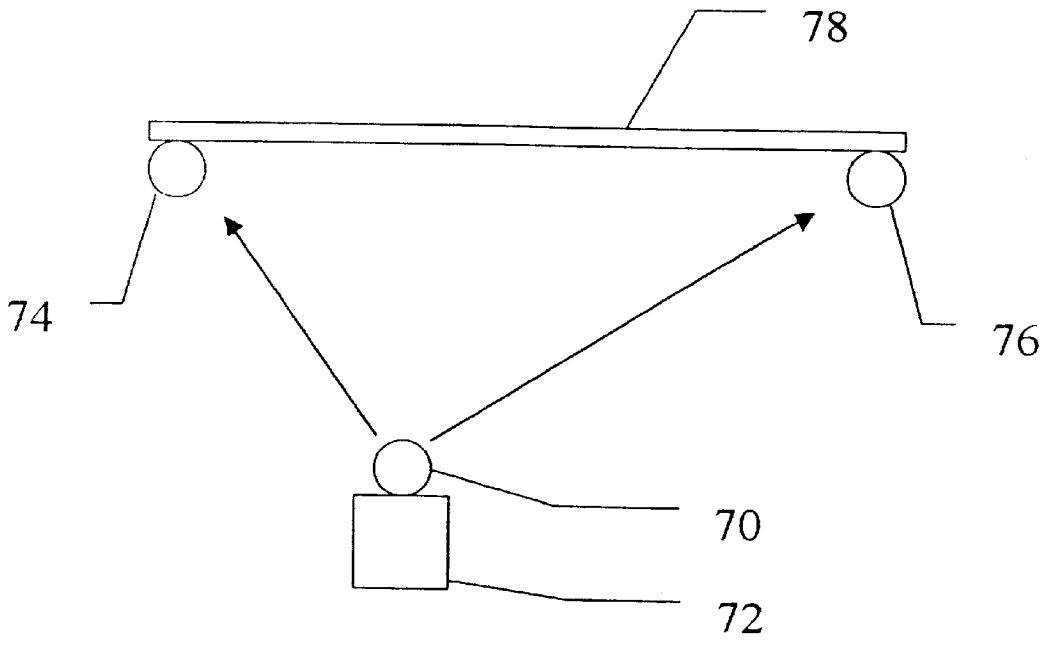


FIG. 12B

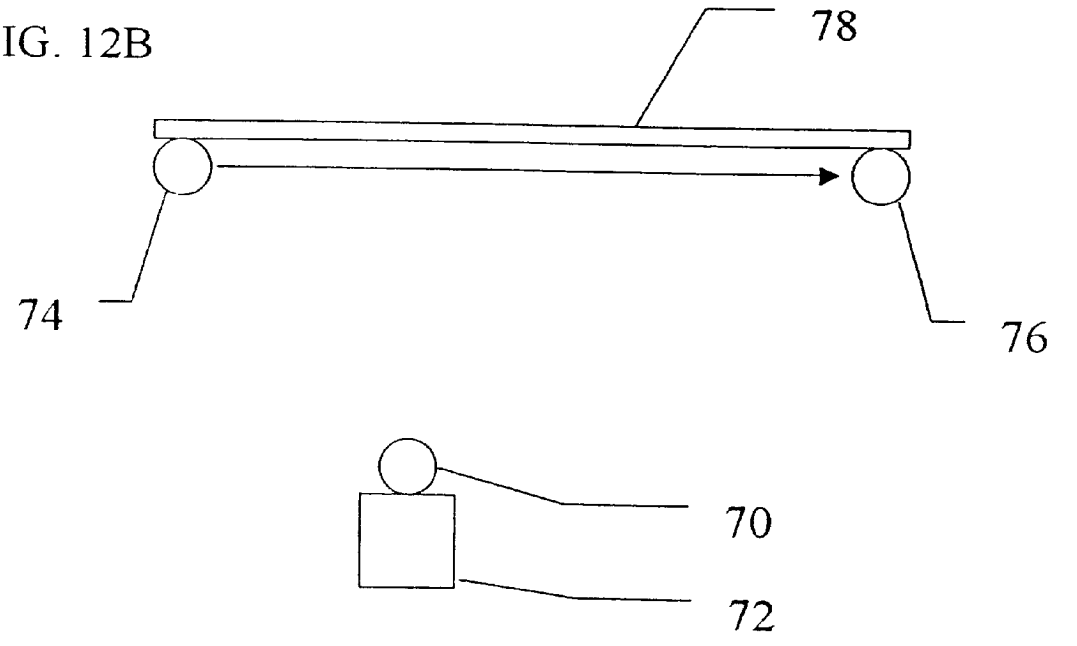


FIG. 13A

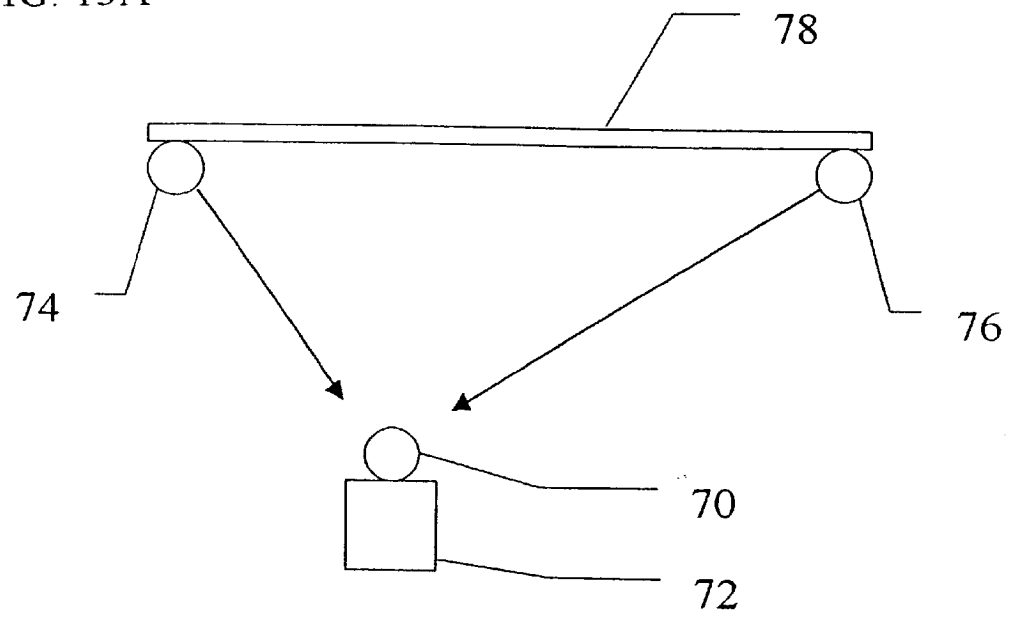


FIG. 13B

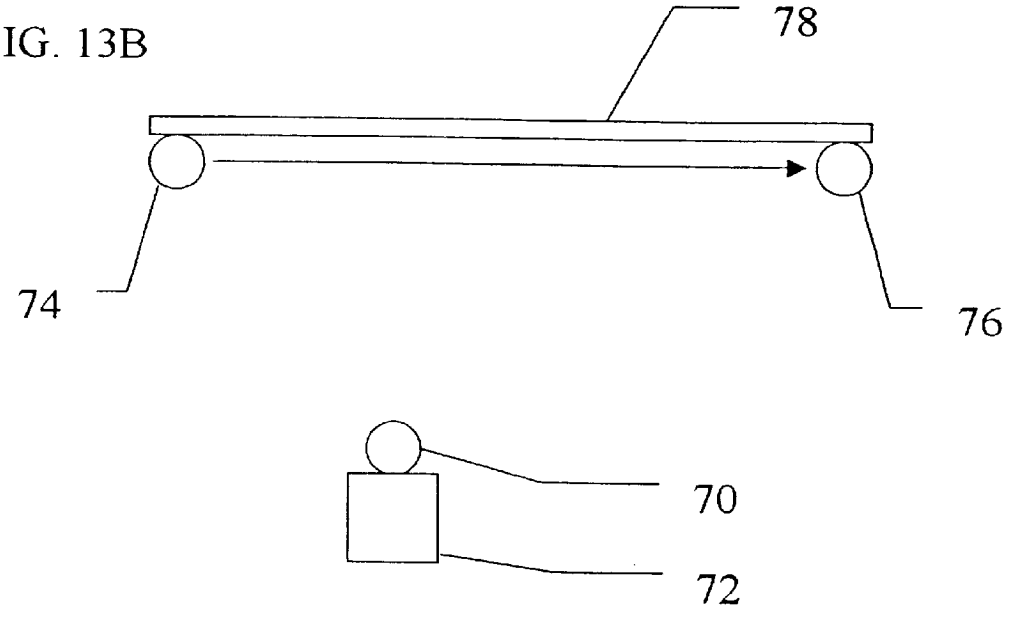
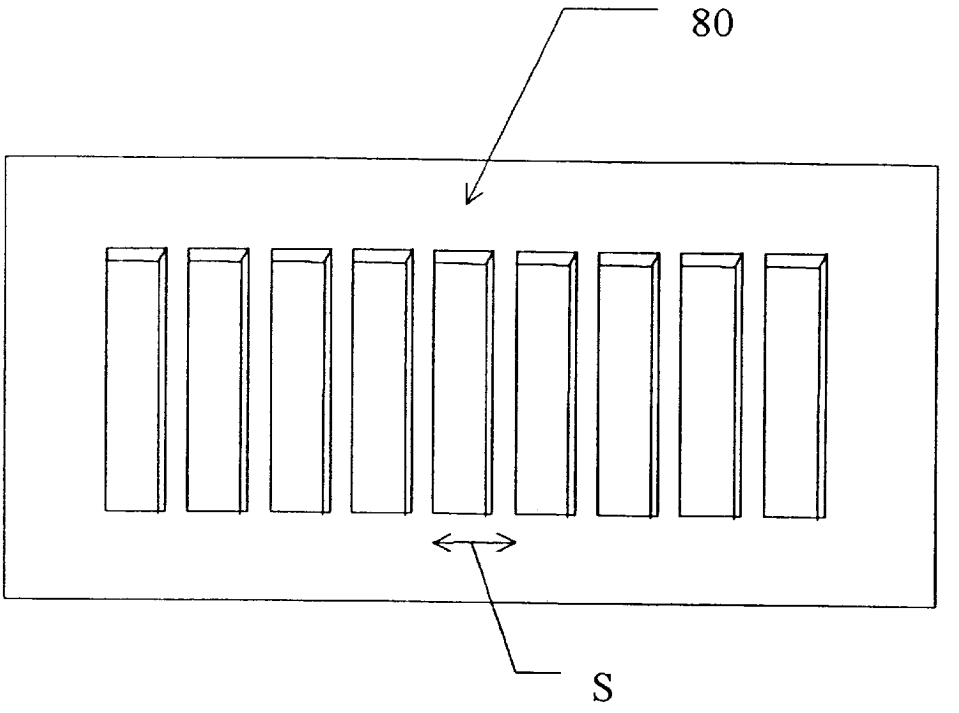


FIG. 14



CYLINDRICAL ULTRASOUND RECEIVERS AND TRANSCEIVERS FORMED FROM PIEZOELECTRIC FILM

FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to ultrasound transducers and, in particular, it concerns cylindrical ultrasound receivers and transceivers formed from piezoelectric films, and their applications in digitizer systems.

It is known to employ cylindrical ultrasound transducers for transmitting ultrasound signals in digitizer systems. The cylindrical form provides all-around signal transmission and simplifies the geometry of time-of-flight calculations by providing an effect similar to a point (or more accurately, line) source. These advantages are detailed in U.S. Pat. No. 4,758,691 to De Bruyne. A further advantage of cynlindrical ultrasound transducers is that they can be centered around an element of which the position is to be measured. This is used in a drawing implement digitizer system described in PCT publication WO98/40838.

Structurally, a number of different types of cylindrical transducer have been proposed. the De Bruyne patent proposes a "Sell transducer" which is capacitive device formed from a complicated arrangement of cylindrical layers intended to produce a cylindrical air gap of about 20 μm. Such a structure is costly to manufacture, and is likely to be unreliable.

A second type of transducer which has been proposed in the field of medical applications is based on piezoelectric elements. An example of a medical transducer of this type may be found in U.S. Pat. No. 4,706,681 to Breyer et al. which discloses an ultrasonic marker. Here, a cylindrical piezoelectric collar is sandwiched between two electrodes. Application of an alternating potenial across the electrodes causes vibration of the collar, and hence emits a radially propagating ultrasonic signal.

In principle, any ultrasonic transducer is capable of being operated both as a transmitter and a receiver. In practice, however, many considerations result in many transmitter structures being ineffective as receivers. This is particurlarly true of cylindrical elements in which almost the entire cylinder contributes to wide angle transmission by actuation with a relatively high power while only a small portion of the cylinder is correctly oriented for receiving an incoming signal from a given direction. Furthermore, the inherent capacitance of the large inactive region of the transducer may absorb a large proportion of the amplitude of a received signal, rendering the transducer insensitive as a receiver.

In the field of transducers in general, much work has been invested in development of devices based on piezoelectric films, such as PVDF. Conductive electrodes are formed on opposite faces of the film, typically by selectively printing conductive ink on regions of the surfaces. These films are cheap to produce, and withstand a wide range of operating conditions including exposure to moisture.

Although a cylindrical ultrasound transducer is relatively simple to implement using piezoelectric film, implementation of a receiver poses additional problems beyond the general complications of cylindrical receivers discussed above. Specifically, referring to FIGS. **1** and **2**, there is shown a schematic plan view of a freely suspended cylinder **10** formed from piezoelectric film. FIG. **1** shows its relaxed state, while FIG. **2** shows the response of cylinder **10** to an incoming ultrasound signal wave front **12**. Since the piezoeletric film is flexible, the oscillations of signal **12** generate

waves (exaggerated for clarity) traveling around cylinder **10**. The direction and extent of flexing of the piezoelectric film varies along the wave form created around the cylinder, resulting in reversal of the sense of an electrical potential generated between the electrodes. As a result, much of the potential generated by the piezoelectric film may be dissipated in local eddy currents within the electrodes, greatly reducing the overall signal voltage as measured between the electrodes.

A further problem of implementing a cylindrical ultrasound transducer using pieoelectric film is the tendency for the electrode to act as an antenna picking up unwanted electromagnetic radiation which may result in very low signal to noise ratios.

There is therefore a need for a cylindrical ultrasound receiver structure employing pieoelectric film.

SUMMARY OF THE INVENTION

The present invention is a cylindrical ultrasound receiver structure employing pieoelectric film.

According to the teachings of the present invetnion there is provided, an ultrasound receiver comprising: (a) a hollow cylinder formed primarily from flexible pieoelectric film, the hollow cylinder having an outer surface, an inner surface, a central axis and a height measured parallel to the central axis; (b) a sensing electrode formed from conductive material applied to the inner surface; (c) a grounded electrode formed from conductive material applied to the outer surface; and (d) a support structure for supporting the hollow cylinder, the support structure being configured to support the hollow cylinder in such a manner as to allow propagation of vibration waves circumferentially around a major part of the hollow cylinder, wherein the sensing electrode is formed as a strip extending in an extensional direction substantially parallel to the central axis along a major part of the height, the strip subtending at the central axis an angle of not more than 90°.

According to a further feature of the present invention, the strips subtends at the central axis an angle of not more than 30°.

According to a further feature of the present invention, the grounded electrode extends over a major part of the outer surface.

According to a further feature of the present invention, there is also provided at least one additional electrode formed conductive material applied to the inner surface in pattern non-contiguous with the sensing electrode.

According to a further feature of the present invention, the at least one additional electrode extends over a major part of the inner surface.

According to a further feature of the present invention, the at least one additional electrode is grounded.

According to a further feature of the present invention, configured for use additionally as an ultrasound transmitter, thereby serving as an ultrasound transceiver, the ultrasound transceiver further comprises a control module including: (a) receiver circuitry electrically connected to the sensing electrode; (b) transmitter circuitry; and (c) a switching system associated with an actuating electrode selected from the grounded electrode and the additional electrode and configured to alternately electrically connect the actuating electrode to the transmitter circuitry and to ground.

According to a further feature of the present invention, the support structure includes a conductive core element deployed within the hollow cylinder in such a manner as to

avoid electrical contact with the sensing electrode, the conductive core element being electrically grounded. According to one preferred implementation, the conductive core element is a metal core element. According to an alternative omplementation, the conductive core element is formed from conductive foam.

According to a further feature of the present invention, the flexible piezoelectric film is implemented as PVDF film. p According to a further feature of the present invention, the sensing electrode and the grounded electrode are implemented as substantially transparent electrodes.

There is also provided according to the teachings of the present invention, a method for operating an ultrasound transceiver for receiving and transmitting ultrasound signals, the method comprising the steps of: (a) providing an ultrasound transceiver structure including: (i) a hollow cylinder formed primarily from flexible piezoelectric film, the hollow cylinder having an outer surface, an inner surface, a central axis and a height measured parallel to the central axis, the hollow cylinder being mounted so as to allow propagation of vibration waves circumferentially around a major part of the hollow cylinder, (ii) a sensing electrode formed from conductive material applied to the inner surface, the sensing electrode being formed as a narrow strip extending in an extensional direction substantially parallel to the central axis along a major part of the height, the strip subtending at the axis an angle of not more than 90°, (iii) at least one additional inner electrode formed from conductive material applied so as to extend over a major part of the inner surface in a pattern non-contiguous with the sensing electrode, and (iv) at least one outer electrode formed from conductive material applied so as to extend over a major part of the outer surface; (b) receiving ultrasound signals by: (i) connecting both the additional inner electrode and the outer electrode to ground, and (ii) electrically connecting the sensing electrode to receiver circuitry; and (c) transmitting ultrasound signals by applying a driving voltage to at least one of the additional inner electrode and the outer electrode.

There is also provided according to the teachings of the present invention, a method for operating a system for determining the position of a movable element, the system including a first group of movable ultrasound transducer including al least one ultrasound trandsducer associated with a movable element and a second group of fixed ultrasound transducers including at least two ultrasound transducers maintained in fixed geometrical relation by attachment to a base unit, the method for operating including: (a) operating the system in a measurement mode in which: (i) one of the first and second groups of ultrasound tranducers trnasmits at least one measurement signal which is received by ultrasound transducers in the other of the first and second groups, and (ii) a position of the movable element is derived from time-of-flight measurements for the at least one measurement signal; and (b) intermittently operating the system in a calibration mode in which: (i) at least one ultrasound transducer from the second group transmits a calibration signal and at least one other ultrasound transducer from the second group receives the calibration signal, and (ii) calibration information is derived from time-of-flight measurements for calibration signal.

According to a further feature of the present invention, at least one ultrasound transducer from the second group is implemented as the aforementioned cylindrical ultrasound transducer structure.

There is also provided according to the teachings of the present invention, a method for providing mechanical protection for an ultrasound transducer used for a given frequency of ultrasound signals while minimizing interference with the ultrasound signals, the method comprising positioning a protective grating adjacent to the transducer, the grating having plurality of openings spaced at a spatial frequency of less than about half, and preferably less than about a quarter, of the wavelength of the given frequency of ultrasound in air. For a cylindrical transducer, the grating is preferably configured as a cylindrical grating surrounding the transducer.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

FIG. **1** is a schematic plan view of a freely suspended cylinder formed from piezoelectric film in its relaxed state;

FIG. **2** is a schematic view of the cylinder of FIG. **1** when exposed to an ultrasonic signal;

FIG. **3** is an isometric view of a cylindrical ultrasound transceiver, constructed and operative according to the teachings of the present invention;

FIGS. **4**A and **4**B are plan views of the outer and inner surfaces, respectively, of a piezoelectric film employed in the cylindrical ultrasound transceiver of FIG. **1**, showing the form of electrode patterns applied to each surface;

FIG. **4**C is a schematic plan view of the film of FIGS. **4**A and **4**B in its cylindrical configuration;

FIG. **5** is a isomatic view of metallic core element from the cylindrical ultrasound transceiver of FIG. **1**;

FIG. **6** is an isomatic view of a conductive foam core element which may be used as an alternative to the core element of FIG. **5**;

FIGS. **7**A and **7**B are schematic isomatic views illustrating a first technique for forming electrical contacts with the cylindrical ultrasound transceiver of FIG. **1**, employing conductive adhesive;

FIG. **8** is a schematic isomatic view of illustrating a second technique for forming electrical contacts with the cylindrical ultrasound transceiver of FIG. **1**, employing spring connections;

FIG. **9** is a schematic isomatic view illustrating a third technique for forming electrical contacts with the cylindrical ultrasound transceiver fo FIG. **1**, employing pins;

FIG. **10**A is a schematic plan view of a piezoelectric film for use in the cylindrical ultrasound transceiver of FIG. **1**, showing an alternative configuration of connections tabs;

FIG. **10**B is a schematic isomatic view showing the film of FIG. **10**A rolled into its cylindrical form;

FIG. **11** is a block diagram illustrating the main components of a transceiver assembly including the cylindrical ultrasound transceiver of FIG. **1**;

FIG. **12**A is a schematic representation of the operation of a system for determining the position of a movable element, constructed and operative according to the teachings of the present invention, operating in a primary mode of operation;

FIG. **12**B is a schematic respesentation of the operation of the system of FIG. **12**A while performing a self-calibration operation;

FIG. **13**A is a schematic representation of the operation of an alternative system for determining the position of a movable element, constructed and operative according to the teachings of the present invention, operating in a primary mode of operation;

FIG. **13**B is a schematic respresentation of the operation of the system of FIG. **13**A while performing a self-calibration operation; and

FIG. **14** is a schematic isomatic view of a protective grating, constructed and operative according to the teachings of the present invention, for use with ultrasound transducers.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is a cylindrical ultrasound receiver or transceiver formed from piezoelectirc films. The invention also provides applications of such transceivers in digitizer systems.

The principles and operation of receivers and transceivers according to the present invention may be better understood with reference to the drawings and the accompanying description.

Referring now to the drawings, FIGS. **3–11** illustrate various aspects of an ultrasound receiver, generally designated **20**, and its associated assembly, constructed and operative according to the teachings of the present invention.

Generally speaking, receiver **20** includes a hollow cylinder **22**, formed primarilty from flexible piezoelectric film, having an outer surface **24**, an inner surface **26**, a central axis **28** and a height h measured parallel to axis **28**. Applied to inner surface **26** is a sensing electrode **30** formed from conductive material. A grounded electrode **32** is formed from conductive material applied to the outer surface **24**. Cylinder **22** is supported by a support structure, represented here by a core element **34**, configured to support the hollow cylinder in such a manner as to allow propagation of vibration waves circumferentially around a major part of cylinder **22**.

It is a particular feature of most preferred implementations of the present invention that sensing electrode **30** is formed as a strip extending in an extentional direction substantially parallel to central axis **28** along a major part of height h and subtending at central axis **28** an angle α of not more than 90° (see FIG. **4**C). The dimension of strip **30** is preferably chosen such that it corresponds to less than about ¼ wavelength of the vibrations in cylinder **22** induced by ultrasound vibrations of the intended working frequency. In most cases, the dimensions are chosen such that cylinder **22** supports only about 1 wavelength of the vibrations (rather than the about three wavelengths illustrated schematically in FIG. **2**) so as to minimize interference effects and the like. As a result, phase canceling problems can largely be avoided so long as strip **30** subtends an angle α of less than 90° at axis **28**. Preferably, however, the width of strip **30** is typically chosen to subtend an angle α of between about 20 and 30° at axis **28**.

The principal of operation of receiver **20** may be appreciated by referring back FIGS. **1** and **2**. As described above, incident pressure waves tend to induce vibration waves which propagate around the periphery of the cylinder. As a result, an arbitrarily positioned localized sensor on the surface of the cylinder experiences substantially the same vibrations substantially independent of the direction from which the pressure waves are incident. At the same time, since the circumferential extent of sensing electrode **30** is small relative to the wavelength of the vibrations propagation through the film, the aforementioned problems of phase canceling and large capacitance are avoided. The result is a highly effective, wide angle ultrasound receiver. These and other advantages of the configuration of the present invention will become clearer from the following more detailed description.

With regard to materials, it should be noted that the present invention may be implemented using any piezoelectric film material and suitable conductive electrode material. A particularly preferred example for the film itself is PVDF. The direction of polarization should be oriented circumferemtially around the cylinder. The use of such films provides particular advantages due to its wide frequency-band response. Specifically, it has been found that conventional narrow frequency-band receivers based on piezoceramics tend to shift signal noise into the frequency range of measurement, drastically reducing the signal-to-noise ratio. In contrast, the wide frequency-band receivers of the present invention, used in combination with subsquent filtering to indentify the signal of interest, have been found to provide a greatly enhanced signal-to-noise ratio.

Suitable conductive materials for the electrodes include, but are not limited to, compositions containing carbon, silver and gold. In applications in which a transparent structure is required, a transparent conductive material is used.

As mentioned easrlier, one major problem associated with implementation of a cylindrical ultrasound transducer using pieozelectric film is the tendency of the electrodes to function as an antenna for electromagnetic (EM) radiation. To minimize or eliminate this problem, preferred implementations of the present invention include one or more features which help shield sensing electrode **30** from EM radiation, as will now be detailed.

Firstly, grounded electrode **32** preferably extends over a major part of outer surface **24** of the film. This forms a conductive shell around sensing electrode **30**, thereby tending to exclude EM fileds from the contained volume. This, incidentally, is the reason it is preferred to position sensing electrode **30** on the inner surface of the film rather than externally thereto.

Additional shielding is preferably offered by providing at least one additional grounded electrode **36** formed from conductive material applied to the inner surface in a pattern non-contiguous with the sensing electrode. Preferably, additional electrode **36** extends over a major part of inner surface **26**. Where two or more separate regions are required, they may advantageously be electrically connected by a bridge portion **38** of the conductive material, such as is shown in FIG. **4**B.

A further or alternative contribution to EM shielding is preferably provided by employing an electrically grounded conductive core element **34** disposed within cylinder **22** in such a manner as to avoid electrical contact with sensing electrode **30**. Core element **34** is typically, although not necessarily, part of the support structure for cylinder **22**.

FIG. **5** shows one preferred implementation of core element **34** as a metal core element, which may be solid as shown or hollow. In order to ensure that the film cylinder **22** is free to vibrate, core element **34** is here formed with a reduced diameter portion **38** over a major part of its height. In certain cases, the non-contact regions defined by reduced diameter portion **34** may be sufficient to avoid electrical contact with sensing electrode **30**. Alternatively, an additional insulating layer may be interposed between core element **34** and sensing electrode **30**.

FIG. **6** shows an alternative implementation of core element **34** formed from conductive foam. in this case, contact between core element **34** and cylinder **22** typically does not significantly interfere with propagation of vibrations within cylinder **22**. In this case, an additional insulating layer is generally required between core element **34** and sensing electrode **30**.

In order to make use of receiver **20**, appropriate electrical connections must clearly be made between the various electrodes and the appropriate electrical components of the associated circuitry (to be addressed below). It is noted that a wide range of effective connection configurations are known in the art of piezoelectric device design. For completeness, however, brief reference will be made to a number of connection configurations which are believed to be particurarly advantageous.

Firstly, with reference to FIGS. **3**, **4**A and **4**B, it is noted that a preferred form cylinder **22** is configured such that a tab **40**, carrying all the electrical contacts, projects thereform. Three techniques for connecting these contacts to corresponding contacts of a PCB are illustrated in FIGS. **7**A–**7**B, FIG. **8** and FIG. **9**, respectively.

According to the technique of FIGS. **7**A and **7**B, tab **40** is aligned with, and pressed against, the corresponding contacts **42** of the PCB which have been prepared by depositing a drop of a conductive glue **44** on each.

According to the technique of FIG. **8**, tab **40** is forced between the PCB and one or more spring element **46**. Electrical contacts are provided on one, or typically both, of the PCB and the spring.

According to the technique of FIG. **9**, a number of conductive pins **48** are inserted through the contact portions of tab **40** and engage corresponding contact sockets on the PCB.

Turning briefly to FIGS. **10**A and **10**B, there is shown an alternative configuration of the piezoelectric film in which contact tabs **40***a* and **40***b* extend axially from cylinder **22** rather than tangentially. In other respects, this configuration is fully analogous to that of FIGS. **3**–**4**.

Although device **20** has been described thus far as an ultrasound receiver, the same structure is highly suited for use in a transceiver system, i.e., for both receiving and transmitting signals, as will now be described. Referring back to FIG. **4**B, it will be noted that additional electrode(s) **36** preferably cover a large proportion of surface **26** opposite grounded electrode **32**. Thus, a driving potential applied between these two electrodes is highly effective to generate an unltrasound signal, similar to the operation of a conventional cylindrical ultrasound transmitter.

As mentioned earlier, it is advantageous that both grounded electrode **32** and additional electrode(s) **36** are grounded for shielding purposes during reception of ultrasound signals. In order to maintain this advantage, a switching system may be used to selectively switch connection of one of the grounded electrodes to transmitter circuitry when transmission is required.

Thus, referring to FIG. **11**, there is shown a representation of a transceiver assembly employing device **20**. The transceiver assembly further includes a control module **50** having receiver circuitry **52** electrically connected to sensing electrode **30**, typically via an amplifier **54**. Control module **50** also includes tranmitter circuitry **56**, and a switching system **58**. Switching system **58** is associated with either grounded electrode **32** or additional electrode **36** which serves as an actuating electrode, alternately connecting it to the transmitter circuitry for transmission and to ground during reception. The entire assembly is typically operated under control of a processor **60**, details of which are not essential to the present invention.

In operation, when the assembly is being used for reception, both additional electrode **36** and outer electrode **32** are connected to ground, thereby offering the maximum available EM shielding. When transmission is required, a driving voltage is applied to either grounded electrode **32** or additional electrode **36** to generate the desired signal.

It should be noted at this point that many variations and refinements may be made within the scope of the principles of the present invention. By way of example, it should be noted that receiver **20** may employ more than one sensing electrode **30** spaced around cylinder **22**. This may be useful for a number of reasons. Firstly, by analyzing the detected signals separately and identifying phase differences between the signals, it is possible to derive approximate direction information from measurements at a single receiver. Alternatively, in an example in which the wavelength is short compared to the size of cylinder **22**, it may be possible to chose the spacing of a number of commonly connected sensing electrodes to achieve inherent tuning of the receiver to frequencies of interest. In other words, if the spacing corresponds to in-phase spacing around cylinder for a given frequency, the signals from each sensing electrode will have the same sign and will add up to an increased amplitude. At many other frequencies, some degree of cancellation will occur as was described in the context of FIG. **2** above.

As mentioned earlier, cylinder **22** is preferably configured so that is supports only about a single wavelength of the vibration waves within the piezoelectric film induced by ultrasound signals at the working frequency. More specifically, half of the circumference ($\pi D/2$) is preferably equal to the wavelength of the vibration waves within the film. For this reason, the diameter of the cylinder is generally chosen to be inversely porportional to the intended working frequency. By way of example, for a working frequency of 90 kHz, a cylinder of diameter about 5 mm is generally preferred.

Turning now to FIGS. **12**A–**13**B, it should be noted that the transceiver functionally of the transducers of the present invention are particularly useful for implementing a self-calibration mode according to another aspect of the present invention which offers increased precision and reliability in a system for determining the position of a movable element.

By way of introduction, it should be noted that ultrasound time-of-flight based digitizer systems suffer from problems of accuracy due to significant variations in the speed of sound through air which result from changes in temperature, pressure or humidity. In order to compensate for such variations, the present aspect of the present invention provides a self-calibration facility which will now be described.

Turning first to FIG. **12**A, there is shown schematically a system for determining the position of a movable element, including a movable ultrasound transducer **70** associated with a movable element **72** and at least two ultrasound transducers **74**, **76** maintained in fixed geometrical relation by attachment to a base unit **78**. In the case illustrated here, the normal measurement mode of the system includes transmitting at least one measurement signal from movable ultrasound transducer **70** which is received by fixed ultrsound transducers **74** and **76**. A position of movable element **72** is then derived using time-of-flight measurements for the ultrasound measurement signal.

According to the teachings of the present invention, the system is also intermittently operated in a calibration mode in which transducer **74** switches from its normal receiving function to transmitting, sending out a calibration signal which is received by transducer **76**. Since the distance between transducers **74** and **76** is a fixed value defined by the structure of base unit **78**, time-of-flight measurments for the calibration signal can be used to derive calibration information indicative of variations in the speed of sound in the

enviroment within which the system is currently operating. This calibration information is then used to correct the derivation of the position of movable element **72**.

Referring briefly to FIGS. **13**A and **13**B, these illustrate an implementation of this aspect of the present invention for a system where movable transducer **70** functions as a receiver for receiving signals transmitted by fixed transducers **74** and **76**. In this case, the calibration mode is implemented by momentarily emplying transducer **76** as a receiver to receive a calibration signal trnasmitted by transducer **74**. In all other respects, the principles of the invention remain as before.

Turning now to FIG. **14**, there is shown a protective grating, generally designated **80**, constructed and operative according to the teachings of a further aspect of the present invention, for use to provide mechanical protection for an ultrasound transducer.

Mechancial protection must often be provided for transducers, particularly those using piezoelectric films which are easily damaged. Many existing transducer structures suffer from significant signal distortion and/or "blind spots" (i.e., directions in which transmitted intensity or sensitivity of reception are significantly impaired) due to the presence of various protective structures in front of the transducer.

To minimize or eliminate such problems, the present invention provides a protective grating structure **80** in which a periodic pattern of openings has a spatial period S of no more than $\lambda/2$, and preferably no more than 80 /4, where λ is the wavelength of the ultrasound working frequency in air. By using a grating with a grating step S significantly smaller than existing systems, little or no directional disruption is caused to the ultrasound signals. By way of a practical example, for a working frequency of 90 kHz, corresponding to a wavelength in air of about 4 mm, a grating step of 1.9 mm has been found to offer minimal disruption to the transmission and reception of signals.

To minimize attenuation of the signal, the proportion of the grating which is open is preferably maximized, subject to the mechanical requirements for the structure. In the aforementioned example, the open area of the grating is preferably at least about 70% of the total area within each frating step.

Although shown here schematically in the form of a rectangular grating, grating **80** may clearly be implemented in a range of different forms to suit each particular application. Thus for a cylindrical transducer, such as those described above, grating **80** is preferably implemented as a cylindrical outer sleeve having openings with periodic spacing S.

Specifically for trnasducers associated with the writing point of a writing implement, it should be noted that all components of transducer **20** and grating **80** are preferably implemented as substantially transparent elements (using transparent conductive material for the electrodes and transparent plastics or the like grating **80**) to the extent that the ultrasound transducer can be located very close to, and surround, the writing tip without obscuring the user's view of the tip.

It will be appreciated that the above descriptions are intended only to serve as examples, and that many other embodiments are possible within the spirit and the scope of the present invention.

What is claimed is:

1. An ultrasound receiver comprising:

(a) a hollow cylinder formed primarily from flexible piezoelectric film, said hollow cylinder having an outer surface, an inner surface, a central axis and a height measured parallel to said central axis;

(b) a sensing electrode formed from conductive material applied to said inner surface;

(c) a grounded electrode formed from conductive material applied to said outer surface; and

(d) a support structure for supporting said hollow cylinder, said support structure being configured to support said hollow cylinder in such a manner as to allow propagation of virbration waves circumferentially around a major part of said hollow cylinder,

wherein said sensing electrode is formed as a strip extending in an extensional direction substantially parallel to said central axis along a major part of said height, said strip subtending at said central axis an angle of not more than 90°.

2. The ultrasound receiver of claim **1**, wherein said strip subtends at said central axis and angle of not more than 30°.

3. The ultrasound receiver of claim **1**, wherein the grounded electrode extends over a major part of said outer surface.

4. The ultrasound receiver of claim **3**, further comprising at least one additional electrode formed from conductive material to said inner surface in a pattern non-contiguous with said sensing electrode.

5. The ultrasound receiver of claim **4**, wherein said least one additional electrode extends over a major part of said inner surface.

6. The ultrasounf receiver of claim **5**, wherein said at least one additional electrode is grounded.

7. The ultrasound receiver of claim **5**, configured for use additionally as an ultrasound transmitter, thereby serving as an ultrasound transceiver, the ultrasound transceiver further comprising a control module including:

(a) receiver circuitry electrically connected to said sensing electrode;

(b) transmitter circuitry; and

(c) a switching system associated with an actuating electrode selected from said grounded electrode and said additional electrode and configured to alternately electrically connect said actuating electrode to said transmitter circuitry and to ground.

8. The ultrasound receiver of claim **1**, wherein said support structure includes a conductive core element deployed within said hollow cylinder in such a manner as to avoid electrical contact with said sensing electrode, said conductive core element being electrically grounded.

9. The ultrasound receiver of claim **8**, wherein said conductive core element is a metal core element.

10. The ultrasound receiver of claim **8**, wherein said conductive core element is formed from conductive foam.

11. The ultrasound receiver of claim **1**, wherein said flexible piezoelectric film is implemented as PVDF film.

12. The ultrasound receiver of claim **1**, wherein said sensing electrode and said grounded electrode are implemented as substantially transparent electrodes.

13. A method for operating an ultrasound transceiver for receiving and transmitting ultrasound signals, the method comprising the steps of:

(a) providing an ultrasound transceiver structure including:

(i) a hollow cylinder formed primarily from flexible piezoelectric film, said hollow cylinder having an outer surface, an inner surface, a central axis and a height measured parallel to said central axis, said hollow cylinder being mounted so as to allow propagation of vibration waves circumferentially around a major part of said hollow cylinder,

(ii) a sensing electrode formed from conductive material applied to said inner surface, said sensing electrode being formed as a narrow strip extending in an extensional direction substantially parallel to said central axis along a major part of said height, said strip subtending at said central axis an angle of not more than 90°,

(iii) at least one additional inner electrode formed from conductive material applied so as to extend over a major part of said inner surface in a pattern non-contiguous with said sensing electrode, and

(iv) at least one outer electrode formed from conductive material applied so as to extend over a major part of said outer surface;

(b) receiving ultrasound signals by:

(i) connecting both said additional inner electrode and said outer electrode to ground, and

(ii) electrically connecting said sensing electrode to receiver circuitry; and

(c) transmitting ultrasound signals by appying a driving voltage to at least one of said additional inner electrode and said outer electrode.

14. A method for operating a system for determining the position of a movable element, the system including a first group of movable ultrasound transducers including at least one ultrasound transducer associated with a movable element and a second group of fixed ultrasound tranducers including at least two ultrasound transducers maintained in fixed geometrical relation by attachment to a base unit, the method for operating including:

(a) operating the system in a measurement mode in which:

(i) one of said first and second groups of ultrasound transducers transmits at least one measurement signal which is received by ultrasound transducers in the other of said first and second groups, and (ii) a position of the movable element is derived from time-of-flight measurements for said at least one measurement signal; and

(b) intermittently operating the system in a calibration mode in which:

(i) at least one ultrasound transducer from said second group transmits a calibration signal and at least one other ultrasound transducer from said second group receives said calibration signal, and

(ii) calibration information is derived from time-of-flight measurements for said calibration signal.

15. The method of claim **14**, wherein at least one ultrasound transducer from said second group is formed with a structure including:

(a) a hollow cylinder formed primarily from flexible piezoelectric film, said hollow cylinder having an outer surface, an inner surface, a central axis and a height measured parallel to said central axis, said hollow cylinder being mounted so as to allow propagation of vibration waves circumferentially around a major part of said hollow cylinder;

(b) a sensing electrode formed from conductive material applied to said inner surface, said sensing electrode being formed as a narrow strip extending in an extensional direction substantially parallel to csaid central axis along a major part of said height, said strip subtending at said central axis an angle of not more than 90°,

(c) at least one additional inner electrode formed from conductive material applied so as to extend over a major part of said inner surface in a pattern non-contiguous with said sensing electrode; and

(d) at least one outer electrode formed from conductive material applied so as to extend over a major part of said outer surface.

16. A method for providing mechanical protection for an ultrasound transducer used for given frequency of ultrasound signals while minimizing interference with the ultrasound signals, the method comprising positioning a protective grating adjacent to the transducer, the grating gaving a plurality of openings spaced at a spatial frequency of less than about half of the wavelength of the given frequency of ultrasound in air.

17. The method of claim **16**, wherein the grating has a plurality of openings spaced at a spatial frequency of less than about a quarter of the wavelength of the given frequency of ultrasound in air.

18. The method of claim **16**, wherein the transducer is a cylindrical transducer, the grating being configured as a cylindrical grating surrouding the transducer.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

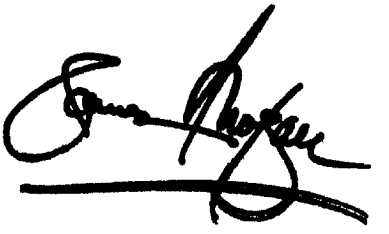
PATENT NO. : 6,392,330 B1
DATED : May 21, 2002
INVENTOR(S) : Zloter et al.

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

Column 10,
Line 28, insert the word -- ultrasound -- and delete "ultrasounf"

Signed and Sealed this

Thirtieth Day of July, 2002



Attest:

Attesting Officer

JAMES E. ROGAN
Director of the United States Patent and Trademark Office

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

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(54) **PRESENTATION BOARD DIGITIZERS**

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(52) **U.S. Cl.** **345/177**; 345/176; 178/18.01; 178/18.04; 178/19.01; 178/19.02

(58) **Field of Search** 345/173, 174, 345/175, 176, 177, 179; 178/18.01, 18.03, 18.04, 18.05, 18.06, 18.07, 19.01, 19.02, 19.03, 19.04

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(74) *Attorney, Agent, or Firm*—Mark M. Friedman

(57) **ABSTRACT**

A handheld device **(200)** includes a housing **(202)** having a cylindrical bore **(204)** therein and which terminates at a distal end **(206)** of the housing with a central orifice communicating therewith. The housing serves for receiving a portion of a body of a drawing implement with its drawing tip extending from the central orifice. The device **(200)** further includes an ultrasonic receiver or transmitter **(220)** mounted within the housing, remote from the drawing tip, yet in close proximity with the bore. This device serves for receiving or transmitting an intermittent ultrasound signal through the bore and the plurality of openings, thereby enabling triangulation of the drawing tip.

12 Claims, 20 Drawing Sheets

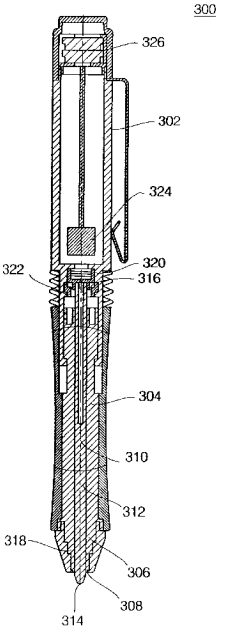


FIG. 1
(PRIOR ART)

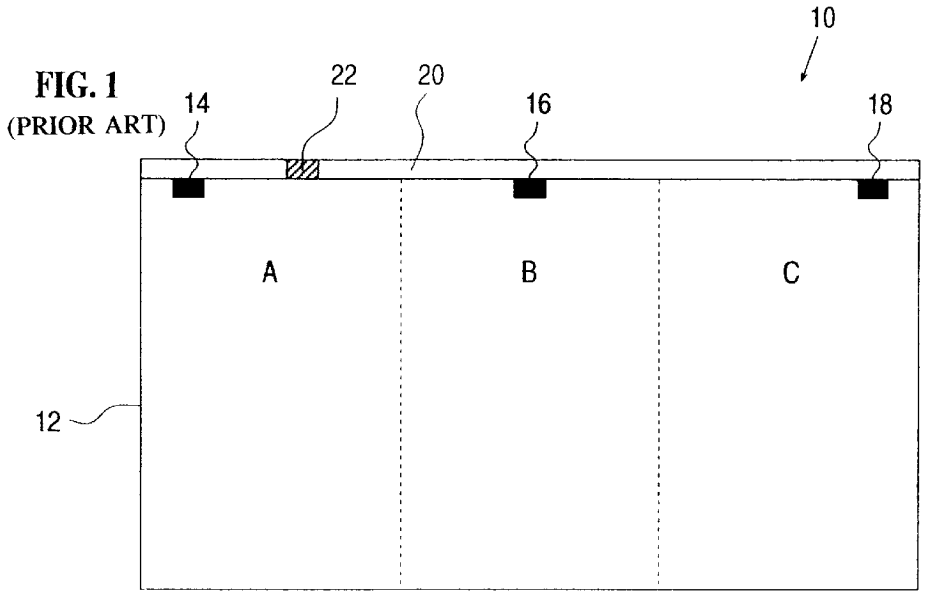


FIG. 2
(PRIOR ART)

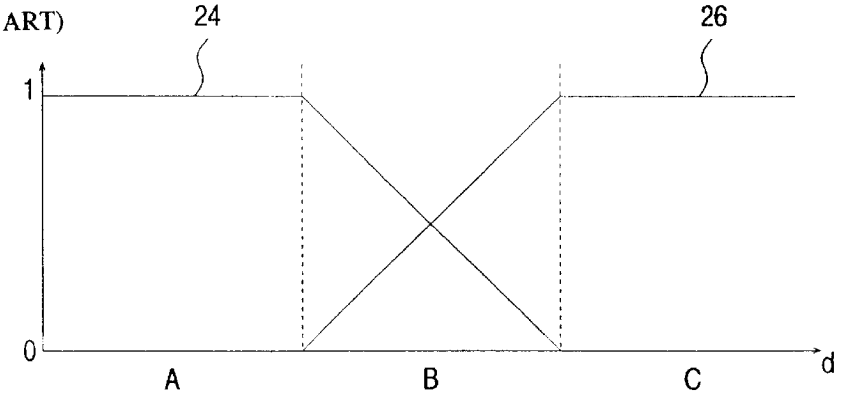


FIG. 3
(PRIOR ART)

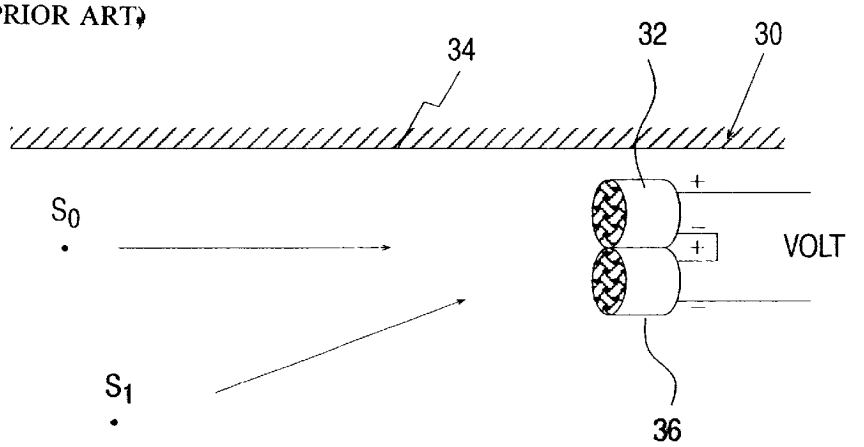


FIG. 4
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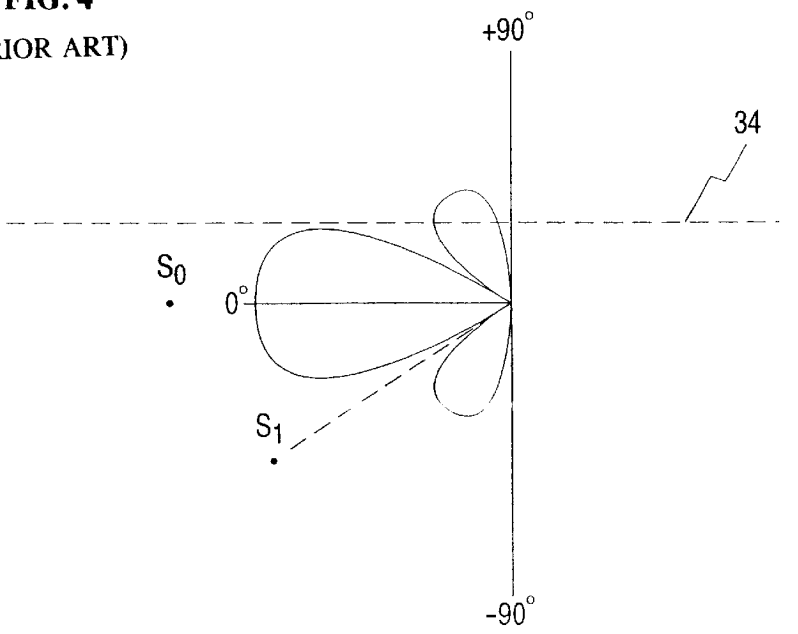
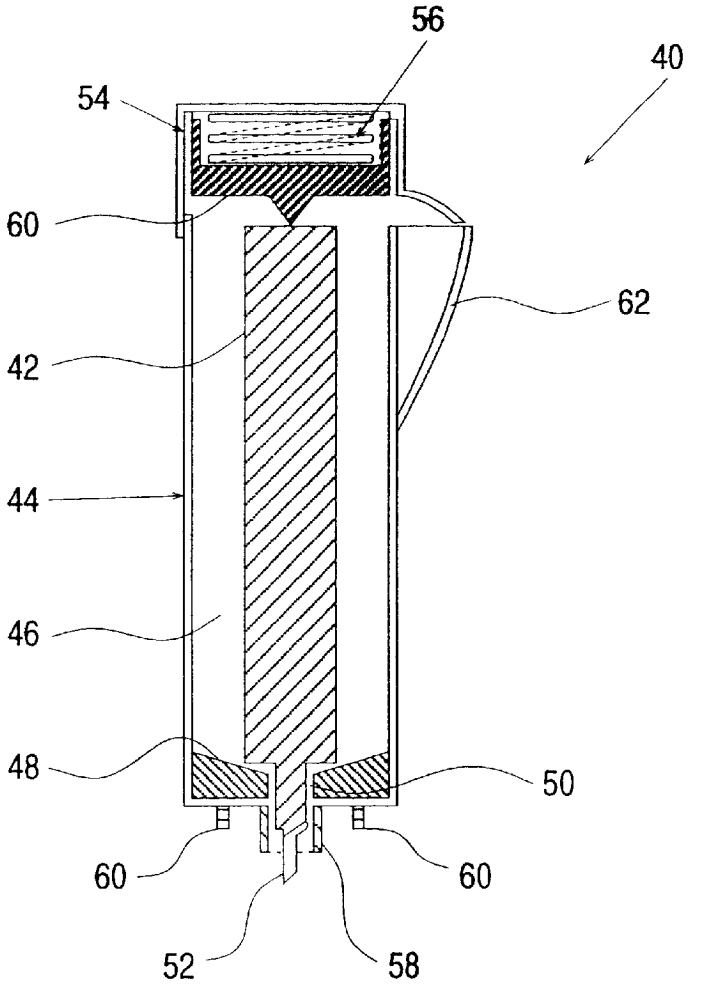


FIG. 5
(PRIOR ART)



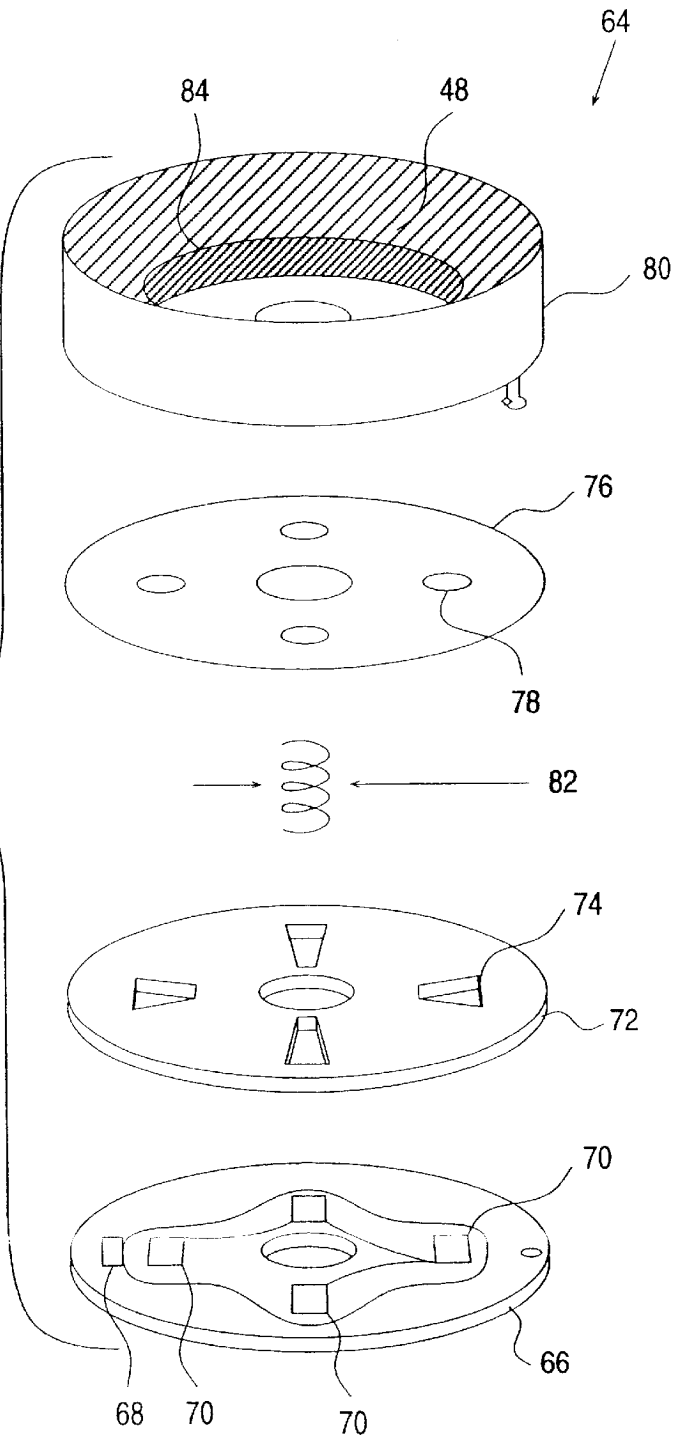


FIG. 6A
(PRIOR ART)

FIG. 6B
(PRIOR ART)

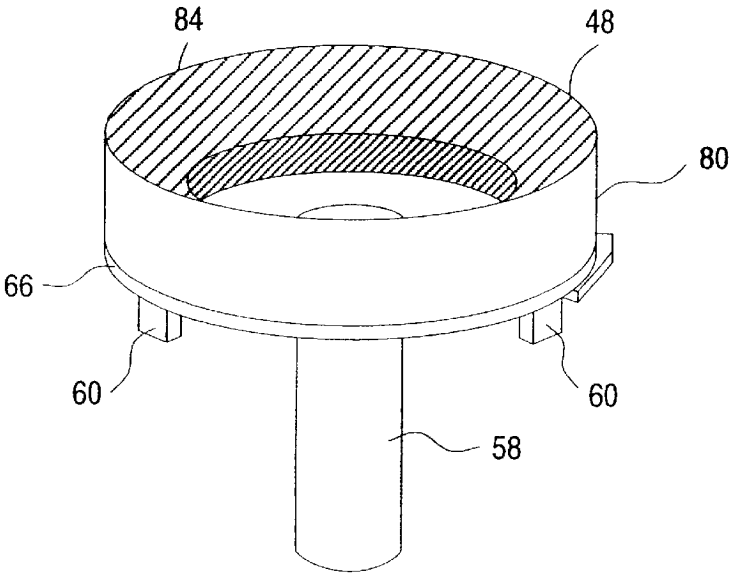


FIG. 6C
(PRIOR ART)

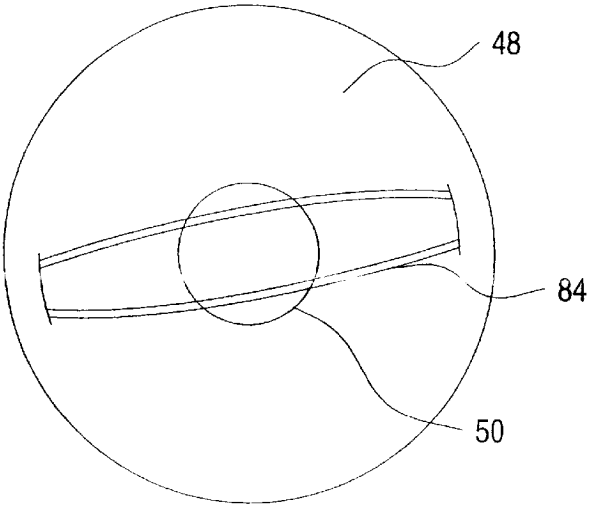
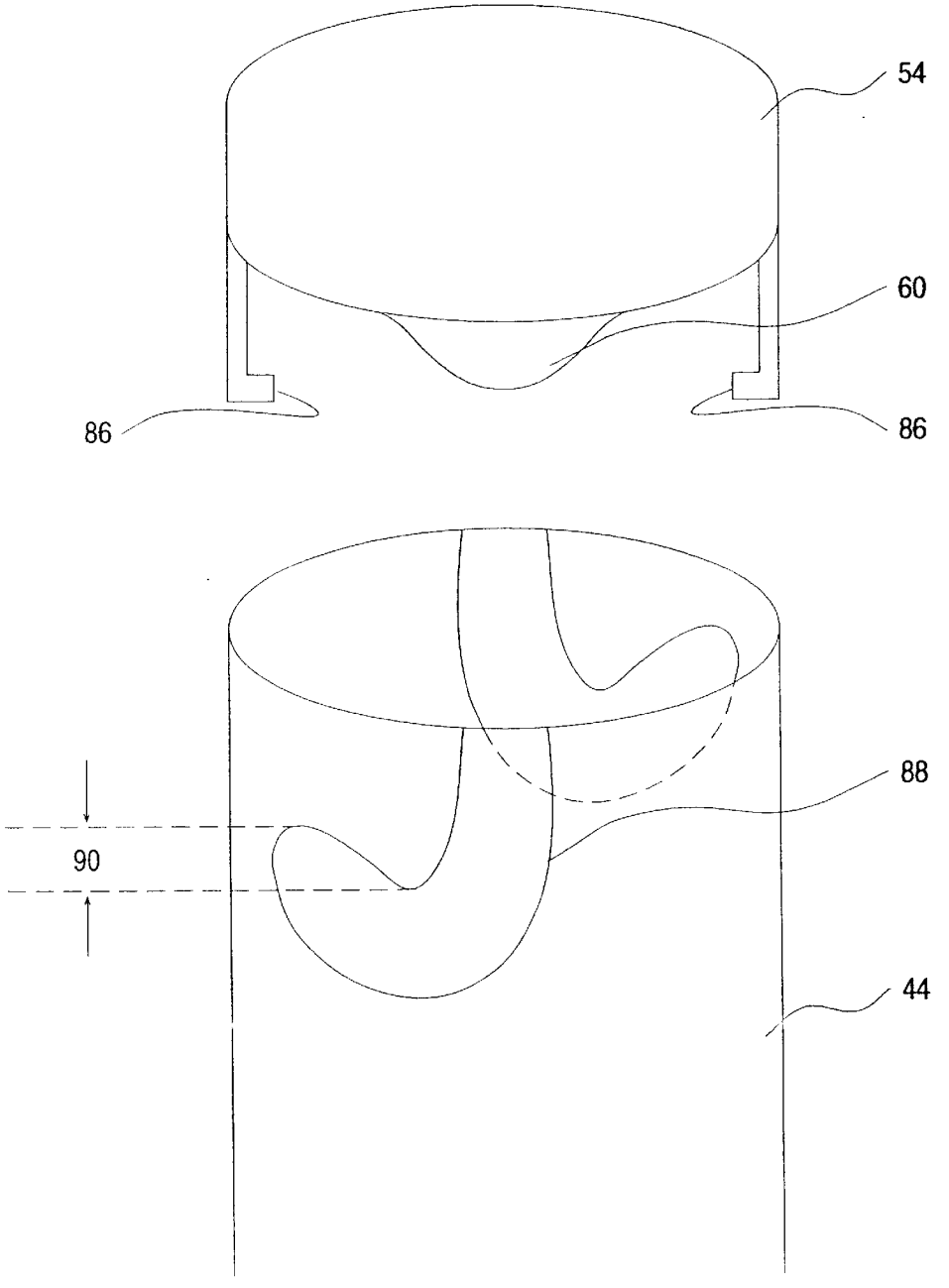


FIG. 7
(PRIOR ART)



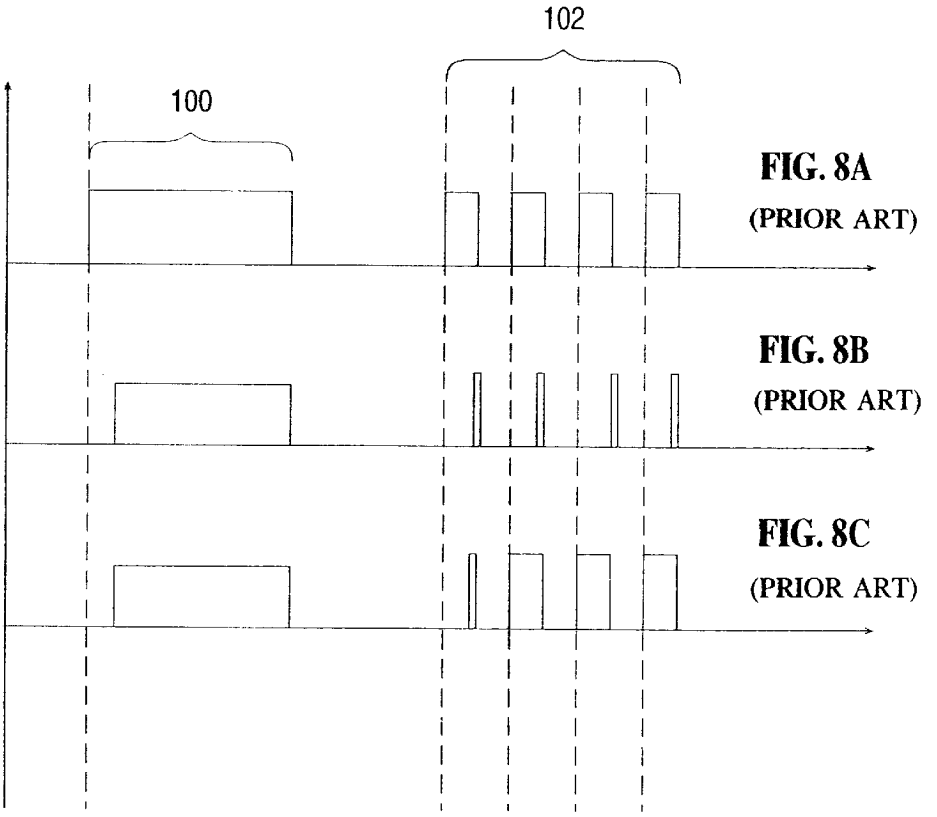


FIG. 8A
(PRIOR ART)

FIG. 8B
(PRIOR ART)

FIG. 8C
(PRIOR ART)

FIG. 9
(PRIOR ART)

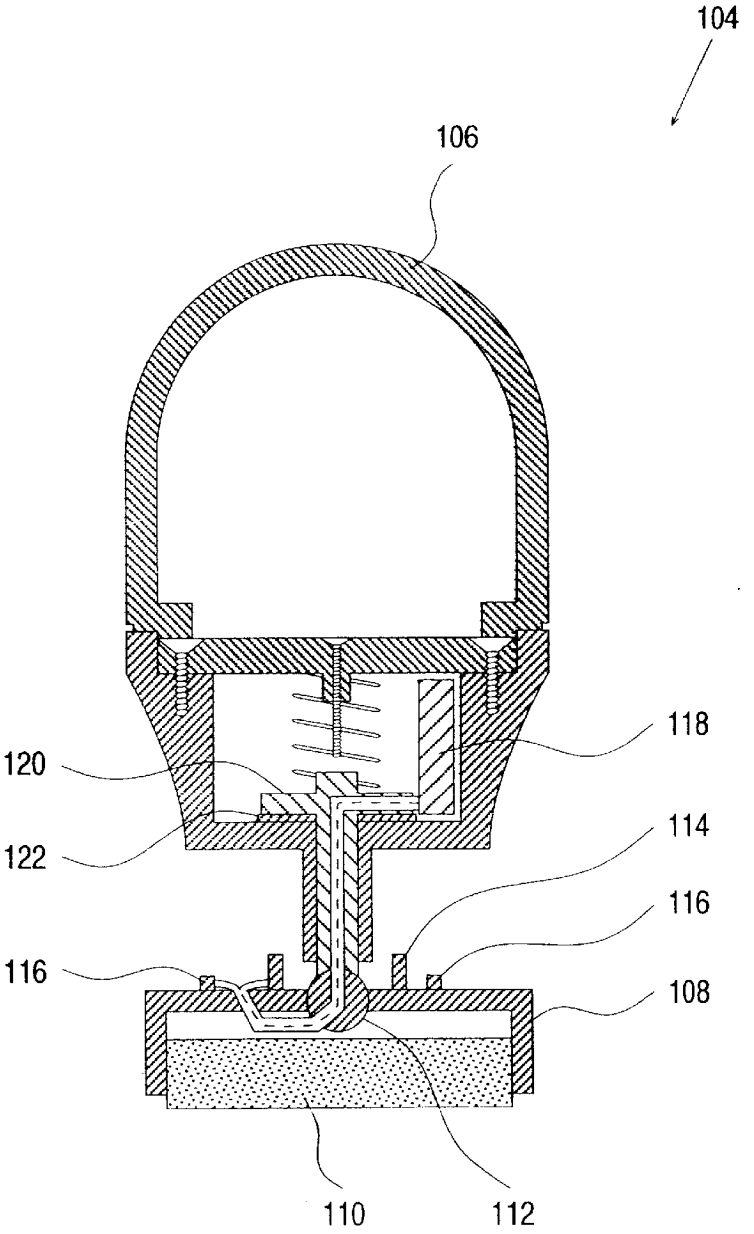
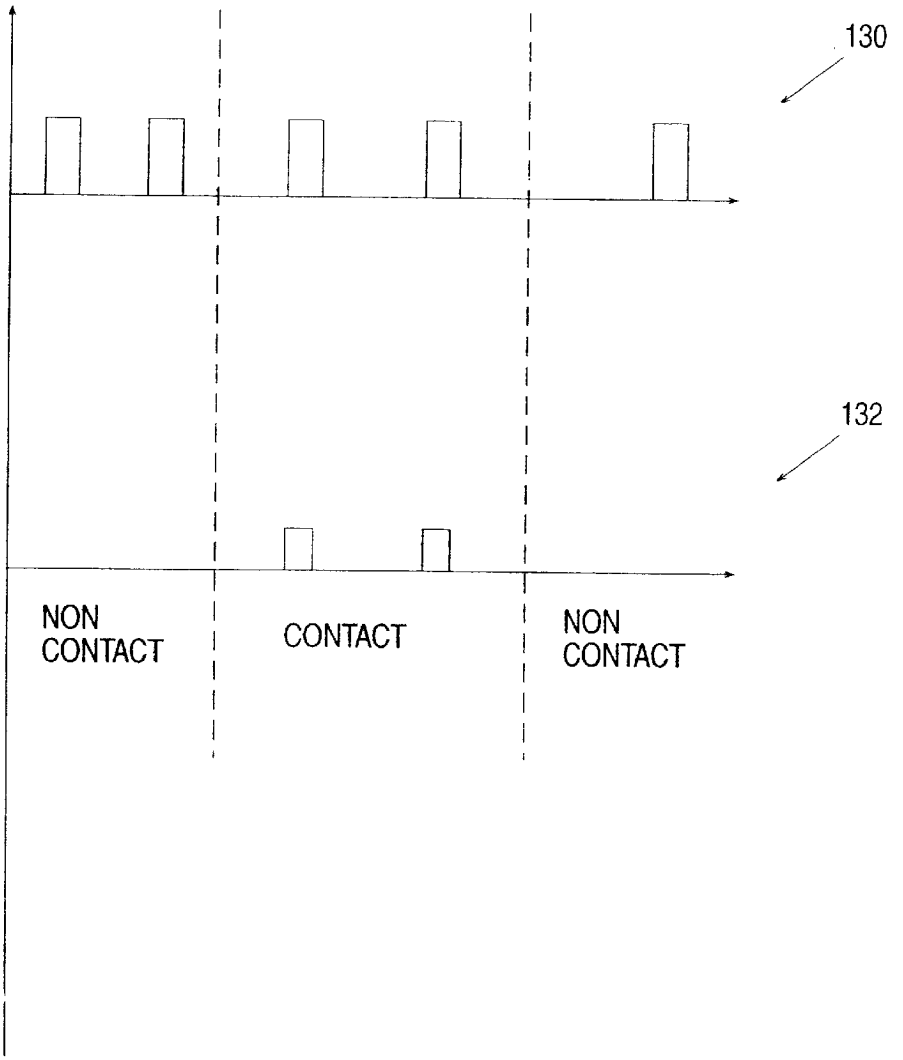


FIG. 10
(PRIOR ART)



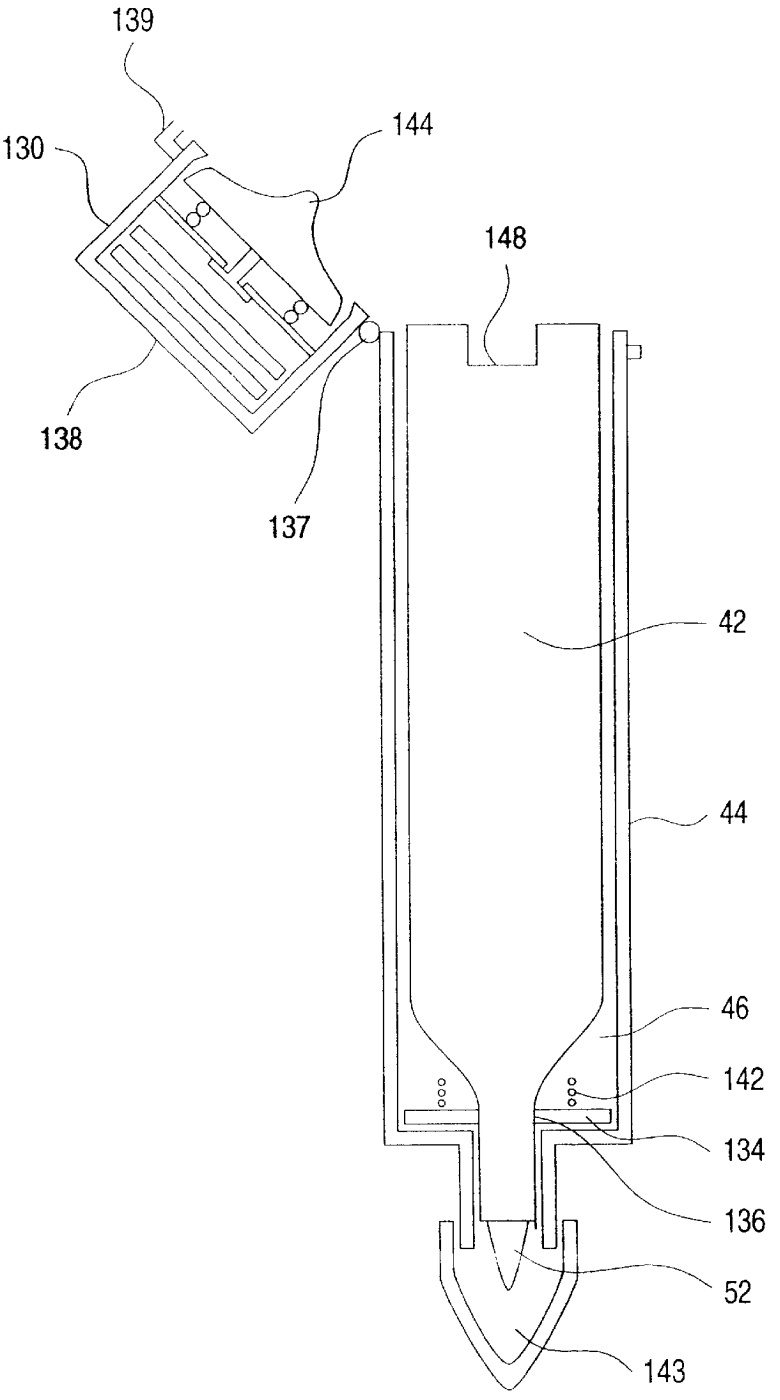


FIG. 11 (PRIOR ART)

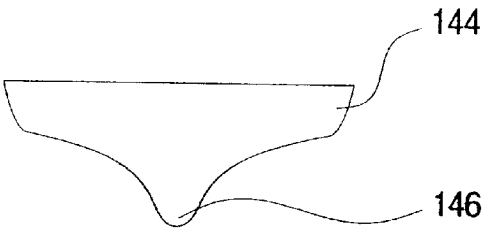


FIG. 12A
(PRIOR ART)

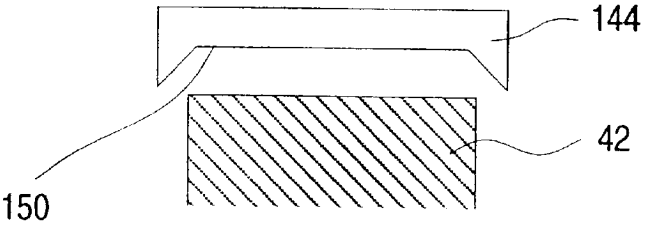


FIG. 12B
(PRIOR ART)

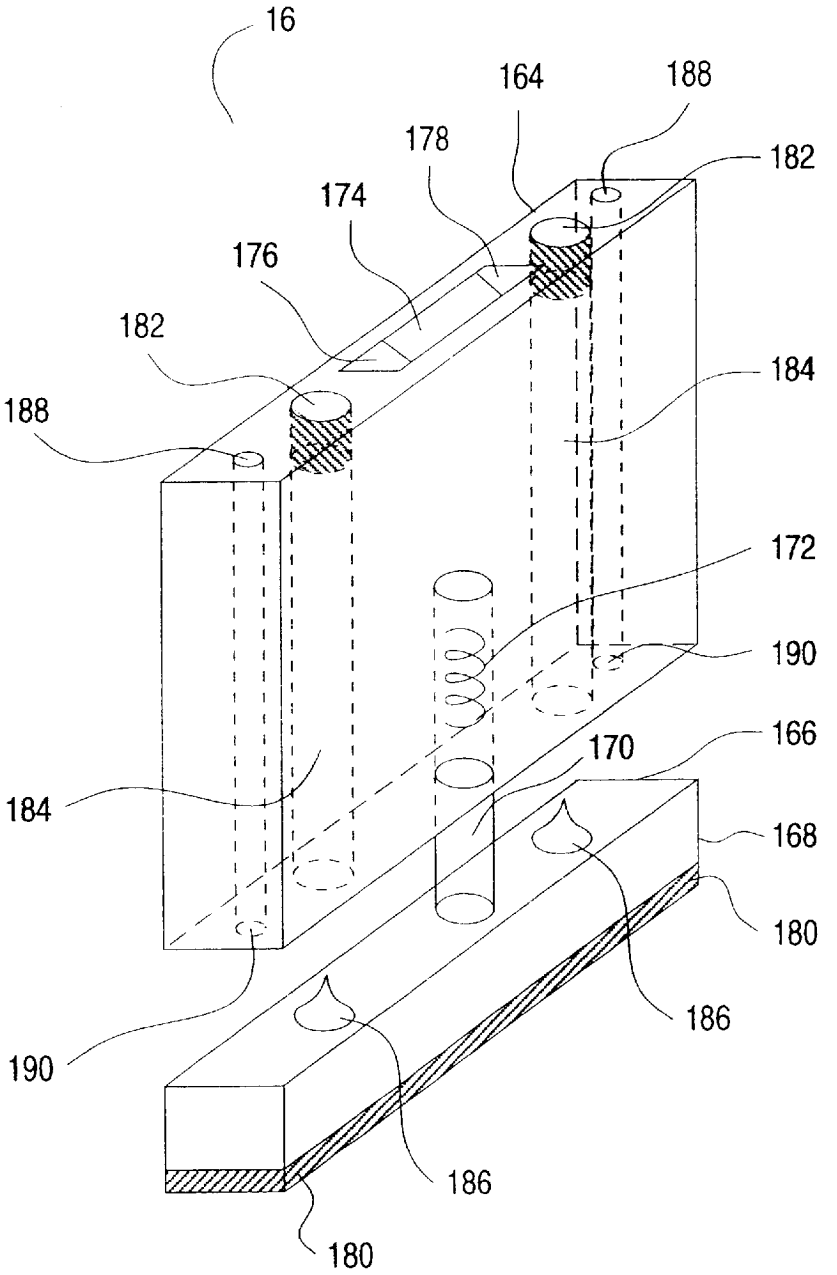


FIG. 13
(PRIOR ART)

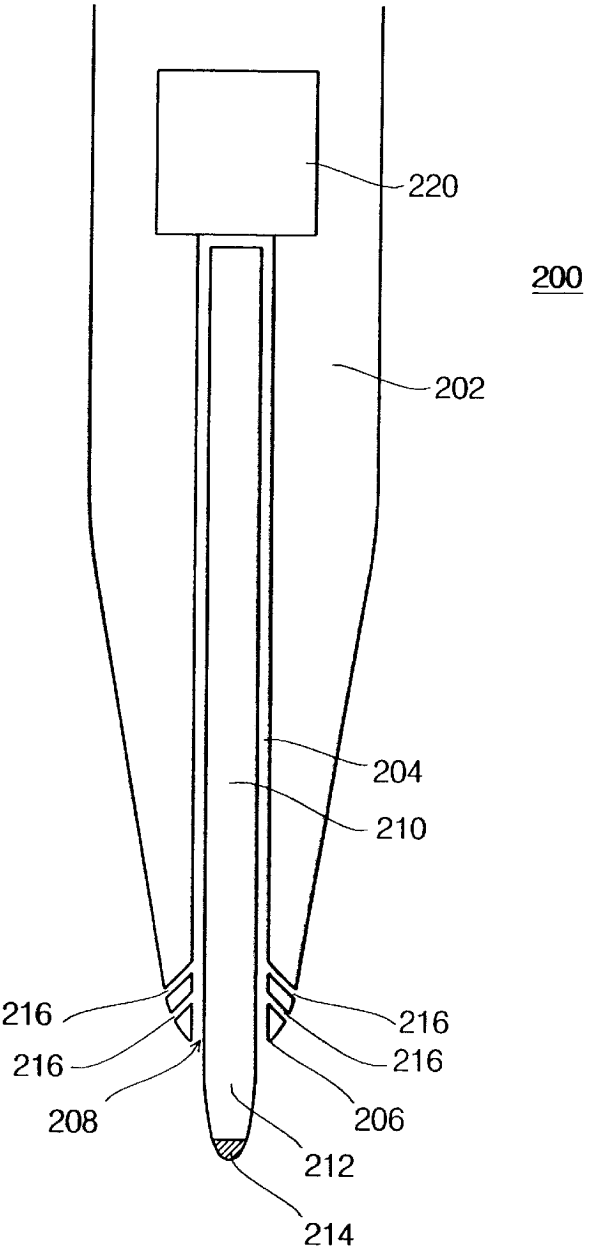
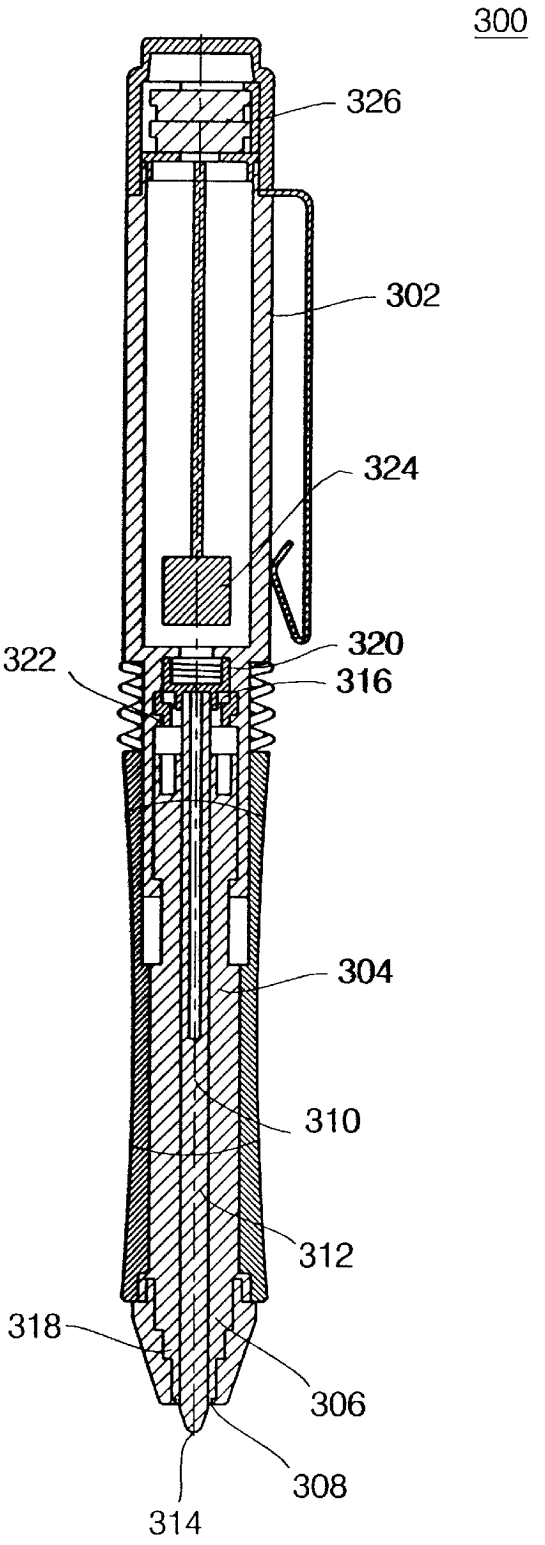


Fig.14

Fig.15



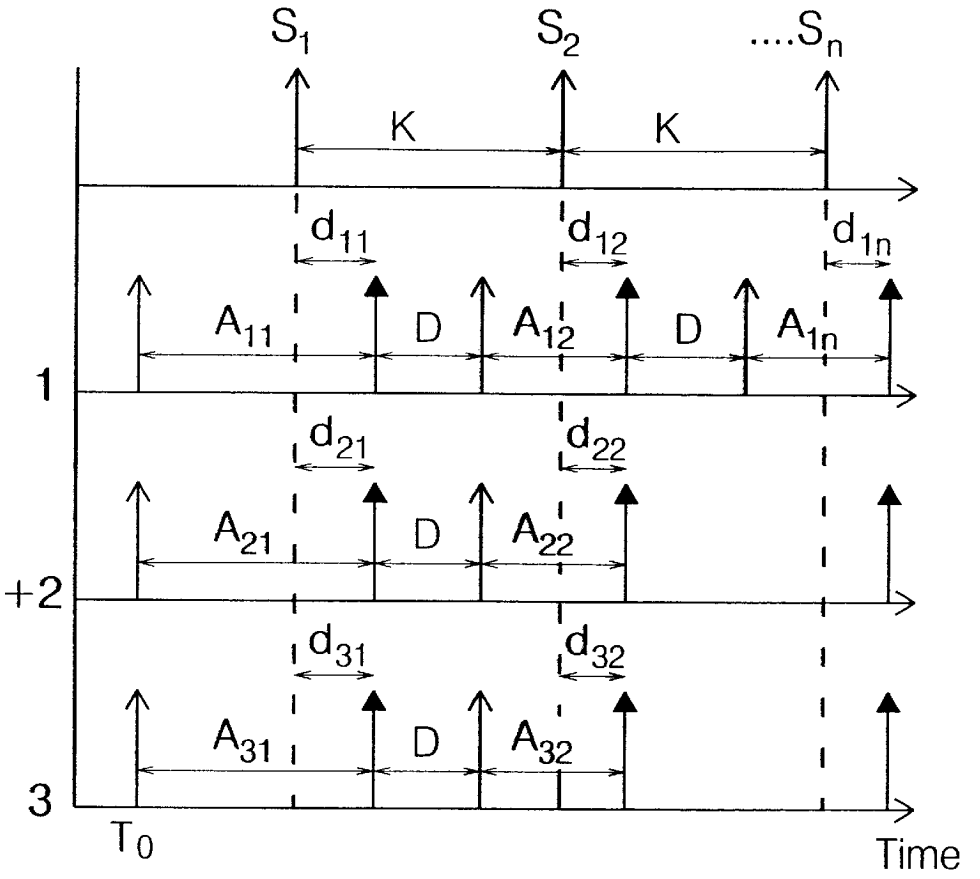

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Fig.16

Fig.17

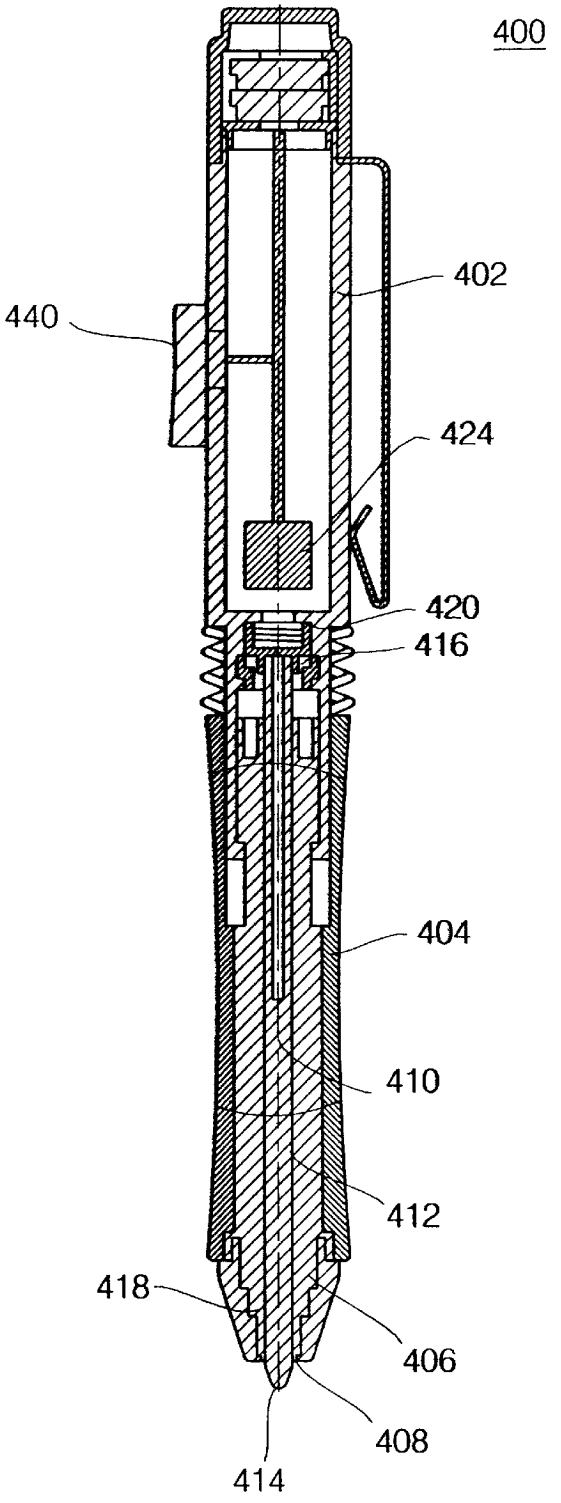
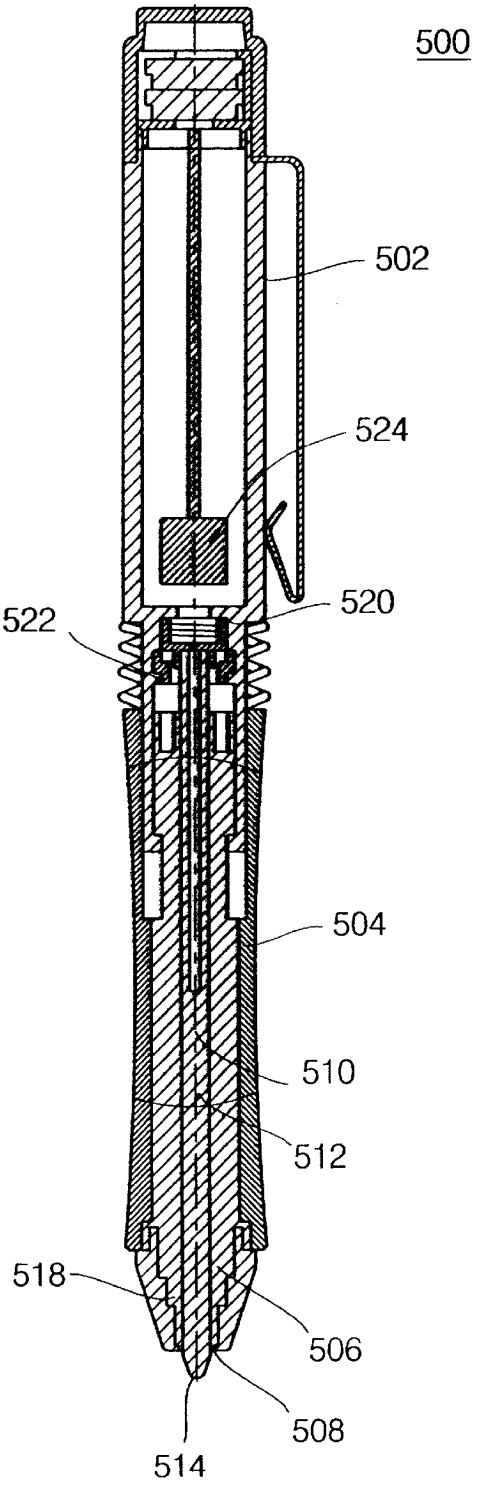


Fig.18



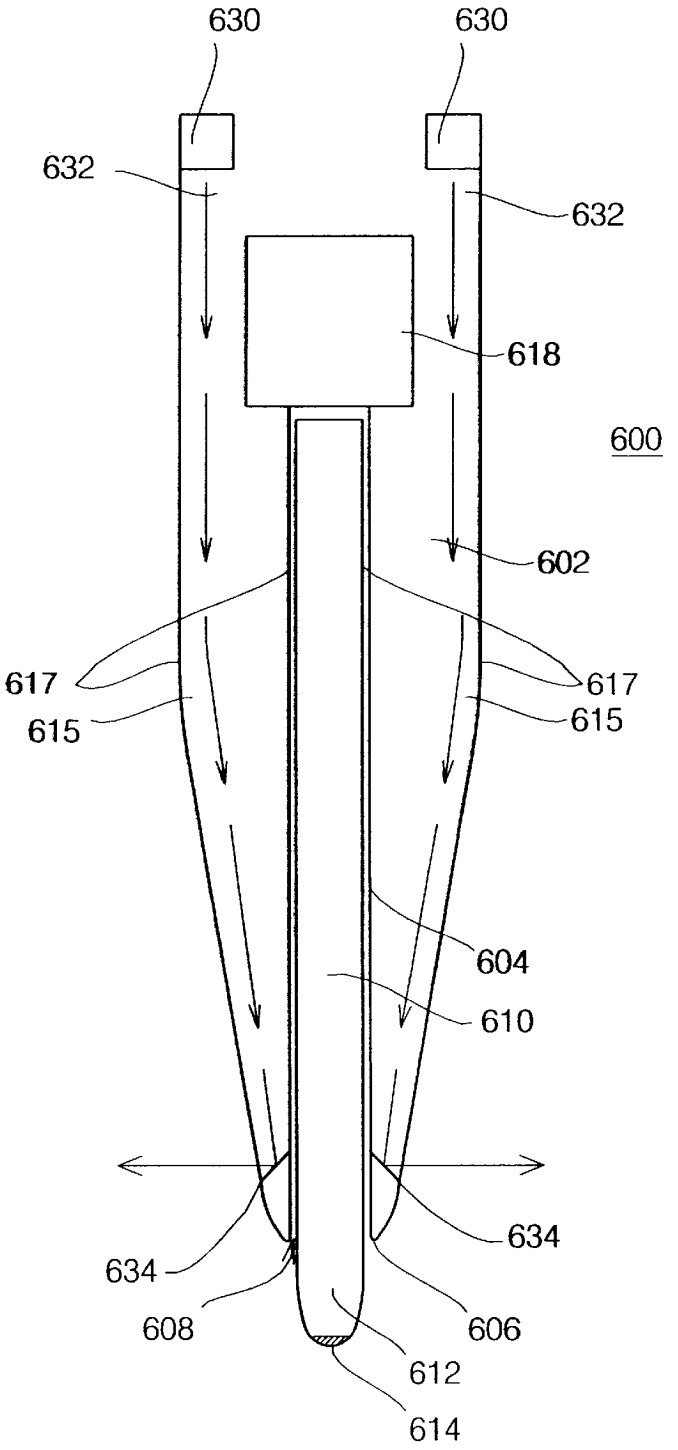

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Fig.19

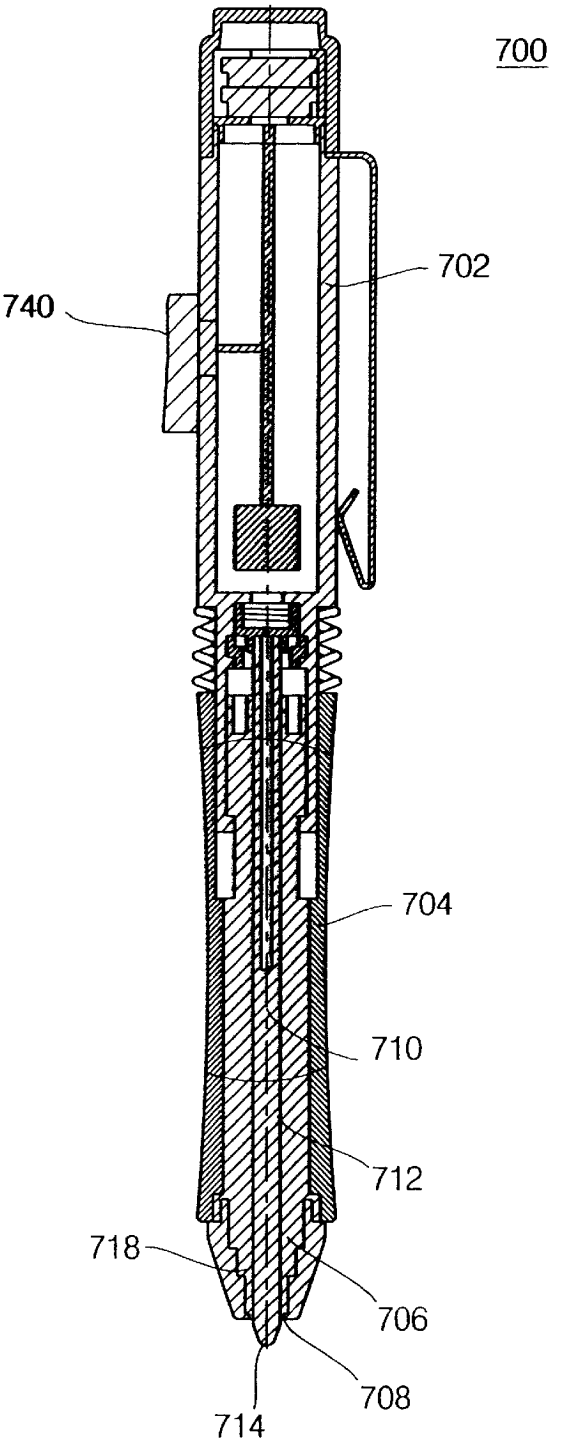
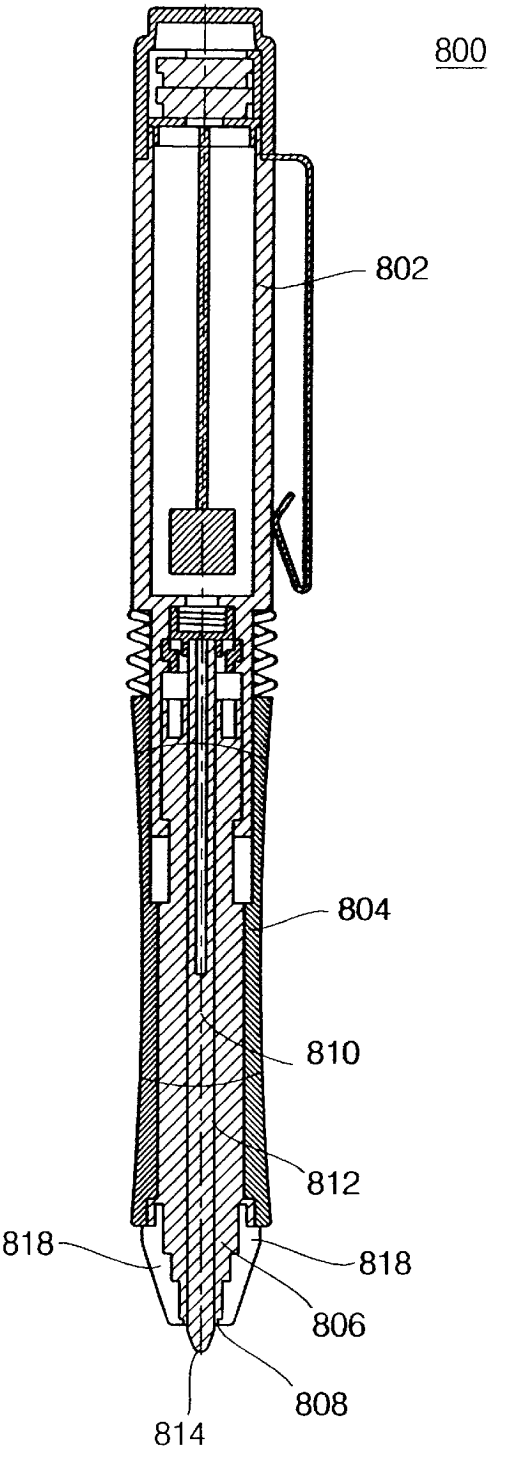


Fig.20

Fig.21



PRESENTATION BOARD DIGITIZERS

FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to digitizers. More particularly, the present invention relates to devices for use with presentation boards and pens for digitizing lines drawn manually thereon.

Throughout the last decade the presentation of data in a group setting has become highly digitized, involving the use of technologically advanced audio-visual devices. As such, the use of a conventional drawing board, such as a whiteboard, in such presentations has rapidly declined.

Still, some presenters often prefer to use a marker and whiteboard to present and develop ideas during group sessions. To enable recording of information presented by such means, several digitized whiteboard systems have been developed.

Such systems typically employ a combination of transmitters and receivers for processing signals from a handheld device. The writing movements produced by these devices are traced and recorded, and as a result the textual and graphical content of a session can be digitized and ported to a computer.

Various techniques are used for determining the position of a handheld device or stylus on a flat surface. U.S. Pat. No. 4,564,928 to Glenn et al., U.S. Pat. No. 4,886,943 to Suzuki et al., U.S. Pat. Nos. 4,910,363 and 5,073,685 to Kobayashi et al. and U.S. Pat. No. 5,097,102 to Yoshimura et al. all disclose systems in which a vibrating element associated with a pen transmits vibrations through the material of a board. The vibrations are detected by transducers attached to the board and the position of the pen is calculated from the transmission time of the vibrations through the board. These systems inherently function exclusively when the pen is in contact with the board such that vibrations are transferred to the board. As a result, no special mechanism is required to distinguish writing from non-writing pen movements.

These systems are generally inaccurate due to non-uniform transmission times through the board. In fact, they typically require highly specialized board structures which renders them expensive and inconvenient.

An alternative approach is the use of air-borne ultrasound signals. Examples of such systems are described in U.S. Pat. No. 4,777,329 to Mallicoat, U.S. Pat. No. 4,814,552 to Stefik et al., U.S. Pat. No. 4,506,354 to Hansen U.S. Pat. No. 4,758,691 and to De Bruyne and PCT/IL98/00093, filed Feb. 25, 1998 by Pegasus Technologies Ltd., which is incorporated by reference as if fully set forth herein.

These systems employ various combinations of ultrasound transmitters and receivers arranged at two points fixed relative to a board and on a movable writing implement. The position of the movable implement is then derived by triangulation. These systems typically require an additional hard-wired or electromagnetic link, such as an infrared link, between the movable implement and a base unit to provide timing information for time-of-flight ultrasound calculations. An additional switch is also required to identify when the movable element is in contact with the board.

These systems are typically limited to relatively small boards. This is because of signal-to-noise ratio (SNR) limitations which interfere with obtaining accurate measurements. The volume of ultrasound used cannot be very high without causing bothersome accompanying whistling noises. Additionally, in a wireless system, power considerations severely limit the transmitted volume. In order to generate reliable position information, the transmitter-to-receiver distance must therefore be kept small. Attempts to use different sets of receivers for different regions of a large board generally result in discontinuities when the movable element travels from one region to another.

Another shortcoming of these systems is their inability to reproduce rapid interrupted pen strokes such as performed when drawing a dashed line. Typically, the transmitter or receiver element in the pen turns off when the pen is inactive and is re-activated each time the pen comes in contact with the board. The system then takes a fraction of a second to resynchronize before it responds correctly. In the case of short strokes, the length of the operative stroke may be comparable with the response time of the system, thereby giving very poor results.

An additional problem of some of the airborne ultrasound digitizer systems is that the ultrasound transmitter or receiver element is mounted asymmetrically to the side of the drawing implement or stylus. As a result, the measured position is offset from the true drawing position in a direction which changes with rotation of the drawing implement. This may result in discontinuities and illegible writing in the digitized image when the drawing implement position is changed between strokes.

Furthermore, conventional presentation board digitizer systems are typically limited to use with specially produced writing implements. This renders them expensive since pens have a very limited lifetime. Even where the ink cartridge is separately replaceable, the components used must be of a very specific design to be compatible.

Finally, styluses which employ a color writing tip are usually restricted to using a single color tip and cannot employ different colors or a tip of a different function, since the recordation system cannot distinguish between the different tips.

There is therefore a need for a reliable, low-cost, digitizer system which may be used with conventional presentation boards of all sizes for determining accurately the position of a drawing implement on the board. Additional needs and improvements provided by the present invention are described in the specification that follows.

SUMMARY OF THE INVENTION

According to one aspect of the present invention there is provided a handheld device for use with a board supplemented with a processing system for digitizing operative strokes of the handheld device on the board, the handheld device comprising (a) a housing having a substantially cylindrical bore therein terminating at a distal end of the housing with a central orifice communicating with the bore, the housing receiving a portion of a body of a drawing implement with its drawing tip extending from the central orifice, the housing being formed with a plurality of openings being circumferencly arranged at the distal end of the housing and communicating with the bore; and (b) an ultrasonic receiver or transmitter device mounted within the housing, remote from the drawing tip, yet in close proximity with the bore, the device being for receiving or transmitting an intermittent ultrasound signal through the bore and the plurality of openings, thereby enabling triangulation of the drawing tip.

According to another aspect of the present invention there is provided a handheld device for use with a board supplemented with a processing system for digitizing operative

strokes of the handheld device on the board, the handheld device comprising (a) a housing having a substantially cylindrical bore therein terminating at a distal end of the housing with a central orifice communicating with the bore, the housing receiving and releasing a portion of a body of a removably attachable drawing implement through the orifice with its drawing tip extending from the central orifice; (b) a retainer in the housing for releasably retaining the removably attached drawing implement within the housing; (c) an ultrasonic receiver or transmitter device being internally or externally connected to the housing for receiving or transmitting an intermittent ultrasound signal; (d) a microswitch in the housing being actuated when contacted by a proximal end of the body, so as to be responsive to a force exerted on the drawing tip of the drawing implement; and (e) an electronic circuitry being in the housing and electronically communicating with the microswitch for affecting operation of the device at least when the microswitch indicates that the force is exerted on the drawing tip of the drawing implement.

According to yet another aspect of the present invention there is provided a handheld device for use with a board or screen supplemented with a processing system for digitizing operative strokes of the handheld device on the board or screen, the handheld device comprising (a) a housing having a substantially cylindrical bore therein terminating at a distal end of the housing with a central orifice communicating with the bore, the housing receiving and releasing a portion of a body of a removably attachable operative implement through the orifice with its operative tip extending from the central orifice, the operative implement being selected from the group consisting of a drawing implement and an annotation implement; (b) a retainer in the housing for releasably retaining the removably attached operative implement within the housing; and (c) an ultrasonic receiver or transmitter device being externally or internally connected to the housing for receiving or transmitting an intermittent ultrasound signal.

According to still another aspect of the present invention, in a board or screen digitizing system including at least three spaced apart ultrasound receivers associated with the board or screen surface, and a handheld device including an intermittent signal transmitter, there is provided a method of tracking the handheld device, the signals being transmitted with a preset first interval therebetween, the method comprising the steps of collecting a plurality of time non-referenced ultrasound signals by each of the at least three spaced apart ultrasound receivers and calculating a position of the handheld device for each of the time non-referenced ultrasound signals, thereby tracking the handheld device. Preferably, reception of each of the at least three spaced apart ultrasound receivers is suspended for a second time interval following the reception of a signal thereby, the second time interval is shorter than the first time interval.

According to an additional aspect of the present invention there is provided a handheld device for use with a board or screen supplemented with a processing system for digitizing operative strokes of the handheld device on the board or screen, the handheld device comprising (a) a housing having a substantially cylindrical bore therein terminating at a distal end of the housing with a central orifice communicating with the bore, the housing receiving and releasing a portion of a body of a removably attachable operative implement through the orifice with its operative tip extending from the central orifice and being selectable among a plurality of different operative implements; (b) a retainer in the housing for releasably retaining the removably attached operative implement within the housing; and (c) an ultrasonic transmitter device being internally or externally connected to the housing for transmitting one of a plurality of intermittent ultrasound signals, each of the plurality of intermittent ultrasound signals having a different frequency, each of the frequencies being associated with one of the plurality of different operative implements; and (d) a controller on or in the housing for setting the transmitter device to transmit an intermittent ultrasound signal of a frequency corroborating with one of the plurality of different operative implements.

According to a still additional aspect of the present invention there is provided a handheld device for use with a board or screen supplemented with a processing system for digitizing operative strokes of the handheld device on the board or screen, the handheld device comprising (a) a housing having a substantially cylindrical bore therein terminating at a distal end of the housing with a central orifice communicating with the bore, the housing receiving a portion of a body of an operative implement with its operative tip extending from the central orifice; (b) an ultrasonic transmitter device being internally or externally connected to the housing for transmitting one of two intermittent ultrasound signals, each of the two intermittent ultrasound signals having a different frequency; (c) a microswitch in the housing being in a first mode or a second mode, the microswitch being in the first mode when in contact with a proximal end of the body and in the second mode when not in contact with the proximal end of the body; and (d) an electronic circuitry electronically communicating between the microswitch and the transmitter device, the electronic circuitry being for associating one of the first and second modes with the transmitter device, such that the intermittent ultrasound signals of the different frequency are transmitted by the transmitting device in a mode dependent manner, thereby informing the processing system whether the operative tip is in contact with, or removed from, the board or screen.

According to a yet additional aspect of the present invention there is provided a handheld device for use with a board or screen supplemented with a processing system for digitizing operative strokes of the handheld device on the board or screen, the handheld device comprising (a) a housing having a substantially cylindrical bore therein terminating at a distal end of the housing with a central orifice communicating with the bore, the housing receiving a portion of a body of an operative implement with its operative tip extending from the central orifice, at least a longitudinal portion of the housing originating at the distal end of the housing being of an infrared conveying material; (b) an ultrasonic receiver or transmitter device being internally or externally connected to the housing for receiving or transmitting an intermittent ultrasound signal; (c) an infrared transmitter device being implemented at a proximal end of the longitudinal portion of the housing, the infrared transmitter device being designed for directing infrared radiation emitted thereby through the longitudinal portion of the housing.

According to further features in preferred embodiments of the invention described below, the longitudinal portion of the housing is supplemented with an infrared reflector for reflecting the infrared radiation out of the housing.

According to a further aspect of the present invention there is provided a handheld device for use with a board or screen supplemented with a processing system for digitizing operative strokes of the handheld device on the board or screen, the handheld device comprising (a) a housing having a substantially cylindrical bore therein terminating at a distal

end of the housing with a central orifice communicating with the bore, the housing receiving a portion of a body of an operative implement with its operative tip extending from the central orifice; (b) an ultrasonic receiver or transmitter device being internally or externally connected to the housing for receiving or transmitting an intermittent ultrasound signal; (c) a pressure sensitive microswitch in the housing being actuated when pressured by a proximal end of the body, so as to be responsive to a force exerted on the drawing tip of the drawing implement; and (d) an electronic circuitry being in the housing and electronically communicating with the microswitch for affecting operation of the device at least when the microswitch indicates that the force is exerted on the drawing tip of the drawing implement.

According to a still further aspect of the present invention there is provided a remotely controlled handheld device for use with a board or screen supplemented with a processing system for digitizing operative strokes of the handheld device on the board or screen, the handheld device comprising (a) a housing having a substantially cylindrical bore therein terminating at a distal end of the housing with a central orifice communicating with the bore, the housing receiving a portion of a body of an operative implement with its operative tip extending from the central orifice; (b) an ultrasonic receiver or transmitter device being internally or externally connected to the housing for receiving or transmitting an intermittent ultrasound signal; and (c) a remote signal receiver for receiving operational command signals from a remote signal transmitter being controlled by an operator.

According to yet a further aspect of the present invention there is provided a handheld device for use with a board or screen supplemented with a processing system for digitizing operative strokes of the handheld device on the board or screen, the handheld device comprising (a) a housing having a substantially cylindrical bore therein terminating at a distal end of the housing with a central orifice communicating with the bore, the housing receiving a portion of a body of an operative implement with its operative tip extending from the central orifice; and (b) a transparent ultrasonic receiver or transmitter device being connected to the housing and surrounding the operative tip for receiving or transmitting an intermittent ultrasound signal, thereby rendering the operative tip visible to a user.

The present invention successfully addresses the shortcomings of the presently known configurations by providing a plurality of improvements to handheld devices for use with a board or screen supplemented with a processing system for digitizing operative strokes of the handheld devices, which improvements are further addressed in the following sections of the specification.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

FIG. **1** is a schematic front view of a prior art presentation board provided with a digitizer system, showing a switch-over zone between regions with different groups of ultrasound receivers;

FIG. **2** is a plot illustrating the variation of relative weighting of position indications from two sets of ultrasound receivers in FIG. **1** as a function of position across the presentation board (prior art);

FIG. **3** is a side view of a twin ultrasound receiver assembly for use in a presentation board digitizer system (prior art);

FIG. **4** is a schematic representation of the reception characteristic of the twin ultrasound receiver assembly of FIG. **3**;

FIG. **5** is a side cross-sectional view of a prior art transmitter device used with a conventional drawing implement in a digitizer system;

FIG. **6**A is an exploded perspective view of a prior art microswitch structure for use in the transmitter device of FIG. **5** (prior art);

FIG. **6**B is a perspective view of the microswitch structure of FIG. **6**A assembled (prior art);

FIG. **6**C is a top view of the microswitch structure of FIG. **6**A showing a retaining spring arrangement (prior art);

FIG. **7** is a schematic perspective view of a prior art structure for attachment of a retaining member to a housing for use in the transmitter device of FIG. **5**;

FIG. **8**A is a plot of the output of a contact switch activated by operational contact between a drawing implement and a presentation board as a function of time (prior art);

FIG. **8**B illustrates the recorded drawing implement operation time profile produced by inferior prior art systems corresponding to the contact profile of FIG. **5**A;

FIG. **8**C illustrates the corresponding recorded drawing implement operation time profile produced according to one embodiment of a prior art presentation board digitizer system;

FIG. **9** is a side cross-sectional view of a prior art eraser transmitter unit for use with a digitizer system;

FIG. **10** illustrates the signals received by air-borne ultrasound receivers and a board-mounted transducer, respectively, according to another embodiment of the prior art presentation board digitizer system;

FIG. **11** shows a second embodiment of the transmitting device (prior art);

FIGS. **12**A and **12**B show two different forms of the upper biasing element (prior art);

FIG. **13** shows a second embodiment of a prior art eraser;

FIG. **14** is a cross sectional view of a distal portion of a handheld device according to one aspect of the present invention, having an ultrasonic receiver or transmitter device located remote from the drawing tip thereof, yet enables triangulation of the drawing tip itself;

FIG. **15** is a cross sectional view of a handheld device according to another aspect of the present invention, having a retainer adapted at frontal replacement of an operative implement thereof and a microswitch actuatable by the operative implement;

FIG. **16** is a graphical depiction demonstrating the operation of a method according to yet another aspect of the present invention, which method is directed at improving the signal-to-noise ratio;

FIG. **17** is a cross sectional view of a handheld device according to still another aspect of the present invention, having a retainer adapted at replacement of an operative implement thereof and a controller for controlling the frequency of an ultrasound transmitter therein, as an indication of a change of the operative implement;

FIG. **18** is a cross sectional view of a handheld device according to yet another aspect of the present invention capable of transmitting frequency encoded ultrasonic information;

FIG. **19** is a cross sectional view of a distal portion of a handheld device according to a further aspect of the present

invention, having an infrared link directed through the housing thereof;

FIG. **20** is a cross sectional view of a remote controlled handheld device according to still a further aspect of the present invention capable of receiving operational commands via remote control communication line; and

FIG. **21** is a cross sectional view of a handheld device according to yet a further aspect of the present invention having a transparent ultrasonic device surrounding the operative tip of the operative implements thereof.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is of a handheld device employable with a board or screen supplemented with a processing system, which can be used for digitizing operative strokes of the handheld device on the board or screen. Specifically, the present invention can be used for digitizing graphical or textual data drawn on the face of a presentation board and for digitizing annotations with relation to a screen, such as a computer screen.

For purposes of better understanding the present invention, as illustrated in FIGS. **14–21** of the drawings, reference is first made to the construction and operation of a conventional (i.e., prior art) handheld device as illustrated in FIGS. **1–13** which are reproduced from PCT/IL98/00093.

FIG. **1** shows a presentation board digitizer system, generally designated **10**, constructed and operative according to the teachings of the prior art, showing a switch-over zone between regions with different groups of ultrasound receivers.

Generally speaking, system **10** features a presentation board **12**, which may be of any conventional type, provided with a plurality of ultrasound receiver assemblies **14**, **16** and **18**. Ultrasound receiver assemblies **14**, **16** and **18** are preferably mounted in a strip **20** adapted for convenient attachment to presentation boards of differing sizes and thicknesses. This attachment may be achieved through clamps or clips of any type. Strip **20** also features an infrared (IR) receiver **22**. A cover (not shown) is preferably provided for shielding ultrasound receiver assemblies **14**, **16** and **18** and IR receiver **22** from sound and radiation originating away from board **12**. System **10** operates with a movable element having both ultrasound and infrared transmitters, an example of which will be described in detail below. The present position of the movable element is derived from the time-of-flight (TOF) of ultrasound signals from the movable element to the receiver assemblies by triangulation. The IR signal provides synchronization information, as well as carrying additional information such as, for example, the color of a pen being used.

In principle, two ultrasound receivers are sufficient to uniquely determine the position of a movable element in contact with board **12**. However, in order to provide reliable ultrasound reception over the entire area of a large-board, system **10** employs more than one set of receivers. Thus, in the system as illustrated, a first set of receivers is defined as the pair of ultrasound receiver assemblies **14** and **16**, and a second set of receivers is defined as the pair of ultrasound receiver assemblies **16** and **18**. Clearly, the first set of ultrasound receivers so defined is well positioned for receiving an ultrasound signal from the transmitter when the movable element is in a first region denoted A, and the second set of ultrasound receivers is well positioned for receiving the signal when the movable element is in a second region denoted C. Thus, optimal precision and reliability is achieved by deriving the position of the movable element from the outputs of ultrasound receiver assemblies **14** and **16** when the movable element is in region A, and from the outputs of ultrasound receiver assemblies **16** and **18** when the movable element is in region C.

In order to avoid possible discontinuities in the tracking of the position of the movable element as it traverses board **12**, some configurations provide a switch-over zone, denoted B, between regions A and C. Within switch-over zone B, the current position of the movable element is derived based on a weighted function of the positions calculated from the outputs of the first and second sets of receivers. The weighted function varies smoothly with position across switch-over zone B such that it approaches the value calculated from the first set of receivers when the movable element borders first region A and approaches the value calculated from the second set of receivers when the movable element borders the second region.

FIG. **2** shows a typical variation of the weighting function with distance across board **12**. Here, plot **24** corresponds to the weighting factor applied to the first group of ultrasound receivers, and plot **26** corresponds to the weighting factor applied to the second group of ultrasound receivers. In this example, the variation within switch-over zone B is shown as linear. However, other, more complex functions may be used as desired. Within region A, plot **24** is constant at 1 and plot **26** is zero, whereas within region B, these values are reversed.

It should be noted that calculation of the current position of the movable element according to the system described requires calculation of weighting factors which are themselves a function of position. This apparent circularity of calculation may be circumvented in a number of ways. Most simply, since the position is measured repeatedly at short intervals, it is reasonable to assume that the new current position is a relatively small distance from the previously measured position. It is therefore reasonable to employ the last measured position for calculating the weighting factors for the subsequent measurement. Alternatively, or for the purposes of making an initial measurement, an approximate measurement may be made with some arbitrary weighting factor such as, for example, 0.5 for each set.

In addition to the switch-over zone algorithm, it is preferable that the ultrasound receivers are located sufficiently close to provide some degree of redundancy of measurement. This redundancy can then be employed (typically independent of the switch-over zone considerations) to provide a self test for accuracy and to identify any erroneous measurements which may occur temporarily.

Specifically, if receivers **14**, **16** and **18** are collinear with equal spacing A, and the distance from each receiver as measured by TOF calculations is s_1, s_2 and s_3, respectively, simple trigonometry dictates that:

$$s_1^2-2s_2^2+s_3^2=2A^2 \text{ (constant)}$$

By calculating this sum whenever three simultaneous TOF measurements are available, the system can continuously test that it is functioning within an acceptable margin of accuracy. In a case that a significant error is found, further statistically based self-analysis algorithms may be implemented to identify which receiver produced the erroneous reading and to temporarily exclude that receiver from position calculations.

Turning now to FIGS. **3** and **4**, a design of an ultrasound receiver assembly, generally designated **30**, for use with presentation board digitizer systems will now be described.

Generally speaking, ultrasound receiver assembly **30** includes a first ultrasound receiver **32** located adjacent to the surface **34** of the presentation board, and a second ultrasound receiver **36** displaced from first ultrasound receiver **32** in a direction substantially perpendicular to surface **34**.

First and second ultrasound receivers **32** and **36** are connected so as to generate a total output signal corresponding to the instantaneous sum of the amplitudes of ultrasound signals which they receive. Typically, for simple transducers, this is achieved by connecting them in series such that their output voltages are additive.

FIG. **4** shows a plot in polar coordinates of the variation of sensitivity of assembly **30** with angle of incidence in a plane perpendicular to the surface **34**. The phase differences between ultrasonic vibrations reaching the two receivers, when added, result in pronounced variation of the sensitivity of assembly **30** with angle of incidence, as shown. Specifically, the maximum sensitivity of assembly **30** occurs in a plane central to the main lobe of FIG. **4** corresponding to a plane of symmetry between receivers **32** and **36**. Signals arriving at the two receivers which are incident from this plane necessarily have zero path and phase difference, thereby producing a maximum amplitude output signal. Reception from the n=1 side lobes is preferably minimized by use of a cover element (not shown) which shields assembly **30** from sound incident at large angles from surface **34**.

By arranging assembly **30** as described, the plane of maximum sensitivity is oriented substantially parallel and adjacent to surface **34**. This is ideal for receiving signals incident from near the presentation board (S_2). Conversely, assembly **30** exhibits greatly reduced sensitivity to signals (S_1) incident from further away from the presentation board. These directional properties greatly help to isolate the ultrasound signals of importance to the digitizer system, increasing the signal-to-noise ratio. This allows the use of lower transmitter intensities and/or larger boards, and solves problems caused by a wide range of common noise sources. It should be noted that the sensitivity profile of assembly **30** parallel to surface **34** remains substantially omnidirectional similar to the profile of an individual receiver.

Turning now to FIGS. **5–7**, a transmitter device, generally designated **40**, for use with a drawing implement **42** in a digitizer system will be described.

Generally speaking, transmitter device **40** includes a housing **44** having a substantially cylindrical opening **46** which terminates at its lower end in an annular wedge surface **48** having a central bore **50**. Drawing implement **42** is received within opening **46** with its operative tip **52** extending through bore **50**.

Transmitter device **40** also includes a retainer **54** in the form of a cover attachable to the upper end of opening **46** to retain drawing implement **42** in position within housing **44**. Retainer **54** features a spring element **56** for biasing drawing implement **42** towards annular wedge surface **48**. An ultrasound transmitter **58** is mounted on the lower surface of housing **44** proximal to bore **50**. Spring element **56** is preferably provided with a shaped abutment surface **60** having features for centering the back end of a drawing implement. Typically, abutment surface **60** has an axial conical projection as shown for centering drawing implements by engaging a rear axial recess which is common to almost all presentation board pens. Alternatively, abutment surface **60** may be formed with a conical recess or other features for centering the back of a drawing implement.

It should be noted that the combination of annular wedge surface **48** and spring element **56** with abutment surface **60** serves to hold drawing implements of a range of lengths and widths in central alignment within cylindrical opening **46** without contacting the sides of housing **44**. This arrangement makes transmitter device **40** insensitive to variations in drawing implement width. The avoidance of frictional contact with the sides of housing **44** is also important for efficient operation of a contact-sensing microswitch, as will be described below.

Ultrasound transmitter **58** is formed as a substantially cylindrical piezoelectric transmitter element attached to the lower end of housing **44** around central bore **50**. This arrangement ensures that, when in use, the cylindrical transmitter is coaxial with drawing implement **42**, circumscribing a part of drawing implement **42** proximal to operative tip **52**. As a result of the symmetry of this arrangement, TOF measurements of the position of drawing implement **42** are completely independent of axial rotation of transmitter device **40**. Furthermore, the position of operative tip **52** can be determined very precisely by adding the radial dimension of transmitter cylinder **58** to the value calculated from the TOF.

Transmitter device **40** also typically features at least one element of an electromagnetic communications link, typically an IR transmitter **60**, and preferably about four such transmitters spaced around the lower end of housing **44**. This ensures that at least one IR transmitter will be correctly oriented facing an IR receiver mounted on the presentation board at any time. It should be noted that a reversed arrangement in which an IR link is formed with a board-mounted transmitter and device **40** is also applicable. The IR link may be dispensed with entirely if three ultrasound receivers are used to calculate each position. However, the arrangement described is preferred for providing higher precision than a purely ultrasound-based system whilst avoiding the need for complex IR signal processing circuitry in the transmitter device. Additionally, the IR transmitter allows transmission of extra information such as pen color and the like.

Ultrasound transmitter **58** and IR transmitters **60** are actuated under the control of electronic circuitry which is battery powered. Both the electronic circuitry and the battery are located in a compartment **62** of housing **44**.

Transmitter device **40** features a switch for detecting contact between operative tip **52** and the surface of a writing board. This switch is associated with the electronic circuitry and is employed to actuate ultrasound transmitter **58** and IR transmitters **60**. The switch is formed as a microswitch positioned to respond to changes in the force applied by drawing implement **42** against annular wedge surface **48**.

FIGS. **6A–6C** show a construction for such a microswitch, generally designated **64**. Microswitch **64** is formed from three functional layers. First, a base layer **66** provides the two terminals of the microswitch, a single peripheral contact **68** and a set of common contacts **70**, spaced-apart around the center of base layer **66**. On top of base layer **66** lies a layer of conductive resilient foam **72** having cut-out holes **74** opposite contacts **70**. A third rigid conducting layer **76** lies above foam layer **72**. Conducting layer **76** has small conductive downward projections **78** aligned with holes **74**. An upper cover **80**, integrally formed with annular wedge surface **48**, attaches loosely to base layer **66** to unify the structure while allowing sufficient vertical motion for operation of the switch. Each layer has a central bore, together corresponding to bore **50** of FIG. **5**.

In a non-compressed state, conductive contact is made between peripheral contact **68** and foam layer **72** and between foam layer **72** and upper conducting layer **76**.

However, the switch remains open since the thickness of foam layer **72** prevents contact between projections **78** and inner contacts **70**. When pressure is applied to compress microswitch **64**, foam layer **72** becomes compressed until projections **78** come into contact with inner contacts **70**, thereby closing the switch. In principle, release of the pressure allows the foam layer to return to its initial state, thereby breaking the circuit. However, in practice, the relaxation response time of the foam material is typically quite slow. For this reason, a spring **82** is mounted between base layer **66** and upper conductive layer **76** such that, when the pressure is released, upper conductive layer **76** is lifted immediately so as to break the circuit.

It will be clear that, when drawing implement **42** is not in use, spring element **56** urges drawing implement **42** downwards against annular wedge surface **48** so as to close microswitch **64**. When drawing implement **42** is used to draw on a presentation board, a force is exerted on operative tip **52** of drawing implement **42** towards housing **44**, causing drawing implement **44** to recoil slightly against spring element **56**. This reduces the pressure exerted on annular wedge surface **48** the circuit of microswitch **64** opens. The electronic circuitry of transmitter device **40** is responsive at least to opening of microswitch **64** to affect a signal transmitted by transmitter device **40**.

FIG. **6**B shows microswitch **64** assembled, together with ultrasound transmitter **58** and IR transmitters **60**. FIG. **6**C shows a pair of spring elements **84** which are mounted within annular wedge surface **48** so as to grip the end of a drawing implement inserted through central bore **50**. This ensures that the upper layer of microswitch **64** is sensitive to movements of drawing element **42**.

With regard to microswitch **64**, it should be noted that correct operation of the switch depends on a degree of freedom of axial motion of drawing implement **42** against spring element **56**. For this reason, it is important that spring element **56** is not fully compressed when retainer **54** is attached.

FIG. **7** shows an example of a structure for attachment of retainer **54** to housing **44**, in which lateral projections **86** engage channels **88** which are shaped to provide a margin of release **90** when fully engaged. Margin of release **90** is designed to be at least sufficient to allow an operative range of motion of microswitch **64**.

A second option for transmitter device **40** is shown in FIG. **11**. Similarly to the configuration shown in FIG. **5**, device **40** is intended for use with drawing implement **42**. Transmitter device **40** also features housing **44** with cylindrical opening **46**. However, cylindrical opening **46** now terminates at its lower end with a gasket **134**. Gasket **134** features a central bore **136**, through which operative tip **52** of drawing implement **42** extends.

In place of retainer **54**, transmitter device **40** features a different type of retainer, which is a holder **138**. Holder **138** is hingedly attached to the upper end of housing **44** with a hinge **137**, and acts to hold drawing implement **42** substantially centered within opening **46**. Holder **138** locks onto housing **44** by a locking pin **139**. Holder **138** features a spring element **140** for biasing drawing implement **42** towards gasket **134**. A second spring element **142**, located near gasket **134**, helps further bias and center drawing implement **42** within opening **46**. Spring element **140** is stronger than second spring element **142**. A cover **143** is also provided for drawing implement **42**.

In order to retain drawing implement **42** in the centered position, holder **138** has an upper biasing element **144**. Upper biasing element **144** can be in one of two shapes, as shown in FIGS. **12**A and **12**B. FIG. **12**A shows upper biasing element **144** with an axial conical projection **146** for centering drawing implement **42** by engaging a rear axial recess **148** which is common to most presentation board pens. However, this embodiment is potentially restricted to use only with presentation board pens having axial recess **148** with a particular diameter, as axial recess **148** is not of uniform diameter between pens. Alternatively and preferably, upper biasing element **144** features a recess **150** into which the upper end of drawing implement **42** is inserted, as shown in FIG. **12**B. This second configuration has the advantage of being usable with most presentation board pens, since the external diameter of these pens is generally uniform.

The combination of upper biasing element **144**, gasket **134** and spring elements **140** and **142** has the advantage of holding drawing implements of a variety of lengths and external diameters in central alignment within cylindrical opening **46** substantially without contacting the sides of housing **44**. As described above for FIG. **5**, the avoidance of frictional contact with the sides of housing **44** is also important for efficient operation of a contact-sensing microswitch **152**.

Holder **138** also has a pressure-sensitive element **152**, which has two parts, a pin **154** and a printed circuit board **156**. Pin **154** contacts upper biasing element **144**, sensing when contact is made between drawing implement **42** and the presentation board. In combination, these two parts allow transmitting device **40** to sense when contact has been made with the presentation board.

Transmitting device **40** also features ultrasound transmitter **58** and IR transmitter **60**, similar to the configuration shown in FIG. **5**. Ultrasound transmitter **58** and IR transmitters **60** are actuated under the control of electronic circuitry **158** which is preferably battery powered by a battery **160**. Both electronic circuitry **158** and battery **160** are located in holder **138** of housing **44**.

Turning to FIGS. **8**A–**8**C, a transmission profile of transmitter device **40** will now be described. FIG. **8**A represents a contact profile of drawing element **42** as measured by microswitch **64** as a function of time. During a first period **100**, drawing implement **42** is kept in contact with the presentation board for an extended period to draw a continuous shape. Then, during a second period **102**, drawing implement **42** is used in a series of short, separate strokes to form a dashed line.

As mentioned above, some digitizer systems suffer from a significant delay in picking-up the beginning of each pen stroke. This is because the transmitters are actuated each time pen contact is made and interrupted each time pen contact ceases. As a result, each pen stroke starts with a dead time during which the receiver system synchronizes and locks on to the transmitted signals. The results of this system are shown in FIG. **8**B. During period **100** the effects are not very serious. There is a small signal loss at the beginning of the period, but the great majority of the stroke is recorded well. During period **102**, however, the system response time is comparable to the length of the pen strokes. As a result, the dashed line is almost completely lost.

To solve this problem, synchronization is maintained between transmitter device **40** and the receiver system for a given period after the end of each pen stroke. Typically, this is achieved by the electronic circuitry continuing to operate IR transmitters **60** for the given time interval after microswitch **64** ceases to indicate a force exerted on the outer housing towards the operative tip of the drawing implement. False drawing signals can be avoided either by

the electronic circuitry disabling ultrasound transmitter **58** during the delay period, or by changing the content of the IR signal to indicate a non-contact pen state.

FIG. **8**C illustrates the response profile of transmitter device **40** as described. During an initial period of a single pen stroke, its response is not dissimilar from that of less comprehensive devices. However, when short repeated strokes are encountered, transmitter device **40** maintains synchronization between successive strokes, thereby providing an accurate response immediately on switching of microswitch **64**.

Turning now to FIG. **9**, an eraser, generally designated **104**, for use with a presentation board digitizer system will be described. A major problem with eraser elements for use with digitizer systems is the common practice of employing only a part of the eraser surface. Since the digitizer is typically unable to distinguish between flat contact and edge contact of the eraser, the digitized image frequently shows a much greater erased area than has actually been cleared from the presentation board itself. To solve this problem, eraser **104** is constructed such that its eraser surface is self-orienting to lie parallel to the presentation board surface. This ensures that the contact area of the eraser element is always precisely defined.

Thus, eraser **104** has a handle **106** and an eraser element **108** which has a substantially flat, eraser surface **110**. Handle **106** and eraser element **108** are connected by a pivot joint **112**, typically in the form of a ball-and-socket, which has two degrees of rotational freedom. The use of pivot joint **112** ensures that, in use, eraser element **108** assumes an orientation with eraser surface **110** parallel to the presentation board surface substantially independent of the orientation at which handle **106** is held.

Eraser **104** also features transmitter device features analogous to those of transmitter device **40** described above. These include a cylindrical ultrasound transmitter element **114**, a number of IR transmitters **116** and an electronic circuitry/battery block **118**. Connection of handle **106** to pivot joint **112** is through a sprung pin assembly **120**. A pressure sensing microswitch **122** is mounted in the seat of pin assembly **120** for sensing contact pressure between handle **106** and eraser element **108**. Wiring from electronic circuitry **118** to transmitters **114** and **116** is preferably located axially within pin assembly **120** and passing through pivot joint **112**.

Eraser surface **110** is circular, and cylindrical ultrasound transmitter element **114** is arranged such that its axis is aligned with the center of eraser surface **110**. By addition of the radius of the cylinder to the TOF measurements, this arrangement allows precise identification of the center of the circle of erasure, and hence of the entire area covered by eraser surface **110**. Eraser **104** thus provides a much higher degree of precision and determination of the erased area than can be achieved by other prior art devices.

A second embodiment of an eraser **162** is shown in FIG. **13**. Eraser **162** is designed for erasing a small area, particularly an area of narrow width, and can thus be described as a "narrow-band eraser". Similarly to eraser **104**, eraser **162** has a handle **164** and an eraser element **166** which has a substantially flat eraser surface **168**. However, handle **164** is connected to eraser element **166** by a pressure-sensitive element **170**. Pressure-sensitive element **170** includes a spring **172**, such that when at least a portion of eraser surface **168** contacts the presentation board, a signal is transmitted to a touch switch **174**. Touch switch **174** includes a printed circuit board **176** and electrical circuitry **178**, which enable touch switch **174** to identify when eraser surface **168** is contacting the presentation board. This is similar to pressure sensing microswitch **122** of eraser **104**.

Another method of identification of touching of the presentation board uses the following features of eraser **162**. Eraser surface **168** has two contact microswitches **180** located substantially at each end of eraser surface **168**, which are substantially similar in function to contact microswitch **64** of FIG. **6**. If only one contact microswitch **180** senses contact with the presentation board, only a small area will be erased, such as a letter, for example. If, however, both contact microswitches **180** sense contact with the presentation board, a zone with the length and width of eraser surface **168** will be erased.

Similarly to eraser **104**, eraser **162** also has transmitter device features. Specifically, eraser **162** has at least one, and preferably two, cylindrical ultrasound transmitters **182**, located in handle **164**, preferably substantially at each end of handle **164**. Since each ultrasound transmitter **182** is located in handle **164**, eraser **162** also features an ultrasound conductor tube **184** for each ultrasound transmitter **182**. Each ultrasound conductor tube **184** goes from handle **164** to eraser element **166**, such that the ultrasound signal from each ultrasound transmitter **182** is transmitted downward. Eraser **162** also has a reflector cone **186** for each ultrasound transmitter **182**. Reflector cone **186** is preferably located in eraser element **166**, reflecting the ultrasound waves in all directions.

Eraser **162** also has two infrared transmitters **188**, located substantially at each end of handle **164**. Each infrared transmitter **188** has an infrared reflector **190**, also located in handle **164**, which serves a similar function as reflector cone **186**.

Turning now to FIG. **10**, this shows the principle of operation of a further embodiment of a transmitter device for use with a presentation board digitizer system. This device is generally similar to transmitter device **40** described above except that it dispenses with microswitch **64**, instead identifying pen-board contact by transmission of vibrations through the board.

As mentioned earlier, digitizer systems employing through-the-board transmission suffer from poor accuracy and dependency on specific board design. However, they have a major advantage of inherent pen-board contact identification. The prior art device described in context with this example combines this feature with all the advantages of precision and independence from board design provided by air-borne ultrasound systems, using the through-the-board detection solely for contact detection.

Thus, this embodiment may be used with a presentation board system essentially similar to that of FIG. **1**, with the addition of a transducer associated with the board (not shown) for detecting vibrations from the transmitter conducted through the board. The processor of the receiver system is then responsive to outputs from the air-borne ultrasound receivers to calculate a current position of the transmitter, and to the output from the board mounted transducer to identify contact between the drawing implement and the board, thereby identifying operative strokes of the drawing implement.

The principle of this system is shown clearly in FIG. **10** in which plot **130** represents the signal from one of the ultrasound receiver assemblies and plot **132** represents the signal from the board-mounted transducer. Plot **130** shows a continuous sequence of pulses since the transmitters operate continuously as long as the pen is in use, according to this embodiment. Plot **132**, on the other hand, only registers corresponding pulses during a period that the pen is in

contact with the board. Although the signal quality of plot **132** is typically inferior, it is more than sufficient for identification of contact or non-contact conditions.

The principles and operation of a handheld device and digitizing system according to the present invention may be better understood with reference to drawings **14–21** and accompanying descriptions.

Before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of the components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments or of being practiced or carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein is for the purpose of description and should not be regarded as limiting.

The present invention provides several improvements to the above described prior art digitizing systems, which render such systems more accurate and/or more comfortable for use.

Thus, according to one aspect, the present invention provides a handheld device for use with a board supplemented with a processing system for digitizing operative strokes of the handheld device on the board. The handheld device according to this aspect of the present invention is shown in FIG. **14** and is referred to hereinbelow as device **200**.

Device **200** includes a housing **202**. Housing **202** has a substantially cylindrical bore **204** therein. Bore **204** terminates at a distal end **206** of housing **202** with a central orifice **208** which communicates with bore **204**. Housing **202** serves for receiving a portion of a body **210** of a drawing implement **212** with its drawing tip **214** extending from central orifice **208**. Housing **202** is formed with a plurality of openings **216** which are circumferencly arranged at distal end **206** of housing **202** and communicating with bore **204**.

Device **200** further includes an ultrasonic receiver or transmitter device **220**, preferably a piezoelectric ultrasonic receiver or transmitter device. Device **220** is mounted within housing **202**, remote from drawing tip **214**, yet in close proximity with bore **204**. Device **220** serves for receiving or transmitting an intermittent ultrasound signal through bore **204** and plurality of openings **216**, thereby enabling triangulation of drawing tip **214** by compatible ultrasound receivers/transmitters located in an appropriate context with the board.

This aspect of the present invention has advantages over configurations in which the device born ultrasound receiver/transmitter is located close to the drawing tip and thickens a portion of a drawing implement which is traditionally narrow. The use of ultrasound tunneling through bore **204** and openings **216** (or vice versa) ensures accurate triangulation of the drawing tip although the handheld device born ultrasound receiver/transmitter is remote therefrom.

It will be appreciated by one ordinarily skilled in the art that other features of the prior art handheld devices described hereinabove and novel features of the handheld devices according to the various aspects of the present invention as further described herein can be combined to operate with device **200**.

According to another aspect, the present invention provides a handheld device for use with a board or screen supplemented with a processing system for digitizing operative strokes of the handheld device on the board or screen. The handheld device according to this aspect of the present invention is shown in FIG. **15** and is referred to hereinbelow as device **300**.

Device **300** includes a housing **302**. Housing **302** has a substantially cylindrical bore **304** therein, terminating at a distal end **306** of housing **302** with a central orifice **308** which communicates with bore **304**. Housing **302** serves for receiving and releasing a portion of a body **310** of a removably attachable operative implement **312** through orifice **308** with its operative tip **314** extending from central orifice **308**.

Thus, according to this aspect of the present invention front loading and replacement of operative implement **312** is enabled, to assist in maintaining the electronic components of device **300** undisturbed upon replacing implements **312** as required or desired. This, in turn, provides for constructional simplicity and cost-effectivity.

Device **300** further includes a retainer **316**. Retainer **316** is engaged in housing **302** for releasably retaining removably attached operative implement **312** within housing **302**.

Device **300** further includes an ultrasonic receiver or transmitter device **318**, preferably a piezoelectric ultrasonic receiver or transmitter device. Device **318** is internally or externally (as shown) connected to housing **302** for receiving or transmitting an intermittent ultrasound signal. In the example shown device **318** has an annular configuration and is surrounding operative tip **314** of implement **312**. It will, however, be appreciated that other constructions, in which, for example, device **318** is remotely engaged within housing **302**, as described, for example, with respect to device **200** above, are also envisaged.

Device **300** further includes a microswitch **320** implemented within housing **302**. Microswitch **320** is actuated when contacted by a proximal end **322** of body **310**, so as to be responsive to a force exerted on operative tip **314** of operative implement **312**. The construction and operation of microswitches are further described above with respect to prior art devices. These descriptions are incorporated herein to describe the construction and operation of microswitch **320**.

Both, touch and pressure actuated microswitches are envisaged. While in the first case, all on none sensation is experienced, in the latter case sensation of a continuous variable is optional. In this case, the pressure information can encode data relating, for example, to different operative implements employed.

In any case, the information sensed by microswitch **320** is typically forwarded to the digitizing system via a dedicated communication line, e.g., an infrared communication line. However, other possibilities are further described hereinunder with respect to additional aspects of the present invention are envisaged.

Device **300** further includes an electronic circuitry **324**. Circuitry **324** is engaged within housing **302** and electronically communicates with microswitch **320** for affecting operation of device **300** at least when microswitch **320** indicates that force is exerted on operative tip **314** of operative implement **312**.

A power source **326** (e.g., a pair of batteries) serves to provide device **318** and microswitch **320** with power for operation.

Operative implement according to this and other aspects of the present invention can be, for example, a drawing implement, an annotation implement or an eraser.

It will be appreciated by one ordinarily skilled in the art that other features of the prior art handheld devices described hereinabove and novel features of the handheld devices according to the various aspects of the present invention as further described herein can be combined to operate with device **300**.

As shown in FIG. **16**, according to still another aspect of the present invention there is provided a method operative in a board or screen digitizing system including at least three spaced apart ultrasound receivers associated with the board or screen surface, and a handheld device including an intermittent signal transmitter (e.g., using frequencies of 40–100 kHz while transmitting a signal). The method serves for collecting ultrasound signals from the handheld device and for tracking the movement of the handheld device with respect to the board.

Assume that the time interval between adjacent ultrasonic signals $S_1 \ldots S_n$, generated by the handheld device is substantially constant and equals K. At an arbitrary time point, T_0, each of the three ultrasound receivers, CH**1**, CH**2** and CH**3**, is turned on so as to receive the first signal S_1. The time of that reception for each of the receivers, A_{11}, A_{21} and A_{31}, depends on the distance between each of the receivers and the handheld device at the time of transmission, so as the time between the actual transmittance of the first signal S_1 and the delayed time of reception, d_{11}, d_{2l}, d_{31}, thereof, for each of the receivers. The time between adjacent signal receptions for each of the receivers depends on the movement and therefore change of position of the handheld device relative to each of the receivers. This time is shown in FIG. **16** to include a constant D, which is selected shorter (e.g., about 20–60% shorter) than K and a position dependent interval, $A_{11}, A_{12}, \ldots A_{1n}$; $A_{21}, A_{22} \ldots A_{2n}$; and $A_{31}, A_{32} \ldots A_{3n}$. The time interval between the actual transmittance of the signals and their reception for each of the receivers is represented by $d_{11}, d_{12}, \ldots d_{1n}$; $d_{21}, d_{22} \ldots d_{2n}$; and $d_{31}, d_{32} \ldots d_{3n}$. As already mentioned, D is a constant and defines a time period following the reception of a signal by any of the receivers. Since D is selected shorter than K, it is anticipated that during D, no signal is expected to arrive at any of the receivers and therefore, signal collection thereby can be shut down or disregarded for the D time period. This, in turn, reduces the background signals collected by each of the receivers and improves the signal to noise ration of the system.

Thus, in order for the system to track the position of the handheld device, in a signal timing free manner, the following steps are undertaken.

First, the handheld device is selected to transmit signals of a predetermined frequency, the time interval therebetween equals K.

Second, an arbitrary time point for signal collection, T_0, in which each of the receivers is switched on, is set.

Third, for each of the receivers the system calculates the time elapsed between the actual transmission and actual reception of a signal. For example, the time elapsed between the actual transmission and actual reception of the second signal by the first receiver is calculated as follows:

$$d_{12}=D+A_{12}-K+d_{11}$$

This calculation is repeated for each of the receivers and each of the signals.

However, d_{11} is unknown. In order to calculate d_{11}, d_{21} and d_{31} the system employs two pairs of the three receivers, say CH**1**–CH**2** and CH**1**–CH**3** or CH**2**–CH**3**, and calculates, for each of the two pairs the time difference in reception of signals S_1 to S_n. It will be appreciated that such differences, for each pair of receivers, are represented by a hyperbolic plot. It will further be appreciated that the intersection between the two hyperbolic plots represents the coordinates of the handheld device at time of first transmission, S_1, from which d_{11}, d_{21} and d_{3l} can be calculated.

Thus, using the method herein described, one can follow the location of the handheld device by (i) calculating its position when transmitting a first signal and further by (ii) calculating the change in its position thereafter, when transmitting subsequent signals.

In order to further substantiate the results, some corrections are preferably undertaken.

Data pertaining to the first m points (m typically ranges between 20 and 100, preferably about 50) is collected. Each data point is calculated first as described above using the differences between pairs of receivers to calculate the first data point and thereafter the m−1 data points that follows, and second by considering each data point as a reference to the following data point. Then averaging for m data points is undertaken to substantiate the results.

Additional averaging process taking into account the rational speed of the handheld device with respect to the board or screen and the continuity of the hand holding the device when sketching or writing thereon, can be effected to further substantiate the results.

It will be appreciated that K is not always a constant since the frequency of signals depend on the specific piezoelectric crystal employed and to some extent environmental factors, such as humidity and temperature. Since all of the above calculations depend on the value of K, the actual K pertaining to the system at a given time should be calculated.

In order to calculate the actual K value at a given time of operation, the following equation is employed:

$$K=D+A_{12}-d_{12}+d_{11}$$

d_{12} and d_{11} are calculated as described above, whereas K is recalculated for every signal by:

$$K_j = \frac{(j-1)K_{j-1} + K_j}{j}$$

wherein j is the last signal sampled, say the thousandth signal. K is thus calculated for every signal and averaged.

Thus, according to this aspect of the present invention a plurality of time non-referenced ultrasound signals are collected by each one of at least three spaced apart ultrasound receivers and the position of the handheld device is calculated for each of the time non-referenced ultrasound signals, thereby enabling to track the handheld device, while obviating the need for an infrared link for referencing the time of each of the signals, which link is known to be a high energy consumer.

As mentioned hereinabove, the length of the D interval as compared to the K interval is selected so as to ensure picking-up of each of the actual signals transmitted by the transmitter, to thereby provide much higher signal-to-noise ratio and track more accurately the operative tip of the handheld device.

It will be appreciated by one ordinarily skilled in the art that other features of the prior art handheld devices described hereinabove and novel features of the handheld devices according to the various aspects of the present invention as further described herein can be combined to operate with the method herein described.

According to yet another aspect, the present invention provides a handheld device for use with a board or screen supplemented with a processing system for digitizing operative strokes of the handheld device on the board or screen. The handheld device according to this aspect of the present invention is shown in FIG. **17** and is referred to hereinbelow as device **400**.

Device **400** includes a housing **402**. Housing **402** has a substantially cylindrical bore **404** therein. Bore **404** termi-

nates at a distal end **406** of housing **402** with a central orifice **408** communicating with bore **404**. Housing **402** serves for receiving and releasing a portion of a body **410** of a removably attachable operative implement **412** through orifice **408**, with its operative tip **414** extending from central orifice **408**. Operative implement **412** is selectable among a plurality of different operative implements, including, but not limited to, drawing implements, e.g., of different colors, eraser implements and annotation implements.

Device **400** further includes a retainer **416**. Retainer **416** is engaged within housing **402** and serves for releasably retaining removably attached operative implement **412** within housing **402**.

Device **400** further includes an ultrasonic transmitter device **418**. Device **418** is internally, or as shown, externally, connected to housing **402** for transmitting one of a plurality of intermittent ultrasound signals. Each of the plurality of intermittent ultrasound signals according to this aspect of the present invention has a somewhat different frequency, say in the range of 40–100 kHz, wherein each of the frequencies employed is associated with one of the plurality of different operative implements **412** applicable for use with device **400**.

Device **400** according to this aspect of the present invention further includes a controller **440** being on or in housing **402** for setting transmitter device **418** to transmit an intermittent ultrasound signal of a frequency corroborating with one of the plurality of different operative implements **412**.

Thus, according to this aspect of the present invention the digitized system is made aware of the operative implement employed at a given time and responds accordingly. It will be appreciated that controller **440** can be integrated with the different operative implements **412**, such that insertion of one of implements **412** into housing **402**, directly results in automatic identification of the inserted implement **412**. Alternatively, and as specifically shown in FIG. **17**, a user interface is employed as part of controller **440**. It will further be appreciated, as further detailed hereinunder, that controller **440** can be remotely controlled by means of remote control communication.

It will be appreciated by one ordinarily skilled in the art that other features of the prior art handheld devices described hereinabove and novel features of the handheld devices according to the various aspects of the present invention as further described herein can be combined to operate with device **400**.

According to still another aspect, the present invention provides a handheld device for use with a board or screen supplemented with a processing system for digitizing operative strokes of the handheld device on the board or screen. The handheld device according to this aspect of the present invention is shown in FIG. **18** and is referred to hereinbelow as device **500**.

Device **500** includes a housing **502**. Housing **502** has a substantially cylindrical bore **504** therein. Bore **504** terminates at a distal end **506** of housing **502** with a central orifice **508** which communicates with bore **504**. Housing **502** serves for receiving therein a portion of a body **510** of an operative implement **512**, with its operative tip **514** extending from central orifice **508**.

Device **500** further includes an ultrasonic transmitter device **518**. Device **518** is internally or externally connected to housing **502** for transmitting one of two intermittent ultrasound signals. Each of the two intermittent ultrasound signals has a somewhat different frequency, say in the range of 40–100 kHz.

Device **500** further includes a microswitch **520** engaged within housing **502**. Microswitch **520** can acquire a first mode or a second mode of operation. Microswitch **520** acquires the first mode of operation when it is in contact with a proximal end **522** of body **510** and the second mode of operation when it is not in contact with proximal end **522** of body **510**. Microswitch **520** can be, for example, a touch or pressure sensitive microswitch.

Device **500** further includes an electronic circuitry **524**. Circuitry **524** electronically communicates between microswitch **520** and transmitter device **518**. Electronic circuitry **524** serves for associating one of the first and the second modes of operation of microswitch **520** with transmitter device **518**, such that intermittent ultrasound signals of different frequency are transmitted by transmitting device **518** in a mode dependent manner, thereby informing the processing system whether operative tip **514** is in contact with, or removed from, the board or screen.

The use of frequency encoded information obviated the need for a separate line of communication, such as infrared communication, to forward such information to the digitizing system. This, in turn, saves battery power.

It will be appreciated by one ordinarily skilled in the art that other features of the prior art handheld devices described hereinabove and novel features of the handheld devices according to the various aspects of the present invention as further described herein can be combined to operate with device **500**.

According to yet another aspect, the present invention provides a handheld device for use with a board or screen supplemented with a processing system for digitizing operative strokes of the handheld device on the board or screen. The handheld device according to this aspect of the present invention is shown in FIG. **19** and is referred to hereinbelow as device **600**.

Device **600** includes a housing **602**. Housing **602** has a substantially cylindrical bore **604** therein. Bore **604** terminates at a distal end **606** of housing **602** with a central orifice **608** which communicates with bore **604**. Housing **602** serves for receiving a portion of a body **610** of an operative implement **612** with its operative tip **614** extending from central orifice **608**.

At least a longitudinal portion **615** of housing **602**, originating at distal end **606** of housing **602**, and preferably terminating at a proximal end of housing **602**, is made of an infrared conveying material. According to a preferred embodiment all of housing **602** is made of the infrared conveying material and is coated by an infrared reflecting coat **617**, which preferably also coats bore **604**. Examples of infrared conveying materials suitable for housing **602** include, but are not limited to, lexan, which can be made to include pigments which renders it opaque.

Device **600** further includes an ultrasonic receiver or transmitter device **618**. Device **618** is internally or externally connected to housing **602** and serves for receiving or transmitting an intermittent ultrasound signal.

Device **600** further includes at least one infrared transmitter device **630**. Device **630** is implemented at a proximal end **632** of longitudinal portion **615** of housing **602**. Infrared transmitter device **630** is designed for directing infrared radiation emitted thereby through longitudinal portion **615** of housing **602**. At a distal end thereof, portion **615** includes at least one infrared reflector **634** to reflect the infrared radiation out of housing **602**.

Thus, according to this aspect of the present invention the infrared transmitter can be located at a position which is remote from the operative tip, which is traditionally the narrowest region of the device, say the proximal end or medial portion of the device, which is, in many cases,

shielded by the hand of the user and under such conditions becomes inoperative.

It will be appreciated by one ordinarily skilled in the art that other features of the prior art handheld devices described hereinabove and novel features of the handheld devices according to the various aspects of the present invention as further described herein can be combined to operate with device **600**.

According to another aspect, the present invention provides a remotely controlled handheld device for use with a board or screen supplemented with a processing system for digitizing operative strokes of the handheld device on the board or screen. The handheld device according to this aspect of the present invention is shown in FIG. **20** and is referred to hereinbelow as device **700**.

Device **700** includes a housing **702**. Housing **702** has a substantially cylindrical bore **704** therein, Bore **704** terminates at a distal end **706** of housing **702** with a central orifice **708** which communicates with bore **704**. Housing **702** serves for receiving a portion of a body **710** of an operative implement **712** with its operative tip **714** extending from central orifice **708**.

Device **700** further includes an ultrasonic receiver or transmitter device **718**. Device **718** is internally or externally connected to housing **702** and serves for receiving or transmitting an intermittent ultrasound signal.

Device **700** further includes a remote signal receiver **740** for receiving operational command signals from a remote signal transmitter (remote control) which is controlled by an operator. Operational commands according to this aspect of the present invention, include 'on' and 'off' commands, operative implement change commands, etc.

It will be appreciated by one ordinarily skilled in the art that other features of the prior art handheld devices described hereinabove and novel features of the handheld devices according to the various aspects of the present invention as further described herein can be combined to operate with device **700**.

According to still another aspect, the present invention provides a handheld device for use with a board or screen supplemented with a processing system for digitizing operative strokes of the handheld device on the board or screen. The handheld device according to this aspect of the present invention is shown in FIG. **21** and is referred to hereinbelow as device **800**.

Device **800** includes a housing **802**. Housing **802** has a substantially cylindrical bore **804** therein. Bore **804** terminates at a distal end **806** of housing **802** with a central orifice **808** which communicates with bore **804**. Housing **802** serves for receiving a portion of a body **810** of an operative implement **812** with its operative tip **814** extending from central orifice **808**.

Device **800** further includes a transparent ultrasonic receiver or transmitter device **818**. Device **818** is connected to housing and surrounds operative tip **814** for receiving or transmitting an intermittent ultrasound signal, thereby rendering operative tip **814** visible to a user. Transparent piezoelectric polymers are known in the art. Examples include PVdF, PVF2 and P(VF2–VF3) copolymer.

It will be appreciated that this feature of device **800** is of great importance. The most straight forward location for locating device **818** is at or close to operative tip **814** because the operative tip is to be tracked by sequential triangulation. However, when using an operative implement, such as a drawing or annotation implement, a user is in many cases accustomed at viewing the operative tip thereof. This habit is hampered in prior art devices by the ultrasonic device implemented thereat. Providing a transparent device overcomes this limitation.

It will be appreciated by one ordinarily skilled in the art that other features of the prior art handheld devices described hereinabove and novel features of the handheld devices according to the various aspects of the present invention as further described herein can be combined to operate with device **800**.

Although the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, it is intended to embrace all such alternatives, modifications and variations that fall within the spirit and broad scope of the appended claims.

What is claimed is:

1. A handheld device for use with a board supplemented with a processing system for digitizing operative strokes of the handheld device on the board, the handheld device comprising:

(a) a housing having a substantially cylindrical bore therein terminating at a distal end of said housing with a central orifice communicating with said bore, said housing receiving a portion of a body of a drawing implement with its drawing tip extending from said central orifice, said housing being formed with a plurality of openings being circumferencly arranged at said distal end of said housing and communicating with said bore; and

(b) an ultrasonic receiver or transmitter device mounted within said housing, remote from said drawing tip, yet in close proximity with said bore, said device being for receiving or transmitting an intermittent ultrasound signal through said bore and said plurality of openings, thereby enabling triangulation of said drawing tip.

2. A handheld device for use with a board supplemented with a processing system for digitizing operative strokes of the handheld device on the board, the handheld device comprising:

(a) a housing having a substantially cylindrical bore therein terminating at a distal end of said housing with a central orifice communicating with said bore, said housing receiving and releasing a portion of a body of a removably attachable drawing implement through said orifice with its drawing tip extending from said central orifice;

(b) a retainer in said housing for releasably retaining said removably attached drawing implement within said housing;

(c) an ultrasonic receiver or transmitter device being connected to said housing for receiving or transmitting an intermittent ultrasound signal;

(d) a microswitch in said housing being actuated when contacted by a proximal end of said body, so as to be responsive to a force exerted on said drawing tip of said drawing implement; and

(e) an electronic circuitry being in said housing and electronically communicating with said microswitch for affecting operation of said device at least when said microswitch indicates that said force is exerted on said drawing tip of said drawing implement.

3. A handheld device for use with a board or screen supplemented with a processing system for digitizing operative strokes of the handheld device on the board or screen, the handheld device comprising:

(a) a housing having a substantially cylindrical bore therein terminating at a distal end of said housing with

a central orifice communicating with said bore, said housing receiving and releasing a portion of a body of a removably attachable operative implement through said orifice with its operative tip extending from said central orifice, said operative implement being selected from the group consisting of a drawing implement and an annotation implement;

(b) a retainer in said housing for releasably retaining said removably attached operative implement within said housing; and

(c) an ultrasonic receiver or transmitter device being connected to said housing for receiving or transmitting an intermittent ultrasound signal.

4. In a board or screen digitizing system including at least three spaced apart ultrasound receivers associated with the board or screen surface, and a handheld device including an intermittent signal transmitter, a method of tracking the handheld device, the signals being transmitted with a preset first interval therebetween, the method comprising the steps of collecting a plurality of time non-referenced ultrasound signals by each of the at least three spaced apart ultrasound receivers and calculating a position of the handheld device for each of the time non-referenced ultrasound signals, thereby tracking the handheld device.

5. The method of claim **4**, wherein reception of each of said at least three spaced apart ultrasound receivers is suspended for a second time interval following the reception of a signal thereby, said second time interval is shorter than said first time interval.

6. A handheld device for use with a board or screen supplemented with a processing system for digitizing operative strokes of the handheld device on the board or screen, the handheld device comprising:

(a) a housing having a substantially cylindrical bore therein terminating at a distal end of said housing with a central orifice communicating with said bore, said housing receiving and releasing a portion of a body of a removably attachable operative implement through said orifice with its operative tip extending from said central orifice and being selectable among a plurality of different operative implements;

(b) a retainer in said housing for releasably retaining said removably attached operative implement within said housing; and

(c) an ultrasonic transmitter device being connected to said housing for transmitting one of a plurality of intermittent ultrasound signals, each of said plurality of intermittent ultrasound signals having a different frequency, each of said frequencies being associated with one of said plurality of different operative implements; and

(d) a controller on or in said housing for setting said transmitter device to transmit an intermittent ultrasound signal of a frequency corroborating with one of said plurality of different operative implements.

7. A handheld device for use with a board or screen supplemented with a processing system for digitizing operative strokes of the handheld device on the board or screen, the handheld device comprising:

(a) a housing having a substantially cylindrical bore therein terminating at a distal end of said housing with a central orifice communicating with said bore, said housing receiving a portion of a body of an operative implement with its operative tip extending from said central orifice;

(b) an ultrasonic transmitter device being connected to said housing for transmitting one of two intermittent ultrasound signals, each of said two intermittent ultrasound signals having a different frequency;

(c) a microswitch in said housing being in a first mode or a second mode, said microswitch being in said first mode when in contact with a proximal end of said body and in said second mode when not in contact with said proximal end of said body; and

(d) an electronic circuitry electronically communicating between said microswitch and said transmitter device, said electronic circuitry being for associating one of said first and second modes with said transmitter device, such that said intermittent ultrasound signals of said different frequency are transmitted by said transmitting device in a mode dependent manner, thereby informing the processing system whether said operative tip is in contact with, or removed from, the board or screen.

8. A handheld device for use with a board or screen supplemented with a processing system for digitizing operative strokes of the handheld device on the board or screen, the handheld device comprising:

(a) a housing having a substantially cylindrical bore therein terminating at a distal end of said housing with a central orifice communicating with said bore, said housing receiving a portion of a body of an operative implement with its operative tip extending from said central orifice, at least a longitudinal portion of said housing originating at said distal end of said housing being of an infrared conveying material;

(b) an ultrasonic receiver or transmitter device being connected to said housing for receiving or transmitting an intermittent ultrasound signal;

(c) an infrared transmitter device being implemented at a proximal end of said longitudinal portion of said housing, said infrared transmitter device being designed for directing infrared radiation emitted thereby through said longitudinal portion of said housing.

9. The handheld device of claim **8**, wherein said longitudinal portion of said housing is supplemented with an infrared reflector for reflecting said infrared radiation out of said housing.

10. A handheld device for use with a board or screen supplemented with a processing system for digitizing operative strokes of the handheld device on the board or screen, the handheld device comprising:

(a) a housing having a substantially cylindrical bore therein terminating at a distal end of said housing with a central orifice communicating with said bore, said housing receiving a portion of a body of an operative implement with its operative tip extending from said central orifice;

(b) an ultrasonic receiver or transmitter device being connected to said housing for receiving or transmitting an intermittent ultrasound signal;

(c) a pressure sensitive microswitch in said housing being actuated when pressured by a proximal end of said body, so as to be responsive to a force exerted on said drawing tip of said drawing implement; and

(d) an electronic circuitry being in said housing and electronically communicating with said microswitch for affecting operation of said device at least when said microswitch indicates that said force is exerted on said drawing tip of said drawing implement.

11. A remotely controlled handheld device for use with a board or screen supplemented with a processing system for

digitizing operative strokes of the handheld device on the board or screen, the handheld device comprising:

(a) a housing having a substantially cylindrical bore therein terminating at a distal end of said housing with a central orifice communicating with said bore, said housing receiving a portion of a body of an operative implement with its operative tip extending from said central orifice;

(b) an ultrasonic receiver or transmitter device being connected to said housing for receiving or transmitting an intermittent ultrasound signal; and

(c) a remote signal receiver for receiving operational command signals from a remote signal transmitter being controlled by an operator.

12. A handheld device for use with a board or screen supplemented with a processing system for digitizing operative strokes of the handheld device on the board or screen, the handheld device comprising:

(a) a housing having a substantially cylindrical bore therein terminating at a distal end of said housing with a central orifice communicating with said bore, said housing receiving a portion of a body of an operative implement with its operative tip extending from said central orifice;

(b) a transparent ultrasonic receiver or transmitter device being connected to said housing and surrounding said operative tip for receiving or transmitting an intermittent ultrasound signal, thereby rendering said operative tip visible to a user.

* * * * *

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

(10) **Patent No.: US 6,841,742 B2**
(45) **Date of Patent: Jan. 11, 2005**

(54) **PRESENTATION BOARD DIGITIZER SYSTEMS**

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(73) Assignee: **Luidia Inc.**, San Carlos, 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.

(21) Appl. No.: **10/803,817**

(22) Filed: **Mar. 16, 2004**

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Related U.S. Application Data

(62) Division of application No. 10/161,903, filed on Jun. 4, 2002, which is a continuation of application No. 09/850,875, filed on May 7, 2001, now abandoned, and a continuation-in-part of application No. 09/916,558, filed on Jul. 26, 2001, now Pat. No. 6,424,340, which is a continuation of application No. 09/030,825, filed on Feb. 26, 1998, now Pat. No. 6,300,580, which is a continuation of application No. 08/811,947, filed on Mar. 5, 1997, now Pat. No. 6,292,177.

(30) **Foreign Application Priority Data**

Mar. 10, 1997 (IL) 120417

(51) **Int. Cl.**[7] **G08C 21/00**

(52) **U.S. Cl.** **178/18.04**; 178/18.01; 178/18.03; 178/19.01; 178/19.02

(58) **Field of Search** 178/18.01–18.07, 178/19.01, 19.03, 19.04, 19.05; 345/173–179

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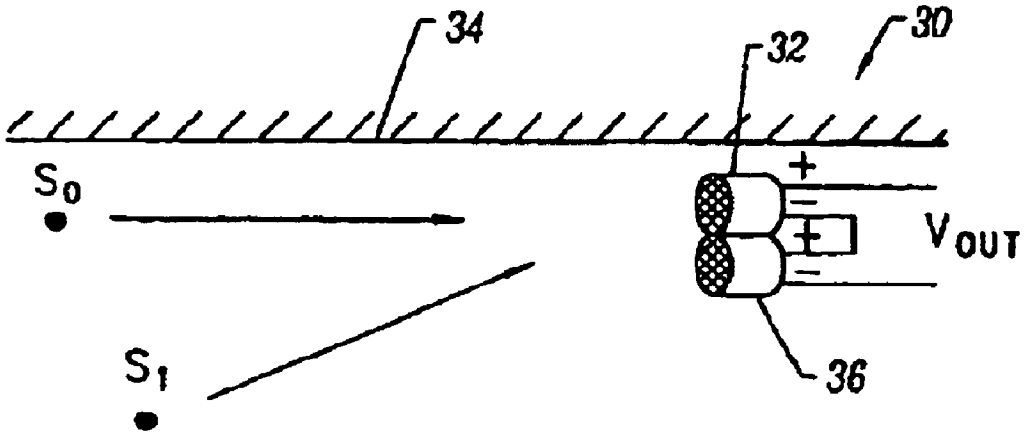
* cited by examiner

Primary Examiner—Vijay Shankar
(74) *Attorney, Agent, or Firm*—Dov Rosenfeld; Inventek

(57) **ABSTRACT**

A presentation board digitizer system for large boards preferably employs at least three spaced-apart ultrasound receivers assemblies. A current position of an ultrasound transmitter is assigned as a weighted centroid of time-of-flight position measurements based on at least two pairs of receiver assemblies. The weighting used varies as a function of the position of the transmitter across the board. A preferred structure of an ultrasound receiver assembly for use in the system employs a pair of ultrasound receivers arranged side-by-side in a line perpendicular to the surface of the presentation board. The receivers are connected so as to generate a total output signal corresponding to the instantaneous sum of the ultrasound signals received at each, such that the receiver assembly is most sensitive to ultrasound signals incident from a plane adjacent to the presentation board. Also described are a transmitter device for use with a conventional pen in which the ultrasound transmitter is a cylindrical element lying coaxial with the pen and adjacent to its tip, and a jointed eraser structure.

10 Claims, 9 Drawing Sheets



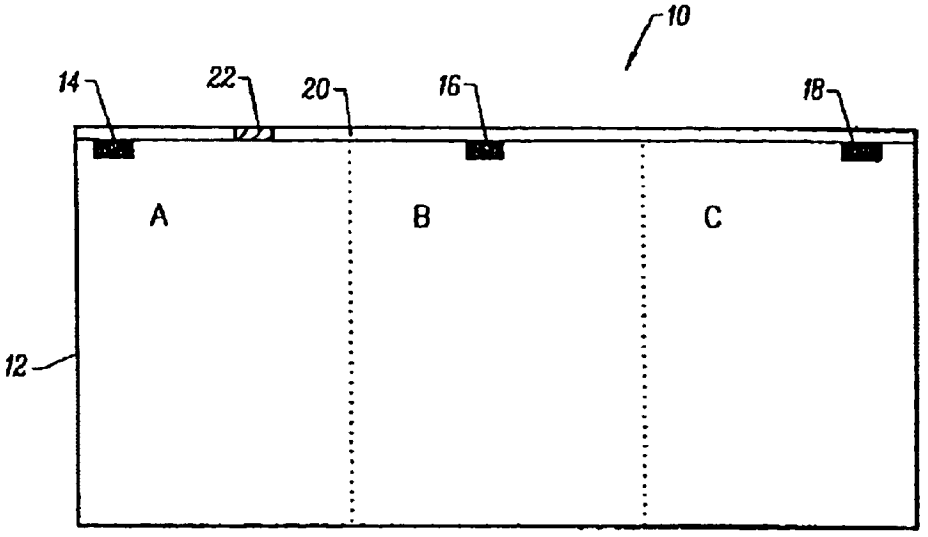


FIG. 1

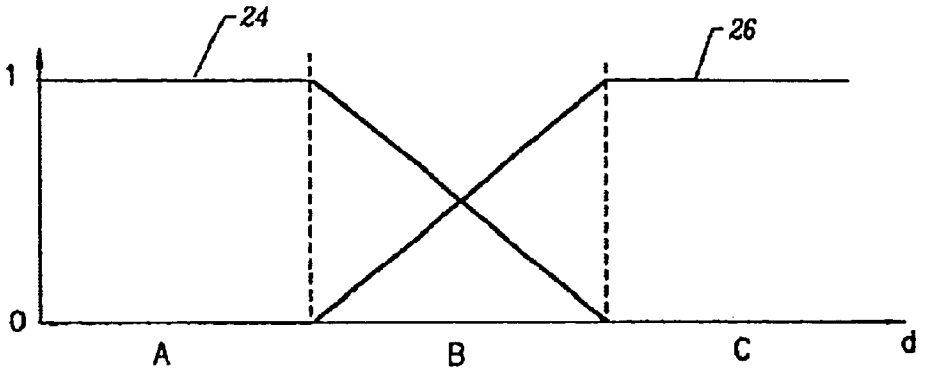


FIG. 2

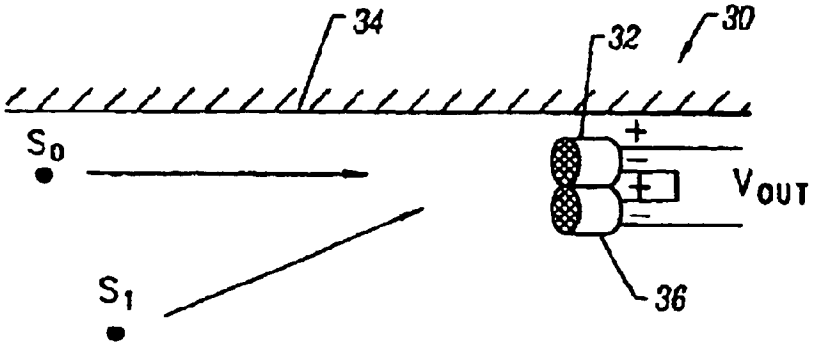


FIG. 3

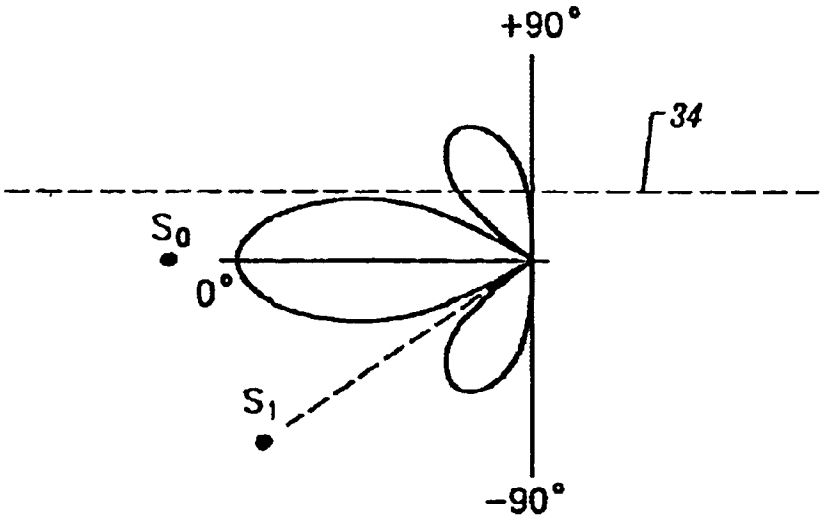


FIG. 4

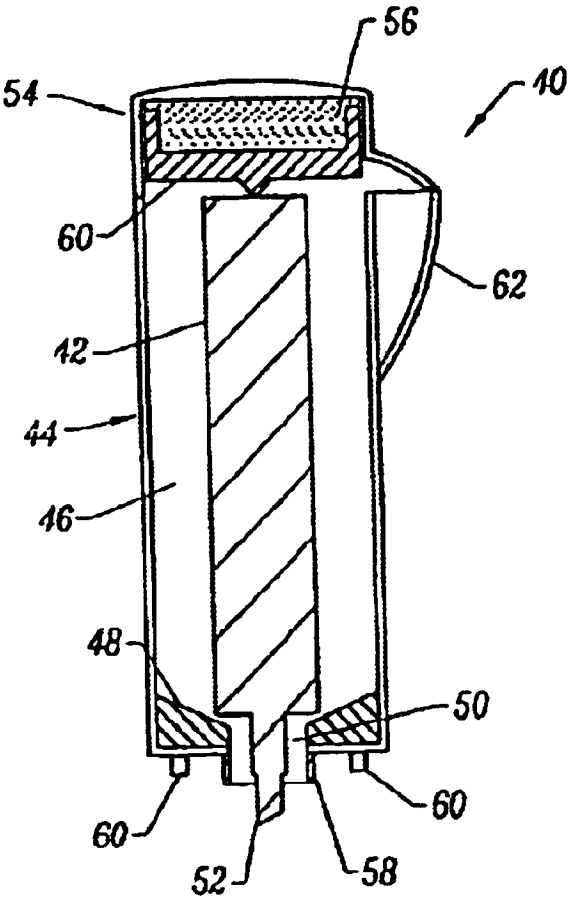


FIG. 5

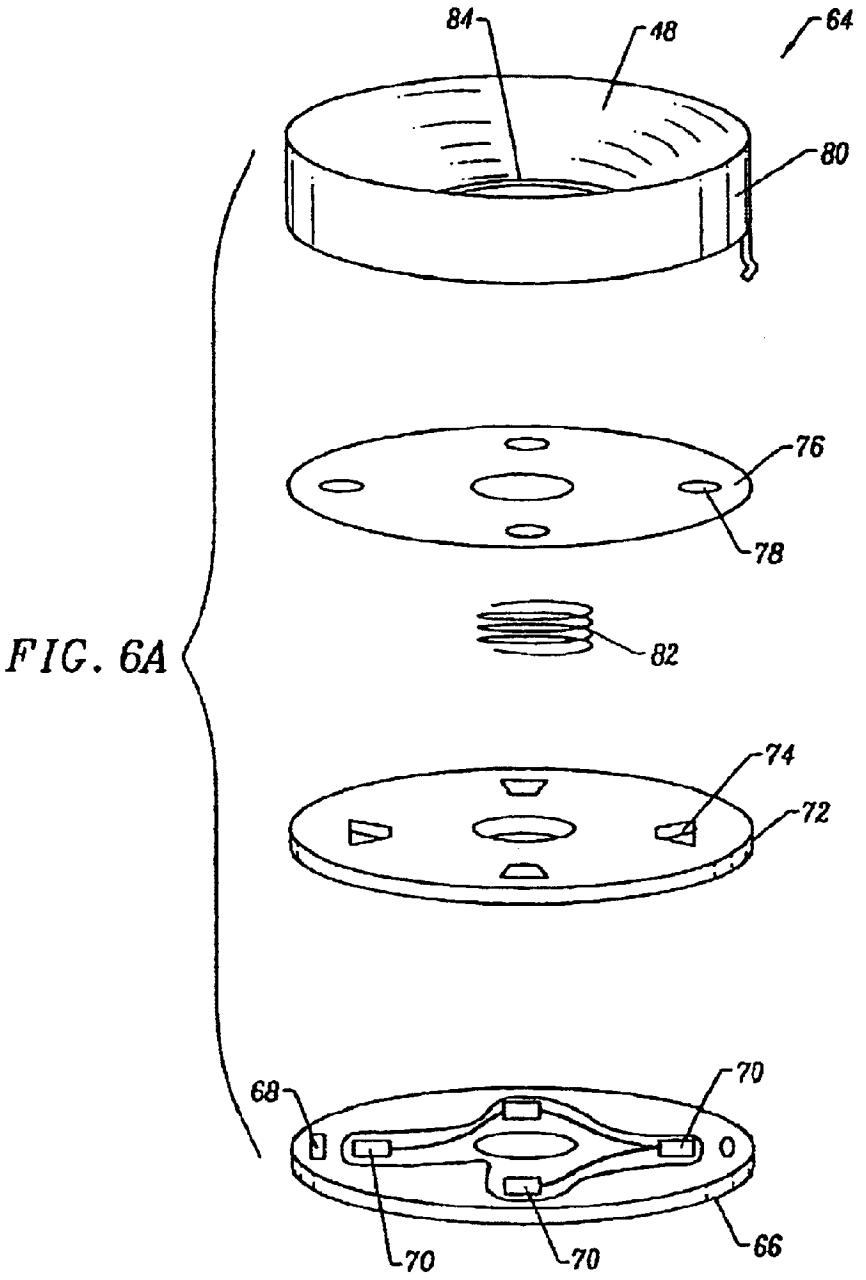


FIG. 6A

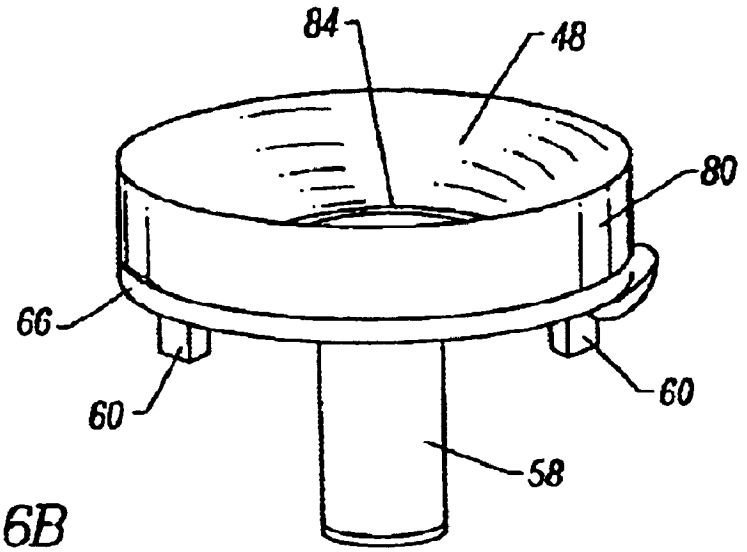


FIG. 6B

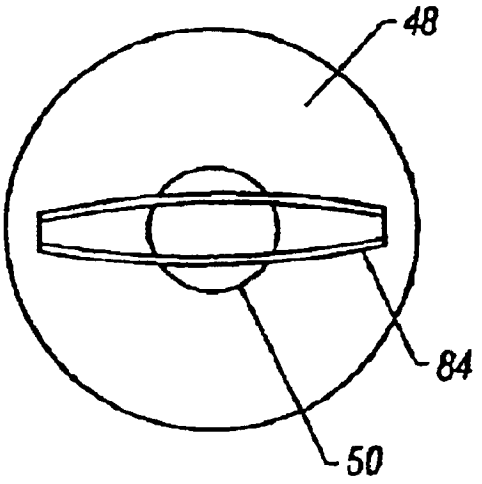


FIG. 6C

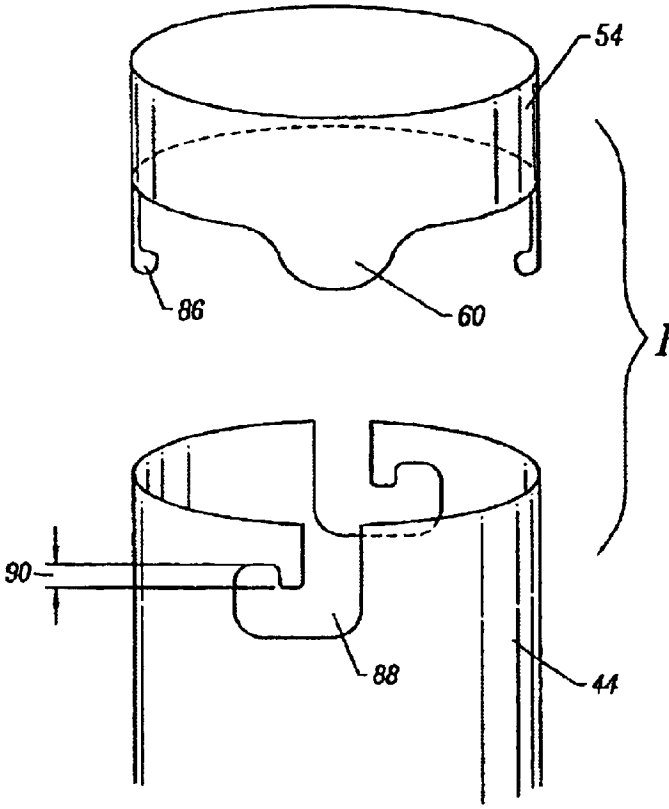


FIG. 7

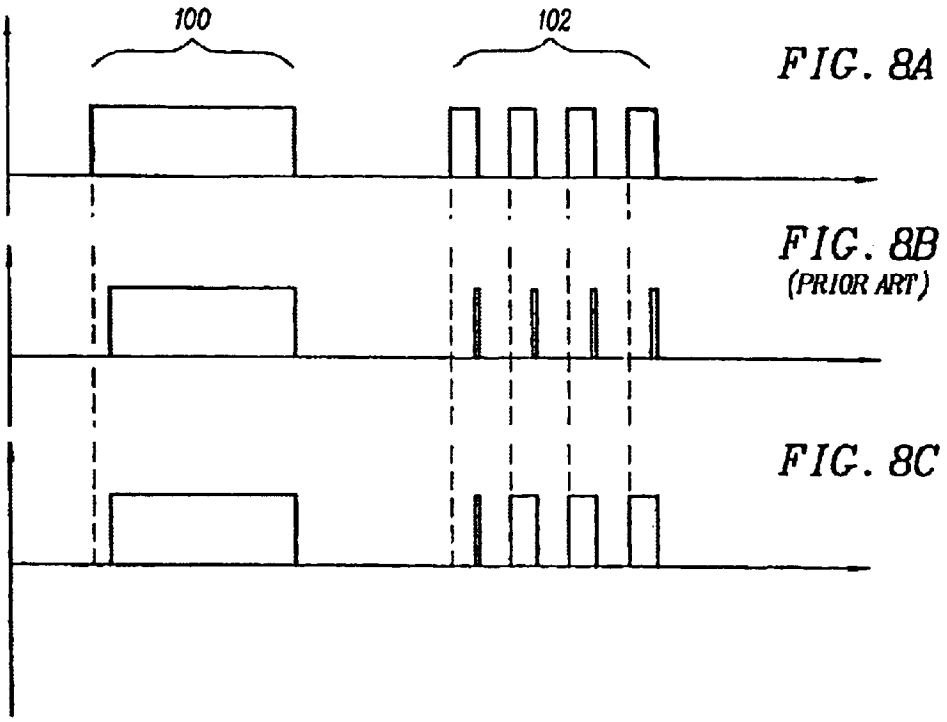


FIG. 8A

FIG. 8B
(PRIOR ART)

FIG. 8C

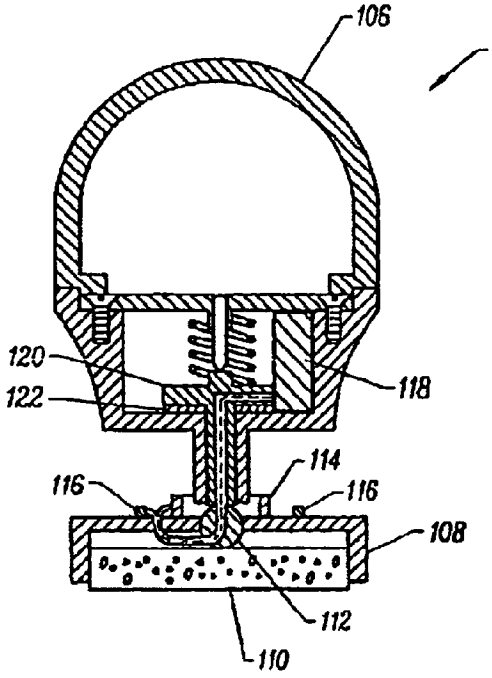


FIG. 9

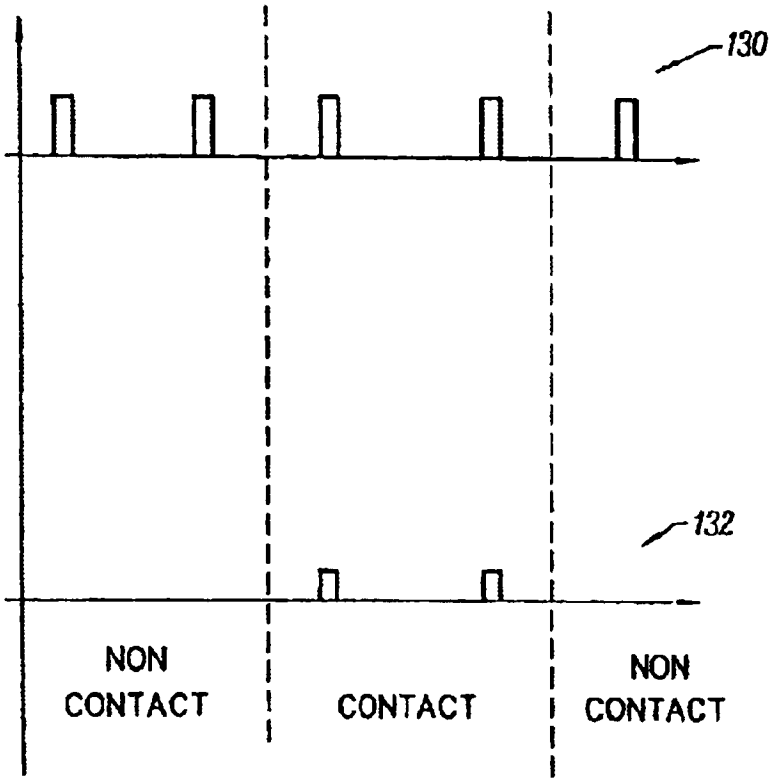


FIG. 10

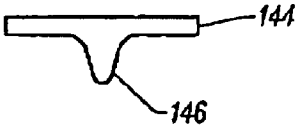


FIG. 12A

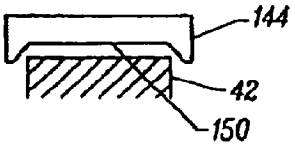


FIG. 12B

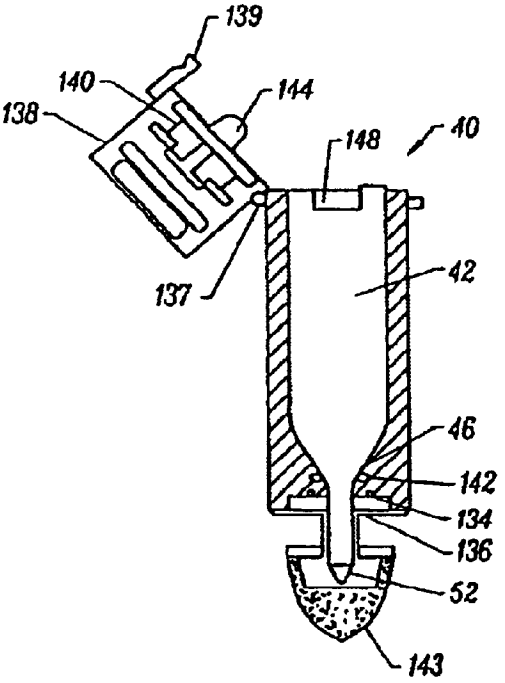


FIG. 11

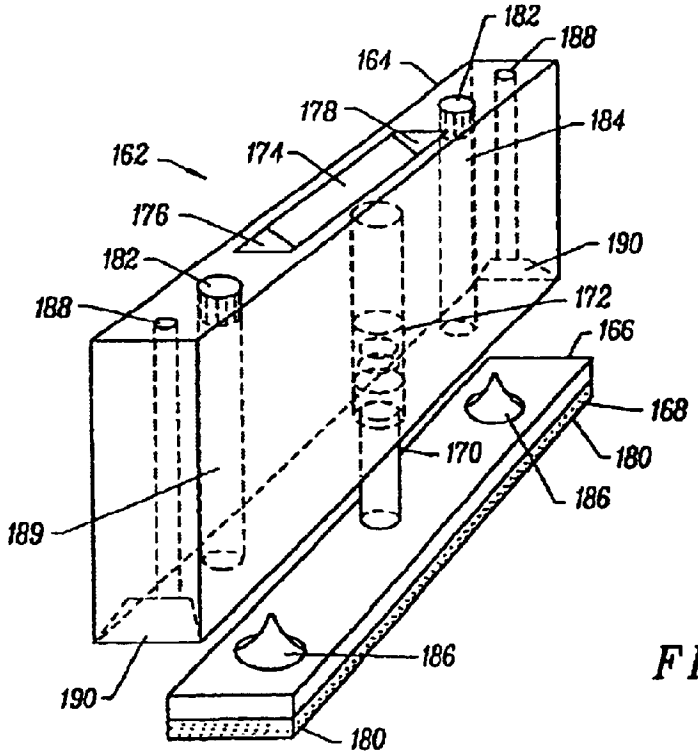


FIG. 13

PRESENTATION BOARD DIGITIZER SYSTEMS

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a division of U.S. application Ser. No. 10/161,903 filed Jun. 4, 2002.

U.S. application Ser. No. 10/161,903 is a continuation of U.S. application Ser. No. 09/850,875, filed May 7, 2001, now abandoned.

U.S. application Ser. No. 10/161,903 is also a continuation-in-part of U.S. application Ser. No. 09/916,558, filed Jul. 26, 2001, now U.S. Pat. No. 6,424,340, which is a continuation of U.S. application Ser. No. 09/030,825, filed Feb. 26, 1998, now U.S. Pat. No. 6,300,580, which in turn is a continuation of U.S. application Ser. No. 08/811,947, filed Mar. 5, 1997, now U.S. Pat. No. 6,292,177.

FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to digitizers and, in particular, it concerns devices for use with conventional presentation boards and pens for digitizing lines drawn manually.

It is known to use various techniques for determining the position of a writing implement or stylus on a flat surface. Glenn et al. U.S. Pat. No. 4,564,928, Suzuki et al. U.S. Pat. No. 4,886,943, Kobayashi et al. U.S. Pat. Nos. 4,910,363 and 5,073,685, and Yoshimura et al. U.S. Pat. No. 5,097,102, all disclose systems in which a vibrating element associated with a pen transmits vibrations through the material of a board. The vibrations are detected by transducers attached to the board and the position of the pen is calculated from the transmission time of the vibrations through the board. These systems inherently function exclusively when the pen is in contact with the board such that vibrations are transferred to the board. As a result, no special mechanism is required to distinguish writing from non-writing pen movements.

These systems are generally inaccurate due to non-uniform transmission times through the board. In fact, they typically require highly specialized board structures which renders them expensive and inconvenient.

An alternative approach is the use of air-borne ultrasound signals. Examples of such systems are described in Mallicoat U.S. Pat. No. 4,777,329, Stefik et al. U.S. Pat. No. 4,814,552, Hansen U.S. Pat. No. 4,506,354, and De Bruyne U.S. Pat. No. 4,758,691. These systems employ various combinations of ultrasound transmitters and receivers arranged at two points fixed relative to a board and on a movable writing implement. The position of the movable implement is then derived by triangulation. The systems typically require an additional hard-wired or electromagnetic link between the movable implement and a base unit to provide timing information for time-of-flight ultrasound calculations. An additional switch is also required to identify when the movable element is in contact with the board.

These previously known systems are typically limited to relatively small boards. This is because of signal to noise ratio (SNR) limitations. The volume of ultrasound used cannot be very high without causing bothersome accompanying whistling noises. Additionally, in a wireless system, power considerations severely limit the transmitted volume. To generate reliable position information, the transmitter-to-receiver distance must therefore be kept small. Attempts to use different sets of receivers for different regions of a large board generally result in discontinuities when the movable element travels from one region to another.

Another shortcoming of these previously systems is their inability to reproduce rapid interrupted pen strokes, such as performed when drawing a dashed line. Typically, the transmitter or receiver element in the pen turns OFF when the pen is inactive and is re-activated each time the pen comes in contact with the board. The system then takes a fraction of a second to resynchronize before it responds correctly. In the case of short strokes, the length of the operative stroke may be comparable with the response time of the system, thereby giving very poor results.

An additional problem of the previously known airborne ultrasound digitizer systems is that the ultrasound transmitter or receiver element is mounted asymmetrically to the side of the drawing implement. As a result, the measured position is offset from the true drawing position in a direction which changes with rotation of the drawing implement. This may result in discontinuities and illegible writing in the digitized image when the drawing implement position is changed between strokes.

Finally, conventional presentation board digitizer systems are typically limited to use with specially produced writing implements. This renders them expensive since pens have a very limited lifetime. Even where the ink cartridge is separately replaceable, the components used must be of a very specific design to be compatible.

There is therefore a need for a reliable, low-cost, digitizer system which may be used with conventional presentation boards of all sizes for determining accurately the position of a drawing implement on the board. It would also be advantageous to have a transmitter device for use with presentation board which can be used with a wide range of conventional writing implements.

SUMMARY OF THE INVENTION

The present invention is of presentation board digitizer systems for use with presentation boards of all sizes which allow accurate reproduction of short pen strokes and which may be used with conventional writing implements.

According to the teachings of the present invention there is provided, an ultrasound receiver assembly for use in a presentation board digitizer system, the receiver assembly comprising: (a) a first ultrasound receiver located adjacent to the surface of the presentation board; and (b) a second ultrasound receiver displaced from the first ultrasound receiver in a direction substantially perpendicular to the surface of the presentation board, the first and second ultrasound receivers being connected so as to generate a total output signal corresponding to the instantaneous sum of the ultrasound signals received at each of the first and second ultrasound receivers such that the receiver assembly is most sensitive to ultrasound signals incident from a plane substantially adjacent to the presentation board.

According to a further feature of the present invention, the first and second receivers are connected in series.

In the context of an ultrasound-based digitizing system for identifying the position of an ultrasound transmitter associated with an element movable relative to a surface, the system having at least three spaced apart ultrasound receivers associated with the surface, there is also provided according to the teachings of the present invention, a method of analyzing outputs from the ultrasound receivers comprising the step of identifying as a current position a weighted centroid of at least a first calculated position derived from the outputs of a first pair of the receivers and a second

calculated position derived from the outputs of a second pair of the receivers, wherein the weighting varies as a continuous function of approximate position relative to the ultrasound receivers.

According to a further feature of the present invention, the ultrasound receivers are substantially collinear, and the weighting varies linearly with distance in the direction of alignment of the ultrasound receivers over at least a given switch-over zone.

According to a further feature of the present invention, the weighted centroid approximates to the first calculated value when the movable element is within a first given region of the surface.

There is also provided according to the teachings of the present invention, a presentation board digitizer system for digitizing operative strokes of a drawing implement carrying an ultrasound transmitter against the board, the system comprising: (a) at least two ultrasound receivers mounted relative to the board for receiving air-borne ultrasound signals; (b) a transducer associated with the board so as to detect vibrations from the transmitter conducted through the board; and (c) a processor responsive to outputs from the at least two ultrasound receivers to calculate a current position of the transmitter, the processor being additionally responsive to an output from the transducer to identify contact between the drawing implement and the board, thereby identifying operative strokes of the drawing implement.

There is also provided according to the teachings of the present invention, a transmitter device for use with a system for digitizing operative strokes of a hand-held drawing implement, the drawing implement having a body and an operative tip, the transmitter device comprising: (a) a housing having a substantially cylindrical opening terminating at a first end in an annular wedge surface with a central bore, the housing receiving a portion of the body of the drawing implement with its operative tip extending from the central bore; (b) a retainer attachable to a second end of the opening to retain the drawing implement within the housing, the retainer having a spring element for biasing the drawing implement towards the annular wedge surface; and (c) a transmitter mounted relative to the housing proximal to the central bore.

According to a further feature of the present invention, the housing further includes: (a) a microswitch actuated by changes in pressure exerted on the annular wedge surface so as to be responsive to a force exerted on the operative tip of the drawing implement towards the housing; and (b) electronic circuitry responsive to the microswitch to affect operation of the transmitter at least when the microswitch indicates a force exerted on the operative tip of the drawing implement towards the housing.

According to a further feature of the present invention, the electronic circuitry operates the transmitter for a given time interval after the microswitch ceases to indicate a force exerted on the outer housing towards the operative tip of the drawing implement.

According to a further feature of the present invention, the given time interval is at least about half a second.

According to a further feature of the present invention, the transmitter transmits continuously, and the electronic circuitry is responsive to the microswitch to change a signal transmitted by the transmitter while the microswitch indicates a force exerted on the operative tip of the drawing implement towards the housing.

According to a further feature of the present invention, the transmitter is an ultrasound transducer.

According to a further feature of the present invention, there are also provided elements of an electromagnetic communications link, the elements being associated with the electronic circuitry.

There is also provided according to the teachings of the present invention, an ultrasound transmitter device for use with a system for digitizing the position of a hand-held drawing implement, the drawing implement having a central axis and an operative tip, the transmitter device comprising a substantially cylindrical piezoelectric transmitter element positioned coaxially with the drawing implement so as to circumscribe a part of the drawing implement proximal to the operative tip.

There is also provided according to the teachings of the present invention, an eraser device for use with a presentation board digitizer system, the eraser device comprising: (a) a handle; (b) an eraser element having a substantially flat eraser surface; and (c) a pivot joint connecting between the handle and the eraser element, the pivot joint having two degrees of rotational freedom such that, in use, the eraser element assumes an orientation with the eraser surface parallel to the presentation board surface substantially independent of the orientation at which the handle is held.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

FIG. **1** is a schematic front view of a presentation board provided with a digitizer system, constructed and operative according to the teachings of the present invention, showing a switch-over zone between regions with different groups of ultrasound receivers;

FIG. **2** is a plot illustrating the variation of relative weighting of position indications from two sets of ultrasound receivers in FIG. **1** as a function of position across the presentation board;

FIG. **3** is a side view of a twin ultrasound receiver assembly for use in a presentation board digitizer system constructed and operative according to the teachings of the present invention;

FIG. **4** is a schematic representation of the reception characteristic of the twin ultrasound receiver assembly of FIG. **3**;

FIG. **5** is a side cross-sectional view of a transmitter device, constructed and operative according to the teachings of the present invention, used with a conventional drawing implement in a digitizer system;

FIG. **6**A is an exploded perspective view of a microswitch structure, constructed and operative according to the teachings of the present invention, for use in the transmitter device of FIG. **5**;

FIG. **6**B is a perspective view of the microswitch structure of FIG. **6**A assembled;

FIG. **6**C is a top view of the microswitch structure of FIG. **6**A showing a retaining spring arrangement;

FIG. **7** is a schematic perspective view of a preferred structure for attachment of a retaining member to a housing for use in the transmitter device of FIG. **5**;

FIG. **8**A is a plot of the output of a contact switch activated by operational contact between a drawing implement and a presentation board as a function of time;

FIG. **8**B illustrates the recorded drawing implement operation time profile produced by prior art systems corresponding to the contact profile of FIG. **5**A;

FIG. **8**C illustrates the corresponding recorded drawing implement operation time profile produced according to a first embodiment of a presentation board digitizer system, constructed and operative according to the teachings of the present invention;

FIG. **9** is a side cross-sectional view of an eraser transmitter unit, constructed and operative according to the teachings of the present invention, for use with a digitizer system;

FIG. **10** illustrates the signals received by air-borne ultrasound receivers and a board-mounted transducer, respectively, according to a second embodiment of a presentation board digitizer system, constructed and operative according to the teachings of the present invention;

FIG. **11** shows a second embodiment of the transmitting device;

FIGS. **12**A and **12**B show two different forms of the upper biasing element; and

FIG. **13** shows a second embodiment of the eraser.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is of presentation board digitizer systems for use with presentation boards of all sizes which allow accurate reproduction of short pen strokes and which may be used with replaceable conventional pen elements.

The principles and operation of digitizer systems according to the present invention may be better understood with reference to the drawings and the accompanying description.

Referring now to the drawings, FIG. **1** shows a presentation board digitizer system, generally designated **10**, constructed and operative according to the teachings of the present invention, showing a switch-over zone between regions with different groups of ultrasound receivers.

Generally speaking, system **10** features a presentation board **12**, which may be of any conventional type, provided with a plurality of ultrasound receiver assemblies **14**, **16** and **18**. Ultrasound receiver assemblies **14**, **16** and **18** are preferably mounted in a strip **20** adapted for convenient attachment to presentation boards of differing sizes and thickness. This attachment may be achieved through clamps or clips of any type. Strip **20** also features an infrared (IR) receiver **22**. A cover (not shown) is preferably provided for shielding ultrasound receiver assemblies **14**, **16** and **18** and IR receiver **22** from sound and radiation originating away from board **12**. System **10** operates with a movable element having both ultrasound and infrared transmitters, an example of which will be described in detail below. The present position of the movable element is derived from the time-of-flight (TOF) of ultrasound signals from the movable element to the receiver assemblies by triangulation. The IR signal provides synchronization information, as well as carrying additional information such as, for example, the color of a pen being used.

In principle, two ultrasound receivers are sufficient to uniquely determine the position of a movable element in contact with board **12**. However, to provide reliable ultrasound reception over the entire area of a large board, system **10** employs more than one set of receivers. Thus, in the system as illustrated, a first set of receivers is defined as the pair of ultrasound receiver assemblies **14** and **16**, and a second set of receivers is defined as the pair of ultrasound receiver assemblies **16** and **18**. Clearly, the first set of ultrasound receivers so defined is well positioned for receiving an ultrasound signal from the transmitter when the movable element is in a first region denoted A, and the second set of ultrasound receivers is well positioned for receiving the signal when the movable element is in a second region denoted C. Thus, optimal precision and reliability is achieved by deriving the position of the movable element from the outputs of ultrasound receiver assemblies **14** and **16** when the movable element is in region A, and from the outputs of ultrasound receiver assemblies **16** and **18** when the movable element is in region C.

To avoid possible discontinuities in the tracking of the position of the movable element as it traverses board **12**, preferred embodiments of the present invention provide a switch-over zone, denoted B, between regions A and C. Within switch-over zone B, the current position of the movable element is derived based on a weighted function of the positions calculated from the outputs of the first and second sets of receivers. Preferably, the weighted function varies smoothly with position across switch-over zone B, such that it approaches the value calculated from the first set of receivers when the movable element borders first region A and approaches the value calculated from the second set of receivers when the movable element borders second region C.

FIG. **2** shows a typical variation of the weighting function with distance across board **12**. Here, plot **24** corresponds to the weighting factor applied to the first group of ultrasound receivers, and plot **26** corresponds to the weighting factor applied to the second group of ultrasound receivers. In this example, the variation within switch-over zone B is shown as linear. However, it should be appreciated that other more complex functions may be used as desired. Within region A, plot **24** is preferably constant at 1 and plot **26** is zero, whereas within region C, these values are reversed.

Calculation of the current position of the movable element according to the system described requires calculation of weighting factors which are themselves a function of position. This apparent circularity of calculation may be circumvented in a number of ways. Most simply, since the position is measured repeatedly at short intervals, it is reasonable to assume that the new current position is a relatively small distance from the previously measured position. It is therefore reasonable to employ the last measured position for calculating the weighting factors for the subsequent measurement. Alternatively, or for the purposes of making an initial measurement, an approximate measurement may be made with some arbitrary weighting factor such as, for example, 0.5 for each set.

Although the concept of the switch-over zone has been illustrated in a simple implementation with only two sets of receivers, the concept can clearly be extended to more complex arrangements of multiple sets of receivers, both co-linearly and on opposite sides of a board. In the latter case, the weighting factor becomes a function of position in two dimensions, as will be clear to one ordinarily skilled in the art.

In addition to the switch-over zone algorithm, it is preferable that the ultrasound receivers are located sufficiently close to provide some degree of redundancy of measurement. This redundancy can then be employed (typically independent of the switch-over zone considerations) to provide a self test for accuracy and to identify any erroneous measurements which may occur temporarily.

Specifically, if receivers **14**, **16** and **18** are collinear with equal spacing A, and the distance from each receiver as measured by TOF calculations is s**1**, s**2** and s**3**, respectively, simple trigonometry dictates that:

$$s12-2s22+s32=2A2 \text{ (constant)}$$

By calculating this sum whenever three simultaneous TOF measurements are available, the system can continuously test that it is functioning within an acceptable margin of accuracy. If a significant error is found, further statistically-based self-analysis algorithms may be implemented to identify which receiver produced the erroneous reading and to temporarily exclude that receiver from position calculations.

Turning now to FIGS. **3** and **4**, a preferred design of ultrasound receiver assembly, generally designated **30**, constructed and operative according to the teachings of the present invention, for use with presentation board digitizer systems will now be described. Assembly **30** may be used to advantage with a wide range of digitizer systems, including but not limited to system **10** described above.

Generally speaking, ultrasound receiver assembly **30** includes a first ultrasound receiver **32** located adjacent to the surface **34** of the presentation board, and a second ultrasound receiver **36** displaced from first ultrasound receiver **32** in a direction substantially perpendicular to surface **34**.

First and second ultrasound receivers **32** and **36** are connected so as to generate a total output signal corresponding to the instantaneous sum of the amplitudes of ultrasound signals which they receive. Typically, for simple transducers, this is achieved by connecting them in series such that their output voltages are additive.

FIG. **4** shows a plot in polar coordinates of the variation of sensitivity of assembly **30** with angle of incidence in a plane perpendicular to the surface **34**. The phase differences between ultrasonic vibrations reaching the two receivers, when added, result in pronounced variation of the sensitivity of assembly **30** with angle of incidence, as shown. Specifically, the maximum sensitivity of assembly **30** occurs in a plane central to the main lobe of FIG. **4** corresponding to a plane of symmetry between receivers **32** and **36**. Signals arriving at the two receivers which are incident from this plane necessarily have zero path and phase difference, thereby producing a maximum amplitude output signal. Reception from the n=1 side lobes is preferably minimized by use of a cover element (not shown) which shields assembly **30** from sound incident at large angles from surface **34**.

By arranging assembly **30** as described, the plane of maximum sensitivity is oriented substantially parallel and adjacent to surface **34**. This is ideal for receiving signals incident from near the presentation board (**S0**). Conversely, assembly **30** exhibits greatly reduced sensitivity to signals (**S1**) incident from further away from the presentation board. These directional properties greatly help to isolate the ultrasound signal of importance to the digitizer system, increasing the signal-to-noise ratio. This allows the use of lower transmitter intensities and/or larger boards, and solves problems caused by a wide range of common noise sources. The sensitivity profile of assembly **30** parallel to surface **34** remains substantially omnidirectional similar to the profile of an individual receiver.

Turning now to FIGS. **5–7**, a preferred embodiment of a transmitter device, generally designated **40**, constructed and operative according to the teachings of the present invention, for use with a drawing implement **42** in a digitizer system will be described. Transmitter device **40** may be used to advantage with a wide range of ultrasound based digitizer systems including, but not limited to, the presentation board digitizer systems described above.

Generally speaking, transmitter device **40** includes a housing **44** having a substantially cylindrical opening **46** which terminates at its lower end in an annular wedge surface **48** having a central bore **50**. Drawing implement **42** is received within opening **46** with its operative tip **52** extending through bore **50**.

Transmitter device **40** also includes a retainer **54** in the form of a cover attachable to the upper end of opening **46** to retain drawing implement **42** in position within housing **44**. Retainer **54** features a spring element **56** for biasing drawing implement **42** towards annular wedge surface **48**. An ultrasound transmitter **58** is mounted on the lower surface of housing **44** proximal to bore **50**.

It is a particular feature of preferred embodiments of the transmitter device of the present invention that they can accommodate drawing implements of a range of lengths and widths. To this end, spring element **56** adjusts to any variations in length, and biases drawing implement **42** towards the lower end of housing **44** to ensure a correct position for use. This biasing, in conjunction with the shape of annular wedge surface **48**, serves to center the front end of a drawing implement of any size or shape. In addition, spring element **56** is preferably provided with a shaped abutment surface **60** having features for centering the back end of a drawing implement. Typically, abutment surface **60** has an axial conical projection as shown for centering drawing implements by engaging a rear axial recess which is common to almost all presentation board pens. Alternatively, abutment surface **60** may be formed with a conical recess or other features for centering the back of a drawing implement.

The combination of annular wedge surface **48** and spring element **56** with abutment surface **60** serves to hold drawing implements of a range of lengths and widths in central alignment within cylindrical opening **46** without contacting the sides of housing **44**. This arrangement makes transmitter device **40** insensitive to variations in drawing implement width. The avoidance of frictional contact with the sides of housing **44** is also important for efficient operation of a contact-sensing microswitch, as will be described below.

It is a particular feature of certain preferred embodiments of the present invention that ultrasound transmitter **58** is formed as a substantially cylindrical piezoelectric transmitter element attached to the lower end of housing **44** around central bore **50**. This arrangement ensures that, when in use, the cylindrical transmitter is coaxial with drawing implement **42**, circumscribing a part of drawing implement **42** proximal to operative tip **52**. As a result of the symmetry of this arrangement, TOF measurements of the position of drawing implement **42** are completely independent of axial rotation of transmitter device **40**. Furthermore, the position of operative tip **52** can be determined very precisely by adding the radial dimension of transmitter cylinder **58** to the value calculated from the TOF.

Transmitter device **40** also typically features at least one element of an electromagnetic communications link, typically an IR transmitter **60**, and preferably about four such transmitters spaced around the lower end of housing **44**. This ensures that at least one IR transmitter will be correctly oriented facing an IR receiver mounted on the presentation board at any time. It should be noted that a reversed arrangement in which an IR link is formed with a board-mounted transmitter and device **40** carries a receiver also falls within the scope of the present invention. Furthermore, the IR link may be dispensed with entirely if three ultrasound receivers are used to calculate each position. However, the arrangement described is preferred for providing higher precision than a purely ultrasound-based system whilst avoiding the need for complex IR signal processing circuitry in the transmitter device. Additionally, the

IR transmitter allows transmission of extra information such as pen color and the like.

Ultrasound transmitter **58** and IR transmitters **60** are actuated under the control of electronic circuitry which is preferably battery powered. Both the electronic circuitry and the battery are preferably located in a compartment (not shown) of housing **44**.

Transmitter device **40** preferably also features a switch for detecting contact between operative tip **52** and the surface of a writing board. This switch is associated with the electronic circuitry and is employed to actuate ultrasound transmitter **58** and IR transmitters **60**. Preferably, the switch is formed as a microswitch positioned to respond to changes in the force applied by drawing implement **42** against annular wedge surface **48**. FIGS. **6**A–**6**C show a preferred construction for such a microswitch, generally designated **64**, constructed and operative according to the teachings of the present invention.

Microswitch **64** is formed from three functional layers. First, a base layer **66** provides the two terminals of the microswitch, a single peripheral contact **68** and a set of common contacts **70**, spaced-apart around the center of base layer **66**. On top of base layer **66** lies a layer of conductive resilient foam **72** having cut-out holes **74** opposite contacts **70**. A third rigid conducting layer **76** lies above foam layer **72**. Conducting layer **76** has small conductive downward projections **78** aligned with holes **74**. An upper cover **80**, integrally formed with annular wedge surface **48**, attaches loosely to base layer **66** to unify the structure while allowing sufficient vertical motion for operation of the switch. Each layer has a central bore, together corresponding to bore **50** of FIG. **5**.

In a non-compressed state, conductive contact is made between peripheral contact **68** and foam layer **72** and between foam layer **72** and upper conducting layer **76**. However, the switch remains open since the thickness of foam layer **72** prevents contact between projections **78** and inner contacts **70**. When pressure is applied to compress microswitch **64**, foam layer **72** becomes compressed until projections **78** come into contact with inner contacts **70**, thereby closing the switch. In principle, release of the pressure allows the foam layer to return to its initial state, thereby breaking the circuit. However, in practice, the relaxation response time of the foam material is typically quite slow. For this reason, a spring **82** is mounted between base layer **66** and upper conductive layer **76** such that, when the pressure is released, upper conductive layer **76** is lifted immediately to break the circuit.

It will be clear that, when drawing implement **42** is not in use, spring element **56** urges drawing implement **42** downwards against annular wedge surface **48** to close microswitch **64**. When drawing implement **42** is used to draw on a presentation board, a force is exerted on operative tip **52** of drawing implement **42** towards housing **44**, causing drawing implement **44** to recoil slightly against spring element **56**. This reduces the pressure exerted on annular wedge surface **48** the circuit of microswitch **64** opens. The electronic circuitry of transmitter device **40** is responsive at least to opening of microswitch **64** to affect a signal transmitted by transmitter device **40**.

FIG. **6**B shows microswitch **64** assembled, together with ultrasound transmitter **58** and IR transmitters **60**. FIG. **6**C shows a pair of spring elements **84** which are mounted within annular wedge surface **48** so as to grip the end of a drawing implement inserted through central bore **50**. This ensures that the upper layer of microswitch **64** is sensitive to movements of drawing element **42**.

It should be noted that the structure described here for microswitch **64** is by way of example only. Alternative structures may be used such as, for example, a switch based on a piezoelectric pressure sensor or the like.

Finally with regard to microswitch **64**, it should be noted that correct operation of the switch depends on a degree of freedom of axial motion of drawing implement **42** against spring element **56**. For this reason, it is important that spring element **56** is not fully compressed when retainer **54** is attached. FIG. **7** shows an example of a preferred structure for attachment of retainer **54** to housing **44**, in which lateral projections **86** engage channels **88** which are shaped to provide a margin of release **90** when fully engaged. Margin of release **90** is designed to be at least sufficient to allow an operative range of motion of microswitch **64**.

A second preferred embodiment of transmitter device **40** is shown in FIG. **11**. Similarly to the preferred embodiment shown in FIG. **5**, device **40** is intended for use with drawing implement **42**. Transmitter device **40** also features housing **44** with cylindrical opening **46**. However, cylindrical opening **46** now terminates at its lower end with a gasket **134**. Gasket **134** features a central bore **136**, through which operative tip **52** of drawing implement **42** extends.

In place of retainer **54**, transmitter device **40** features a different type of retainer, which is a holder **138**. Holder **138** is hingedly attached to the upper end of housing **44** with a hinge **137**, and acts to hold drawing implement **42** substantially centered within opening **46**. Holder **138** locks onto housing **44** by a locking pin **139**. Holder **138** features a spring element **140** for biasing drawing implement **42** towards gasket **134**. A second spring element **142**, located near gasket **134**, preferably helps further bias and center drawing implement **42** within opening **46**. Preferably, spring element **140** is stronger than second spring element **142**. A cover **143** is also provided for drawing implement **42**.

To retain drawing implement **42** in the centered position, holder **138** preferably has an upper biasing element **144**. Upper biasing element **144** can be in one of two shapes, as shown in FIGS. **12**A and **12**B. FIG. **12**A shows upper biasing element **144** with an axial conical projection **146** for centering drawing implement **42** by engaging a rear axial recess **148** which is common to most presentation board pens. However, this embodiment is potentially restricted to use only with presentation board pens having axial recess **148** with a particular diameter, as axial recess **148** is not of uniform diameter between pens. Alternatively and preferably, upper biasing element **144** features a recess **150** into which the upper end of drawing implement **42** is inserted, as shown in FIG. **12**B. This second embodiment has the advantage of being usable with most presentation board pens, since the external diameter of these pens is generally uniform.

The combination of upper biasing element **144**, gasket **134** and spring elements **140** and **142** has the advantage of holding drawing implements of a variety of lengths and external diameters in central alignment within cylindrical opening **46** substantially without contacting the sides of housing **44**. As described above for FIG. **5**, the avoidance of frictional contact with the sides of housing **44** is also important for efficient operation of a contact-sensing microswitch **152**.

Holder **138** also has a pressure-sensitive element **152**, which has two parts, a pin **154** and a printed circuit board **156**. Pin **154** contacts upper biasing element **144**, sensing when contact is made between drawing implement **42** and the presentation board. In combination, these two parts allow transmitting device **40** to sense when contact has been made with the presentation board.

Transmitting device **40** also features ultrasound transmitter **58** and IR transmitter **60**, similar to the embodiment shown in FIG. **5**. Ultrasound transmitter **58** and IR transmitters **60** are actuated under the control of electronic circuitry **158** which is preferably battery powered by a battery **160**. Both electronic circuitry **158** and battery **160** are preferably located in holder **138** of housing **44**.

Turning to FIGS. **8**A–**8**C, a preferred transmission profile of transmitter device **40** will now be described. FIG. **8**A represents a contact profile of drawing element **42** as measured by microswitch **64** as a function of time. During a first period **100**, drawing implement **42** is kept in contact with the presentation board for an extended period to draw a continuous shape. Then, during a second period **102**, drawing implement **42** is used in a series of short, separate strokes to form a dashed line.

As mentioned above, the prior art digitizer systems suffer from a significant delay in picking-up the beginning of each pen stroke. This is because the transmitters are actuated each time pen contact is made and interrupted each time pen contact ceases. As a result, each pen stroke starts with a dead time during which the receiver system synchronizes and locks on to the transmitted signals. The results of this system are shown in FIG. **8**B. During period **100**, the effects are not very serious. There is a small signal loss at the beginning of the period, but the great majority of the stroke is recorded well. During period **102**, however, the system response time is comparable to the length of the pen strokes. As a result, the dashed line is almost completely lost.

To solve this problem, the present invention is preferably designed to maintain synchronization between transmitter device **40** and the receiver system for a given period after the end of each pen stroke. Typically, this is achieved by the electronic circuitry continuing to operate IR transmitters **60** for the given time interval after microswitch **64** ceases to indicate a force exerted on the outer housing towards the operative tip of the drawing implement. False drawing signals can be avoided either by the electronic circuitry disabling ultrasound transmitter **58** during the delay period, or by changing the content of the IR signal to indicate a non-contact pen state. The delay period is typically at least about half a second, and preferably between about 1 and about 2 seconds.

FIG. **8**C illustrates the response profile of transmitter device **40** as described. During an initial period of a single pen stroke, its response is not dissimilar from that of the prior art. However, when short repeated strokes are encountered, transmitter device **40** maintains synchronization between successive strokes, thereby providing an accurate response immediately on switching of microswitch **64**.

Turning now to FIG. **9**, an eraser, generally designated **104**, constructed and operative according to the teachings of the present invention, for use with a presentation board digitizer system will be described. A major problem with eraser elements for use with digitizer systems is the common practice of employing only a part of the eraser surface. Since the digitizer is typically unable to distinguish between flat contact and edge contact of the eraser, the digitized image frequently shows a much greater erased area than has actually been cleared from the presentation board itself. To solve this problem, eraser **104** is constructed such that its eraser surface is self-orienting to lie parallel to the presentation board surface. This ensures that the contact area of the eraser element is always precisely defined.

Thus, eraser **104** has a handle **106** and an eraser element **108** which has a substantially flat, eraser surface **110**. Handle **106** and eraser element **108** are connected by a pivot joint **112**, typically in the form of a ball-and-socket, which has two degrees of rotational freedom. The use of pivot joint **112** ensures that, in use, eraser element **108** assumes an orientation with eraser surface **110** parallel to the presentation board surface substantially independent of the orientation at which handle **106** is held.

Eraser **104** also features transmitter device features analogous to those of transmitter device **40** described above. These include a cylindrical ultrasound transmitter element **114**, a number of IR transmitters **116** and an electronic circuitry/battery block **118**. Connection of handle **106** to pivot joint **112** is through a sprung pin assembly **120**. A pressure sensing microswitch **122** is mounted in the seat of pin assembly **120** for sensing contact pressure between handle **106** and eraser element **108**. Wiring from electronic circuitry **118** to transmitters **114** and **116** is preferably located axially within pin assembly **120** and passing through pivot joint **112**.

Eraser surface **110** is preferably circular, and cylindrical ultrasound transmitter element **114** is preferably arranged such that its axis is aligned with the center of eraser surface **110**. By addition of the radius of the cylinder to the TOF measurements, this arrangement allows precise identification of the center of the circle of erasure, and hence of the entire area covered by eraser surface **110**. Eraser **104** thus provides a much higher degree of precision and determination of the erased area than can be achieved by prior art devices.

A second embodiment of an eraser **162** is shown in FIG. **13**. Eraser **162** is designed for erasing a small area, particularly an area of narrow width, and can thus be described as a "narrow-band eraser." Similarly to eraser **104**, eraser **162** has a handle **164** and an eraser element **166** which has a substantially flat eraser surface **168**. However, handle **164** is connected to eraser element **166** by a pressure-sensitive element **170**. Pressure-sensitive element **170** includes a spring **172**, such that when at least a portion of eraser surface **168** contacts the presentation board, a signal is transmitted to a touch switch **174**. Touch switch **174** preferably includes a printed circuit board **176** and electrical circuitry **178**, which enable touch switch **174** to identify when eraser surface **168** is contacting the presentation board. This is similar to pressure sensing microswitch **122** of eraser **104**.

A second method of identification of touching of the presentation board uses the following features of eraser **162**. Eraser surface **168** has two contact microswitches **180**, preferably located substantially at each end of eraser surface **168**, which are substantially similar in function to contact microswitch **64** of FIG. **6**. If only one contact microswitch **180** senses contact with the presentation board, only a small area will be erased, such as a letter, for example. If, however, both contact microswitches **180** sense contact with the presentation board, a zone with the length and width of eraser surface **168** will be erased.

Similarly to eraser **104**, eraser **162** also has transmitter device features. Specifically, eraser **162** has at least one, and preferably two, cylindrical ultrasound transmitters **182**, located in handle **164**, preferably substantially at each end of handle **164**. Since each ultrasound transmitter **182** is located in handle **164**, eraser **162** also features an ultrasound conductor tube **184** for each ultrasound transmitter **182**. Each ultrasound conductor tube **184** goes from handle **164** to eraser element **166**, such that the ultrasound signal from each ultrasound transmitter **182** is transmitted downward. Eraser **162** also has a reflector cone **186** for each ultrasound transmitter **182**. Reflector cone **186** is preferably located in eraser element **166**, reflecting the ultrasound waves in all directions.

Eraser **162** also has two infrared transmitters **188**, preferably located substantially at each end of handle **164**. Each infrared transmitter **188** has an infrared reflector **190**, also located in handle **164**, which serves a similar function as reflector cone **186**.

Although one particular embodiment of these transmitter device features has been described, it will be appreciated that a number of different embodiments are possible, substantially as described above for the transmitter device.

Turning now to FIG. **10**, this shows the principle of operation of a further embodiment of a transmitter device, constructed and operative according to the teachings of the present invention, for use with a presentation board digitizer system. This device is generally similar to transmitter device **40** described above except that it dispenses with microswitch **64**, instead identifying pen-board contact by transmission of vibrations through the board.

As mentioned earlier, digitizer systems employing through-the-board transmission suffer from poor accuracy and dependency on specific board design. However, they have a major advantage of inherent pen-board contact identification. The device of the present invention combines this feature with all the advantages of precision and independence from board design provided by air-borne ultrasound systems, using the through-the-board detection solely for contact detection.

Thus, this embodiment may be used with a presentation board system essentially similar to that of FIG. **1**, with the addition of a transducer associated with the board (not shown) for detecting vibrations from the transmitter conducted through the board. The processor of the receiver system is then responsive to outputs from the air-borne ultrasound receivers to calculate a current position of the transmitter, and to the output from the board mounted transducer to identify contact between the drawing implement and the board, thereby identifying operative strokes of the drawing implement.

The principle of this system is shown clearly in FIG. **10** in which plot **130** represents the signal from one of the ultrasound receiver assemblies and plot **132** represents the signal from the board-mounted transducer. Plot **130** shows a continuous sequence of pulses since the transmitters operate continuously as long as the pen is in use, according to this embodiment. Plot **132**, on the other hand, only registers corresponding pulses during a period that the pen is in contact with the board. Although the signal quality of plot **132** is typically inferior, it is more than sufficient for identification of contact or non-contact conditions.

It will be appreciated that the above descriptions are intended only to serve as examples, and that many other embodiments are possible within the spirit and the scope of the present invention.

What is claimed is:

1. A digitizer system for digitizing operative strokes of a drawing implement comprising a body, a back end, and a front end opposite the back end against a board, the system comprising:

a movable transmitter device comprising a housing and a central bore, the central bore receiving a portion of the body of the drawing implement with its operative tip extending through the central bore, and an ultrasound transmitter mounted relative to the housing proximal central bore;

at least two ultrasound receivers mounted relative to the board for receiving air-borne ultrasound signals;

a transducer associated with the board to detect vibrations from the transmitter device conducted through the board; and

a processor responsive to outputs from the at least two ultrasound receivers to calculate a current position of the transmitter, the processor being additionally responsive to an output from the transducer to identity contact between the drawing implement and the board, thereby identifying operative strokes of the drawing implement.

2. A system for digitizing operative strokes of a drawing implement comprising a body, a back end, and a front end opposite the back end comprising an operative tip, the system comprising:

at least one ultrasound receiver assembly;

a housing comprising a substantially cylindrical opening terminating at a first end, and an inner housing surface having a central bore, the housing receiving a portion of the drawing implement, the operative tip extending through the central bore;

a retainer attachable to a second end of the opening to retain the drawing implement within the housing, the retainer having a spring element for biasing the drawing implement towards the inner housing surface; and

an ultrasound transmitter mounted relative to the housing proximal the central bore.

3. The system of claim **2**, wherein the transmitter is a substantially cylindrical piezoelectric transmitter attached to the housing around the central bore.

4. The system of claim **2**, wherein the housing further comprises:

a microswitch actuated by changes in pressure exerted on the surface to be responsive to a force exerted on the operative tip of the drawing implement towards the housing; and

electronic circuitry responsive to the microswitch to affect operation of the ultrasonic transmitter at least when the microswitch indicates a force exerted on the operative tip of the drawing implement towards the housing.

5. the system of claim **4**, wherein the electronic circuitry operates the transmitter for a given time interval after the microswitch ceases to indicate a force exerted on the outer housing towards the operative tip.

6. The system of claim **4**, wherein the transmitter transmits continuously, and wherein the electronic circuitry is responsive to the microswitch to change a signal transmitted by the transmitter while the microswitch indicates a force exerted on the operative tip of the drawing implement towards the housing.

7. The system of claim **4**, wherein the ultrasound transmitter comprises a piezoelectric ultrasound transmitter.

8. A system for digitizing the position of a drawing implement in relation to a presentation board, the drawing implement comprising a central axis and an operative tip, the system comprising:

at least one receiver assembly; and

a transmitter device comprising a substantially cylindrical piezoelectric transmitter element positioned coaxially with the drawing implement so as to circumscribe a part of the drawing implement proximal to the operative tip.

9. The system of claim **8**, further comprising:

an eraser device comprising a handle, an eraser element comprising a substantially flat eraser surface, and a pivot joint connecting between the handle and the eraser element, the pivot joint having two degrees of rotational freedom such that, in use, the eraser element assumes an orientation with the eraser surface parallel to the presentation board substantially independent of the orientation at which the handle is held.

10. The system of claim **8**, further comprising:

a narrow-band eraser device comprising a handle, an eraser element having a substantially flat eraser surface, and a plurality of contact microswitches located on the eraser surface, such that when a portion of the eraser surface contacts the presentation board, at least one microswitch corresponding to the portion is activated and such that when substantially an entirety of the eraser surface contacts the presentation board, substantially all of the microswitches are activated.

* * * * *

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

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(45) **Date of Patent: *Dec. 4, 2001**

(54) **MARKING DEVICE FOR ELECTRONIC PRESENTATION BOARD**

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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.

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(58) **Field of Search** 345/179, 180; 178/19.01, 19.02, 19.03, 19.04, 19.05

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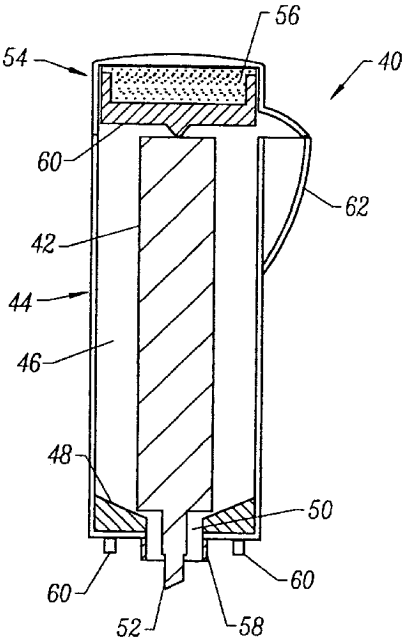
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(74) *Attorney, Agent, or Firm*—Michael A. Glenn

(57) **ABSTRACT**

A transmitter device is disclosed for use with a conventional pen in which the ultrasound transmitter is a cylindrical element lying coaxial with the pen and adjacent to its tip, and a jointed eraser structure. Conventional triangulation techniques are used to track the position and motion of a writer or eraser. An encoding facility associated with the pen provides the ability to distinguish whether the pen is used for marking or an as erasing implement, as well as determining the nature or character of written line width or eraser swath. A data stream thus generated can be used in a variety of ways, such as for example, to feed information into the memory of a digital computer, and/or to feed information for transmission to remote stations.

4 Claims, 6 Drawing Sheets



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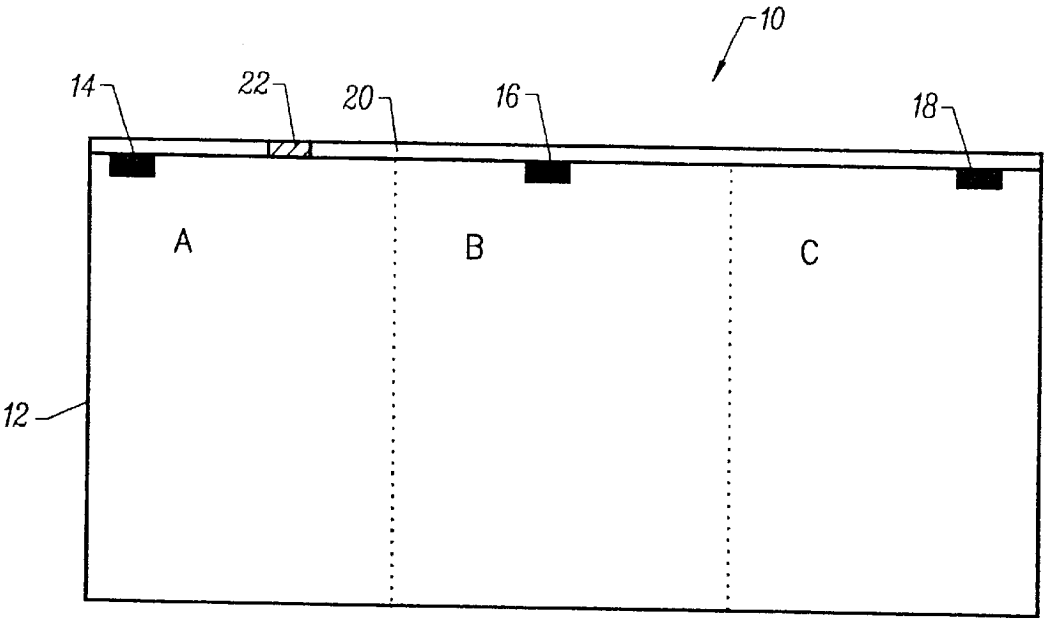


FIG. 1

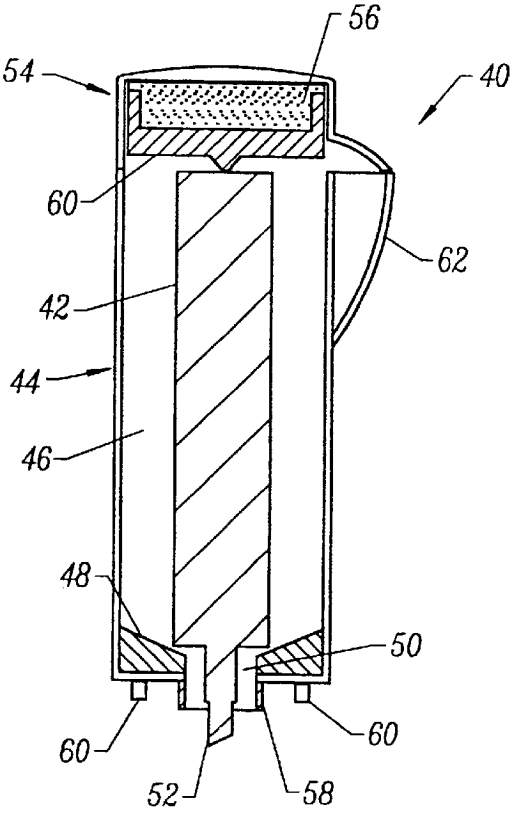


FIG. 2

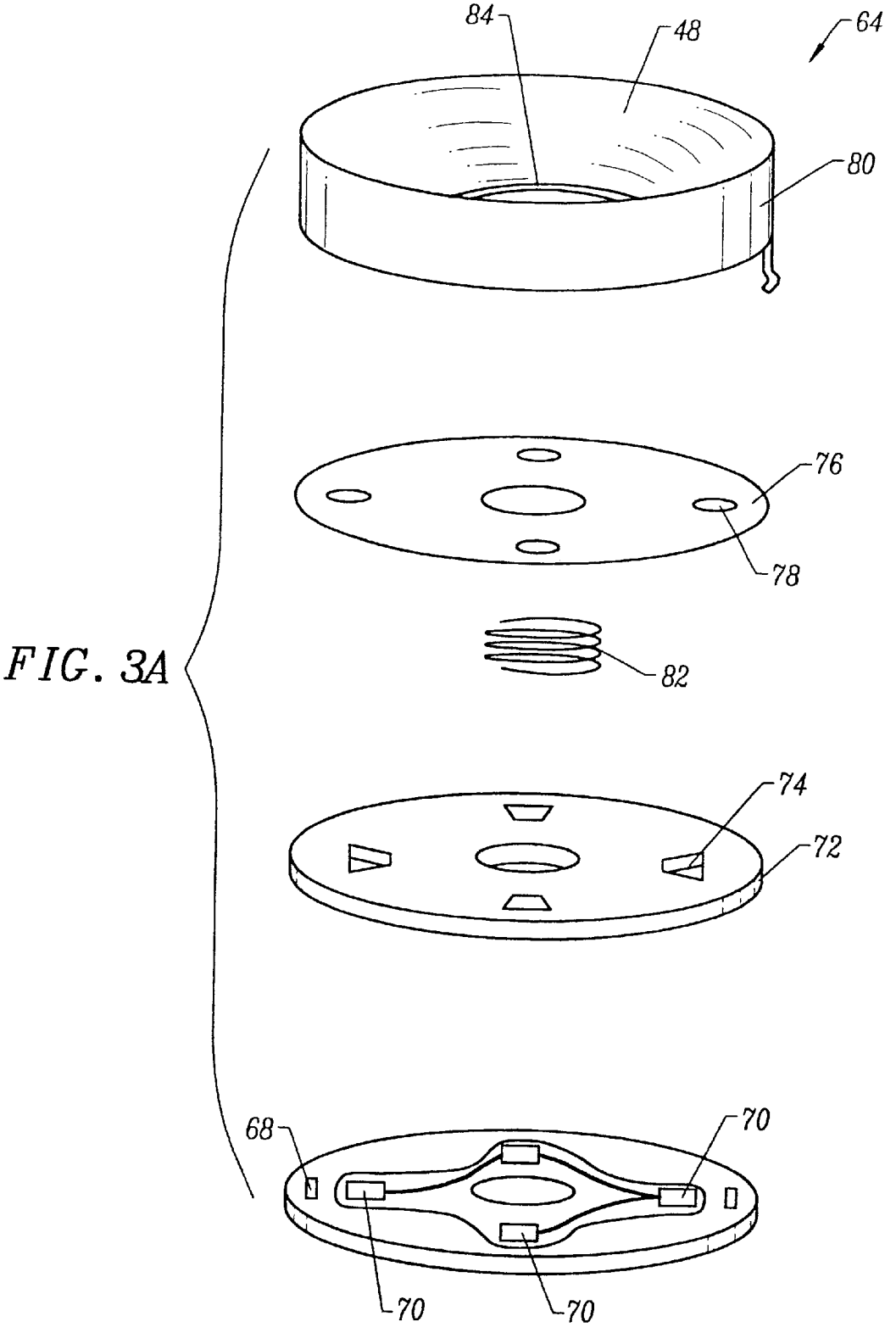


FIG. 3A

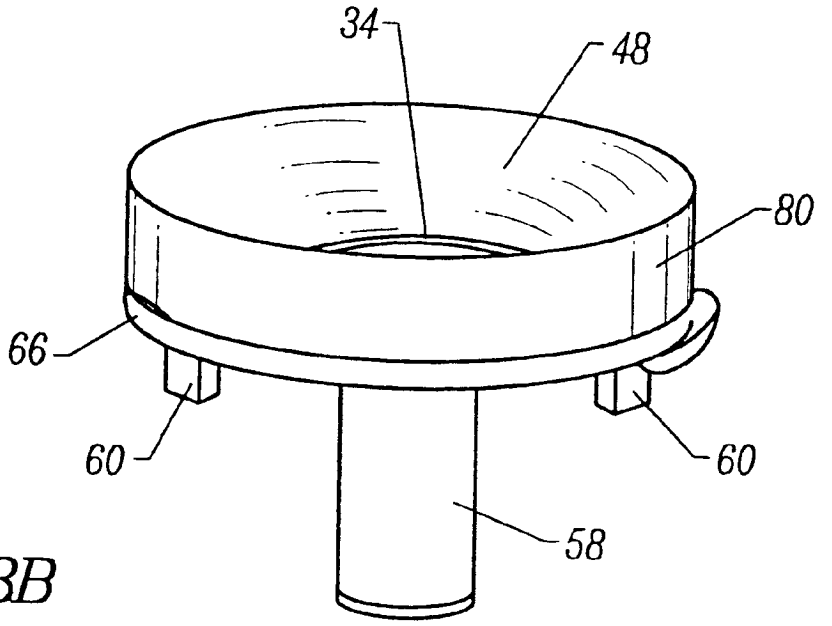


FIG. 3B

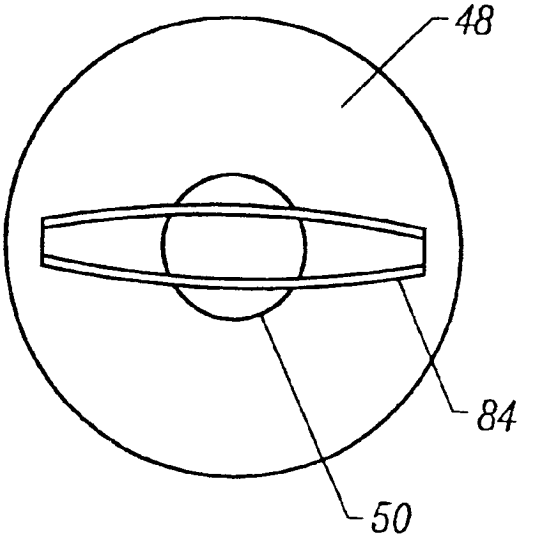


FIG. 3C

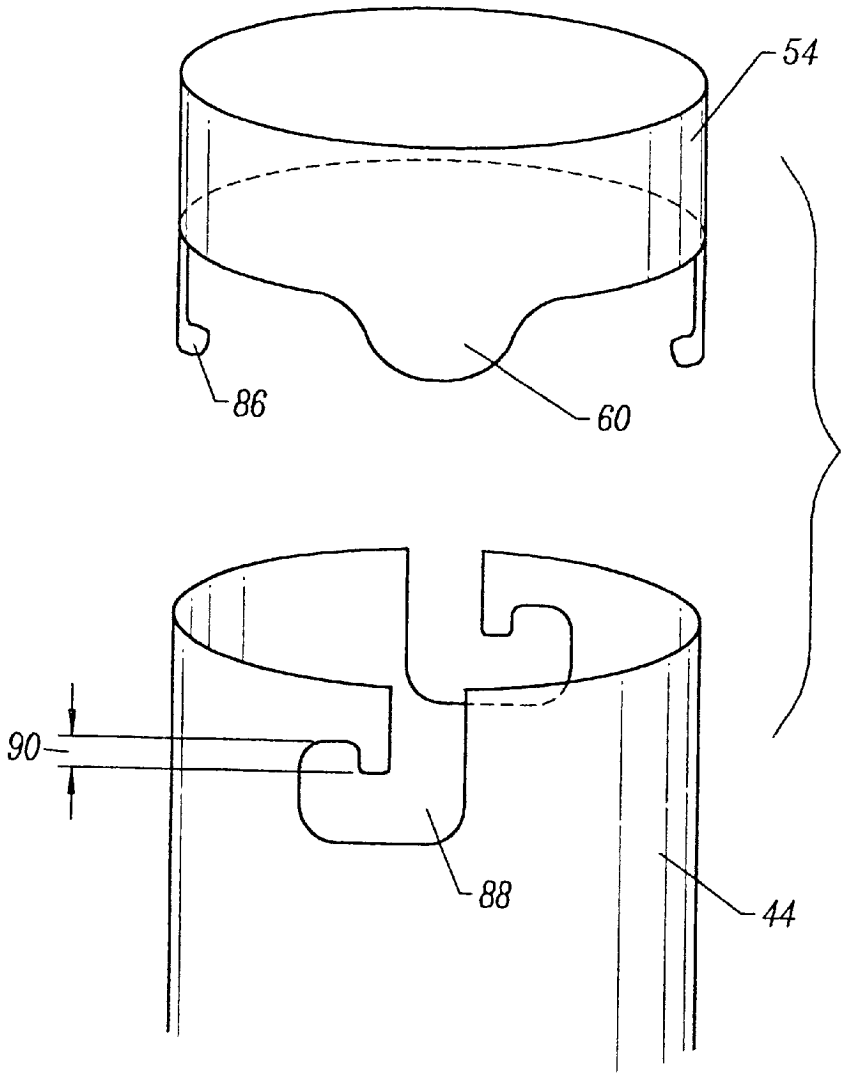


FIG. 4

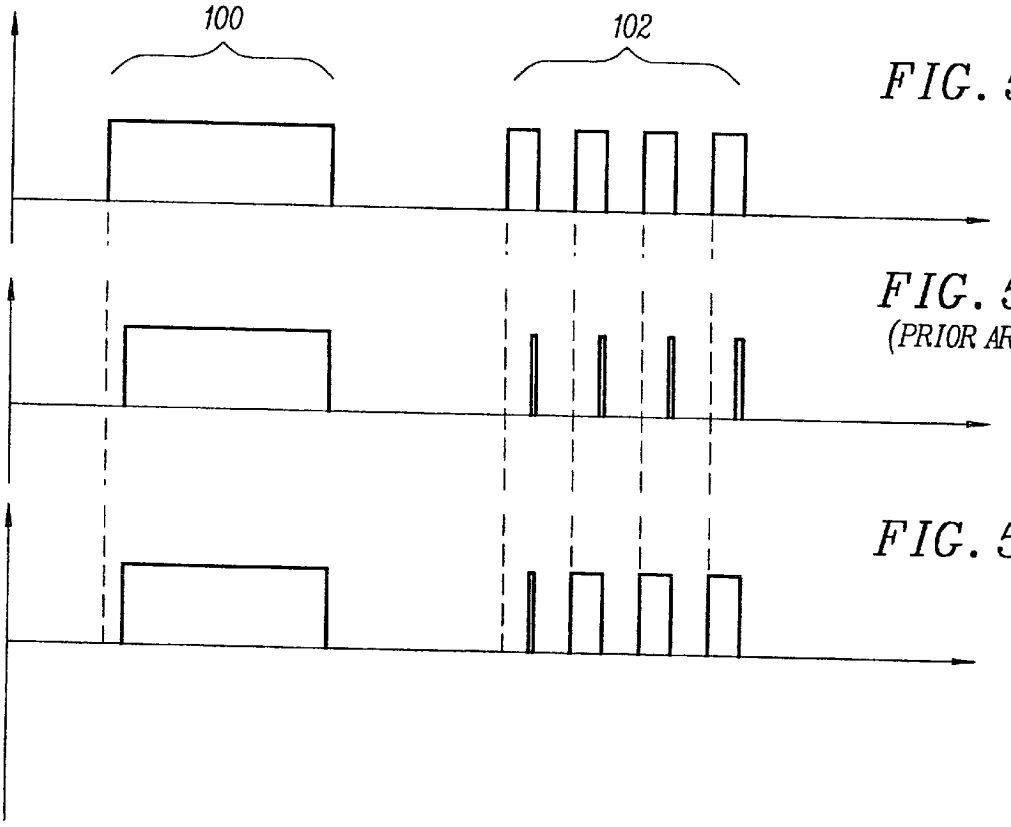


FIG. 5A

FIG. 5B
(PRIOR ART)

FIG. 5C

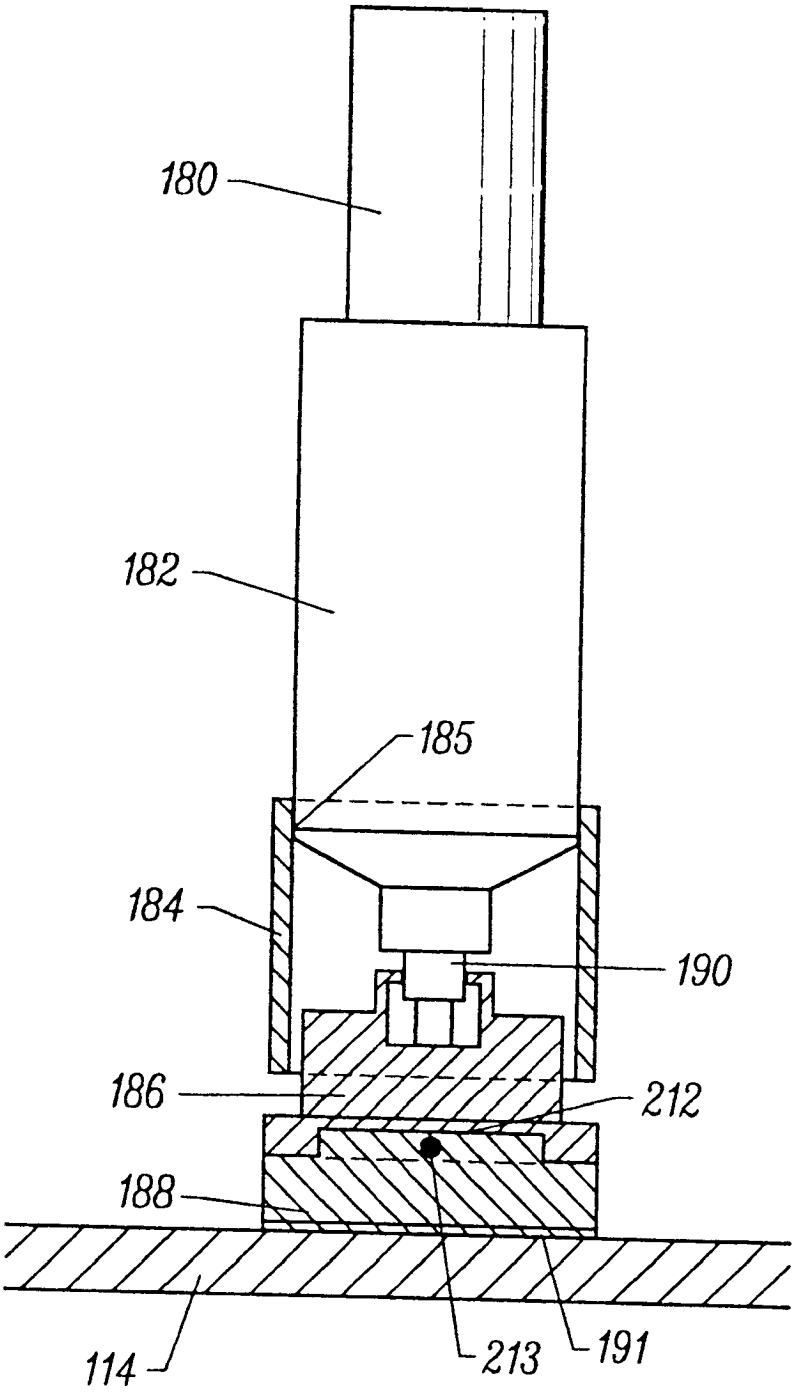


FIG. 6

MARKING DEVICE FOR ELECTRONIC PRESENTATION BOARD

BACKGROUND OF THE INVENTION

1. Technical Field

The invention relates to an electronic presentation board. More particularly, the invention concerns devices for use with conventional presentation boards and pens for digitizing lines drawn manually.

2. Description of the Prior Art

It is known to use various techniques for determining the position of a writing implement or stylus on a flat surface. U.S. Pat. No. 4,564,928 to Glenn et al., U.S. Pat. No. 4,886,943 to Suzuki et al., U.S. Pat. Nos. 4,910,363 and 5,073,685 to Kobayashi et al. and U.S. Pat. No. 5,097,102 to Yoshimura et al. all disclose systems in which a vibrating element associated with a pen transmits vibrations through the material of a board. The vibrations are detected by transducers attached to the board and the position of the pen is calculated from the transmission time of the vibrations through the board. These systems inherently function exclusively when the pen is in contract with the board such that vibrations are transferred to the board. As a result, no special mechanism is required to distinguish writing from non-writing pen movements.

These systems typically require highly specialized board structures which renders them expensive and inconvenient.

An alternative approach is the use of airborne ultrasound signals. Examples of such systems are described in U.S. Pat. No. 4,777,329 to Mallicoat, U.S. Pat. No. 4,814,552 to Stefik et al., U.S. Pat. No. 4,506,354 to Hansen and U.S. Pat. No. 1,758,691 to De Bruyne. These systems employ various combinations of ultrasound transmitters and receivers arranged at two points fixed relative to a board and on a movable writing implement. The position of the movable implement is then derived by triangulation. The systems typically require an additional hard-wired or electromagnetic link between the movable implement and a base unit to provide timing information for time-of-flight ultrasound calculations. An additional switch is also required to identify when the movable element is in contact with the board.

These systems are typically limited to relatively small boards. This is because of signal to noise ration (SNR) limitations. The volume of ultrasound used cannot be very high without causing bothersome accompanying whistling noises. Additionally, in a wireless system, power considerations severely limit the transmitted volume. To generate reliable position information, the transmitter-to-receiver distance must therefore be kept small. Attempts to use different sets of receivers for different regions of a large board generally result in discontinuities when the movable element travels from one region to another.

Another shortcoming of these systems is their inability to reproduce rapid interrupted pen strokes such as performed when drawing a dashed line. Typically, the transmitter or receiver element in the pen turns off when the pen is inactive and is re-activated each time the pen comes in contact with the board. The system then takes a fraction of a second to resynchronize before it responds correctly. In the case of short strokes, the length of the operative stroke may be comparable with the response time of the system, thereby giving very poor results.

An additional problem of the airborne ultrasound digitizer systems is that the ultrasound transmitter or receiver element is mounted asymmetrically to the side of the drawing implement. As a result, the measured position is offset from the true drawing position in a direction which changes with rotation of the drawing implement. This may result in discontinuities and illegible writing in the digitized images when the drawing implement position is changed between strokes.

Finally, conventional presentation board digitizer systems are typically limited to use with specially produced writing implements. This renders them expensive since pens have a very limited lifetime. Even where the ink cartridge is separately replaceable, the components used must be of a very specific design to be compatible.

There is therefore a need for a reliable, low cost, digitizer system which may be used with conventional presentation boards of all sizes for determining accurately the position of a drawing implement on the board. It would also be advantageous to have a transmitter device for use with presentation board which can be used with a wide range of conventional writing implements.

SUMMARY OF THE INVENTION

The invention provides an electronic presentation board for use with presentation boards of all sizes. The presentation board includes a digitizer system for digitizing operative strokes of a drawing implement carrying a transmitter against the board. The preferred system includes at least two receivers mounted relative to the board for receiving airborne signals. A processor responsive to outputs from said at least two receivers calculates a current position of the transmitter, said processor being additionally responsive to identify contact between the drawing implement and the board, thereby identifying operative strokes of the drawing implement.

An alternative embodiment of the invention provides a transmitter device for use with a system for digitizing operative strokes of a hand held drawing implement. In this embodiment of the invention, the drawing implement has a body and an operative tip. The transmitter device includes a housing having a substantially cylindrical opening terminating at a first end in an annular wedge surface with a central bore. The housing receives a portion of the body of the drawing implement with its operative tip extending from the central bore. The device also includes a retainer that is attachable to a second end of the opening to retain the drawing implement within the housing. The retainer has a spring element for biasing the drawing implement towards the annular wedge surface. A transmitter is mounted relative to the housing proximal to the central bore.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic front view of a presentation board according to the invention;

FIG. **2** is a side cross sectional view of a transmitter device, constructed and operative according to the invention, used with a conventional drawing implement in a digitizer system;

FIG. **3**A is an exploded perspective view of a microswitch structure, constructed and operative according to the invention, for use in the transmitter device of FIG. **2**;

FIG. **3**B is a perspective view of the microswitch structure of FIG. **3**A assembled;

FIG. **3**C is a top view of the microswitch structure of FIG. **3**A showing a retaining spring arrangement;

FIG. **4** is a schematic perspective view of a preferred structure for attachment of a retaining member to a housing for use in the transmitter device of FIG. **2**;

FIG. **5**A is a plot of the output of a contact switch activated by operational contact between a drawing implement and a presentation board as a function of time;

FIG. **5**B illustrates the recorded drawing implement operation time profile produced by prior art systems corresponding to the contact profile of FIG. **3**A;

FIG. **5**C illustrates the corresponding recorded drawing implement operation time profile produced according to a first embodiment of a presentation board digitizer system, constructed and operative according to the invention; and

FIG. **6** is a side cross sectional view of an eraser transmitter unit, constructed and operative according to the invention, for use with a digitizer system.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The invention provides a presentation board digitizer system for use with presentation boards of all sizes and which may be used with replaceable conventional pen elements.

FIG. **1** shows a presentation board digitizer system, generally designated **10**, constructed and operative according to the invention. System **10** features a presentation board **12**, which may be of any conventional type, provided with a plurality of receiver assemblies **14**, **16**, and **18**. The receiver assemblies **14**, **16**, and **18** are preferably mounted in a strip **20** adapted for convenient attachment to presentation boards of different sizes and thicknesses. This attachment may be achieved through clamps or clips of any type (see, for example, commonly assigned and copending patent application Ser. No. 08/804,497, filed Feb. 21, 1997 (Retrofittable Apparatus For Converting A Substantially Planar Surface Into An Electronic Data Capture Device). Strip **20** also features a receiver **22**. The present position of the movable element is derived from the time-of-flight (TOF) of signals from the movable element to the receiver assemblies by triangulation. An additional signal provides information such as, for example, the color of a pen being used.

In principle, two receivers are sufficient to determine the position of a movable element in contact with board **12**. However, to provide reliable reception over the entire area of a large board, system **10** employs more than one set of receivers. Thus, in the system as illustrated, a first set of receivers is defined as the pair of receiver assemblies **14** and **16**, and a second set of receivers is defined as the pair of receiver assemblies **16** and **18**. The first set of receivers so defined is positioned for receiving a signal from the transmitter when the movable element is in a first region denoted A, and the second set of receivers is positioned for receiving the signal when the movable element is in a second region denoted C. Thus, optimal precision and reliability is achieved by deriving the position of the movable element from the outputs of receiver assemblies **14** and **16** when the movable element is in region A, and from the outputs of receiver assemblies **16** and **18** when the movable element is in region C. It should be appreciated that other position detection schemes may be used in connection with practice of the herein disclosed invention.

FIGS. **2**–**4** show a preferred embodiment of a transmitter device, generally designated **40**, constructed and operative according to the invention, for use with a drawing implement **42** in a digitizer system. Transmitter device **40** may be used to advantage with a wide range of digitizer systems including, but not limited to, the presentation board digitizer systems described above.

Generally speaking, transmitter device **40** includes a housing **44** having a substantially cylindrical opening **46** which terminates at its lower end in an annular wedge surface **48** having a central box **50**. Drawing implement **42** is received within opening **46** with its operative tip **52** extending through bore **50**.

Transmitter device **40** also includes a retainer **54** in the form of a cover attachable to the upper end of opening **46** to retain drawing implement **42** in position within housing **44**. Retainer **54** features a spring element **56** for biasing drawing **42** towards annular wedge surface **48**. A transmitter **58** is mounted on the lower surface of housing **44** proximal to bore **50**.

It is a particular feature of preferred embodiments of the transmitter device that they can accommodate drawing implements of a range of lengths and widths. To this end, spring element **56** adjusts to any variations in length, and biases drawing implement **42** towards the lower end of housing **44** to ensure a correct position for use. This biasing, in conjunction with the shape of annular wedge surface **48**, serves to center the front end of a drawing implement of any size or shape. In addition, spring element **56** is preferably provided with a shaped abutment surface **60** having features for centering the back end of a drawing implement. Typically, abutment surface **60** has an axial conical projection as shown for centering drawing implements by engaging a rear axial recess which is common to almost all presentation board pens. Alternatively, abutment surface **60** maybe formed with a conical recess or other features for centering the back of a drawing implement.

It should be noted that the combination of annual wedge surface **48** and spring element **56** with abutment surface **60** serves to hold drawing implements of a range of lengths and widths in central alignment within cylindrical opening **46** without contacting the sides of housing **44**. This arrangement makes transmitter device **40** insensitive to variations in drawing implement width. The avoidance of frictional contact with the sides of housing **44** is also important for efficient operation of a contact sensing microswitch, as is described below.

FIG. **5**A is a plot of the output of a contact switch activated by operational contact between a drawing implement and a presentation board as a function of time. FIG. **5**A shows a drawing stroke period **100** for a continuous line segment, as well as individual stroke periods **102** for a dashed line. FIG. **5**B illustrates the recorded drawing implement operation time profile produced by prior art systems corresponding to the contact profile of FIG. **3**A. It can be seen that for the continuous line segment (period **100**), the effects of signal loss (shown by the dashed line) are not sufficient to interfere with tracking of the line. Thus, there is a small signal loss at the beginning of the period, but the majority of the stroke is recorded well. However, during period **102** the system response time is comparable to the length of the pen strokes. As a result, the dashed line is almost completely lost.

The preferred embodiment of the invention solves the foregoing problem by maintaining synchronization between the transmitter device **40** and the receiver system for a given period of time after the end of each pen stroke. This may be achieved, for example, by the use of electronic circuitry that continues to operate the transmitter **60** for a given time interval after the microswitch **64** ceases to indicate a force exerted on the other housing towards the operative tip of the drawing implement. False drawings signals are avoided by either disabling the transmitter **58** during the delay period, or

by changing the content of the signal to indicate a non-contact pen state. The delay period is typically from about ½ second, and preferably between 1 and about 2 seconds, in duration.

FIG. **5**C illustrates the corresponding recorded drawing implement operation time profile produced according to a first embodiment of a presentation board digitizer system, constructed and operative according to the invention. FIG. **5**C shows the response profile of the transmitter device **40** as described. During an initial period of a single pen stroke, the response curve is similar to that shown on FIG. **5**B for the prior art. However, when short repeated strokes are encountered, the transmitter device **40** maintains synchronization between successive strokes, thereby providing an accurate response immediately on switching of the microswitch **64**.

FIG. **6** is a side cross sectional view of an eraser transmitter unit, constructed and operative according to the invention, for use with a digitizer system. While various multifunction writing implements have been identified above in connection with the prior art, it is thought that such devices are somewhat limited in their ability to operate in connection with various tracking schemes. Thus, some such implements are especially designed for optical schemes, while other implements are especially designed for electromagnetic tracking schemes. A major problem with eraser elements for use with digitizer systems is the common practice of employing only a part of the eraser surface. Because the digitizer is typically unable to distinguish between flat contact and edge contact of the eraser, the digitized image frequently shows a much greater erased area than has actually been cleared from the presentation board itself. To solve this problem, the invention provides an eraser that is constructed such that the eraser surface is self-orienting to lie parallel to the presentation board surface. This ensures that the contact area of the eraser element is always precisely defined.

The implement shown on FIG. **6** may be used for several purposes. Thus, the implement includes a sleeve **182** that comprises a handle, and an eraser **188**, which has a substantially flat, eraser surface **191**. The eraser surface is preferably circular. The handle and eraser may be connected by a pivot joint **212**, which may be a ball and socket having two degrees of rotational freedom. The pivot joint ensures that the eraser assumes an orientation with the eraser surface **191** parallel to the presentation board surface substantially independent of the orientation of the handle. Connection of the handle to the pivot joint is through a spring assembly **213**. The implement also includes a transmitter similar to the transmitter **40** discussed above. A pressure sensing microswitch **190** is mounted to sense contact pressure between the handle and the eraser and operate the transmitter accordingly.

The writing implement shown on FIG. **6** provides a sleeve **182** that has an inner diameter that is adapted to receive and securely retain a standard dry erase marker **180**. Thus, one using the herein disclosed marking implement uses a marker that is familiar. The sleeve is tapered to follow the tapered contour of the pen and terminates with a switch **190** that detects movement of the pen tip, i.e. when the tip of the pen is placed to the writing surface. Such detection generates a signal that is communicated to the sensor array to indicate that the marking implement is now in contact with the writing surface (and not above the writing surface, as such detection would provide a false plane of information to the sensor array). Thus, the sensor array only tracks marking implement position when the marking implement is registered to the writing surface. Such signal may also communicate actual positional information, for example by providing a relay or feedback of tracking information received at the pen, such that a time based marking implement position may be derived.

Such signal may also be modulated or digitally coded to identify a particular marking implement function or color, for example whether the marking implement is a red or blue pen, whether the marking implement is drawing a thin line or a thick line, or whether the marking implement is an eraser. In connection with this last point, the marking implement herein disclosed includes a collar **184** that is adapted to be securely fitted to the sleeve **182**. The collar activates a switch **185** that indicates it is fitted to the sleeve. A plunger **186** is movable fitted within the collar. An eraser **188** is securely received within the plunger.

In operation, the eraser is pressed to the writing surface to erase marking thereon. This action pushes the plunger into the collar, thereby activating the switch **190**, and thereby indicating contact of the eraser with the writing surface. The presence of the collar operates the switch **185**, thereby indicating that the marking implement is performing an eraser function. With regard to the actual determination of the position of the marking implement, the invention is readily adapted for use with any modern locating technique, including any of those techniques discussed above in connection with the prior art.

Although the invention is described herein with reference to the preferred embodiment, one skilled in the art will readily appreciate that other applications may be substituted for those set forth herein without departing from the spirit and scope of the present invention. Accordingly, the invention should only be limited by the Claims included below.

What is claimed is:

1. A transmitter device for use with a system for digitizing operative strokes of a handheld drawing implement, the drawing implement having a body and an operative tip, the transmitter device comprising:

a housing;

a transmitter mounted relative to said housing;

a microswitch that is responsive to a force exerted on the operative tip of the drawing implement towards said housing;

electronic circuitry responsive to said microswitch to affect operation of said transmitter, wherein said electronic circuitry operates said transmitter for a given time interval after said microswitch ceases to indicate a force exerted on said housing towards the operative tip of the drawing implement.

2. The device of claim **1**, wherein said given time interval is at least about half a second.

3. The device of claim **1**, whereby said transmitter transmits continuously, and wherein said electronic circuitry is responsive to said microswitch to change a signal transmitted by said transmitter while said microswitch indicates a force exerted on the operative tip of the drawing implement towards said housing.

4. The device of claim **1** for use with a system for digitizing the position of a handheld drawing implement, said drawing implement having a central axis and an operative tip, said transmitter device further comprising:

a substantially cylindrical transmitter element positioned coaxially with the drawing implement so as to circumscribe a part of the drawing implement proximal to said operative tip.

* * * * *

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31 December, 2006

EPOS Development Ltd.
4 Haharash St. P.O. Box 7159
Hod-Hasharon, 45240
Israel
Fax: 97297625777

Dear Sirs,

This firm represents Pegasus Technologies Ltd. hereinafter "Pegasus" in intellectual property matters. Pegasus maintains a large portfolio of patents and patent applications designed to protect its highly valuable proprietary technology.

It has recently come to Pegasus' attention that EPOS Technologies Ltd. is about to introduce an ultasonic digital pen product. We believe that this product infringes one or more claims of at least the following issued US patents:

US 6,392,330

US 6,724,371

US 6,841,742

US 6,326,565

You are hereby requested to forbear from making, using and/or selling the infringing product. Pegasus is determined to vigorously enforce its intellectual property and will weigh all its legal options.

Yours truly,

Dr. Mark Friedman

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Shlomo Caine, Director, Central and Eastern Europe, Russia @ Israel Ruthie
Sharon: Marketing Manager

Cc: Walden Israel
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P.O. Box 4078
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CIVIL COVER SHEET

JS-44
(Rev.1/05 DC)

I (a) PLAINTIFFS

EPOS TECHNOLOGIES LTD.

(b) COUNTY OF RESIDENCE OF FIRST LISTED PLAINTIFF 99999
(EXCEPT IN U.S. PLAINTIFF CASES)

DEFENDANTS

PEGASUS TECHNOLOGIES LTD.

COUNTY OF RESIDENCE OF FIRST LISTED DEFENDANT
(IN U.S. PLAINTIFF CASES ONLY)
NOTE: IN LAND CONDEMNATION CASES, USE THE LOCATION OF THE TRACT OF LAND INVOLVED

(c) ATTORNEYS (FIRM NAME, ADDRESS, AND TELEPHONE NUMBER)

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ATTORNEYS (IF KNOWN)

II. BASIS OF JURISDICTION

(PLACE AN x IN ONE BOX ONLY)

- ○ 1 U.S. Government Plaintiff
- ◉ 3 Federal Question (U.S. Government Not a Party)
- ○ 2 U.S. Government Defendant
- ○ 4 Diversity (Indicate Citizenship of Parties in item III)

III CITIZENSHIP OF PRINCIPAL PARTIES (PLACE AN x IN ONE BOX FOR PLAINTIFF AND ONE BOX FOR DEFENDANT) FOR DIVERSITY CASES ONLY!

	PTF	DFT		PTF	DFT
Citizen of this State	○ 1	○ 1	Incorporated or Principal Place of Business in This State	○ 4	○ 4
Citizen of Another State	○ 2	○ 2	Incorporated and Principal Place of Business in Another State	○ 5	○ 5
Citizen or Subject of a Foreign Country	○ 3	○ 3	Foreign Nation	○ 6	○ 6

IV. CASE ASSIGNMENT AND NATURE OF SUIT

(Place a X in one category, A-N, that best represents your cause of action and one in a corresponding Nature of Suit)

○ A. *Antitrust*

- ☐ 410 Antitrust

○ B. *Personal Injury/ Malpractice*

- ☐ 310 Airplane
- ☐ 315 Airplane Product Liability
- ☐ 320 Assault, Libel & Slander
- ☐ 330 Federal Employers Liability
- ☐ 340 Marine
- ☐ 345 Marine Product Liability
- ☐ 350 Motor Vehicle
- ☐ 355 Motor Vehicle Product Liability
- ☐ 360 Other Personal Injury
- ☐ 362 Medical Malpractice
- ☐ 365 Product Liability
- ☐ 368 Asbestos Product Liability

○ C. *Administrative Agency Review*

- ☐ 151 Medicare Act

Social Security:
- ☐ 861 HIA ((1395ff)
- ☐ 862 Black Lung (923)
- ☐ 863 DIWC/DIWW (405(g)
- ☐ 864 SSID Title XVI
- ☐ 865 RSI (405(g)

Other Statutes
- ☐ 891 Agricultural Acts
- ☐ 892 Economic Stabilization Act
- ☐ 893 Environmental Matters
- ☐ 894 Energy Allocation Act
- ☐ 890 Other Statutory Actions (If Administrative Agency is Involved)

○ D. *Temporary Restraining Order/Preliminary Injunction*

Any nature of suit from any category may be selected for this category of case assignment.

(If Antitrust, then A governs)

◉ E. *General Civil (Other)* OR ○ F. *Pro Se General Civil*

Real Property
- ☐ 210 Land Condemnation
- ☐ 220 Foreclosure
- ☐ 230 Rent, Lease & Ejectment
- ☐ 240 Torts to Land
- ☐ 245 Tort Product Liability
- ☐ 290 All Other Real Property

Personal Property
- ☐ 370 Other Fraud
- ☐ 371 Truth in Lending
- ☐ 380 Other Personal Property Damage
- ☐ 385 Property Damage Product Liability

Bankruptcy
- ☐ 422 Appeal 28 USC 158
- ☐ 423 Withdrawal 28 USC 157

Prisoner Petitions
- ☐ 535 Death Penalty
- ☐ 540 Mandamus & Other
- ☐ 550 Civil Rights
- ☐ 555 Prison Condition

Property Rights
- ☐ 820 Copyrights
- ☒ 830 Patent
- ☐ 840 Trademark

Federal Tax Suits
- ☐ 870 Taxes (US plaintiff or defendant
- ☐ 871 IRS-Third Party 26 USC 7609

Forfeiture/Penalty
- ☐ 610 Agriculture
- ☐ 620 Other Food &Drug
- ☐ 625 Drug Related Seizure of Property 21 USC 881
- ☐ 630 Liquor Laws
- ☐ 640 RR & Truck
- ☐ 650 Airline Regs
- ☐ 660 Occupational Safety/Health
- ☐ 690 Other

Other Statutes
- ☐ 400 State Reapportionment
- ☐ 430 Banks & Banking
- ☐ 450 Commerce/ICC Rates/etc.
- ☐ 460 Deportation
- ☐ 470 Racketeer Influenced & Corrupt Organizations
- ☐ 480 Consumer Credit
- ☐ 490 Cable/Satellite TV
- ☐ 810 Selective Service
- ☐ 850 Securities/Commodities/ Exchange
- ☐ 875 Customer Challenge 12 USC 3410
- ☐ 900 Appeal of fee determination under equal access to Justice
- ☐ 950 Constitutionality of State Statutes
- ☐ 890 Other Statutory Actions (if not administrative agency review or Privacy Act

G. *Habeas Corpus/ 2255*	H. *Employment Discrimination*	I. *FOIA/PRIVACY ACT*	J. *Student Loan*
☐ 530 Habeas Corpus-General ☐ 510 Motion/Vacate Sentence	☐ 442 Civil Rights-Employment (criteria: race, gender/sex, national origin, discrimination, disability age, religion, retaliation) *(If pro se, select this deck)*	☐ 895 Freedom of Information Act ☐ 890 Other Statutory Actions (if Privacy Act) *(If pro se, select this deck)*	☐ 152 Recovery of Defaulted Student Loans (excluding veterans)

K. *Labor/ERISA (non-employment)*	L. *Other Civil Rights (non-employment)*	M. *Contract*	N. *Three-Judge Court*
☐ 710 Fair Labor Standards Act ☐ 720 Labor/Mgmt. Relations ☐ 730 Labor/Mgmt. Reporting & Disclosure Act ☐ 740 Labor Railway Act ☐ 790 Other Labor Litigation ☐ 791 Empl. Ret. Inc. Security Act	☐ 441 Voting (if not Voting Rights Act) ☐ 443 Housing/Accommodations ☐ 444 Welfare ☐ 440 Other Civil Rights ☐ 445 American w/Disabilities-Employment ☐ 446 Americans w/Disabilities-Other	☐ 110 Insurance ☐ 120 Marine ☐ 130 Miller Act ☐ 140 Negotiable Instrument ☐ 150 Recovery of Overpayment & Enforcement of Judgment ☐ 153 Recovery of Overpayment of Veteran's Benefits ☐ 160 Stockholder's Suits ☐ 190 Other Contracts ☐ 195 Contract Product Liability ☐ 196 Franchise	☐ 441 Civil Rights-Voting (if Voting Rights Act)

V. ORIGIN

◉ 1 Original Proceeding ○ 2 Removed from State Court ○ 3 Remanded from Appellate Court ○ 4 Reinstated or Reopened ○ 5 Transferred from another district (specify) ○ 6 Multi district Litigation ○ 7 Appeal to District Judge from Mag. Judge

VI. CAUSE OF ACTION (CITE THE U.S. CIVIL STATUTE UNDER WHICH YOU ARE FILING AND WRITE A BRIEF STATEMENT OF CAUSE.)

35 U.S.C. §§ 1 et seq.: This is an action for a declaratory judgment of patent noninfringement and invalidity.

VII. REQUESTED IN COMPLAINT ☐ CHECK IF THIS IS A CLASS ACTION UNDER F.R.C.P. 23 **DEMAND $** _____ Check YES only if demanded in complaint **JURY DEMAND:** YES ☒ NO ☐

VIII. RELATED CASE(S) IF ANY (See instruction) YES ☐ NO ☒ If yes, please complete related case form.

DATE 03/01/2007 **SIGNATURE OF ATTORNEY OF RECORD** G. Brian Busey

INSTRUCTIONS FOR COMPLETING CIVIL COVER SHEET JS-44

Authority for Civil Cover Sheet

The **JS-44** civil cover sheet and the information contained herein neither replaces nor supplements the filings and service of pleadings or other papers as required by law, except as provided by local rules of court. This form, approved by the Judicial Conference of the United States in September 1974, is required for the use of the Clerk of Court for the purpose of initiating the civil docket sheet. Consequently a civil cover sheet is submitted to the Clerk of Court for each civil complaint filed. Listed below are tips for completing the civil cover sheet. These tips coincide with the Roman Numerals on the Cover Sheet.

I. COUNTY OF RESIDENCE OF FIRST LISTED PLAINTIFF/DEFENDANT (b) County of residence: Use 11001 to indicate plaintiff is resident of Washington, D.C.; 88888 if plaintiff is resident of the United States but not of Washington, D.C., and 99999 if plaintiff is outside the United States.

III. CITIZENSHIP OF PRINCIPAL PARTIES: This section is completed only if diversity of citizenship was selected as the Basis of Jurisdiction under Section II.

IV. CASE ASSIGNMENT AND NATURE OF SUIT: The assignment of a judge to your case will depend on the category you select that best represents the primary cause of action found in your complaint. You may select only one category. You must also select one corresponding nature of suit found under the category of case.

VI. CAUSE OF ACTION: Cite the US Civil Statute under which you are filing and write a brief statement of the primary cause.

VIII. RELATED CASES, IF ANY: If you indicated that there is a related case, you must complete a related case form, which may be obtained from the Clerk's Office.

Because of the need for accurate and complete information, you should ensure the accuracy of the information provided prior to signing the form.